(*)Escola de Enxeñaría de Telecomunicación

(*)Páxina web

(*)

www.teleco.uvigo.es

(*)Presentación

The School of Telecommunication Engineering (EET) is a higher education school of the University of Vigo that offers Bachelor's degrees, Master's degrees and Doctoral programs in the fields of Telecommunications Engineering.

Bachelors Degree in Telecommunication Technologies Engineering (EUR-ACE®).

The mail goal of the Bachelors Degree in Telecommunication Technologies Engineering is to form professionals at the forefront of technological knowledge and professional competences in telecommunication engineering. This Bachelor has been recognized with the best quality seals, like the EUR-ACEs. **It has a bilingual option: up to 80% of the degree credits can be taken in English**.

http://teleco.uvigo.es/images/stories/documentos/gett/degree_telecom.pdf

www: http://teleco.uvigo.es/index.php/es/estudios/gett

Master in Telecommunication Engineering

The Master in Telecommunication Engineering is a Master's degree that qualifies to exercise the profession of Telecommunication Engineer, in virtue of the established in the Order CIN/355/2009 of 9 of February.

http://teleco.uvigo.es/images/stories/documentos/met/master_telecom_rev.pdf

www: http://teleco.uvigo.es/index.php/es/estudios/mit

Interuniversity Masters

The current academic offer includes interuniversity masters degrees that are closely related to the business sector:

Master in Cybersecurity: www: https://www.munics.es/

Master in Industrial Mathematics: www: http://m2i.es

International Master in Computer Vision: www: https://www.imcv.eu/

(*)Equipo directivo

MANAGEMENT TEAM

Directora: Rebeca Pilar Díaz Redondo (teleco.direccion@uvigo.gal)

Secretaría e Subdirección de Novas Titulacións: Pedro Rodríguez Hernández

(teleco.subdir.secretaria@uvigo.gal;teleco.subdir.novastitulacions@uvigo.gal)

Subdirección de Organización Académica: Pedro Comesaña Alfaro (teleco.subdir.academica@uvigo.gal)

Subdirección de Relaciones Internacionais e Subdirección de Infraestructuras: María Verónica Santalla del Río (teleco.subdir.internacional@uvigo.gal; teleco.subdir.infraestructuras@uvigo.gal)

Subdirección Difusión e Captación: Laura Docio Fernández (teleco.subdir.captacion@uvigo.gal)

Subdirección de Calidade: Ana María Cao Paz(teleco.subdir.calidade@uvigo.gal)

BACHELOR SDEGREE IN TELECOMMUNICATION TECHNOLOGIES ENGINEERING

Generalcoordinator: Lucía Costas Pérez (teleco.grao@uvigo.gal)

https://teleco.uvigo.es/es/documentos/acordos-es/comisions-academicas-es/miembros-de-la-comision-academica-del-gett/

MASTER IN TELECOMMUNICATION ENGINEERING

Generalcoordinator: Manuel García Sánchez (teleco.master@uvigo.gal)

https://teleco.uvigo.es/es/documentos/acordos-es/comisions-academicas-es/miembros-de-la-comision-academica-del-met/

MASTER INCYBERSECURITY

General coordinator:Ana Fernández Vilas (teleco.munics@uvigo.gal)

https://teleco.uvigo.es/es/documentos/acordos-es/comisions-academicas-es/miembros-de-la-comision-academica-del-munics/

MASTER ININDUSTRIAL MATHEMATICS

Generalcoordinator: Elena Vázquez Cendón (USC)

UVigo coordinator:José Durany Castrillo (durany@dma.uvigo.es)

http://www.m2i.es/?seccion=coordinacion

INTERNATIONALMASTER IN COMPUTER VISION

General coordinator: Xose Manuel Pardo López (USC)

UVigo coordinator:José Luis Alba Castro (jalba@gts.uvigo.es)

https://www.imcv.eu/legal-notice/

MASTER'S DEGREE IN QUANTUM INFORMATION SCIENCE AND TECHNOLOGIES (MQIST)

General coordinator: Javier Mas (USC)

Coordinador UVIGO: Manuel Fernández Veiga(teleco.mqist@uvigo.es)

https://quantummastergalicia.es/info

Grado en Ingeniería de Tecnologías de Telecomunicación

Subjects			
Year 1st			
Code	Name	Quadmester	Total Cr.
V05G301V01101	Mathematics: Calculus 1	1st	6
V05G301V01102	Mathematics: Linear algebra	1st	6
V05G301V01103	Physics: Fundamentals of Mechanics and Thermodynamics	1st	6
V05G301V01104	Business: Company Fundamentals	1st	6

V05G301V01105	Programming I	1st	6
V05G301V01106	Mathematics: Calculus 2	2nd	6
V05G301V01107	Mathematics: Probability and Statistics	2nd	6
V05G301V01108	Physics: Analysis of Linear Circuits	2nd	6
V05G301V01109	Informatics: Computer Architecture	2nd	6
V05G301V01110	Programming II	2nd	6

Year 2nd

Code	Name	Quadmester	Total Cr.
V05G301V01201	Physics: Fundamentals of electronics	1st	6
V05G301V01202	Physics: Fields and Waves	1st	6
V05G301V01203	Digital electronics	1st	6
V05G301V01204	Data Communication	1st	6
V05G301V01205	Digital Signal Processing	1st	6
V05G301V01206	Electronic technology	2nd	6
V05G301V01207	Electromagnetic Transmission	2nd	6
V05G301V01208	Signal Transmission and Reception Techniques	2nd	6
V05G301V01209	Fundamentals of Sound and Image	2nd	6
V05G301V01210	Computer Networks	2nd	6

Year 3rd

Code	Name	Quadmester	Total Cr.
V05G301V01301	Internet Services	1st	6
V05G301V01302	Programmable Electronic Circuits	1st	6
V05G301V01303	Operating Systems	1st	6
V05G301V01304	Data Networks: Technology and Architecture	1st	6
V05G301V01305	Network Security	1st	6
V05G301V01306	Distributed and Concurrent Programming	2nd	6
V05G301V01307	Network and Switching Theory	2nd	6
V05G301V01308	Multimedia Networks	2nd	6
V05G301V01309	Information Systems	2nd	6
V05G301V01310	Architectures and Services	2nd	6
V05G301V01311	Analogue Electronics	1st	6
V05G301V01312	Electronic Systems for Signal Processing	1st	6
V05G301V01313	Engineering of Electronic Equipment	1st	6
V05G301V01314	Data Acquisition Systems	2nd	6
V05G301V01315	Power Electronics	2nd	6

V05G301V01316	Electronic Instrumentation and Sensors	2nd	6
V05G301V01317	Microelectronics Design	2nd	6
V05G301V01318	Electronic Systems for Digital Communications	2nd	6
V05G301V01319	Radio Frequency Circuits	1st	6
V05G301V01320	Radio Communication Systems	1st	6
V05G301V01321	Multimedia Signal Processing	1st	6
V05G301V01322	Microwave Circuits	2nd	6
V05G301V01323	Radio Spectrum Management	2nd	6
V05G301V01324	Principles of Digital Communications	2nd	6
V05G301V01325	Optical Telecommunication Infrastructures	2nd	6
V05G301V01326	Wireless Systems and Networks	2nd	6
V05G301V01327	Fundamentals of Acoustics Engineering	1st	6
V05G301V01328	Sound Processing	1st	6
V05G301V01329	Video and Television	1st	6
V05G301V01330	Room Acoustics	2nd	6
V05G301V01331	Interactive Audio Systems	2nd	6
V05G301V01332	Imaging Systems	2nd	6
V05G301V01333	Fundamentals of Image Processing	2nd	6
V05G301V01334	Design of audiovisual installations	2nd	6

Year 4th

Code	Name	Quadmester	Total Cr.
V05G301V01401	Multimedia services	1st	6
V05G301V01402	Wireless and mobile networks	1st	6
V05G301V01403	Intelligent systems programming	1st	6
V05G301V01404	Integrated systems design	1st	6
V05G301V01405	New computerised services	1st	6
V05G301V01406	Application Design with micro-controllers	1st	6
V05G301V01407	Optoelectronic devices	1st	6
V05G301V01408	Design and synthesis of digital systems	1st	6
V05G301V01409	Advanced electronic sensors	1st	6
V05G301V01411	Remote sensing	1st	6
V05G301V01412	Navigation systems and satellite communications	1st	6
V05G301V01413	Digital processing in real time	1st	6
V05G301V01414	Digital Communications	1st	6
V05G301V01415	Basics of bioengineering	1st	6
V05G301V01416	Image and video analysis	1st	6

V05G301V01417	Video games and virtual reality	1st	6
V05G301V01418	Advanced acoustics	1st	6
V05G301V01419	Legislation and noise measurement techniques	1st	6
V05G301V01420	Audiovisual production CGI	1st	6
V05G301V01426	Technology Management	2nd	6
V05G301V01427	Projects Lab	2nd	12
V05G301V01981	Externships: Internships I	1st	6
V05G301V01982	Externships: Internships II	1st	6
V05G301V01991	Final Year Dissertation	2nd	12

IDENTIFYING DATA				
Mathematics: Calculus 1				
Subject	Mathematics: Calculus 1			
Code	V05G301V01101			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	1st	1st
Teaching language	Spanish			
Department				
Coordinator	Fernández Manin, Generosa			
Lecturers	Bajo Palacio, Ignacio Calvo Ruibal, Natividad Fernández Manin, Generosa Prieto Gómez, Cristina Magdalena			
E-mail	gmanin@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The aim of this subject is to introduce the student in the basic techniques of Differential Calculus in one and several real variables and its applications. At the end of the semester it is expected that students have achieved the understanding of the basic concepts, handle the usual differential operators of the mathematical physics and learn the techniques of differential calculus for the determination of extremes local approximation of functions and numerical solution of systems of equations. Besides, the student will learn to handle some computer programs of symbolic calculation and graphic representation.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C1	CE1/FB1: The ability to solve mathematical problems in Engineering. The aptitude to apply knowledge about linear algebra, geometry, differential geometry, differential and integral calculus, differential and partial differential equations; numerical methods, numerical algorithms, statistics and optimization
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Understanding of the basic concepts of the differential calculation in one and several variables.	B3 B4	C1	D2 D3
Knowledge and handle of the usual differential operators of the mathematical physics.		C1	
Knowledge and handle of the technicians of differential calculation for the research of extremes, the local approximation of functions and the numerical resolution of systems of equations.	B4	C1	D2
Knowledge of some computer program of symbolic calculation and graphic representation.	B3		D3

Contents	
Topic	
Topic 1. Introduction.	Sets of numbers and functions of one variable.
Topic 2. Continuity of functions of one variable.	Limit of a function in a point. One-sided limits. Continuity. The intermediate value theorem. Bolzano's theorem. The bisection method.
Topic 3. Continuity of functions of several variables.	n-dimensional space. Inner product, Norm. Vector product. Functions of several variables. Limits. Continuity. Bolzano's theorem.

Topic 4. Derivatives of functions of one variable and applications of the derivative.	Derivatives of a function at a point. Derivative function, successive derivatives, properties. Chain rule. Implicit differentiation. Derivative of inverse functions. Maxima and minima. Mean value theorem. L'Hopital's rule. Local study of the graph of a function. Taylor polynomials. Newton's method.
Topic 5. Differential of functions of several variables.	Directional derivatives. Partial derivatives. Jacobian matrix. The chain rule. Higher order derivatives. Differential operators.
Topic 6. Applications of the differential calculus.	Extreme values. Extreme values with equality constraints. Newton's method.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	47	61.5	108.5
Problem solving	9	14	23
Laboratory practical	2	1.5	3.5
Problem and/or exercise solving	1	1	2
Problem and/or exercise solving	1	2	3
Problem and/or exercise solving	1	3	4
Problem and/or exercise solving	2	4	6

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The teachers will expose the theoretical contents of the matter. Through this methodology competencies CG3, CE1 and CT3 are developed.
Problem solving	The teachers will solve problems and exercises of each of the topics and the student will have to solve similar exercises. Through this methodology competencies CG3, CG4, CE1, CT2 and CT3 are developed.
Laboratory practical	The students will use computer tools (Maxima and/or Matlab) to solve exercises and apply the knowledge achieved in the theoretical classes. Through this methodology competencies CG3, CG4, CE1, CT2 and CT3 are developed.

Personalized assistance

Methodologies	Description
Lecturing	The teachers will discuss personally the doubts and queries of the students in the schelude of personal tutorials (http://moovi.uvigo.gal) in person, whenever this is possible, and also by the distance learning method, through appointment modality, using the telematic means provided by the Universidade of Vigo.
Problem solving	The teachers will discuss personally the doubts and queries of the students in the schelude of personal tutorials (http://moovi.uvigo.gal) in person, whenever this is possible, and also by the distance learning method, through appointment modality, using the telematic means provided by the Universidade of Vigo.

Assessment

	Description	Qualification	Training and Learning Results	
Problem and/or exercise solving	First session (1 hour): Topic 1.	10	B3 B4	C1
Problem and/or exercise solving	Second session (1 hour): Topics 2 and 3.	20	B3 B4	C1
Problem and/or exercise solving	Third session (1 hour): Topics 4 and 5.	30	B3 B4	C1
Problem and/or exercise solving	Final exam on topics 5 and 6 of the subject.	40	B4	C1

Other comments on the Evaluation

Following the guidelines of the degree, two evaluation systems will be offered to the students: continuous assessment or exam-only assessment.

1. Continuous assessment

Continuous assessment consists of the previous three one-hour sessions detailed and a final exam. If a student cannot attend a particular test on the date for which it is scheduled, he or she will miss that test.

In this case, the final grading for a student is given by the formula:

N = C + E

C : grading, between 0 and 6, obtained as the sum of the marks of the three one-hour sessions.

E : grading, between 0 and 4, obtained in the final exam on the topics 5 and 6 of the subject.

In this mode, a student has successfully completed the course when N is greater than or equal to 5. Gradings obtained in the tests will be valid only for the academic year in which they are done.

On the day of final exam, the students can choose continuous evaluation or to be graded exclusively with global assessment.

2. Global assessment and end-of-program call

Those students who do not choose to be graded by continuous assessment, will be graded by means of a final exam (topics: 1, 2, 3, 4, 5, and 6) which will not necessarily be the same as the one for the students who chose continuous assessment. This exam will be graded in a scale of 10 points and the passing grade cutoff will be 5.

3. Extraordinary exam

On the day of this second final exam, the students who were graded by continuous evaluation may choose to be graded exclusively by this second exam or to be graded taking into account the points obtained in their continuous evaluation by the same formula used earlier, that is:

NR= C + D

C : Mark, between 0 and 6, obtained as the sum of the gradings of the one-hour sessions.

D : Mark, between 0 and 4, obtained in an exam on the topics 5 and 6 of the subject.

In this mode, a student has successfully completed the course when NR is greater than or equal to 5.

Those students who choose to be graded exclusively by the second final exam on topics: 1, 2, 3, 4, 5, and 6 which will not necessarily be the same as the one for the students who made the other choice. This exam will be graded in a scale of 10 points and the passing grade cutoff will be 5.

4. Qualification of ''No Presentado''

A student will obtain a qualification of ''No Presentado'' if the student did not attend sessions of continous evaluation and did not attend the final exams.

5. Ethical behaviour

It is expected a correct and ethical behavior of all students in all written tests and exams, which are meant to truly reflect the knowledge and abilities attained by each student. Any unethical behavior detected in a particular test (such as copying or using prohibited material) will result in a grading of 0 in that test and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information
Basic Bibliography
J. Stewart, **Cálculo de una variable: conceptos y contextos.**, 4ª edición, Cengage Learning, 2011
E. Marsden y A.J. Tromba, **Cálculo vectorial**, 6ª edición, Pearson, 2018
Complementary Bibliography

Recommendations
Subjects that continue the syllabus
Physics: Analysis of Linear Circuits/V05G301V01108 Mathematics: Calculus 2/V05G301V01106 Mathematics: Probability and Statistics/V05G301V01107 Physics: Fields and Waves/V05G301V01202 Digital Signal Processing/V05G301V01205 Electromagnetic Transmission/V05G301V01207
Subjects that are recommended to be taken simultaneously

IDENTIFYING DATA				
Mathematics: Linear algebra				
Subject	Mathematics: Linear algebra			
Code	V05G301V01102			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	1st	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	González Rodríguez, Ramón			
Lecturers	González Rodríguez, Ramón Martín Méndez, Alberto Lucio			
E-mail	rgon@dma.uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The subject Linear Algebra is taught in the first four-month period of the first course of the Grado en Ingeniería de Tecnologías de Telecomunicación, with the main objective of providing students with a clear understanding of the complex numbers, systems of linear equations and elementary techniques of matrix algebra as well as an introduction to the fundamental concepts of Vector Spaces which will be needed in later subjects. Special attention will be paid to the applications of Linear Algebra.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C1	CE1/FB1: The ability to solve mathematical problems in Engineering. The aptitude to apply knowledge about linear algebra, geometry, differential geometry, differential and integral calculus, differential and partial differential equations; numerical methods, numerical algorithms, statistics and optimization
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Skill development the basic operations of matrix algebra.	B3 B4	C1	D2 D3
Knowledge of numerical methods for solving systems of linear equations and knowledge of the basic concepts involving vector spaces and linear maps.	B3		D3
Knowledge of the properties of vector spaces with inner product.		C1	
Skill development some applications of linear algebra: the method of least squares, singular value decomposition and classification of quadratic forms	B3	C1	D3
To know the arithmetic of complex numbers.	B3 B4	C1	D2 D3

Contents	
Topic	
Topic 1. Complex numbers.	Operations with complex numbers. Geometric concepts associated with complex numbers. Euler's formula and its consequences.
Topic 2. Matrices and determinants.	Matrix operations: addition, scalar multiplication and product of matrices. Matrix inverse. Block matrices. Determinants.
Topic 3. Systems of linear equations.	Systems of linear equations. Elementary row operations and Gauss method. Numerical methods for systems of linear equations.
Topic 4. Vector spaces and linear transformations.	Linear independence. Subspaces. Basis. Dimension. Rank of a system of vectors. Introduction to linear transformations. Matrix of a linear transformation.

Topic 5. Matrix diagonalization.	Eigenvalues and eigenvectors. Eigenspace. Matrix diagonalization and diagonalizable matrices.
Topic 6. Spaces with inner product and applications	Spaces with inner product. Orthogonallity. Gram-Schmidt Method. Ortogonal and unitary Diagonalization. Singular value decomposition. Matrix rank reduction. The method of least squares. Quadratic forms.

Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	2	2	4
Lecturing	46	69	115
Problem solving	9	9	18
Problem and/or exercise solving	3	5	8
Essay questions exam	3	2	5

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Laboratory practical	Solving assigned exercises and model problems. Use of the computer tool MATLAB. Through this methodology the competences B3, B4, C1, D2 and D3 are developed.
Lecturing	Explanation and development by the teacher of the contents of the various topics in the syllabus. Through this methodology the competences B3, C1 and D3 are developed.
Problem solving	Resolution by part of the professor of suitable exercises adapted to each topic. The students will also have to take part in the resolution of exercises in order to strengthen their knowledge. Through this methodology the competences B3, B4, C1, D2 and D3 are developed.

Personalized assistance

Methodologies	Description
Problem solving	Personalized tutoring will be available from all the teachers of the subject. For request or consult tutorials, the student can access the corresponding link in https://moovi.uvigo.gal/login/index.php
Laboratory practical	Personalized tutoring will be available from all the teachers of the subject. For request or consult tutorials, the student can access the corresponding link in https://moovi.uvigo.gal/login/index.php
Lecturing	Personalized tutoring will be available from all the teachers of the subject. For request or consult tutorials, the student can access the corresponding link in https://moovi.uvigo.gal/login/index.php
Tests	**Description**
Problem and/or exercise solving	Personalized attention will be available for assistance in the revision of tests and exams. For request or consult tutorials, the student can access the corresponding link in https://moovi.uvigo.gal/login/index.php

Assessment

	Description	Qualification	Training and Learning Results	
Problem and/or exercise solving	Continuous evaluation consists in three tests to be given in the class hour. The planning will be the following: 1. Exam of topic 1 and 2. 2. Exam of topic 3 and 4. 3. Exam of topic 5 and 6. Each test will have a weight of 20% in the final grade. The total weight of the continuous evaluation in the final grade will therefore be of 60%. The planning of the different intermediate evaluation tests will be approved in an Academic Commission of Degree and it will be available at the beginning of the semester.	60	B3 B4	C1
Essay questions exam	A written exam, with a maximum duration of three hours, of topics 1, 2, 3, 4, 5 and 6 at the end of the semester in date, time and venue determined in the official exams calendar of the School.	40	B3 B4	C1

Other comments on the Evaluation

Ordinary assessment:

Continuous assessment:

The final grade is calculated by the formula:

$$M = (2 \times (E1 + E2 + E3) + 4 \times EF) / 10$$

where E1, E2 and E3 are the points, in a scale 0 to 10, obtained in the three tests of the continuous evaluation and where EF represents the points, in a scale 0 to 10, obtained in the final exam. Before doing each test, the procedure and date of revising the grading of that test will be announced. After the test, the grades will be announced in a reasonable amout of time. If a student, for any circumstance, cannot attend a particular test on the date for which it is scheduled, he or she will miss that test and it will not be repeated.

The points obtained in the tests of continuous evaluation will be valid only for the academic year in which they are obtained.

It will be considered that a student has chosen to follow the continuous evaluation if he takes the second exam, that is, that of topics 3 and 4.

Global assessment**:**

The students who do not choose to be graded by continuous evaluation, will be graded by means of a final exam of all the topics of the subject. This exam will be graded in a scale of 10 points and the passing grade cutoff will be 5.

Extraordinary exam:

The students who at the end of the semester do not obtain a passing grade will have the opprtunity of writing a second final exam on date, time and venue determined in the official exams calendar of the School. This exam will cover topics 1, 2, 3, 4, 5 and 6 and it will be graded in a scale of 10 points and the passing grade cutoff will be 5.

Remark: During the exam correction period some students could be contacted by phone or telematically by the teacher to clarify aspects of their answers; in that case, such answers may have an impact on the exam grade.

"No presentado":

A student will obtain a grade of "No Presentado" in the ordinary exam if that student did not attend neither the continuous evaluation nor the final exam.

A student will obtain a grade of "No Presentado" in the second edition of the final grades if and only if that student obtained "No Presentado" in the first call and did not attend the second final exam.

End-of-program exam:

The students which attend the end-of-program exam will write an exam covering topics 1, 2, 3, 4, 5 and 6 which will be graded in a scale of 10 points and the passing grade cutoff will be 5.

Ethical Behavior:

It is expected a correct and ethical behavior of all students in all written tests and exams, which are meant to truly reflect the knowledge and abilities attained by each student. Any unethical behavior detected in a particular test (such as copying or using prohibited material) will result in a grading of 0 in that test and the issue of the corresponding report for the School Director's Office.

English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.

Sources of information

Basic Bibliography

R. González Rodríguez, **Álxebra Linear: Historia, Teoría e práctica**, 978-84-8158-9191-1, Servizo de Publicacións da Universidade de Vigo, 2021

D. C. Lay, **Álgebra lineal y sus aplicaciones**, 3ª, Pearson Educación, 2007

L. Merino; E. Santos, **Álgebra lineal con métodos elementales**, 1ª, Paraninfo, 2006

Complementary Bibliography

J. de Burgos, **Álgebra lineal y geometría cartesiana**, 2ª, McGraw-Hill/Interamericana de España, S. A. U., 2000

D. Poole, **Álgebra lineal: Una introducción moderna**, 2º, Cengage Learning Editores S.A., 2006

Recommendations
Subjects that continue the syllabus
Physics: Analysis of Linear Circuits/V05G301V01108
Mathematics: Calculus 2/V05G301V01106
Physics: Fields and Waves/V05G301V01202

Subjects that are recommended to be taken simultaneously
Mathematics: Calculus 1/V05G301V01101

IDENTIFYING DATA

Physics: Fundamentals of Mechanics and Thermodynamics

Subject	Physics: Fundamentals of Mechanics and Thermodynamics			
Code	V05G301V01103			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	1st	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Schiussi , Stefano			
Lecturers	Fernández Doval, Ángel Manuel Schiussi , Stefano			
E-mail	schiussi@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Introduction to the basic concepts on the general laws of Mechanics and Thermodynamics as well as to their application to the resolution of problems in engineering. "English Friendly" subject. International students may request from the lecturers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) tests and assessments in English.			

Training and Learning Results

Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
C3	CE3/FB3: Comprehension and command of basic concepts about the general laws of mechanics, thermodynamics, electromagnetic fields and waves and electromagnetism and their application to solve Engineering problems.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Understanding and mastering of the basic concepts on the general laws of Mechanics and of Thermodynamics.	B3	C3	
Ability to use the basic instrumentation to measure physical quantities.	B3 B5 B6	C3	D3
Ability to evaluate experimental data.	B3 B5	C3	
Ability to solve the elementary technical problems in engineering.	B3	C3	

Contents

Topic	
1.- Physical quantities and units. The International System.	(*)
2.- Vectorial tools for Mechanics.	(*)
3.- Point Kinematics.	(*)
4.- Point Kinetics.	(*)
5.- Statics.	(*)
6.- Oscillations.	(*)
7.- Wave motion.	(*)
8.- Zero principle of Thermodynamics. Temperature.	(*)
9.- First principle of Thermodynamics.	(*)
10.- Second principle of Thermodynamics.	(*)

Lab 1.- Measurement instruments. Error and uncertainty. Estimation of uncertainties in direct measurements.	(*)
Lab 2.- Measurement of the reaction time to a given stimulus. Measurement of the gravitational acceleration by means of a pendulum. Estimation of uncertainty in indirect measurements.	(*)
Lab 3.- Verification of Hooke's Law. Linear fit.	(*)
Lab 4.- Longitudinal and transversal standing waves. Measurements by linearization of non-linear relations and linear fit. Graphical representation of measurement results.	(*)
Lab 5.- Simple harmonic motion. Free standing oscillation of a spring. Measurements by linearization of non-linear relations and linear fit. Graphical representation of measurement results.	(*)

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	28	34	62
Problem solving	21	40	61
Laboratory practical	9	13	22
Essay questions exam	0.5	0	0.5
Problem and/or exercise solving	3.5	0	3.5
Report of practices, practicum and external practices	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Prior personal work: -Preliminary reading of the proposed bibliography on the subject. During the lectures: -Presentation of theoretical concepts. -Application of the theoretical concepts to simple cases and situations. -Experimental demonstrations. -Audiovisual presentations. Ulterior personal work: -Revision of theoretical concepts. -Solving of questions and exercises from the bibliography. -Consult the bibliography. -Identification of weak points which require tutorial aid. Through this methodology, competencies B3, C3, B5, B6 are worked out.
Problem solving	Solving of average-difficulty problems involving one or more theoretical concepts. During the lectures: -Presentation of solving strategies and techniques by solving example-problems. Personal work: -Solving of problems from the bibliography. -Identification of weak points which require tutorial aid. Through this methodology, competencies B3, C3, B5, B6 are worked out.

Laboratory practical	Prior personal work: -Preparation of the practical session by studying the corresponding guide and reviewing the theory. During the practical session: -Description of the experiment highlighting which theoretical concepts are involved. -Training on material and instrumentation handling. -Execution of the experiment. -Preliminary result processing. Ulterior personal work: -Processing and analysis of the results. -Weak-point identification. -Consult the bibliography. Through this methodology, competencies B3, C3, B5, B6 and D3 are worked out.

Personalized assistance

Methodologies	Description
Lecturing	Questions will be solved by the lecturers in their respective tuitional-aid time. Tutoring sessions will be held: individually or in small groups (typically of two or three students), by appointment to the corresponding lecturer (unless stated otherwise) and, preferably, in the place and timetable of the corresponding lecturer which will be published at the beginning of the semester. The appointment shall be arranged either by e-mail (see https://moovi.uvigo.gal) or in person at the beginning or end of a lecture.
Problem solving	Questions will be solved by the lecturers in their respective tuitional-aid time. Tutoring sessions will be held: individually or in small groups (typically of two or three students), by appointment to the corresponding lecturer (unless stated otherwise) and, preferably, in the place and timetable of the corresponding lecturer which will be published at the beginning of the semester. The appointment shall be arranged either by e-mail (see https://moovi.uvigo.gal) or in person at the beginning or end of a lecture.
Laboratory practical	Questions will be solved by the lecturers in their respective tuitional-aid time. Tutoring sessions will be held: individually or in small groups (typically of two or three students), by appointment to the corresponding lecturer (unless stated otherwise) and, preferably, in the place and timetable of the corresponding lecturer which will be published at the beginning of the semester. The appointment shall be arranged either by e-mail (see https://moovi.uvigo.gal) or in person at the beginning or end of a lecture.

Assessment

	Description	Qualification	Training and Learning Results		
Essay questions exam	Solving of questions related to the theoretical concepts of the topics in both the classroom and laboratory syllabi.	10	B3 B5 B6		
Problem and/or exercise solving	(Problem solving) Solving of simple exercises related to the theoretical concepts of the topics in the syllabus. Solving of problems involving one or more theoretical topics.	70	B3 B5 B6	C3	
Report of practices, practicum and external practices	Execution of real and simulated measurements. Real- and simulated-measurement result processing.	20	B3 B5 B6		D3

Other comments on the Evaluation

(This is a translation, in case of any discrepancy or dispute, the original Spanish version shall prevail.)

The common assessment and grading rules of the University of Vigo are established in:

[RAUV] "Regulamento sobre a avaliación, a cualificación e a calidade da docencia e do proceso de aprendizaxe do estudantado" (available only in Galician language at https://secretaria.uvigo.gal/uv/web/normativa/public/show/565).

Each student summoned to an assessment test must appear with an original official document proving their identity (DNI, NIE, passport, university card or Spanish driving licence). [RAUV Art.28.4].

In the event that a fraudulent action is detected in the performance or revision of any of the assessment tests (copying, plagiarism, impersonation, introduction or use of means not permitted by the rules and instructions of the exercises and assessment tests, alteration, subtraction or destruction of the same, etc.) [RAUV Art.42]:

- The person(s) involved shall be identified and immediately expelled from the assessment test.

- A final grade of zero points (fail) will be assigned to the person(s) involved.

- A report will be submitted to the school management for disciplinary action to be taken.

1. ORDINARY ASSESSMENT OPPORTUNITY

1.1. INTERMEDIATE CONTINUOUS ASSESSMENT TESTS

The schedule of the intermediate assessment tests will be made available by the beginning of the semester in which this subject is taught. These intermediate tests are not recoverable, i.e., they can be only taken in the scheduled dates.

The assessment tests that the student has not taken will be graded with 0 (zero points).

The corrected exercises may be revised, by requesting a tutoring session from the corresponding lecturer, during the fourteen days following the date of publication of the marks.

There will be four intermediate tests:

1.1.1 CONTINUOUS ASSESSMENT EXAMS (EC1 and EC2)

Written exams with questions, exercises and problems (marks EC1 and EC2 between 0 and 2,5 points for each exam). Duration: nominally 1 hour in one lecture on theory or problems.

1.1.2 EVALUATED LABORATORY PRACTICES (LC1 and LC2)

Experimental laboratory exercises comprising the execution of actual measurements and the processing of the results, consisting in taking an experimental laboratory class, individually processing (during the last 30 minutes) the assessable results which will be specified in the corresponding experiments guide and handing them in at the end of the class (marks LC1 and LC2 between 0 and 1 point for each of the exercises).

1.2. FINAL EXAMINATION

Written exam with three optional parts:

E12F)

-Questions, exercises and problems corresponding to the contents of EC1 and EC2 (mark E12F between 0 and 4 points).

-If a student does not take this part, the E12F mark will be assigned the sum of the EC1 and EC2 marks.

E3F)

-Questions, exercises and problems (E3F mark between 0 and 4 points).

-If a student does not take this part, it will be graded with 0 (zero points).

LF)

-Laboratory problem comprising the execution of real or simulated measurements and the processing of the results (LF mark between 0 and 2 points).

-If a student does not take this part, the LF mark will be assigned the sum of the LC1 and LC2 marks.

Duration 4 hours on the place and date officially assigned for the subject in the examinations schedule of the Centre.

1.3. FINAL GRADING OF THE ORDINARY ASSESSMENT OPPORTUNITY

A student who does not take any of the three parts of the final examination (§1.2) will be regarded as "not presented" to the ordinary assessment opportunity.

A combined mark CCF will be calculated as the sum of the marks of the three parts of the final examination (§1.2).

The final grade FINAL_F will be the lower of 10 points and CCF.

CCF = E12F+E3F+LF

FINAL_F = min{CCF, 10}

2. EXTRAORDINARY ASSESSMENT OPPORTUNITY

2.1. RESIT EXAMINATION

Written exam with three optional parts:

E12R)

-Questions, exercises and problems corresponding to the contents of E12F (mark E12R between 0 and 4 points).

-If a student does not take this part, the E12R mark will be assigned the E12F mark.

E3R)

-Questions, exercises and problems (E3R mark between 0 and 4 points).

-If a student does not take this part, the E3R mark will be assigned the mark obtained in E3F.

LR)

-Laboratory problem comprising the execution of real or simulated measurements and the processing of the results (LR mark between 0 and 2 points).

-If a student does not take this part, the LR mark will be assigned the LF mark.

Duration 4 hours on the place and date officially assigned for the subject in the examinations schedule of the Centre.

2.2. FINAL GRADING OF THE EXTRAORDINARY ASSESSMENT OPPORTUNITY

A student who does not take any of the three parts of the resit examination (§2.1) will be regarded as "not presented" to the extraordinary assessment opportunity.

A combined mark CCR will be calculated as the sum of the marks of the three parts of the resit examination (§2.1).

The final grade FINAL_R will be the lower of 10 points and CCR.

CCR = E12R+E3R+LR

FINAL_R = min{CCR, 10}

3. END-OF-PROGRAM CALL

3.1. END-OF-PROGRAM EXAMINATION

Written exam with:

-Questions

-Exercises

-Problems

-Laboratory problems (with real or simulated measurements and processing of the results)

FINAL_E mark between 0 and 10 points.

Duration 3 hours on the place and date officially assigned for the subject in the examinations schedule of the Centre.

3.2. FINAL GRADING OF THE END-OF-PROGRAM CALL

The final grade FINAL_E will be the one obtained in the end-of-program examination (§3.1).

4. CALCULATIONS AND ROUNDING:

I) All of the aforesaid calculations to obtain the marks will be performed with a resolution equal to or better than one hundredth of a point (0,01 point).

II) The final marks will be rounded to the nearest multiple of 0,1 point (one tenth of a point); if the two nearest multiples of 0,1 point are equidistant, the overall grade will be rounded to the higher of them.

III) The minimum final grade required to pass the course is 5,0 points. [RAUV Art.31]

Sources of information

Basic Bibliography

H.D. Young y R.A. Freedman, **Sears-Zemansky. Física Universitaria**, 9, 11, 12 o 13, Addison-Wesley,

H.D. Young y R.A. Freedman, **University Physics**, 9, 11, 12 or 13, Addison-Wesley,

Present and past lecturers of this subject, **Laboratory Notes for the practical sessions of**, 2023-2024, 2023

Profesorado presente y pasado de la asignatura., **Guiones de las prácticas de «Física Fundamentos de Mecánica y Termodinámica»**, 2022-2024, 2023

Bureau Internationale des Poids et Mesures (BIPM), **SI Brochure: The International System of Units (SI)**, 9, Bureau Internationale des Poids et Mesures (BIPM), 2019

Oficina Internacional de Pesas y Medidas (BIPM), **Sistema Internacional de Unidades SI**, 9, Centro Español de Metrología, 2019

Complementary Bibliography

I.N. Bronshtein, K.A. Semendiaev, **Manual de Matemáticas para Ingenieros y Estudiantes**, (cualquier edición), MIR,

Raymond A. Serway, John W. Jewett, **Física, Tomo 1**, 3, Thomson, 2003

Paul A. Tipler, **Física, Tomo 1**, 5, Reverté, 2005

W. Edward Gettys, et al., **Física Clásica y Moderna**, Mc Graw-Hill, 1991

Douglas C. Giancoli, **Física para universitarios, Tomo 1**, 3, Prentice-Hall, 2002

Marcelo Alonso, Edward J. Finn, **Física**, Addison-Wesley, 1995

Susan M. Lea, John R. Burke, **Física. La naturaleza de las cosas, Tomo 1**, Paraninfo, 2001

Ambler Thompson, Barry N. Taylor, **NIST Special Publication 811, «Guide for the Use of the International System of Units (SI)»**, 2008, National Institute of Standards and Technology, 2008

Comité Conjunto para las Guías en Metrología (JCGM), **Vocabulario Internacional de Metrología (VIM)**, 3, Centro Español de Metrología, 2012

Joint Commitee for Guides in Metrology (JCGM), **International vocabulary of metrology (VIM)**, 3, Bureau International des Poids et Mesures, 2012

Recommendations

Subjects that are recommended to be taken simultaneously

Mathematics: Linear algebra/V05G301V01102

Mathematics: Calculus 1/V05G301V01101

Other comments

To adequately follow this subject, it is highly advisable to master the contents of high-school subjects on Mathematics and Physics.

IDENTIFYING DATA

Business: Company Fundamentals

Subject	Business: Company Fundamentals			
Code	V05G301V01104			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	1st	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	González Vázquez, Beatriz			
Lecturers	González Vázquez, Beatriz Urgal González, Begoña			
E-mail	bgonza@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The objective of this subject is to make known the organisation, management and institutional framework of the company. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results

Code	
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B8	CG8: To know and apply basic elements of economics and human resources management, project organization and planning, as well as the legislation, regulation and standarization in Telecommunications.
C5	CE5/FB5: The necessary knowledge of business concepts, of law and institutional frameworks. business organization and management .
D2	CT2 Understanding Engineering within a framework of sustainable development.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
To establish guidelines on the metrics and indicators that will be used to allow the managers the evaluation and monitoring the company.	B4 B8	C5	D2
Control the start-up and to propose improvement solutions.	B8	C5	D2
Manage the requirements and the products to reduce the time of realisation of the tasks, and improve the coherence and the precision in the business management	B8		

Contents

Topic	
UNIT 1: INTRODUCTION TO BUSINESS ADMINISTRATION	1.1. The concept of firm. 1.2. Main objectives of a business firm. 1.3. Business ownership and types of companies. 1.4. The company as a system. 1.5. Business environment. 1.6. Information and communication technologies.
UNIT 2: ECONOMIC AND FINANCIAL STRUCTURE OF THE COMPANY	2.1. Economic anf Financial Structure of the company 2.2. Working capital analysis 2.3. Operating cycle and cash conversion cycle
Unit 3: THE RESULTS OF THE COMPANY AND THE BUSINESS STRATEGY	3.1. The results of the company 3.2. Profitability and competitive strategy 3.3. Solvency and liquidity
UNIT 4: THE INVESTMENT IN THE COMPANY	4.1. Concept of investment 4.2. Classes of investments 4.3. Criteria for the evaluation and selection of investments: static and dynamic
UNIT 5: FINANCIAL OF THE COMPANY	5.1. Concept of source of finance 5.2. Types of sources of finance

UNIT 6: OPERATION MANAGEMENT (PART I). GENERAL FEATURES	6.1. Functions of Operations Management. 6.2. Classification of productive processes. 6.3. The productivity: indicators of productivity. 6.4 Innovation concept and typology.
UNIT 7: OPERATION MANAGEMENT (PART II).	7.1. The costs of production. 7.2. Break-even point. 7.3. Make-or-Buy decisions. 7.4. Operational leverage. 7.5. Inventory control.
UNIT 8: MARKETING MANAGEMENT	8.1. The market. 8.2. The competition. 8.3. Marketing system. 8.4. Marketing-mix.
UNIT 9: MANAGEMENT AND ORGANIZATION	9.1. The management system. 9.2. Human Resources management.
PRACTICAL CLASSES	The practices of the subject will adjust to the contents taught in the Theory classes

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Lecturing	30	41	71
Practices through ICT	24	36	60
Problem solving	4	9	13
Objective questions exam	4	0	4
Essay questions exam	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	On the first day of class the teaching team will try to know the students' level of the basic concepts of this subject.
Lecturing	Presentation by the professor of the contents on the subject of study, theoretical bases and / or guidelines of a work, exercise or project to be developed by the student. With this methodology, the D2 Competition; Skill C5; Knowledge B8; and Training and Learning Results A1 and A3 are worked on.
Practices through ICT	It is a kind of classes in which the students will work individually or in pairs the practical contents of the subject. Knowledge application activities will be carried out in specific situations. In this methodology, the Skill C5 and knowledge B4 and B8, as well as Training and Learning Results A1, A2 and A3.
Problem solving	Activities in which they formulate problems and/or exercises related with the matter. The student/to has to develop the more appropriate or correct solutions. In this methodology they work on Skill C5 in a practical way; knowledge B4 and B8; as well as the results of Training and Learning A1 and A2.

Personalized assistance

Methodologies	**Description**
Lecturing	In the master sessions, the professor will attend, guide and solve the doubts of the students about the contents addressed in the theoretical classes. Students will have the right to personalized tutorials, in the schedule established for this purpose in the teleteaching platform. These tutorials are intended to solve doubts and guide students on the development of the contents addressed both in the theoretical classes as well as in the practical classes. Likewise, constant communication will also be maintained between professors and students through the educational platform.
Practices through ICT	In the practical sessions the professor will pose diverse activities to the students. The students will resolve said activities, and will be able to pose to the professor the questions or questions that consider on the contents of the exercises or problems posed.
Introductory activities	In the first theory session, the teaching team will try to know individually the level that the students have on the most basic issues of this subject.

Assessment

	Description	Qualification	Training and Learning Results

Objective questions exam	The content of the theory and practical classes will be evaluated. (40% the first test and 20% the practices)	60	B4 B8	C5	D2
Essay questions exam	Test of all the contents of the subject developed in theory and practical classes.	40	B4 B8	C5	D2

Other comments on the Evaluation

Following the guidelines established in the degree, two evaluation systems will be offered: continuous assessment and exam-only assessment at the end of the semester. In any of the two evaluation systems, and all the Training and Learning Results, Knowledge and Skills of the subject are evaluated.

1. Continuous assessment

The qualification by the continuous evaluation system will be determined from the following tests and activities:

- Two tests. They will be carried out during the teaching period in theory classes. Each of them will constitute 40% of the final grade for the subject. The first test does not have a liberating nature, that is, each of them will deal with the contents seen up to the moment of taking the test, both in theory and practical classes.

- Practices. The tasks assigned during the practices will account for 20% of the final grade for the subject.

The dates to take the tests will be planned by the Academic Committee of Degree and will be available at the beginning of the semester. These tests are not recoverable, that is, if a student does not perform them on the stipulated day, the professor does not have the duty to repeat them (unless there is a cause of force majeure). A student will be considered to have opted for continuous assessment when participating in the second test.

Students who opt for continuous evaluation and do not pass the subject will not be able to take the final global evaluation exam in the ordinary call.

2. Global assessment

For those students who do not opt for continuous assessment, they will be offered an evaluation procedure that allows them to obtain the highest grade. This procedure will consist in a final exam that includes the contents developed in the classes of theory and practical classes.

3. About the extraordinary call

For the extraordinary call, all students will be evaluated by the global evaluation system.

4. Qualification Of Absent

A student will be considered absent if, at most, took part in the first assessment test of continuous evaluation method. In any another case, the students will be considered as submitted to the assessment and they will receive their corresponding grade.

5. About the end-of-program call

It will consist of an exam that includes the theoretical and practical contents of the subject.

Sources of information

Basic Bibliography

Pérez Gorostegui, E., **Curso de introducción a la economía de la empresa**, EDITORIAL UNIVERSITARIA RAMON ARECES, 2009

Diez-Viel, I., Martin de Castro, G., Montoro Sanchez, M.A., **Introduction to Business Administration**, S.L. CIVITAS EDICIONES, 2012

Complementary Bibliography

Barroso Castro, C. (Coord.), **Economía de la empresa**, Pirámide, 2012

García Márquez, F., **Dirección y Gestión Empresarial**, McGraw-Hill, 2013

Moyano Fuentes, J.; Bruque Cámara, S.; Maqueira Marín, J.M.; Fidalgo Bautista, F.A.; Martínez Jurado, **Administración de empresas: un enfoque teórico-práctico**, Grupo Anaya, 2011

Iborra Juan, M.; Dasi Coscollar, A.; Dolz Dolz, C.; Ferrer Ortega, C.., **Fundamentos de dirección de empresas. Conceptos y habilidades directivas**, Paraninfo, 2014

Recommendations

Other comments

Students must attend a conference related to the topic of Human Resources that will be announced well in advance.

IDENTIFYING DATA				
Programming I				
Subject	Programming I			
Code	V05G301V01105			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Rodríguez Hernández, Pedro Salvador			
Lecturers	Caeiro Rodríguez, Manuel García Duque, Jorge González Castaño, Francisco Javier López Bravo, Cristina Mikic Fonte, Fernando Ariel Rodríguez Estévez, Judith Soledad Rodríguez Hernández, Pedro Salvador Sousa Vieira, Estrella			
E-mail	pedro.rodriguez@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The aim of the course is to provide students with basic skills to program in a high level language. The programming paradigm followed is that of "structured programming". English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C6	CE6/T1: The ability to learn independently new knowledge and appropriate techniques for the conception, development and exploitation of telecommunication systems and services
C12	CE12/T7: The knowledge and use of basics in telecommunication networks, systems and service programming.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Express the solution of a simple problem by means of algorithms using top-down design.		C12	
Identify the data needed to solve a problem and associate them with appropriate datatypes based on their features (size, range, associated operators)		C12	
Code simple algorithms using the basic types of statements: assignment, selection and iteration.		C12	
Declare and define functions with a proper use of parameters.		C12	
Handle I/O operations and file management.		C12	
Define and use structured data types.		C12	
Define and manage dynamic data structures (lists, stacks, queues and trees).		C12	
Create modules and library functions and use them in programs.		C6 C12	
Predict the result of a sequence of statements, knowing the input data.		C12	
Handle basic tools in an integrated development environment: text editor, compiler, linker, debugger and documentation tools.		C6	
Develop a small scale project following all the phases: requirements analysis, design, implementation, testing and documentation.	B4 B9	C6 C12	D2 D4

Contents

Topic	
Lecture 1: The algorithm and the programming languages.	1. A computers structure and operation 2. How the program gets into the computer 3. C Programming language 4. The process of developing programs 5. Simple Programming Examples 6. Software engineering concepts
Lecture 2: Grammar and basic elements of C language.	1. Basic elements of a C program 2. Identifiers 3. Expressions 4. Declaration and initialization 5. The assignment statement 6. Formatted input/output
Lecture 3: Iteration and selection statements	1. Control statements 2. Decision statements: (a) if statement (b) if-else statement (c) switch statement 3. Iteration statements: (a) do-while statement (b) while statement (c) for statement 4. Statements for altering the control flow: break and continue statements
Lecture 4: Arrays and pointers	1. Data Structures 2. Arrays: (a) One-dimensional arrays (b) Two-dimensional arrays 3. Strings 4. Copy of arrays
Lecture 5: Functions	1. Function declaration and definition 2. Functions with no parameters 3. C inter function communication: local, global and static variables 4. Functions with parameters by value
Lecture 6. Pointers	1. Pointers 2. Pointer arithmetic 3. Dynamic memory allocation 4. Arrays and pointers 5. Pointers to pointers 6. Functions with parameters by reference 7. Command line arguments
Lecture 7: Files	1. Introduction: Types of files 2. Text files in C 3. Declaration 4. File opening and closing 5. File management 6. Operations on characters 7. Operations on strings 8. Formatted operations
Lecture 8: Structured type variables	1. Introduction: Structured data types 2. struct type. Declaration 3. struct type. Operations 4. Pointers and struct type 5. struct as parameters 6. Creation of data types
Lecture 9: Lists	1. Introduction: the need for dynamic data structures 2. Dynamic data structures 3. Linked lists (a) Types (b) Most common operations

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	2	0	2
Lecturing	24	24	48
Laboratory practical	30	20	50
Laboratory practice	4	20	24
Objective questions exam	2	18	20
Problem and/or exercise solving	1	5	6

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description

Introductory activities	Introduction to theoretical and practical activities.
Lecturing	Professors present the main theoretical contents related to the subject These sessions can include the development of works and programs by the students. Through this methodology the competencies CE12 and CT2 are developed.
Laboratory practical	During the first part of the term the student codifies, compiles and documents simple programs guided by the instructor. In this laboratory, the Ubuntu Linux operating system and the gcc compiler will be used. Some of these activities can require the submission of a report in order to be evaluated. Through this methodology the competencies CG4, CG9, CE6, CE12, CT2, and CT4 are developed.

Personalized assistance

Methodologies	Description
Lecturing	The professors will provide individual attention to the students along the term, solving their doubts and questions. Questions will be answered during the master sessions or during tutorial sessions. The professors will establish timetables for this purpose at the beginning of the term. This schedule will be published on the subject website. Tutorial sessions could also be agreed by appointment. The tutorial schedule of the professors is avaliable in their Moovi profiles: https://moovi.uvigo.gal/user/view.php?id=11584 https://moovi.uvigo.gal/user/view.php?id=11583
Laboratory practical	The professors will provide individual attention to the students along the term, solving their doubts and questions about the laboratory practises. Questions will be answered during the lab sessions or during tutorial sessions. The professors will establish timetables for this purpose at the beginning of the term. This schedule will be published on the subject website. Tutorial sessions could also be agreed by appointment. The tutorial schedule of the professors is avaliable in their Moovi profiles: https://moovi.uvigo.gal/user/view.php?id=11584 https://moovi.uvigo.gal/user/view.php?id=11583 https://moovi.uvigo.gal/user/view.php?id=59589 https://moovi.uvigo.gal/user/view.php?id=11342 https://moovi.uvigo.gal/user/view.php?id=11665 https://moovi.uvigo.gal/user/view.php?id=11299 https://moovi.uvigo.gal/user/view.php?id=11585 https://moovi.uvigo.gal/user/view.php?id=11338

Assessment

	Description	Qualification	Training and Learning Results		
Laboratory practice	The student will take 2 midterm laboratory tests consisting in the development of small programs on the computer. Each of these tests will assess the student's progress on a portion of the laboratory practical exercises. The final laboratory test will assess the student's progress on the practical exercises as a whole.	50	B4 B9	C6 C12	D2 D4
Objective questions exam	The student will take 1 midterm theoretical test that may consist of: - short answer questions - multiple choice questions This exam will assess individually the student's mastery of the concepts introduced in the lecture sessions. The final theoretical exam will also contain this type of questions.	40	B4	C12	
Problem and/or exercise solving	The theoretical exams will have a part consisting of problem and/or exercise solving	10	B4	C12	

Other comments on the Evaluation

Following the guidelines specific to the degree program, each student will have 2 opportunities (the **ordinary** and **extraordinary** calls) to pass the course.

Furthermore, in the ordinary call, there will be 2 evaluation procedures (**continuous** and **global**).

ASSESSMENT TESTS

Throughout the semester, several intermediate assessment tests will be given. Specifically, there will be two **Midterm LaboratoryTests** (PL1 and PL3) and one **Midterm TheoreticalTest** (PT2). The schedule of the different intermediate assessment tests will be approved by the Academic Degree Committee (CAG) and will be available at the beginning of the semester.

During the regular examination period of the School, the **Final Theoretical Test** (ETF) and the **Final Laboratory Test** (EFL) will be given.

During the extraordinary examination period of the School, the **Extraordinary Theoretical Test** (ETX) and the **Extraordinary Laboratory Test** (EXL) will be given.

Each theoretical test may include short-answer and/or multiple-choice questions, as well as problem-solving and/or exercise resolution questions. It assesses students' knowledge of the content covered in the lectures.

All the practical exercises are mandatory. Prior to each laboratory test, it will be necessary to have uploaded to Moovi all the corresponding assignments for that test. Each laboratory test consists of making modifications to the submitted practical exercises. It evaluates those submitted practical exercises.

ORDINARY CALL

Each student taking this course may choose between the 2 evaluation procedures: continuous assessment and global assessment.

Taking the second midterm test (PT2) will be interpreted as the decision to choose continuous assessment. No taking it will be interpreted as the decision to choose global assessment.

CONTINUOUS ASSESSMENT

The condition for passing the course using the continuous assessment procedure is obtaining a final grade (NFC) equal to or higher than 5.

The final grade for continuous assessment will be calculated as the weighted arithmetic mean of the midterm and final test grades. It will be given by the following expression:

NFC = 0.6 NPP + 0.2 ETF + 0.2 EFL

Where:

NPP is the Midterm Test Grade, calculated as the weighted arithmetic mean of all midterm tests, according to the following expression:

NPP = (1PL1 + 3PT2 + 2*PL3) / 6

ETF is the grade obtained on the Final Theoretical Test.

EFL is the grade obtained on the Final Laboratory Test.

A minimum grade of 2.5 points will be required in the three components of this grade (NPP, ETF, and EFL). If the student fails to reach this minimum in any of them, the final grade for continuous assessment will be at most 4.0 (Fail).

Continuous assessment consists of the tests detailed in this guide, which are not recoverable. In other words, if a student cannot complete them within the specified timeframe, the teaching staff is not obliged to repeat them.

Before each test, the date and procedure for reviewing the grades will be indicated. Students will have the option to know the grade of each test and review the correction within approximately 2 weeks.

GLOBAL ASSESSMENT

The condition for passing the course using the global assessment procedure is obtaining a final grade (NFG) equal to or higher than 5.

This method will consist of the same final tests as the continuous assessment, although with different weights. The final grade for global assessment will be given by the following expression:

NFG = (ETF + EFL) / 2

A minimum grade of 2.5 points will be required in the two components of this grade (ETF and EFL). If the student fails to reach this minimum in any of them, the final grade for global assessment will be at most 4.0 (Fail).

Each student taking the final tests for the course will have both grades calculated: the final grade for continuous assessment (NFC) and the final grade for global assessment (NFG). The higher of the two grades will be awarded as the final grade in the ordinary call.

The grade will be "No-show" if the student does not attend any test after the first Midterm Test (PL1).

EXTRAORDINARY CALL

Each student who does not pass the course in the ordinary call will have a second opportunity.

In the extraordinary call, the condition for passing the course is obtaining a final grade (NFX) equal to or higher than 5.

The final grade in the extraordinary call will be given by the following expression:

NFX = (NTX + NXL) / 2

Where:

NTX is the Extraordinary Theoretical Grade: if the student takes the Extraordinary Theoretical Test, NTX will be the grade obtained in that test:

NTX = ETX

If not, NTX will be the theoretical grade obtained in the ordinary call:

NTX = 0.6 PT2 + 0.4 ETF

NXL is the Extraordinary Laboratory Grade: if the student takes the extraordinary Laboratory Test, NXL will be the grade obtained in that test:

NXL = EXL

If not, NXL will be the laboratory grade obtained in the ordinary call:

NXL = 0.2 PL1 + 0.4 PL2 + 0.4 EFL

A minimum grade of 2.5 points will be required in the two components of this grade (NTX and NXL). If the student fails to reach this minimum in any of them, the final grade in the extraordinary call will be at most 4.0 (Fail).

END-OF-PROGRAM TEST

Following the guidelines specific to the degree program, students who have 3 or fewer courses remaining to graduate will have end-of-program test call in those courses.

In the end-of-program test call, the condition for passing the course is obtaining a final grade (NFX) equal to or higher than 5.

In this call, a test with short-answer and/or multiple-choice questions, as well as problem-solving and/or exercise resolution questions, will be conducted (End-of-program Theoretical Test, ETZ), and a laboratory test evaluating the lab work (End-of-program Laboratory Test, ELZ). The final grade in the end-of-program test call will be given by the following expression:

NFZ = (ETZ + ELZ) / 2

A minimum grade of 2.5 points will be required in the two components of this grade (ETZ and ELZ). If the student fails to reach this minimum in any of them, the final grade in the end-of-program test call will be at most 4.0 (Fail).

The grade obtained in any of the assessable tasks will be valid only for the academic year in which they are performed, meaning that no grade is carried over from one year to the next.

If plagiarism is detected on any of the assignments/tests, the grade will be Fail (0), and the teaching staff will report the incident to the School's administration for appropriate action to be taken.

The use of generative artificial intelligence (GAI) is permitted in the completion of academic activities for this subject. Its use must be ethical, critical, and responsible. If GAI is used, any results it provides should be critically evaluated, and any generated citations or references must be carefully verified. Additionally, it is recommended to disclose the tools used.

Sources of information

Basic Bibliography

Brian W. Kernighan, Dennis M. Ritchie, **The C Programming Language**, 1995, Prentice Hall, 1983

Brian W. Kernighan, Dennis M. Ritchie, **El Lenguaje de Programación C**, 1995, Prentice Hall, 1983

Manuel Caeiro Rodríguez, Enrique Costa Montenegro, Ubaldo García Palomares, Cristina López Bravo, J, **Practicar Programación en C**, 2014,

Complementary Bibliography

Ignacio Alvarado Aldea, Jose María Maestre Torreblanca, Carlos Vivas Venegas, Ascensión Zafra Cabeza, **100 Problemas Resueltos de Programación en Lenguaje C para Ingeniería**, 2017, Paraninfo, 2017

https://www.tutorialspoint.com/cprogramming/, **Learn C Programming**, 2021,

https://www.programiz.com/c-programming, **Learn C Programming**, 2021,

Stephen G. Kochan, **Programming in C**, 2014, Addison Wesley, 2005

Osvaldo Cairo Battistuti, **Fundamentos de Programación**, 2006, Pearson Education,

José Rafael García-Bermejo Giner, **Programación Estructurada en C**, 2008, Prentice Hall,

James L. Antonakos, Kenneth C. Mansfield Jr., **Programación Estructurada en C**, 2004, Prentice Hall, 1997

Jorge A. Villalobos S., Rubby Casallas G., **Fundamentos de Programación: Aprendizaje Activo Basado en Casos**, 2006, Prentice Hall,

Recommendations

Subjects that continue the syllabus

Informatics: Computer Architecture/V05G301V01109

Programming II/V05G301V01110

Other comments

Programming II course continues this course in the second semester of the first year.

IDENTIFYING DATA				
Mathematics: Calculus 2				
Subject	Mathematics: Calculus 2			
Code	V05G301V01106			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Álvarez Vázquez, Lino José			
Lecturers	Álvarez Vázquez, Lino José Martínez Varela, Áurea María			
E-mail	lino@dma.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The matter of Calculus II of the Degree in Engineering of Technologies of Telecommunication provides basic and common training to the branch of the telecommunication. Such as it figures in the memory of the degree, students should be able to formulate, to solve and to interpret mathematically problems within engineering of telecommunication at the end of the lectures. For this, they should know how to calculate integrals of functions of one and several variables and its meaning and they should handle the basic numerical methods of approximation for this kind of integrals. On the other hand, they should become familiar with the developments of functions in Fourier series. Also, they will have to know how to solve differential equations of first and second order. Finally, they should know to handle the Laplace transform in order to solve differential equations. All of these contents are notable for several matters that they must to study simultaneously or later in the degree.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C1	CE1/FB1: The ability to solve mathematical problems in Engineering. The aptitude to apply knowledge about linear algebra, geometry, differential geometry, differential and integral calculus, differential and partial differential equations; numerical methods, numerical algorithms, statistics and optimization
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Managing the transformation of Laplace as a tool of analysis of the linear systems.	B3 B4	C1	D2 D3
Knowledge of the necessary theoretical bases for the analysis of Fourier.	B3 B4	C1	D2 D3
Knowledge and handle of the simple techniques for the integration of ordinary differential equations.	B3 B4	C1	D2 D3
Understanding the basic theory of integration of functions of one and several variables.	B3 B4	C1	D2 D3

Contents	
Topic	
Subject 1. Integral calculus in R.	The Riemann integral: integrable functions. Fundamental theorems of the integral calculus. Computation of primitives: integration by parts and change of variable. Improper integrals.
Subject 2. Numerical methods for the approximation of integrals.	Quadrature rules of interpolating polynomial type. Properties. Interpolation error. Particular cases: Poncelet, Trapezoidal and Simpson. Composite quadrature rules.

Subject 3. Fourier series and Fourier transform.	Orthogonal functions. Fourier series. Developments of Fourier series for odd and even functions. Convergence. The Fourier transform.
Subject 4. Multiple integration.	The double and triple integrals in elementary regions. Change in the order of integration. Theorems for the change of variable. Applications.
Subject 5. The Laplace transform.	Definition of the Laplace transform. Properties.
Subject 6. Ordinary differential equations.	Generalities on the differential equations: concept of solution, families of curves and orthogonal trajectories. Differential equations of first order: existence and uniqueness of solution, exact equations, separate variables, homogeneous equations and linear equations. Differential equations of second order: existence and uniqueness of solution for linear differential equations, application of the Laplace transform, indeterminate coefficients, variation of parameters, equation of Cauchy-Euler.

Planning

	Class hours	Hours outside the classroom	Total hours
Problem solving	21	21	42
Laboratory practical	3	0	3
Lecturing	36	60	96
Problem and/or exercise solving	3	6	9

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Problem solving	In these hours of work the professor will solve problems of each one of the subjects and will enter new methods of solution no contained in the master classes from a practical point of view. The student also will have to solve problems proposed by the professor with the aim to apply the obtained knowledges. Through this methodology the competencies B3, B4, C1, D2 and D3 are developed.
Laboratory practical	In these practices, the computer tool MATLAB will be used to study and to apply the numerical methods of approximation of integrals described in the Theme 2 of the matter. Through this methodology the competencies B4, C1, D2 and D3 are developed.
Lecturing	The professor will expose in this type of classes the theoretical contents of the matter. Through this methodology the competencies B3, C1, D2 and D3 are developed.

Personalized assistance

Methodologies	**Description**
Lecturing	The professor will attend personally the doubts and queries of the students. He will solve doubts in his office, in the classes of problems, and in the laboratory. Also the Web platform Moovi and the email will be used to help the students. They will have occasion of to attend tutorial sessions in a timetable established at the beginning of the course and which will be published in Moovi (https://moovi.uvigo.gal/user/profile.php?id=11586).
Problem solving	The professor will attend personally the doubts and queries of the students. He will solve doubts in his office, in the classes of problems, and in the laboratory. Also the Web platform Moovi and the email will be used to help the students. They will have occasion of to attend tutorial sessions in a timetable established at the beginning of the course and which will be published in Moovi (https://moovi.uvigo.gal/user/profile.php?id=11586).
Laboratory practical	The professor will attend personally the doubts and queries of the students. He will solve doubts in his office, in the classes of problems, and in the laboratory. Also the Web platform Moovi and the email will be used to help the students. They will have occasion of to attend tutorial sessions in a timetable established at the beginning of the course and which will be published in Moovi (https://moovi.uvigo.gal/user/profile.php?id=11586).

Assessment

Description	Qualification	Training and Learning Results

Problem and/or exercise solving	* Three "one hour sessions": 1st session: Themes 1, 2 and 3. 2nd session: Theme 4. 3rd session: Themes 5 and 6. These three sessions account for 60% of the score with the following weights: First: 20% (2 points) Second: 20% (2 points) Third: 20% (2 points) * One final exam: 40% (4 points) Individual assessment	100	B3 B4	C1	D2 D3

Other comments on the Evaluation

The evaluation will preferably be continuous. The student will be enrolled in this kind of assessment if he attends any evaluable session. Once enrolled, it is impossible to unsubscribe from continuous assessment.

The exams of continuous evaluation are not recoverable, ie, if a student can not attend the test in the date stipulated by the teacher, it is impossible to require the repetition. Before performing each test, both the approximate date of publication of the qualifications and the date and procedure for review them will be communicated. The score obtained at the evaluable tasks will be only valid for the academic year in which the student make them.

In tests of continuous assessment the student will solve problems and exercises of the topics of matter.

The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester.

1. Continuous assessment.

The final score for a student who makes continuous assessment is given by the formula

N = C + E

C: Grade obtained by adding the scores of the three sessions of the items 1, 2, 3, 4, 5 and 6.
E: Grade of the final examination of the items 4, 5 and 6.

In this mode **a student will pass the subject when N is greater than or equal to 5**.

2. Global assessment.

Those students who fail to continuous assessment may be submitted to a final exam of all topics in the subject on the same date that the final exam of continuous assessment.

These students will be evaluated from 0 to 10 points and **they will pass the subject when the obtained score is greater than or equal to 5**.

3. Extraordinary exam.

Previously to the exam students who chose continuous assessment may choose, if desired, for an exam of the items 4, 5 and 6. The final grade is obtained as

NR = C + ER

C: Grade obtained by adding the scores of the three sessions of the items 1, 2, 3, 4, 5 and 6.
ER: Grade the final recovery examination of the items 4, 5 and 6.

In this mode a student **will pass the subject when NR is greater than or equal to 5**.

If they do not choose that option, the student will be assessed in all the issues on the subject.

In this other method they will be evaluated from 0 to 10 points. A student **will pass the subject when the obtained score is greater than or equal to 5**.

4. Qualification of not presented.

Finally, a student is considered not presented **if is not enrolled in the continuous assessment and does not attend any of the examinations** of the subject. Otherwise the student is considered presented.

5. End-of-program exam.

The student will be assessed in all the issues on the subject.

Sources of information
Basic Bibliography
D. Zill - W.S. Wright, **Cálculo de una variable**, 4ª, McGraw-Hill, 2011
J.E. Marsden - A.J. Tromba, **Cálculo vectorial**, 5ª, Addison-Wesley, 2004
D.G. Zill - M.R. Cullen, **Ecuaciones diferenciales**, 3ª, Thomson, 2002
Complementary Bibliography
A. Quarteroni - F. Saleri, **Cálculo científico con Matlab y Octave**, 1ª, Springer, 2006

Recommendations
Subjects that continue the syllabus
Physics: Fields and Waves/V05G301V01202

Subjects that are recommended to be taken simultaneously

Physics: Analysis of Linear Circuits/V05G301V01108
Mathematics: Probability and Statistics/V05G301V01107

Subjects that it is recommended to have taken before

Mathematics: Linear algebra/V05G301V01102
Mathematics: Calculus 1/V05G301V01101

IDENTIFYING DATA				
Mathematics: Probability and Statistics				
Subject	Mathematics: Probability and Statistics			
Code	V05G301V01107			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Fernández Bernárdez, José Ramón Alonso Alonso, Ignacio			
Lecturers	Docampo Amoedo, Domingo Fernández Bernárdez, José Ramón Mojón Ojea, Artemio			
E-mail	ignacio.alonso@uvigo.es jramon.fernandez@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The aim of this subject is to study some basic concepts of statistics, probability and random processes. These concepts are necessary in order to easily follow other subsequent subjects.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C1	CE1/FB1: The ability to solve mathematical problems in Engineering. The aptitude to apply knowledge about linear algebra, geometry, differential geometry, differential and integral calculus, differential and partial differential equations; numerical methods, numerical algorithms, statistics and optimization
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Learn how to distinguish between deterministic or random models	B4	C1	D2
Identify a probabilistic model that fits with the needs of a specific problem	B3 B4	C1	D2 D3
Propose solutions to simplify statistical models by using deterministic parameters	B3 B4	C1	D2 D3

Contents	
Topic	
Probability theory	Concept of probability. Axiomatic definition. Conditional probability, total probability and Bayes theorems. Independence.
One-dimensional random variables	Concept of random variable (RV). Classification. Cumulative distribution function (CDF) and properties. Discrete random variables: probability mass function. Continuous random varriables: density function. Functions of an RV. CDF and discrete RV. Transformation of continuous RVs: fundamental theorem. Mean and variance.

Random vectors	CFD and continuous RV. Marginals. Point and line masses. Conditional density. Continuous versions of Bayes and total probability theorems. Functions of two-dimensional RVs: fundamental theorem. Changes of dimension. Correlation and regression.
Estimation and limit theorems	Sample and population. Estimators. Estimation of mean and variance. Sequences of RVs. Laws of large numbers. Central limit theorem.
Stochastic processes	Description of a stochastic process. Statistics of a stochastic process. Stationarity. Examples.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	28	14	42
Problem solving	17	34	51
Practices through ICT	14	7	21
Problem and/or exercise solving	1	6	7
Objective questions exam	1	6	7
Essay questions exam	2	14	16
Essay	0	6	6

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The course is divided in five main topics. Each topic will have a theoretical part that will be exposed by the teacher. Students will be required to perform a previous reading of the contents. Through this methodology the competencies CG3, CE1 and CT3 are developed.
Problem solving	Each topic will be complemented with problem resolution. The problems could be developed and solved in big or small group classes. The students will be required to work previously on these problems. Through this methodology the competencies CG3, CG4, CE1, CT2 and CT3 are developed.
Practices through ICT	Each topic will be completed with one or several sessions of computer practices. For this, a software developed by the teachers (based on Python) and specific questionnaires for each topic will be used. Students will be required to perform a previous reading of the contents. Through this methodology the competencies CG3, CG4, CE1, CT2 and CT3 are developed.

Personalized assistance

Methodologies	Description
Lecturing	Students will have the opportunity to attend one-on-one tutorials, in person or online. Each teacher, at the beginning of the term, will establish the schedule and characteristics of the offered tutorials. The contact details of the teaching staff are specified on the subject's page, on MooVi (https://moovi.uvigo.gal), within the "Teaching staff and tutorials" section.
Problem solving	Students will have the opportunity to attend one-on-one tutorials, in person or online. Each teacher, at the beginning of the term, will establish the schedule and characteristics of the offered tutorials. The contact details of the teaching staff are specified on the subject's page, on MooVi (https://moovi.uvigo.gal), within the "Teaching staff and tutorials" section.
Practices through ICT	Students will have the opportunity to attend one-on-one tutorials, in person or online. Each teacher, at the beginning of the term, will establish the schedule and characteristics of the offered tutorials. The contact details of the teaching staff are specified on the subject's page, on MooVi (https://moovi.uvigo.gal), within the "Teaching staff and tutorials" section.

Assessment

Description	Qualification	Training and Learning Results

Problem and/or exercise solving	Students must solve a problem individually	20	B3 B4	C1
Objective questions exam	Students must answer a multiple choice test individually	25	B3 B4	C1
Essay questions exam	Individual final exam	40	B3 B4	C1
Essay	Individual submission of a problem solved independently	15	B3 B4	C1

Other comments on the Evaluation

Following the guidelines of the degree, two assessment systems will be offered to the students: Continuous assessment or Global assessment.

Each student can decide himself to follow or not Continuous assessment. It is assumed that a student follows this assessment system if he sits task 2 (around the seventh week of the term) or any later task. Sitting Task 1 (both, part 1 and part 2) does not bind the student to Continuous assessment. Even so, on the day of the final exam, the student will be able to choose Global assessment.

Students who choose Continuous assessment:

Several midterm tasks are assessed with a grade between 0 and 10. In this assessment method, the final grade will be calculated as a weighted average, with the weights specified below, of the grades of the different midterm tasks and the final exam. The schedule of the midterm tasks will be approved in the Comisión Académica de Grado (CAG) and it will be available at the beginning of each academic semester.

A brief description of the tasks and their weight in the final grade is listed below:

- Task 1: Weight 20%. Two parts, both with the same weight:
    - Part 1: Individual resolution of a problem
    - Part 2: Correction of a solution of the same problem solved by someone else
- Task 2: Individual resolution of a multiple choice test. Weight 25%
- Task 3: Submission of a problem solved individually. Once the problem has been assigned, the deadline for submission is 48 hours later. Weight 15%
- Last Task: Final exam. A reduced version of the exam to be carried out by the students who choose Global assessment. Weight 40%

Before the completion or delivery of each task, the date and procedure for its review will be indicated. Students will have the option to know the grade of each task and review its correction within a reasonable period of time (around one week).

These tasks are not recoverable, that is, if a student cannot sit them, teachers will not be committed to repeat them, unless in the case of documented justified reasons.

Throughout the course, during the classes, some exercises will be proposed. Those participating in continuous assessment and completing these exercises may receive a bonus of up to 0.5 marks. If awarded, this bonus will be added to the final grade achieved through the continuous assessment method. If the sum is higher than 10, the final grade will be 10.

The obtained grades will be valid only for the current academic course.

If a student is binded to Continuous assessment and does not pass the course he/she will receive a grade of fail, regardless of he/she sits the final exam or not.

Students who choose Global assessment or End-of-program exam:

In these cases students will just carry out a single final exam. This exam will be graded between 0 and 10, and this value will be the final grade of the student.

Extraordinary exam:

The extraordinary exam is only available for students who have not passed the subject previously and they have to choose between Continuous and Global assessment, regardless of the system they chose at the Ordinary exam. The choice has to be made when handing in the exam to the teacher. On the other hand, grades will be obtained using the corresponding assessment system as it has been described above.

The subject is considered passed if the final grade obtained is greater than or equal to 5.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information

Basic Bibliography

JR Fernández, I. Alonso y A. Mojón, **Apuntes de Probabilidad y Estadística**, 14 ed, 2025

JR Fernández, I. Alonso and A. Mojón, **Notes on Probability and Statistics**, 4 ed, 2025

A Mojón, I. Alonso y JR Fernández, **Vídeos de la asignatura de Probabilidad y Estadística**, 1 ed, UVigoTV, 2014

X. Rong Li, **Probability, Random Signals and Statistics**, 1 ed, CRC Press, 1999

R. Cao y otros, **Introducción a la estadística y sus aplicaciones**, 1 ed, Pirámide, 2001

Complementary Bibliography

H. Stark y J.W. Woods, **Probability, Random Processes, and estimation theory for engineers**, 2 ed, Prentice Hall, 1994

D. Peña, **Estadística, modelos y métodos. Tomo 1: Fundamentos**, 2 ed, Alianza Universidad Textos, 1991

P. Peebles, **Principios de probabilidad, variables aleatorias y señales aleatorias**, 4 ed, McGraw-Hill, 2006

A. Papoulis, **Probability, random variables and stochastic processes**, 4 ed, McGraw-Hill, 2002

A. Blasco y S. Pérez-Díaz, **Modelos aleatorios en ingeniería**, 1 ed, Paraninfo, 2015

Recommendations

Subjects that continue the syllabus

Data Communication/V05G301V01204
Computer Networks/V05G301V01210
Signal Transmission and Reception Techniques/V05G301V01208
Basics of bioengineering/V05G301V01415

Subjects that are recommended to be taken simultaneously

Mathematics: Calculus 2/V05G301V01106

Subjects that it is recommended to have taken before

Mathematics: Linear algebra/V05G301V01102
Mathematics: Calculus 1/V05G301V01101

IDENTIFYING DATA				
Physics: Analysis of Linear Circuits				
Subject	Physics: Analysis of Linear Circuits			
Code	V05G301V01108			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	1st	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	García-Tuñón Blanca, Inés			
Lecturers	García Mateo, Carmen García-Tuñón Blanca, Inés Gómez Araújo, Marta Pérez Eijo, Lorena María			
E-mail	inesgt@com.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The course introduces the fundamentals of the lumped circuit principles and abstractions on which the design of electronic systems is based. These include lumped circuit models for sources, resistors, inductors, and capacitors. It intends to present some techniques to analyze (to determine currents and voltages) such systems: conventional analysis (integer-differential analysis, phasors and impedances in sinusoidal regime) and linear systems theory based analysis (by using the Laplace transform). English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C4	CE4/FB4: Comprehension and command of basic concepts in linear systems and their related functions and transforms; electric circuits theory, electronic circuits, physical principles of semiconductors and logical families, electronic and photonic devices, materials technology and their application to solve Engineering problems.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
To know the elements and laws involved in lumped circuit analysis.		C4	
To show the ability to analyse linear circuits in different circumstances: -. to know how to choose among different alternatives when solving a problem. -. to know simplifying techniques, their constraints, and how to decide which ones must be used.	B4	C4	D2
To translate the time domain into the transformed domains, by using transforms basic concepts.		C4	
To be able to qualitatively justify the role played by circuit elements and their interactions.	B3	C4	D3
Handle with solvency the language and symbolism of the discipline.	B3 B4	C4	

Contents	
Topic	
I: Introduction to the circuit analysis	Fundamental and derived magnitudes. Circuit elements. Kirchhoff's laws. Resistors in series. Resistor in parallel. Divider circuits: voltage-divider and current-divider.

II: Techniques of circuit analysis in steady-state continuous regime.	Analysis by the mesh current method. Analysis by the node voltage method. Source transformations. Thévenin and Norton equivalent circuits. Maximum power transfer. Superposition.
III: Reactive elements	Inductors and capacitors. Series-parallel combinations of inductors and capacitors. Inductors and capacitors in steady-state continuous regime. Transient regime. Natural and step response of RL and RC circuits.
IV: Sinusoidal steady-state analysis	Definition and parameters. Rms and medium value. Concepts of phasor and impedance. Mesh and node analysis of steady-state sinusoidal regime networks. Thévenin and Norton equivalent circuits. Ideal transformers. Power expressions and calculations.
V: Two-port circuits	Definition of a two-port circuit. Characteristic parameters. Interconnected two-port circuits. Analysis of the terminated two-port circuit.
VI: Circuit analysis in the transformed domain	Steady-state response in a circuit. The transfer function. Circuit elements in the s domain. Circuit analysis in the s domain.
VII: Frequency selective circuits	Filter concept. Low-pass filters. High-pass filters. Bandpass filters. Bandreject filters.
VIII: Circuit analysis in the time domain	Classification of signals. Classification of systems. Linear and time invariant systems. Direct and inverse Laplace Transform. Poles and zeros diagram. Response to impulse. Convolution integral.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	0.5	0	0.5
Lecturing	24.5	49	73.5
Practices through ICT	12	12	24
Laboratory practical	8	4	12
Problem solving	9	4	13
Problem and/or exercise solving	3	9	12
Systematic observation	1	2	3
Essay questions exam	2	10	12

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Presentation of the course: syllabus, bibliography, teaching methodology, and assessment and grading procedures. Through this methodology the competencies CT2 and CT3 are developed.
Lecturing	The goal of this methodology is the presentation of the theoretical contents and the practical assessment about students learning abilities. Different exercises and problems related to the specific subject will be solved during these sessions, by the Professor or the students with his/her support, either individually or working in a group. Through this methodology the competencies CG3, CG4, CE4, CT2 and CT3 are developed.

Practices through ICT	Theses sessions will consist on a supervised either individual or team problem solving of practical applications related to the theoretical content of the subject. The solutions could be analyzed, checked and compared using computational tools. Through this methodology the competencies CG3, CG4 and CE4 are developed.
Laboratory practical	Practical sessions will be carried out in the hardware lab, assembling and measuring circuits tasks will be covered. Through this methodology the competencies CG3, CG4 and CE4 are developed.
Problem solving	Theses sessions will consist on a supervised team problem solving of practical applications related to the theoretical content of the subject. Through this methodology the competencies CG3, CG4 and CE4 are developed.

Personalized assistance

Methodologies	Description
Lecturing	Needs and study matter queries of students will be address by the professors on tutoring hours (avaliables at ttps://moovi.uvigo.gal).
Laboratory practical	Professors set the pace of the session and resolve any questions that arise during the realization of practice. Also on the schedule tutoring (avaliable at ttps://moovi.uvigo.gal)., professors address the needs and queries of the students related to laboratory practices.
Practices through ICT	Professors set the pace of the session and resolve any questions that arise during the realization of practice. Also on the schedule tutoring (avaliable at ttps://moovi.uvigo.gal)., professors address the needs and queries of the students related to practices in computer rooms.
Problem solving	Professors set the pace of the session and resolve any questions that arise during the session. Also on the schedule tutoring (avaliable at ttps://moovi.uvigo.gal)., professors address the needs and queries of the students related to problem solving.

Assessment

	Description	Qualification	Training and Learning Results		
Problem and/or exercise solving	There will be 3 tests in Group A schedule: ECA1, ECA2 and ECA3. The score of each of these three tests will be 2 points. The schedule of the tests will be approved in the CAG and will be available at the beginning of the semester.	60	B3 B4	C4	
Systematic observation	Throughout the course, at the end of different practical sessions (practices through ICT and laboratory practices), the subject's teaching staff will propose the resolution of some simple exercises related to the content of the session and previous sessions. Students who participate in the continuous evaluation and solve these exercises may receive a total bonus of up to 0.5 points (Bonus). The bonus received will be added to the final continuous evaluation grade and if the maximum possible grade is exceeded, the final continuous evaluation grade would be truncated by 10.	5	B3 B4	C4	D2 D3
Essay questions exam	Global Test (PG). It will cover all the contents of the subject, both theoretical and practical, and may include multiple choice tests, reasoning questions, problem solving and / or exercises, as well as the development of practical cases. There will be a version of this exam for students who follow the continuous assessment, whose maximum score will be 4 points, and another extended version of it with a score of 10 points for the rest of the students.	40	B3 B4	C4	

Other comments on the Evaluation

The student, in agreement to the official academic-year schedule, will have two opportunities during the academic year to pass the course:

1. Ordinary exam at the end of the semester.

Students can freely choose the continuous assessment system described in the previous section, without this excluding the possibility of taking a final exam.

Possible cases:

- Students who only take the final exam: they are graded with the score they have obtained in it (0 to 10 points).
- Students who follow the continuous assessment: they are qualified with the sum of all the scores, truncated by 10:

Mark = min (ECA1 + ECA2 + ECA3 + Bonus + PG , 10)

2. Extraordinary exam.

Students who did not pass the course at the end of the semester can take an extraordinary final exam that will cover all the contents of the subject, both theoretical and practical, and that may include multiple choice tests, reasoning questions, problem solving and / or exercises, as well as the development of practical cases. The score achieved in it (between 0 and 10) will be the final grade.

Students whos have followed the continuous assessment may decide, on the same day of the exam, whether or not to keep their continuous assessment grade in the same way as in the first opportunity final exam.

End-of-program exam:

There will be an exam that will cover all the contents of the subject, both theoretical and practical, and that may include multiple choice tests, reasoning questions, problem solving and / or exercises, as well as the development of practical cases. The score achieved in it (between 0 and 10) will be the final grade.

Additional comments:

- Students must attend the practices in the group assigned to them at the beginning of the semester.
- All marks in the evaluation are individual.
- Taking the ECA2 or successive scoring tests and / or any of the final exams will mean that the student will have a different grade than "Not presented".
- The grade obtained in continuous evaluation will be valid only for the academic year in which it is carried out.
- The subject is considered approved if the final grade is equal to or greater than 5.

Re-scheduling of tests.

In case of missing a test, instructors have not any compulsion to rescheduling.

Test results.

Before each test, the date and revision procedure of assigned grading marks will be indicated. Such dates will imply a reasonable delay (in general, not greater than three weeks) between the date of test and the release of the grading marks.

Plagiarism.

Plagiarism is regarded as serious dishonest behaviour. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Use of Generative Artificial Intelligence

In carrying out the academic activities of this subject, the use of generative artificial intelligence (GAI) is allowed. Its use must be carried out in an ethical, critical and responsible manner. In the case of using IAG, any results it provides should be critically evaluated, and any citations or references generated should be carefully verified. It is also recommended to declare the use of the tools used.

Sources of information
Basic Bibliography
James W. Nilsson, **Electric Circuits**, 10, PEARSON, 2014
Material docente, **Página web**, moovi.uvigo.gal,
Complementary Bibliography
J.H. McClellan, R.W. Schafer, M.A. Yoder, **Signal Processing First**, PEARSON, 2003

Recommendations
Subjects that continue the syllabus

Physics: Fundamentals of electronics/V05G301V01201
Digital Signal Processing/V05G301V01205
Signal Transmission and Reception Techniques/V05G301V01208

Subjects that are recommended to be taken simultaneously

Mathematics: Calculus 2/V05G301V01106

Subjects that it is recommended to have taken before

Mathematics: Linear algebra/V05G301V01102
Mathematics: Calculus 1/V05G301V01101

Other comments

It is strongly recommended that students are familiar with complex numbers, trigonometric functions, linear equation system solving, elemental function derivatives and computation of simple integrals.

IDENTIFYING DATA				
Informatics: Computer Architecture				
Subject	Informatics: Computer Architecture			
Code	V05G301V01109			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	1st	2nd
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Llamas Nistal, Martín			
Lecturers	Anido Rifón, Luis Eulogio Llamas Nistal, Martín Rivas Costa, Carlos Santos Gago, Juan Manuel			
E-mail	martin@uvigo.es			
Web	http://moovi.uvigo.es			
General description	Students of the degree in Engineering in Telecommunication Technologies interact with computers both as specialized users and as designers and developers of complex systems, where computers play a central role in their design and even as systems components. Hence, the motivation for a course in computer architectures is to provide students with a fundamental understanding of computer operations. For this, computers are studied at the conventional machine level, which abstracts away implementation details that will be discussed in electronics/microelectronics courses and serves as the foundation for the symbolic machine level, at which computers are programmed using high-level languages. Besides, this course provides an introduction to the operating machine level by discussing basic operating systems concept, and shows an example application of the symbolic machine level through the introduction of the Database Management Systems. This is an English Friendly course: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C2	CE2/FB2: The basic knowledge about using and programming computers, operative systems, databases and Engineering applied software.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Knowledges of the main concepts related with the architecture of the computers and capacity for his handle through models.	B3		
Capacity for the handle of the systems of representation of the information used in the computers	B3		
Knowledges of the types of instructions more representative and variations more notable and capacity to determine the implications of his use by part of the programmer of conventional machine	B3 B4		
Knowledges of the main ways of addressing modes in assembler language and capacity for the efficient handling of these.	B3 B4	C2	
Acquisition of skills on the design of algorithms and the construction of programs to level of conventional machine	B3 B4	C2	D2 D3
Knowledge of the principles and fundamental components of the operating systems	B3	C2	D3
Understanding of the main functions of the operating systems	B3	C2	D3
Knowledge of the fundamental aspects of the databases.	B3	C2	D3

Understanding of the distinct models of organisation of the information in databases	B3	C2	D3
Acquisition of basic skills on the languages of query to databases	B3 B4	C2	D2 D3

Contents	
Topic	
1. Preliminaries	Information Representation in computers. von Neumann Model. Structural, procesal and functional models.
2. Von Neumann Model	Components of von Neumman machine. Simple Machine. Central Processing Unit, Arithmetic and Logic Unit, memory, registers, buses.
3. Symbolic Representation and Processing .	Representation of basic data elements: integer, character, floating point. Conventions for data storage. Processing operations. Introduction to symbolic processing. Assembler language.
4. Instructions and addressing	Instructions and addressing modes. Software considerations. Registers at the conventional machine level. Register transfer language (RT level). Instruction formats. Addressing modes. Stacks and subprograms. RISC and CISC computers.
5. RISC Computer	Instruction sets & formats. Addressing modes. Assembler. Example programs.
6. CISC Computer	Instruction sets & formats. Addressing modes. Assembler. Example programs.
7. Device Management.	Device types. Management of variety. Models. Secondary memories. Interrupts. Service Rutines. DMA: justification.
8. Parallelism and parallel Architectures	Pipelining. Parallelism and memory access. Associative Memory. Parallel architectures. Vector processors. Multiprocessors.
9. Operating systems	The operating machine. Introduction to operating systems. Definition of an operating system.
10. Databases	Introduction to the database systems. Database types.

Planning			
	Class hours	Hours outside the classroom	Total hours
Laboratory practical	22	27.5	49.5
Introductory activities	5	5	10
Problem solving	10	17.5	27.5
Lecturing	12	24	36
Self-assessment	0	3	3
Laboratory practice	2	4	6
Laboratory practice	2	4	6
Problem and/or exercise solving	1	4	5
Problem and/or exercise solving	2	5	7

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Laboratory practical	The course includes programming assignments that will performed using an ARM simulator. Using this methodology, competences CG3, CG4, CT2, CT3 and CE2 are developed.
Introductory activities	Presentation of course contents, methodology, tutoring hours, evaluation, lab work, and any other issue related to the subject. Through this methodology, competences
Problem solving	Programming, information representation, and other problems and exercises will be solved at lecture time. Some will be solved by students in advance at home, and they will participate actively in the solution of additional problems. Through this methodology, competencies CG, CT2 and CE2 are developed.
Lecturing	Theoretical concepts and their practical application will be introduced during the classes. Students will be encouraged to participate by alternating lectures with problem and exercise solving. Therefore, sessions will include lectures and time for exercises and problems. Through this methodology the competencies CG3, CT3 and CE2 are developed.

Personalized assistance

Methodologies	Description
Lecturing	Students will have the chance to attend tutorial sessions at the teacher´s office. Teachers will define an schedule for this purpose at the beginning of the course. This schedule will be published on the course website.

Laboratory practical	Students will have the chance to attend tutorial sessions at the teacher´s office. Teachers will define an schedule for this purpose at the beginning of the course. This schedule will be published on the course website.
Problem solving	Students will have the chance to attend tutorial sessions at the teacher´s office. Teachers will define an schedule for this purpose at the beginning of the course. This schedule will be published on the course website.

Assessment

	Description	Qualification	Training and Learning Results		
Self-assessment	Exam questions will be available for students, in order to perform self assessment.	0	B3 B4	C2	
Laboratory practice	EP1 continuous evaluation exam consisting of practical exercises at the laboratory on the part P1 of the lab syllabus.	16	B3 B4	C2	D2 D3
Laboratory practice	EP2 continuous evaluation exam consisting of practical exercises at the laboratory on the part P2 of the lab syllabus.	24	B3 B4	C2	D2 D3
Problem and/or exercise solving	ET1 continuous evaluation classroom exam consisting on questions and/or exercises, covering the part T1 of the classroom syllabus.	24	B3 B4	C2	D2 D3
Problem and/or exercise solving	ET2 continuous evaluation classroom exam consisting on questions and/or exercises, covering the part T2 of the classroom syllabus.	36	B3 B4	C2	D2 D3

Other comments on the Evaluation

ASSESSMENT

This subject is organized in two parts: Theory and Lab.

The final grade for the course (FG) is computed as the weighted average (WA) of the theory grade (TG) and Lab Grade (PG): FG = WA = 0.6 x TG + 0.4 x LG

However, if any of TG or LG is less than 3.5 and WA is greater than 4.0, then the final grade will be 4.0 or the weighted average WA of both grades, whatever is the lowest value.

To pass the course, FG must be greater than or equal than 5.0

Both parts can be evaluated by Continuous Assessment (CA) or by a Global assessment (GA), in the latter case by means of a final exam (FE).

The FE will have two parts, Theory and Lab, and will take place at the officially approved date and time.

CA will be based on the tests defined in this guide. In the case an student misses a CA test it cannot be retaken or rescheduled.

CA test grades are only valid for the current academic year, being discarded in case the student fails the course.

CLASSROOM SESSIONS / THEORY

The Theory part is divided into two sub-parts: T1 and T2. T1 corresponds to approximately half of the syllabus, while T2 covers all the syllabus.

CLASSROOM. REGULAR CALL (CONVOCATORIA ORDINARIA) ASSESSMENT

CLASSROOM. REGULAR CALL. CONTINUOUS ASSESSMENT (CA).

In the case of CA, it consists of two exams: ET1 and ET2 that correspond to the two parts in which classroom content is divided. ET1 & ET2 exam dates will be approved at a Degrees Academic Committee (CAG) meeting and will be available at the beginning of the academic term.

Additionally, during the classroom lectures, short exercises may be proposed to be completed using your cell phone. Altogether, they can add up to one additional point to the theory grade of each part and/or extra time to CA exams.

Thus, the grade for each part will be the one obtained in the exam (0-10 points) plus the one obtained by solving the short exercises (0-1 points).

The theory CA grade for the Regular call is TG=0.4xT1 + 0.6xT2 (i.e., the weights of T1 & T2 in the final grade are respectively 40% & 60%).

CLASSROOM. REGULAR CALL. GLOBAL ASSESSMENT

All students that have not attended CA will have to attend the Final classroom exam (FCE). The FCE consists of two exercises for T1 and T2.

The global assessment's theory grade is computed as: TG=0.4xT1 + 0.6xT2

CLASSROOM. SUPPLEMENTARY CALL (CONVOCATORIA EXTRAORDINARIA) ASSESSMENT

The Supplementary call exam has the same structure as the Regular call one.

Not attending the Supplementary Call implies accepting the grade obtained at the Regular call.

If you failed the theory part (both in CA and GA), you can:

- sit both parts (ET1 and ET2), which would supersede the theory grade obtained in CA or GA.

- sit only one of the two parts (ET1 or ET2), which would supersede the grade obtained for that part in CA or GA.

- not to take any part and keep the theory grade obtained in CE or GA.

In case of CA, the grade obtained by solving the short exercises during the classroom lectures will be kept and added to the final grade.

The theory grade will be the one computed as 0.4xT1 + 0.6xT2, with the new grades from ET1 and/or ET2, if applicable. Sitting any part (ET1 and/or ET2) implies renouncing to the previously obtained grade.

CLASSROOM. END-OF-STUDIES CALL

It will consist of an exam similar to the Final exam of the Regular call.

LAB ASSESSMENT

The lab part is carried out on an ARM/Thumb assembler. It is divided into two parts: P1 deals with about half of the syllabus and P2 the whole syllabus.

LAB. REGULAR CALL

LAB. REGULAR CALL. CONTINUOUS ASSESSMENT (CA)

The Lab's CA consists of 2 exercises EP1, EP2 that correspond to the two parts in which lab activities are divided. The EP1 exams date will be approved in a Degrees Academic Committee (CAG), will take place in the afternoon and all the details will be available at the beginning of the academic term. EP2 will take place on the day of the Regular calls GA. There will be a separate exam for those who opt for CA and for those who decide to sit the GA only.

Additionally, during the lab sessions, short exercises may be proposed to be completed using your cell phone. Altogether, they can add up to one additional point to the lab grade and/or extra time to CA exams..

Thus, the grade for each part will be the one obtained in the exam (0-10 points) plus the one obtained by solving the short exercises (0-1 points).

The lab CA grade for the Regular call is TG=0.4xT1 + 0.6xT2

LAB. REGULAR CALL. GLOBAL ASSESSMENT

All students opting for GA will have to attend a final lab exam (FLE).

The FLE will consist of an exercise on the complete ARM/Thumb syllabus to be performed in the lab.

The lab grade in this case is the grade obtained in the FLE.

LAB. SUPPLEMENTARY CALL EXAM

The Supplementary call's exam will be similar to the GA's FLE of the Regular call. All students who did not pass the lab part, independently of them of opting for CA or not, may attend this exam. Not attending the Supplementary call's assessment implies accepting the grade obtained at the Regular call. Nevertheless, CA students will keep the average grade obtained (0-1) from the short lab exercises.

LAB. END-OF-STUDIES CALL

It will consist of an exam similar to the FLE of the Regular call.

GENERAL REMARKS

All exercises and exams in this course are graded from 0 to 10. **As a consequence of short exercises, the student's grade may be higher than 10. In that case, the final grade would be 10, considering the total grade higher than 10 for the awarding of honours.**

Not participating in the Supplementary call assessment process implies accepting the grade obtained at the Regular call assessment.

TUTORING

Tutoring sessions will be suspended t**wo school days prior** to any official exam.

CONTINUOUS ASSESSMENT ELIGIBILITY

Students may opt for CA independently for the classroom/theory part and lab/practical part. To be eligible for CA, students must take the first exam in that part (theory/ET1 and/or lab/EP1).

Once being enrolled in CA for theory or lab, students cannot opt for GA for the corresponding part. As pointed out above, students may opt to be assessed differently (CA or GA) for theory and lab.

OFFICIAL TRANSCRIPTS

If a student is graded at least once after taking any of the exams in CA or GA, its final grade will be computed according to this guide.

EXAMS

To take any classroom exam (ET1, ET2, FE) or lab exam (EP1, EP2, FLE), all students must register using the designated software tool. The registration process will be open and notified with a minimum of 5 calendar days prior to the corresponding exam.

GRADING INFO

The date and procedure for grade review will be published in advance.

COMMUNICATION WITH STUDENTS

Communication between students and lecturers will be done by means of the standard procedures established by the University. **It is assumed that all students read their email (the one registered in Moovi) at least once a day.**

ETHICAL CODE

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution. All students are expected to have an ethical behavior in all exams, ensuring equal opportunities for all students. If an infraction is detected in an exam, the score obtained in that test will automatically be zero (0) and a report will be issued to the School Direction to take actions.

These are some examples of unethical behavior: use of electronic devices (mobile phones, tablets, computers, etc.), copy from another peer, use of unauthorized material in an exam, etc.

Sources of information
Basic Bibliography
Gregorio Fernández Fernández, **Curso de Ordenadores. Conceptos básicos de arquitectura y sistemas operativos.**, 5ª, Fundación Rogelio Segovia para el Desarrollo de l, 2004
Silberschatz, H.F. Horth y S. Sudarshan, **Fundamentos de Bases de Datos.**, 6ª, McGraw-Hill Interamericana de España S.L., 2014
Complementary Bibliography
A. S. Tanenbaum, **Organización de Computadoras. Un enfoque estructurado.**, 4ª, Pearson Educación, 2000
J.L. Hennessy y D.A. Patterson, **Arquitectura de los Computadores. Un enfoque cuantitativo**, McGraw-Hill Interamericana de España S.L., 2010
Martín Llamas Nistal, Fernando A. Mikic Fonte y Manuel J. Fernández Iglesias, **Arquitectura de Ordenadores: Problemas y Cuestiones de Teoría**, 1ª, Andavira, 2012
Alberto Gil Solla, **Ejercicios resueltos sobre Fundamentos de los Ordenadores**, 1ª, Andavira, 2004
Alberto Gil Solla, **Problemas resueltos de programación en ensamblador**, 1ª, Andavira, 2004

Fernando A. Mikic Fonte y Martín Llamas Nistal, **Arquitectura de Ordenadores: Problemas de Programación en Ensamblador**, 1ª, Andavira, 2012

C. Costilla Rodríguez, **Introducción a las Bases de Datos Modernas**, Fundación Rogelio Segovia para el Desarrollo de la, 2996

V.C. Hamacher, Z.G. Vranesic, S.G. Zaky,, **Organización de Computadoras**, 2ª, McGraw-Hill Interamericana de España S.L., 1996

D. A. Patterson y J.L. Hennessy (Traducido por J.M. Sánchez), **Organización y diseño de Computadores. La interfaz hardware/software**, McGraw-Hill, 1995

Peter Knaggs, **ARM: Assembly Language Programming**, Peter J. Knaggs, 2016

Gregorio Fernández Fernández, **Elementos de Sistemas Operativos, de representación de la información y de procesadores hardware y software**, DIT-UPM, 2015

Sergio Barrachina Mir, Maribel Castillo Cata- lán, Germán Fabregat Llueca, Juan Carlos Fernández Fer, **Introducción a la arquitectura de computadores con QtARMSim y Arduino**, Universitat Jaume I, 2018

Sergio Barrachina Mir, Maribel Castillo Cata- lán, Germán Fabregat Llueca, Juan Carlos Fernández Fer, **Prácticas de inntroducción a la arquitectura de computadores con QtARMSim y Arduino**, Universitat Jaume I, 2014

Recommendations

IDENTIFYING DATA				
Programming II				
Subject	Programming II			
Code	V05G301V01110			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	2nd
Teaching language	Spanish English			
Department				
Coordinator	Fernández Iglesias, Manuel José Blanco Fernández, Yolanda			
Lecturers	Blanco Fernández, Yolanda Fernández Masaguer, Francisco Gil Solla, Alberto			
E-mail	yolanda@det.uvigo.es manolo@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The general objective of the course is to provide students with the theoretical foundations and practical skills that will allow them to analyze, design, implement and debug computer applications following the object-oriented paradigm. This is an eminently practical, student-centred course, where students have to complete several programming assignments. In order to facilitate the completion of the assignments, the course will first include a brief introduction to the discipline of Software Engineering, connecting it with the paradigm of Object Oriented Programming (OOP). The elements of OOP will then be analyzed in detail, with the help of UML elements and diagrams. English Friendly course: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English. In the completion of academic activities for this subject, the use of generative artificial intelligence (GAI) is permitted. Its use must be ethical, critical, and responsible. In the case of using GAI, any results it provides must be critically evaluated, and any generated citations or references must be carefully verified. Additionally, it is recommended to declare the use of the tools utilized.			

Training and Learning Results	
Code	
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B14	CG14 The ability to use software tools to search for information or bibliographical resources.
C50	(CE50/T18)The ability to develop, interpret and debug programs using basic concepts of Object Oriented Programming (OOP): classes and objects, encapsulation, relations among classes and objects, and inheritance.
C51	(CE51/T19) The ability of basic application of phases of analysis, design, implementation and debugging of OOP programs.
C52	(CE52/T20) The ability of manipulation of CASE tools (editors, debuggers).
C53	(CE53/T21) The ability of developing programs considering to the basic principles of software engineering quality taking into account the main existing sources of norms, standards and specifications.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
To know the main UML diagrams for the documentation in the phases of analysis and design of programs according to the OOP.	B6 B14	C52 C53
To acquire maturity in techniques of development and debugging of programs to allow the autonomous learning of new skills and programming languages.	B6	C51 C52 C53
To understand the basic concepts of Object Oriented Programming (OOP).	B14	C50
To develop skills in the process of analysis, design, implementation and debugging of applications according to the OOP, taking into account the main standards and norms of quality.	B6 B14	C51 C53

Contents
Topic

1. Introduction to the object oriented paradigm	a. Brief introduction to the subject and its organization. b. Birth of the paradigm c. Foundations: classes and objects d. Concepts of encapsulation, inheritance (generalization), and polymorphism e. Brief introduction to UML
2. Encapsulation	a. Classes, interfaces and packages b. Methods and member variables. Visibility. Scope of resolution c. Constructor method d. Parameter passing: pointers and references e. Pointers to objects f. Use of UML class diagrams.
3. Inheritance	a. Derived classes and types of inheritance b. Abstract Classes c. Multiple Inheritance d. Object class
5. Polymorphism	a. Overloading and overwriting b. Abstract classes and interfaces c. Generic classes
6. Exception handling	a. Exceptions foundations b. Handling of Java exceptions
(*)Contidos prácticos.	(*)As prácticas propostas permitirán combinar a aplicación dos conceptos de POO explorados nas sesións teóricas co manexo de estruturas de datos e o desarrollo de lóxica algorítmica.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	25	30	55
Practices through ICT	10	17	27
Practices through ICT	10	21	31
Practices through ICT	13	19	32
Essay questions exam	1.5	0	1.5
Essay questions exam	1.5	0	1.5
Essay questions exam	2	0	2

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Classes involving explanation of OOP-related concepts and resolution of practical exercises. Through this methodology the competencies C50, C51 and C53 are developed.
Practices through ICT	Students will solve independently the assignments proposed. The solutions and doubts that arise when dealing with these assignments will be discussed in order to identify the most common mistakes made. Through this methodology the competencies C50, C51, C52, C53, B6 and B14 are developed.
Practices through ICT	Students will solve independently the assignments proposed. The solutions and doubts that arise when dealing with these assignments will be discussed in order to identify the most common mistakes made. Through this methodology the competencies C50, C51, C52, C53, B6 and B14 are developed.
Practices through ICT	Students will solve independently the assignments proposed. The solutions and doubts that arise when dealing with these assignments will be discussed in order to identify the most common mistakes made. Through this methodology the competencies C50, C51, C52, C53, B6 and B14 are developed.

Personalized assistance

Methodologies	**Description**
Lecturing	Lecturers will solve the doubts raised by the students in relation to the concepts exposed in the lectures. Students may consult and request mentoring sessions through the Moovi platform (https://moovi.uvigo.gal).
Practices through ICT	Lecturers will supervise the level of understanding of the students, assisting them with doubts, design errors and improvements at the object-oriented code level. The Students may consult and request mentoring sessions through the Moovi platform (https://moovi.uvigo.gal).

Practices through ICT	Lecturers will supervise the level of understanding of the students, assisting them with doubts, design errors and improvements at the object-oriented code level. The Students may consult and request mentoring sessions through the Moovi platform (https://moovi.uvigo.gal).
Practices through ICT	Lecturers will supervise the level of understanding of the students, assisting them with doubts, design errors and improvements at the object-oriented code level. The Students may consult and request mentoring sessions through the Moovi platform (https://moovi.uvigo.gal).

Assessment

	Description	Qualification	Training and Learning Results	
Practices through ICT	This is the first lab deliverable (hereinafter, E1). Students will be able to correct errors identified and retry the assessments, with a possible penalty, until a date to be determined (around mid-April). Once E1 assignments are graded, they will be uploaded to MOOVI, to check plagiarism.	10	B6 B14	C50 C51 C52 C53
Practices through ICT	This is the second lab deliverable (hereinafter, E2). Students will be able to correct errors identified and retry the assessments, with a possible penalty, until the latest date allowed by academic regulations and course organization requirements (actual date to be notified in due time). Once E2 assignments are graded, they will be uploaded to MOOVI, to check plagiarism.	20	B6 B14	C50 C51 C52 C53
Practices through ICT	Students will upload E3 assignments to MOOVI. E3 assignments will be graded by course lecturers outside lab sessions.	20	B6 B14	C50 C51 C52 C53
Essay questions exam	Each student will take, individually and without any kind of support material, an exam at the end of the term on the totality of the contents covered in the course. The maximum grade for this exam will be 3 points (out of 5) for students who sit continuous assessment, and 5 points for those students who choose the global assessment.	30		C50 C51 C53
Essay questions exam	Each student will take (individually and without any type of material of support) a test on the date the will be approved by CAG (approximately half of the academic period) on the contents that were explained up to one week before the exam. This test will be carried out only by students who sit continuous assessment, and the maximum grade will be 2 points (out of 5 points).	20		C50 C51 C53
Essay questions exam	This exam will be sit by students who opt for continuous evaluation and have submitted E3. In addition, the lab exam will be compulsory in the global evaluation of the ordinary call, in the extraordinary one and in the end-of-studies exam.	0		C50 C51 C53

Other comments on the Evaluation

There are two assessment mechanisms, continuous assessment (CA) and global assessment (GA), which must be chosen by the students considering the following conditions:

- Both the classroom and lab parts will be evaluated according to the same mechanism, CA or GA, as selected by the student.
- CA includes the exams described in the previous section: two theory exams, design and development of Java assignments collected in deliverables E1, E2 & E3, and a lab exam if E3 is submitted.
- Students will confirm the final evaluation modality (CA or GA) when submitting lab deliverables, depending on the submission date. The chosen evaluation modality will also be applied to the theory/classroom part. Therefore, in the case that a student finally chooses GA, the grade of the first classroom exam, if any, would be discarded.
- A minimum grade of 2 points (out of 5) in both theory/classroom and lab parts is required to pass the course.
- If the grade resulting from adding the classroom and lab grades is equal or higher than 5 points, but the student does not reach the minimum grade required in any of them, his/her final grade will be Fail (4.5).
- If a student attends any of the evaluation tests of the course, he/she will not be able to appear in transcripts as "no-show".
- The CA tests will only take place on the dates established by the teachers, and cannot be resit or delayed.
- Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be *Fail(0)*, and the incident will be reported to the corresponding academic authorities for prosecution.

Assessment procedure for the ordinary call for students who opt for Continuous Assessment (CA)

- **Theory/classroom part (50%)**: The grade of this part (5 points) is obtained by adding the corresponding grades of the two classroom exams (midterm and end-of-semester), with maximum grades of 2 and 3 points, respectively.
- Lab part (50%): The following considerations should be taken into account:
    - There will be deadlines to finish each assignment.
    - Some of the assignments will be reviewed in the laboratory once completed.
    - In addition to the correct functioning of the assignments, students must answer the teachers' questions to be able to continue in CA.
    - The grade for the practical part will depend on the qualifications obtained in the deliverables E1, E2, and E3 (up to 5 points in total).
    - Students who submit E3 must also take a practical exam: if they do not pass it (not approved), the grade for E3 will be 0 points.

Students who do not pass the subject in the ordinary opportunity can retain the grade obtained in both theory and practice for the extraordinary opportunity, provided the following conditions are met:

- The practice will be retained if at least 1.5 out of 5 is obtained in the theory.
- The theory will be retained if the practices were submitted and the minimum laboratory grade (2 points out of 5) was obtained.

Assessment procedure for the ordinary call for students who opt for Global Assessment (GA):

- **Classroom part (50%)**: The grade of this part (5 points) corresponds to an individual exam without any type of supporting material at the end of the academic semester (on the date approved by the school).
- **Lab part (50%)**: The grade for this part depends on the grades obtained in deliverables E1, E2 and E3 (up to 5 points in total) and the result of a practical exam. The deliverables may be identical to those required in CA or include modifications in the functionalities to be developed. They will be delivered through Moovi and will be evaluated by lecturers outside lab sessions. The student must pass a practical exam in which a modification of E2 or E3 will be required (depending on the specific deliverables submitted for assessment). In case of not passing it (i.e., Fail grade), the grade of the corresponding deliverable will be 0 points.

Assessment procedure for the extraordinary call and end-of-program call:

- **Classroom part (50%)**. Individual exam on the date to be approved by the school, requiring a minimum grade of 2 points (out of 5).
- **Lab part (50%)**. The corresponding E1, E2 and E3 deliverables must be uploaded to Moovi and a lab exam must be sit. Assignments may be the same CA/GA assignments or may include modifications in functionality and/or scoring. As there is no CA, assessment procedures are the same as as ordinary call's GA.

Sources of information
Basic Bibliography
Yolanda Blanco Fernández, **Introducción a Programación Orientada a Objetos**, 1ª edición, Andavira, 2019
W. Savitch, **Absolute Java**, 6ª edición, Pearson, 2015
Y. D. Liang, **Introduction to Java programming**, 8ª, Pearson, 2010
P. Deitel, H. Deitel, **Java: How to program**, 11, Pearson, 2017
Complementary Bibliography
B. Eckel, **Thinking in Java**, 4ª edición, Prentice-Hall, 2006
P. Niemeyer, D. Leuck, **Learning Java**, 4ª edición, O'Reilly., 2013
Oracle, **Java SE. Oracle**,
Oracle, **Java API Specifications**, 2022
G. Booch, J. Rumbaugh, I. Jacobson, **The Unified Modeling Language User Guide**, 2, Addison-Wesley., 2005
S. Zakhour, S. Hommel, J. Royal, I. Rabinovitch, T. Risser, M. Hoeber, **The Java Tutorial. A short course on the basics**, 6ª edición, Prentice-Hall, 2014
A. Eberhart, S. Fischer, **Java Tools**, Wiley, 2002
M. Page-Jones, **Fundamentals of object-oriented design in UML**, Addison-Wesley, 2002
M. Fowler, **UML Distilled: A Brief Guide to the Standard Object Modeling Language**, 3ª edicion, Addison-Wesley., 2003

Recommendations

Subjects that it is recommended to have taken before

Programming I/V05G301V01105

IDENTIFYING DATA				
Physics: Fundamentals of electronics				
Subject	Physics: Fundamentals of electronics			
Code	V05G301V01201			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	2nd	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Domínguez Gómez, Miguel Ángel			
Lecturers	Domínguez Gómez, Miguel Ángel Rodríguez Pardo, María Loreto			
E-mail	mdgomez@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The main purpose of this course is to provide students the basis for understanding and mastery of the principles of operation of devices and electronic circuits. It begins with a brief introduction to electronics in order to provide students with a global vision. Afterwards, basic concepts about devices and electronic circuits are taught: · Diodes and circuits with diodes, including concepts such as load line, ideal diodes, rectifiers, shaping circuits, logic circuits, voltage regulators and devices physics. · Characteristics of bipolar transistors, analysis of load line, large-signal models, polarization, amplification and small-signal equivalent circuits. · Study of the FET similar to the previous highlighting the MOSFET. · Check the circuit designs studied using SPICE. Mounting and verification using laboratory electronic instrumentation. · Basic concepts about logic digital circuits. On the other hand, in the framework of the course it takes place the first contact of students with the electronics labs. Therefore, the main objective of the practical part of the course is for students to acquire the bases for a correct management of the most common instruments in the laboratories of electronics. At the end of the course the student must know how to handle the laboratory instruments, distinguish and characterize the different components, and have practical skills in assembly and measurement. Students will also start with simulation of circuits, in order to introduce them to computer-aided design. English Friendly subject. International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B13	CG13 The ability to use software tools that support problem solving in engineering.
C4	CE4/FB4: Comprehension and command of basic concepts in linear systems and their related functions and transforms; electric circuits theory, electronic circuits, physical principles of semiconductors and logical families, electronic and photonic devices, materials technology and their application to solve Engineering problems.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
Understanding and control of the basic concepts of the physical principles of semiconductors.		C4
Understanding and control of the basic concepts of operation of the electronic and photonic devices.		C4
Understanding and control of simple electronic circuits based on the electronic and photonic devices and their applications.		C4
Understanding and control of the basic concepts of the logic families.		C4
Basic knowledges on CAD (Computer Aided Design) tools for the simulation of electronic circuits.	B13	
Capacity utilization of CAD tools for designing simple electronic circuits.	B13	

Contents	
Topic	
Subject 1: Introduction	Electronic systems. Design process. Integrated circuits.

Subject 2: Diodes and circuits with diodes	Characteristics of the diode. Zeners. Analysis of the load line. Ideal model of the diode. Circuits with diodes (rectifiers, clipping and voltage regulator circuits). Small signal equivalent linear circuits. Basic concepts of semiconductors. Physics of the diode. Capacity effects. LED and laser diodes. Photodiodes.
Subject 3: Principles of amplification	General aims: Voltage, current and power gains. Ideal amplifier. Amplifier Models. Limits. Introduction to amplifier frequency response.
Subject 4: Bipolar Junction Transistors (BJT)	Operation of the npn Bipolar Junction Transistor (BJT). Load-Line Analysis of a Common-Emitter Amplifier. The pnp Bipolar Junction Transistor. Models of circuits. Analysis of circuits with BJTs. Phototransistors and optocouplers.
Subject 5: Analysis of amplifiers with Bipolar Junction Transistors	Small-Signal Equivalent Circuits. Analysis in medium frequencies: the Common-Emitter amplifier, the Emitter-Follower amplifier, the Common-Collector amplifier and the Common-Base amplifier.
Subject 6: Field Effect Transistors (FET)	NMOS Transistor. Analysis of the load line of a simplified NMOS amplifier. Polarization circuits. JFET and depletion MOSFET transistors and channel p devices.
Subject 7: Analysis of amplifiers with Field Effect Transistors	Small-Signal Equivalent Circuits. Analysis in medium frequencies: the Common-Source amplifier and the Source Follower amplifiers.
Subject 8: Digital logic circuits	Digital logic circuits. Basic concepts. Electrical specifications of the logic gates. The inverter CMOS. CMOS gates NOR and NAND.
Practice 1: Introduction to the simulation	Simulation of electronic circuits with OrCAD.
Practice 2: Instrumentation I	Use of the voltage source, function generator and multimeter.
Practice 3: Instrumentation II	Use of digital oscilloscope.
Practice 4: Simulation of circuits with diodes	Simulation of circuits with diodes using OrCAD.
Practice 5: Implementation of circuits with diodes	Implementation of circuits with diodes in protoboard and checking of operation using the laboratory instrumentation.
Practice 6: Simulation of circuits with bipolar transistors	Simulation of circuits with bipolar transistors using OrCAD.
Practice 7: Implementation of circuits with bipolar transistors	Implementation of circuits with bipolar transistors in protoboard and checking of operation using laboratory instrumentation.
Practice 8: Simulation of circuits with field effect transistors	Simulation of circuits with field effect transistors using OrCAD.
Practice 9: Implementation of circuits with field effect transistors	Implementation of circuits with field effect transistors in protoboard and checking of operation using laboratory instrumentation.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	1	2
Lecturing	16	27	43
Problem solving	16	36	52
Laboratory practical	22	20	42
Problem and/or exercise solving	2	0	2
Problem and/or exercise solving	2	0	2
Problem and/or exercise solving	2	0	2
Laboratory practice	1	0	1
Laboratory practice	1	0	1
Self-assessment	0	3	3

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Presentation of the subject. Presentation of the laboratory practices and the instrumentation and software to be used. Through this methodology the competencies B13 and C4 are developed.
Lecturing	Exposition of contents. Later personal work of the student reviewing the concepts seen in the classroom and preparing the subjects using the proposed bibliography. Identification of doubts that require to be resolved in personal tutorships. Through this methodology the competency C4 is developed.
Problem solving	Activity to formulate and resolve problems and/or exercises related with the subject. Complement of the theoretical sessions. Personal work of the student with resolution of problems and/or exercises proposed in the classroom and extracted of the bibliography. Identification of doubts that require to be resolved in personal tutorships. Through this methodology the competency C4 is developed.

Laboratory practical	Activities of application of the theoretical knowledge. It will learn to handle the typical instrumentation of an electronic laboratory and it will implement basic electronic circuits seen in the theory sessions. Also they will purchase skills of handle of simulation tools. Personal work of the student preparing the practices using the available documentation and reviewing the theoretical concepts related. Development and analysis of results. Identification of doubts that require to be resolved in personal tutorships. Through this methodology the competency B13 is developed. Software to be used: OrCAD software for students.

Personalized assistance

Methodologies	Description
Lecturing	The students will be able to have personalized tutorials in the schedule that the professors will establish and will publish in the web page of the subject (https://moovi.uvigo.gal/). Here, they will be able to resolve their doubts about the contents given in the Master Sessions and will be oriented about how to deal with them.
Problem solving	The students will be able to have personalized tutorials in the schedule that the professors will establish and will publish in the web page of the subject (https://moovi.uvigo.gal/). Here, they will be able to resolve their doubts about the problems and/or exercises proposed and resolved in the classroom as well as other problems and/or exercises that can appear along the study of the subject.
Laboratory practical	The students will be able to have personalized tutorials in the schedule that the professors will establish and will publish in the web page of the subject (https://moovi.uvigo.gal/). Here, they will be able to resolve their doubts about the development of the laboratory practices, the handle of the instrumentation, the setting of the electronic circuits and the software of simulation.

Assessment

	Description	Qualification	Training and Learning Results	
Problem and/or exercise solving	Test will be carried out in the classroom throughout the year to evaluate the competencies of the student to resolve problems and/or the exercises over the first part of the contents of the subject. These may be test type and/or questions and/or exercises.	23.33		C4
Problem and/or exercise solving	Test will be carried out in the classroom throughout the year to evaluate the competencies of the student to resolve problems and/or the exercises over the second part of the contents of the subject. These may be test type and/or questions and/or exercises.	23.33		C4
Problem and/or exercise solving	Test will be carried out in the classroom throughout the year to evaluate the competencies of the student to resolve problems and/or the exercises over the third part of the contents of the subject. These may be test type and/or questions and/or exercises.	23.33		C4
Laboratory practice	Test will be carried out in the laboratory along the course about management of instrumentation, mounting of electronic circuits and simulation. The skills acquired by the student about the contents of the subject laboratory practices will be evaluated.	12.5	B13	C4
Laboratory practice	Test will be carried out in the laboratory along the course about management of instrumentation, mounting of electronic circuits and simulation. The skills acquired by the student about the contents of the subject laboratory practices will be evaluated.	12.5	B13	C4
Self-assessment	Techniques aimed to collect data about the participation of the student in the proposed self-assessment tests.	5		

Other comments on the Evaluation

1. Ordinary exam (continuous assessment)

A system of continuous assessment will be offered to the students following the guidelines of the bachelor and the agreements of the academic commission. Students who take some of the tests of problem and/or exercise solving or laboratory practice deem to opt for continuous assessment. Those students who take any of those tests deem to renounce to the continuous assessment and they will have the possibility to take the global assessment. Students who have opted for continuous assessment and have not passed the subject can take to the global assessment. Students who do not follow the continuous assessment and do not take the global assessment will be considered "not presented".

1.a Self-assessment tests

The professors will evaluate the execution of the proposed self-assessment tasks, getting the student a rating from 0 to 10

(AE).

The final mark of self-assessment tests (NAE) will be:

NAE = 0.05*AE

1.b Theory

Students will carry out 3 exams (multiple choice test and/or short answer test and/or resolution of problems and/or exercises) properly programmed along the course (PT1, PT2 and PT3). The schedule of these exams will be approved in "CAG" (Degree Academic Commission) and will be made public at te beginning of the corresponding term. PT1 will be about themes 1 and 2 (block 1), PT2 about themes 3, 4 and 5 (block 2) and PT3 about themes 6, 7 and 8 (block 3). These exams will be valued from 0 up to 10 and the final mark will be the average (NPT -> Mark of theory exams):

NPT = (NPT1 + NPT2 + NPT3)/3

It is necessary to obtain a minimum of 3 points out of 10 in each of these exams (NPT1 >= 3, NPT2 >= 3 and NPT3 >= 3) to pass the subject.

The final mark of theory (NT) will be:

NT = 0.7*NPT

The exams are not recoverable, that is to say, if a student cannot assist the day they are scheduled, the professors do not have obligation to repeat them. The mark of the missed exams will be 0.

1.c Practical

Attendance to practical sessions is not compulsory.

Students will carry out 2 practical tests properly programmed along the course. The schedule of these tests will be approved in "CAG" (Degree Academic Commission) and will be made public at te beginning of the corresponding term. These tests will be valued from 0 up to 10 and the final mark of the practical (NP) will be:

NP = 0.25*[(NP1 + NP2)/2]

The practical tests are not recoverable, that is to say, if a student cannot assist the day they are scheduled, the professors do not have obligation to repeat them. The mark of the missed tests will be 0.

1.d Final mark of the subject

It must get a minimum of 4 points out of 10 in theory (NT >= 2.8) and practices (NP >= 1.) to pass the subject. Also it is necessary to get a minimum of 3 points out of 10 in each of the 3 theory exams (NPT1 >= 3, NPT2 >= 3 and NPT3 >= 3).

The final mark (NF) will be:

If NT >= 2.8 and NP >= 1 and NPT1 >= 3 and NPT2 >= 3 and NPT3 >= 3 => NF = NAE + NT + NP

If NT < 2.8 or NP < 1 or NPT1 < 3 or NPT2 < 3 or NPT3 < 3 => NF = min {4.5; NAE + NT + NP}

2. Ordinary exam (global assessment)

The students who do not follow the continuous assessment or had a final mark lower than 5 (failed) in the continuous assessment, will be able to present to a final exam.

The final exam will have a theoretical part and a practical one. The theoretical part will be carried out in the dates established by the School and it will consist in an exam (multiple choice test and/or short answer test and/or resolution of problems and/or exercises). This exam will have 3 parts, one for each block specified in section 1.b. Each part will be evaluated from 0 up to 10 and the final mark of theory (NT) will be the average multiplied by 0.7. It is necessary to get a minimum of 3 points in each of these parts (NPT1 >= 3, NPT2 >= 3 and NPT3 >= 3) and a minimum of 4 points out of 10 in theory (NT >= 2.8) to pass the subject.

The practical exam will be carried out in the laboratory in the dates established by the School and it will consist in a practical test which will be evaluated from 0 up to 10 and the final mark of practices (NP) will be the points of the test multiplied by 0.3. It must get a minimum of 4 points out of 10 in the practical exam (NP >= 1.2) to pass the subject.

By reasons of organization of the groups of examination, the professors will open a period so that the students could enroll for the final exam. Only those students who have inscribed in due time and form, according to the rules indicated by the professors in the corresponding announcement, will be able to take the final exam.

The students who have opted for the continuous assessment and have failed and present to the final exam, can only do the theoretical part or to the practical one or both. They will keep the mark got in the continuous assessment of the missed part if the minimums specified in the continuous assessment process were achieved. The students who take the theoretical part will be able to carry out the blocks they want. The mark of the continuous assessment of the missed blocks (NPT1, NPT2 and NPT3) will be kept. If they do not take the practical part, the practice note (NP) of the continuous assessment is recalculated multiplying by 0.3 instead of by 0.25.

The final mark (NF) will be:

If NT >= 2.8 and NP >= 1.2 and NPT1 >= 3 and NPT2 >= 3 and NPT3 >= 3 => NF = NT + NP

If NT < 2.8 or NP < 1.2 or NPT1< 3 or NPT2 < 3 or NPT3 < 3 => NF = min {4.5; NT + NP}

3. Extraordinary exam

It will have a theoretical part and practical one with the same format as the global assessment.

The students who take this call can only do the theoretical part, the practical one or both. They will keep the mark got in the ordinary exam (continuous or global assessment). The students who take the theoretical part will be able to carry out the blocks they want. The mark of the ordinary exam (continuous or global assessment) of the missed blocks will be kept. The calculation of the final mark of the subject will be as described in section 2.

The final mark of the subject will be the best of the ordinary and extraordinary exam.

By reasons of organization of the groups of examination, the professors will open a period so that the students could enroll for the extraordinary exam. Only those students who have inscribed in due time and form, according to the rules indicated by the professors in the corresponding announcement, will be able to take this exam.

4. End-of-program exam

This exam will be the same as the extraordinary exam.

5. Validity of the marks

The marks of the student in the theoretical and practical parts of the subject will be valid only for the academic course in which they were got.

If a cheating case is detected, the final mark will be FAIL (0) and the case will be communicated to the School Management.

Sources of information

Basic Bibliography

Hambley, A. R., **Electrónica**, 2ª ed., Prentice Hall, 2001

Hambley, Allan R., **Electronics**, 2nd ed., Prentice Hall, 2000

Quintáns Graña, Camilo, **Simulación de circuitos electrónicos con OrCAD 16 Demo**, Marcombo, 2008

Quintáns Graña, Camilo, **Simulación de circuitos electrónicos con OrCAD PSpice**, 2ª edición, Marcombo, 2021

Complementary Bibliography

Recommendations

Subjects that continue the syllabus

Electronic technology/V05G301V01206

Subjects that it is recommended to have taken before

Physics: Analysis of Linear Circuits/V05G301V01108

IDENTIFYING DATA				
Physics: Fields and Waves				
Subject	Physics: Fields and Waves			
Code	V05G301V01202			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	2nd	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Pino García, Antonio			
Lecturers	Pino García, Antonio			
E-mail	agpino@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	Fields and Waves presents the first contact in the student's degree with the phenomena of electromagnetic waves, which are the physical medium for transmission of information at almost instantaneous speed. Mathematical modeling of electromagnetic fields that provide insights into the behavior of electromagnetic waves in real environments will be introduced. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
C1	CE1/FB1: The ability to solve mathematical problems in Engineering. The aptitude to apply knowledge about linear algebra, geometry, differential geometry, differential and integral calculus, differential and partial differential equations; numerical methods, numerical algorithms, statistics and optimization
C3	CE3/FB3: Comprehension and command of basic concepts about the general laws of mechanics, thermodynamics, electromagnetic fields and waves and electromagnetism and their application to solve Engineering problems.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
New	B3	C1 C3	D3
Solve electrostatic and magnetostatic problems: capacity and self-induction.	B3	C1 C3	D3
Calculate the main parameters of electromagnetic waves: frequency, wavelength, propagation constant, polarization, Poynting vector, phase constant, attenuation constant	B3	C3	D3
Analyze the propagación of waves in media with and without losses.	B3	C3	D3
Analyze the incidence of waves over obstacles or discontinuities: decomposition in incident, reflected and transmitted waves.	B3	C3	D3

Contents	
Topic	
1. Vector and differential analysis of fields	1.1 Scalar and vector fields 1.2 Systems of coordinates in space 1.3 Vector Algebra 1.4 Integral operators 1.5 Differential operators 1.6 Properties of operators
2. Electrostatics	2.1 Electric charge 2.2 Electric field and its properties 2.3 Electric potential 2.4 Electric permitivity 2.5 Gauss law 2.6 Equations of Poisson and Laplace. Capacitance

3. Magnetostatics	3.1 Electric current 3.2 Magnetic field and its properties 3.3 Magnetic permeability 3.4 Ampere's Law 3.5 Self-induction
4. Maxwell model	4.1. Maxwell's equations in integral form 4.2. Differential form of Maxwell's equations 4.3. Boundary conditions 4.4. Harmonic time variation and phasor notation 4.5. Energy and power density
5. Fundamentals and characteristics of waves	5.1 Wave equation in the phasor domain 5.2 Solutions in rectangular coordinates 5.3 Wave parameters: frequency, wavelength, propagation constant and impedance of the medium. 5.4 Poynting vector and average power density 5.5 Progressive waves on lossy and lossless media 5.6 Polarization
6. Waves in the presence of obstacles	6.1 Wave incidence on conductors 6.2 Incidence on discontinuity between two media 6.3 Incident, reflected and transmitted wave 6.4 Standing wave diagram 6.5 Power transmission
P1. Vector algebra and coordinate systems.	Review of operations with vectors in space. Vector representation in the Cartesian, cylindrical and spherical systems. Differential elements of length, area and volume in the three systems.
P2. Electrostatics-I.	Integral of circulation of the electric field. The electric dipole. Linear, surface and volume densities of charge. Potential and electric field of charge distributions. Principle of superposition of sources Far field.
P3. Electrostatics-II.	Electric displacement vector flow. Application of Gauss's integral and differential theorem. Capacitors. Image theory.
P4. Magnetostatics.	Integration of surface and volumetric current densities. Magnetic field of current distributions. Principle of superposition of sources. Applications of Ampere's Law integral and differential. Self-induction Imaging theory.
P5. Maxwell's model.	Application of Faraday's and Ampere-Maxwell's laws. Phasor and time domain representation of electromagnetic fields. Application of Maxwell's laws.
P6. Fundamentals and characteristics of waves.	Plane wave propagation. Wave parameters. Determination of wave polarisation. Phasor and time domain representation of plane waves.
P7. Waves in the presence of obstacles	Incidence of a wave on a metallic plane. Incidence of a plane wave on a discontinuity between two dielectric media. Standing wave.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	18	24	42
Case studies	27	36	63
Problem solving	12	16	28
Problem and/or exercise solving	1	1.5	2.5
Case studies	2	4	6
Problem and/or exercise solving	1	1.5	2.5
Case studies	2	4	6

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Exhibition by the professor of the contents on the matter object of study, theoretical bases and/or guidelines of a work, exercise or project to develop by the student. Through this methodology the competencies B3, C1, C3 and D3 are developed.
Case studies	Analysis of a fact, problem or real event with the purpose to know it, interpret it, resolve it, generate hypothesis, contrast data, think about it, complete knowledges, diagnose it and train in alternative procedures of solution. This metodology will be used both in large and medium size groups. Through this methodology the competencies B3, C1, C3 and D3 are developed.

Problem solving	Activities application of knowledge to specific situations, and the acquisition of basic skills and procedural matters related to the object of study, which are held in computer rooms. Electromagnetic simulators will be used. Through this methodology the competencies B3, C1, C3 and D3 are developed.

Personalized assistance

Methodologies	Description
Lecturing	The student will receive personalized attention during the tutoring hours (https://moovi.uvigo.gal/)
Problem solving	The student will receive personalized attention during the tutoring hours (https://moovi.uvigo.gal/)
Case studies	The student will receive personalized attention during the tutoring hours (https://moovi.uvigo.gal/)
Tests	**Description**
Case studies	The student will receive personalized attention during the tutoring hours (https://moovi.uvigo.gal/)
Case studies	The student will receive personalized attention during the tutoring hours (https://moovi.uvigo.gal/)
Problem and/or exercise solving	The student will receive personalized attention during the tutoring hours (https://moovi.uvigo.gal/)
Problem and/or exercise solving	The student will receive personalized attention during the tutoring hours (https://moovi.uvigo.gal/)

Assessment

	Description	Qualification	Training and Learning Results
Problem and/or exercise solving	ECa. Individual proof where students must develop appropriate or correct solutions through the exercise of routines, the application of formulas or algorithms, the application of procedures for transforming available information and the interpretation of results	15	B3 C1 D3 C3
Case studies	ECb. Test for individual evaluation of the competences that includes the approach of a practical case. Students develop the analysis of the situation in order to know it, interpret it, solve it, generate hypothesis, contrast data, reflect, complete knowledge, diagnose it and train in alternative solution procedures.	35	B3 C1 D3 C3
Problem and/or exercise solving	ECc. Individual proof where students must develop appropriate or correct solutions through the exercise of routines, the application of formulas or algorithms, the application of procedures for transforming available information and the interpretation of results	15	B3 C1 D3 C3
Case studies	ECd. Test for individual evaluation of the competences that includes the approach of a practical case. Students develop the analysis of the situation in order to know it, interpret it, solve it, generate hypothesis, contrast data, reflect, complete knowledge, diagnose it and train in alternative solution procedures.	35	B3 C1 D3 C3

Other comments on the Evaluation

Following the policy guidelines of the Center, the students can choose between two systems of evaluation: continuous and global assessment at the end of the term.

In all the evaluation tests, the competences B3, C1, C3 and D3 will be evaluated.

1. CONTINUOUS ASSESSMENT.

- The system of continuous assessment (EC) will consist of:
  - a) A problem solving deliverables or worked in practical classes. The qualification will be ECa, with maximum score of 1.5 points. It will be necessary to reach 40% of the maximum for this test to have an impact on the final grade.
  - b) A problem solving session on topics 1, 2 and 3. The score will be ECb, and the subtotal EC1 = ECa + ECb can have a maximum value of 5 points.
  - c) A problem solving deliverables or worked in practical classes. The qualification will be ECc, with maximum score of 1.5 poins. It will be necessary to reach 40% of the maximum for this test to have an impact on the

final grade.

    - d) A problem solving sessionon topics 4, 5 and 6. The score will be ECd, and the subtotal EC2 = ECc + ECd can have a maximum value of 5 points.

- The final score of the ordinary exam for students who follow continuous assessment (CE) is obtained by adding the two previous subtotals: EC = EC1 + EC2, unless one of the two subtotals is less than 1.5 (30% of the maximum), in which case the final grade will be limited to a maximum of "Suspense (4.9)".
- The planning of the different intermediate assessment tests will be approved by an Academic Committee of Degree (CAG) and will be available at the beginning of the semester.
- Before the completion or delivery of each test, the date and procedure for reviewing the grades obtained will be indicated, which will be public within a reasonable period of time.
- The continuous assessment tests are not recoverable, that is, if a student cannot meet them within the stipulated period, the teacher does not have to repeat them.
- The qualification obtained in the continuous assessment tests (EC1 and EC2) will be valid only for the current academic year.
- It will be understood that a student accepts this system if he/she presents to take the "ECb" test for continuous assessment.

2. EXAM-ONLY ASSESSMENT

- It will be mandatory for students who do not follow continuous assessment to be able to pass the subject at the ordinary exam.
- It will consist of a problem solving session on topics 1 to 6. The score will be EF, and will have the same requirement of achieving 30% of the maximum possible in each of the two parts corresponding to topics 1 to 3 (part 1) and 4 to 6 (part 2).

3. EXTRAORDINARY EXAM.

- Students who followed the continuous assessment:
    - The extraordinary exam will be divided into two parts: EX1 (items 1 to 3) with a maximum value of 5 points, and EX2 (items 4 to 6) with a maximum value of 5 points.
    - The students who followed the continuous evaluation will choose if to do: only EX1, only EX2 or both parts. The final note will be: EF = max (EX1, EC1) + max (EX2, EC2).
- Students who did not follow the continuous evaluation. It consists of a single evaluation with the same format as the first opportunity (a problem solving session on topics 1 to 6).The score will be EF, and will have the same requirement of achieving 30% of the maximum possible in each of the two parts corresponding to topics 1 to 3 (part 1) and 4 to 6 (part 2).

4. END OF PROGRAM EXAM

- It will have the same format as the global assesment.

5. OBSERVATIONS.

- Student who chose continuous assessment or takes any of the two final global exams of first or second opportunity are considered as presented.
- It is considered that the subject is approved if the final grade is equal to or greater than 5 and in each part at least 30% of the maximum possible is reached. If any of the two subtotals is less than 30% of the maximum, the final grade will be limited to a maximum of "Suspenso (4.9)".
- The evaluation systems do not indicate that it is compulsory to attend practices or to make deliveries, except for the scoring tests described above.
- In case of detection of plagiarism in any of the tests, the final grade will be SUSPENSO (0) and the fact will be communicated to the Center Head for the appropriate purposes.
- The use of generative artificial intelligence (IAG) is allowed in the realization of the academic activities of this subject. Its use must be carried out in an ethical, critical and responsible manner. In the case of using IAG, any result it provides must be critically evaluated, and any citation or reference generated must be carefully verified. It is also recommended to declare the use of the tools used.
- English Friendly subject: International students may request from the teachers: a) resources and bibliographic

references in English, b) tutoring sessions in English, c) exams and assessments in English.

Sources of information
Basic Bibliography
F. T. Ulaby, U. Ravaioli, **Fundamentals of Applied Electromagnetics**, Global Edition 7/e, Pearson Education Limited, 2015
D. K. Cheng, **Fundamentos de Electromagnetismo para Ingeniería**, Addison Wesley, 1998
Antonio Pino, F. Obelleiro, **Apuntes de clase**, (moovi.uvigo.gal/), 2020
Complementary Bibliography
D. K. Cheng, **Fundamentals of Engineering Electromagnetics**, New International Edition, Pearson, 2013
David J. Griffiths, **Introduction to Electrodynamics**, 4ª Edición, Pearson Education Limited, 2012
Javier Fraile Peláez, **Apuntes de Electromagnetismo Báscio**, moovi.uvigo.gal, 2023
J. R. Reitz, F. J. Milford, R. W. Christy, **Fundamentos de la Teoría Electromagnética**, 4ª Edición, Addison Wesley, 1996
F. Dios, D. Artigas, et all., **Campos Electromagnéticos**, Ediciones UPC, 1998
W. H. Hayt, J. A. Buck, **Teoría Electromagnética**, 8ª Edición, Mc Graw Hill, 2012
D. K. Cheng, **Field and Wave Electromagnetics**, 2ª Edición, Addison Wesley, 1998
M. F. Iskander, **Electromagnetic Fields and Waves**, 2ª Edición, Prentice Hall, 2012

Recommendations

Subjects that it is recommended to have taken before

Mathematics: Calculus 1/V05G301V01101
Mathematics: Calculus 2/V05G301V01106

IDENTIFYING DATA				
Digital electronics				
Subject	Digital electronics			
Code	V05G301V01203			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Pérez López, Serafín Alfonso			
Lecturers	Nogueiras Meléndez, Andres Augusto Pérez López, Serafín Alfonso			
E-mail	sperez@uvigo.es			
Web	http://moovi.uvigo.es			
General description	This course is an introduction to the basic principles of digital design and the analysis and design of digital circuits and systems. First, logic circuits, basic digital devices and logic gates representation will be introduced. Then, hardware description languages (HDL) based design, description and simulation methods will be described. Combinational and sequential logic design will be explained using the top-down design paradigm. Finally, the common combinational and sequential logic circuits will be described: operation, diagrams, symbols and VHDL description and simulation.			

Training and Learning Results	
Code	
B13	CG13 The ability to use software tools that support problem solving in engineering.
B14	CG14 The ability to use software tools to search for information or bibliographical resources.
C14	CE14/T9: The ability to analyze and design combinatory and sequential, synchronous and asynchronous circuits and the usage of integrated circuits and microprocessors.
C15	CE15/T10: The knowledge and application of the fundamentals of description languages for hardware devices.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
Knowledge of the concepts, components and basic tools of digital design.	B13 B14	C14 C15
Ability to analyse and design combinational systems.	B13	C14 C15
Knowledge of the combinational functional blocks and their aplications.	B14	C14
Knowledge of the basic storage elements, the sequential blocks and their aplications.	B14	C14
Ability to analyse and design synchronous sequential systems.	B13	C14 C15
Knowledge of description and simulation methods based on hardware description languages (HDL).	B13	C14 C15

Contents	
Topic	
Unit 0: Summary	Teaching Staff. Identifying Data. Lecture sessions. Laboratory Sessions. Planning. Assessment. Lecture Scheduling. Laboratory Scheduling. Bibliography.
Unit 1: Introduction to Digital Electronics	Introduction. Number Systems and Digital Codes. Boolean Algebra. Truth tables. Logic Gates. Logic Circuits. Simplyfing logic funcions. Combinational Systems Design with Logic Gates.
Unit 2: Introduction to VHDL	Relevant Language Elements and Concepts for this Course.
Unit 3: Basic Combinational Systems (I)	Functional Blocks. Technologies and Output Types of the Digital Circuits. Decoders.
Unit 4: Basic Combinational Systems (II)	Multiplexers. Encoders. Demultiplexers. Programmable Memories or Look-Up Tables (LUT).
Unit 5: Arithmetic Systems	Comparators. Parity Detection and Generation. Arithmetic Circuits. Application Examples. VHDL Description.
Unit 6: Sequential Logic Systems Principles	Definition and Classification. Latches and flip-flops. Application Examples. VHDL Description.
Unit 7: Synchronous Sequential Systems	Registers. Counters. Shift Registers. Application examples. VHDL description.

Unit 8: Control Synchronous Sequential Logic Design	Control Synchronous Sequential Systems Design. Application Examples. VHDL Description.
Unit 9: Memory Units	Classification. Active and Pasive Random Access Memories (RAM and ROM). Content Access Memories (CAM). Sequential Access Memories (LIFO, FIFO, Circulars).
Practice 1	Introduction to Design using VHDL and the Vivado Design Tool (I).
Practice 2	Introduction to Design using VHDL and the Vivado Design Tool (II).
Practice 3	Combinational System Design and Implemetation (I).
Practice 4	Combinational System Design and Implemetation (II).
Practice 5	Combinational System Design and Implemetation (III).
Practice 6	Combinational System Design and Implemetation (IV).
Practice 7	Arithmetic Circuits.
Practice 8	Arithmetic Systems.
Practice 9	Sequential Circuits.
Practice 10	Sequential Systems (I).
Practice 11	Sequential Systems (II).
Practice 12	Sequential Systems (III).

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Lecturing	17	20	37
Laboratory practical	24	22	46
Problem solving	13	20	33
Laboratory practice	2	2	4
Problem and/or exercise solving	6	24	30

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Subject presentation. Presentation of laboratory sessions, instrumentation and software resources to be used.
Lecturing	The lecturer will explain in the classroom the main contents of the subject. The students have to manage the proposed bibliography to carry out a self-study process in a way that leads to acquire the knowledge and the skills related to the subject. The lecturer will answer the students questions in the classroom or in the office. In these sessions the students will develop the skils C14 and C15 ("know").
Laboratory practical	Activities designed to apply the main concepts and definitions of the subject. The students will be asked to acquire the basic skills to manage the laboratory instrumentation, software tools and components in order to construct and test electronic circuits. The students have to develop and demonstrate autonomous learning and collaborative skills. Possible questions can be answered in the laboratory sessions or in the lecturers office. In these sessions the students will develop the skils C15, B13 and B14 ("know how"). Software to be used: VIVADO of Xilinx.
Problem solving	Activities designed to apply the main concepts of the subject to solve problems and exercices. The lecturer will explain a set of problems and the students have to solve diferent take-home sets of problems. The lecturer will answer the students questions in the classroom or at the office. In these sessions the students will develop the skils C14 and B15 ("know how").

Personalized assistance

Methodologies	Description
Lecturing	The lecturer will answer the students questions and also give instructions to guide the studying and learning process. The timetable will be available on the subject website at the beginning of the term. The tutoring sessions will take place, prior appointment by email (sperez@uvigo.gal), in the EEI office #235 or through remote mode in virtual room 1958.
Problem solving	The lecturer will answer the students questions and also give instructions to guide the studying and learning process. The timetable will be available on the subject website at the beginning of the term. The tutoring sessions will take place, prior appointment by email (sperez@uvigo.gal), in the EEI office #235 or through remote mode in virtual room 1958.
Laboratory practical	The teacher will answer the students questions and also give instructions to guide the studying and learning process. The timetable will be available on the subject website at the beginning of the term. The tutoring sessions will take place, prior appointment by email (sperez@uvigo.gal), in the EEI office #235 or through remote mode in virtual room 1958.

Assessment			
	Description	Qualification	Training and Learning Results
Laboratory practical	The lecturer will check the level of compliance of the students with the goals related to the laboratory skills. Final mark of laboratory, FML, will be assessed in a 10 points scale. For the evaluation of the laboratory sessions, the lecturer will assess the group work (the same mark for each member) and the individual answers to personalized questions for each session (individual mark).	30	B13 B14 C15
Problem and/or exercise solving	The lecturer will check the students' skills to solve exercices and troubleshooting. Marks for each test will be assessed in a 10 points scale. Final mark of theory, FMT, will be assessed in a 10 points scale.	70	C14 C15

Other comments on the Evaluation

1. Continuous assessment in ordinary opportunity

Following the own degree's guidelines and the agreements of the academic committee, students who take this subject will be provided with a **continuous assessment** system.

O estudantado que opte por avaliación global deberá notificalo por escrito ao coordinador da materia no prazo dun mes dende o inicio do cuadrimestre.

*Those students who **opt for a global assessment** must send a written notification to the subject coordinator within one month from the beginning of the term.*

The subjetc assessment comprises two parts: theory and practice. The grades obtained in the assessable tasks will be only valid for the ongoing academic year.

1.a. Theory

The intermediate assessment test (PEI) will be held throughout the semester. The date on which it takes place will be approved by the Degree Academic Committee (CAG) and will be available at the beginning of the semester.

The final assessment test (PEF) will be held at the end of the course, on the date established by the CAG.

Each of these tests will consist of a series of short answer questions and/or problem solving and/or exercises and will be scored from 0 to 10 marks.

1.b. Practice

There will be a set of twelve 2-hour laboratory sessions with 2-student groups, whenever possible.

The first four sessions will be guided, aiming at learning the tool management that will be used for the design of digital systems to be implemented into programmable devices. These first four practices are mandatory but will not be scored. In the same way, sessions 5, 7 and 10 are compulsory but will not be scored either.

Nevertheless, sessions 6, 8, 9, 11 and 12 will be graded through continuous assessment.

Each session will be only assessed on the corresponding day and hours to its completion according to the practice schedule and the laboratory group assigned by the centre.

Each session will be scored with a grade (NP) between 0 and 10 marks. The teaching staff will take into account the student previous work to prepare the proposed tasks and the work in the laboratory as well as the student attitude in their posts.

The score for the sessions will be 0 for students who do not attend without any compelling and justified issue.

Laboratory sessions' mark (NP) will be:

$$NP = (NP6 + NP8 + NP9 + NP11 + NP12) / 5.$$

In the case of missing more than 2 sessions, the final grade will be 0.

1 C. Call's assessment

The continuous assessment mark in ordinary opportunity, which is the one that will appear in the acta, is calculated as follows:

If the mark in PEF is lower than 4, then PEF = 0

NECOD = 0.2.NP + 0.4 PEI + 0.4 PEF

2. Global assessment in ordinary opportunity

Those who discard the continuous assessment must take two tests: the theory one (EGT), which includes all the subject contents, and the laboratory one (EGP), which includes all the concepts involved in the laboratory sessions. Both tests will be scored between 0 and 10 points.

The global assessment grade in global opportunity, which will be the one that will appear in the acta, is calculated as follows:
NEGOD = 0.5 EGP + 0.5 EGT

3. Continuous assessment in extraordinary opportunity

In this case, the mark obtained in the laboratory sessions (NP) will be kept. The exam (EECOE), which includes all the subject contents, will be scored between 0 and 10 points.

The continuous assessment mark in extraordinary opportunity, which will be the one that will appeared in the acta, is calculated as follows:
NECOE = 0.2 NP + 0.8 EECOE

4. Global assessment in extraordinary opportunity

Those who discard the continuous assessment in the extraordinary opportunity must take two tests: the theory one (EGTE), which includes all the subject contents, and the laboratory one (EGPE), which includes all the concepts involved in the laboratory sessions. Both tests will be scored between 0 and 10 marks.

The global assessment mark in extraordinary opportunity, which will be the one that will appear in the acta, is calculated as follows:
NEGOE = 0.5 EGPE + 0.5 EGTE

5. Assessment of the final degree call

Those who sit this exam must take two tests: the theory one (CFCT), which includes all the subject contents, and the laboratory one (CFCP), which includes all the concepts involved in the laboratory sessions. Both tests will be scored between 0 and 10 marks.

The assessment mark of this call, which will be the one that will appear in the acta, is calculated as follows:
NCFC = 0.5 CFCP + 0.5 CFCT

Sources of information
Basic Bibliography
Wakerly J. F., **Digital Design. Principles and Practices**, 4th, Pearson/Prentice Hall, 2007
E. Mandado, **Sistemas Electrónicos Digitales**, 10ª, Marcombo, 2015
Douglas L. Perry, **VHDL : programming by example**, 4th, McGraw-Hill, 2002
Complementary Bibliography
Thomas L. Floyd, **Digital Fundamentals**, 11th, Pearson, 2014
L.J. Álvarez, E. Mandado, M.D. Valdés, **Dispositivos Lógicos Programables y sus aplicaciones**, 1ª, Thomson-Paraninfo, 2002
S. Pérez, E, Soto, S. Fernández, **Diseño de sistemas digitales con VHDL**, Thomson-Paraninfo, 2002
L.J. Álvarez, **Diseño Digital con Lógica Programable**, 1ª, Tórculo, 2004
J. Bhasker, **A VHDL primer**, 3rd, Prentice Hall, 1999

Recommendations
Subjects that continue the syllabus
Programmable Electronic Circuits/V05G301V01302

Subjects that are recommended to be taken simultaneously
Physics: Fundamentals of electronics/V05G301V01201

Subjects that it is recommended to have taken before
Informatics: Computer Architecture/V05G301V01109

IDENTIFYING DATA

Data Communication

Subject	Data Communication			
Code	V05G301V01204			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Díaz Redondo, Rebeca Pilar López García, Cándido Antonio			
Lecturers	López García, Cándido Antonio			
E-mail	candido@det.uvigo.es rebeca@det.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	In this subject the efficiency and reliability of data transmission using discrete memoryless channels will be analyzed, and the next issues will be introduced: * lossless data compression methods, * linear error control codes, * data link layer protocols, and * multiple access channels protocols and technologies.			

Training and Learning Results

Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C11	CE11/T6: The ability to conceive, deploy, organize and manage networks, systems, services and Telecommunication infrastructures in residential (home, city, digital communities), business and institutional environments, being responsible for launching of projects and continuous improvement like knowing their social and economical impact.
C17	CE17/T12: The knowledge and usage of concepts of communication network architecture, protocols and interfaces.
C18	CE18/T13: The ability to differentiate the concepts of access and transport networks, packet and circuit switched networks, mobile and fixed networks, as well as distributed newtwork application and systems, voice, data, video, audio, interactive and multimedia services.
C20	CE20/T15: The knowledge of national, European and international telecommunication regulations and laws.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Understanding the basics of digital transmission of information processes, the mathematical models of channels and the concept of capacity.	B3	C17	
Knowledge and ability to analyze the ways of achieving reliable data transmission.	B3 B4	C17 C20	D2 D3
Understanding the methods of sharing multiple access channels, their limits and the factors that affect their performance.	B3	C11 C18	D3
Master the main technical standards, interfaces and protocols in the field of data transmission and local networks.	B3	C20	D3
Practice with interfaces and protocols in the laboratory, as well as in the development of basic transmission solutions.	B3 B3	C20 C24	D2 D3 D9 D10 D17

Contents

Topic

Unit 1. Fundamentals of discrete Information Theory	1.1. A basic model of data communication systems 1.1.1. Discrete sources: discrete memoryless sources 1.1.2. Discrete channels: discrete memoryless channels 1.1.3. Source coding and channel coding 1.2. Information measures 1.2.1. Entropy. Joint entropy 1.2.2. Conditional entropy 1.2.3. Mutual information 1.3. Shannon's source coding theorem 1.3.1. Uniquely decodable codes: instantaneous codes 1.3.2. Kraft's theorem. McMillan's theorem 1.3.3. Optimal codes. Code redundancy 1.3.4. Shannon's source coding theorem 1.3.5. Compact codes. Huffman's algorithm 1.4. Shannon's noisy channels coding theorem 1.4.1. Channel capacity 1.4.2. Symmetric channels 1.4.3. Shannon's noisy channels coding theorem
Unit 2. Data transmission error control	2.1. Linear codes 2.1.1. Definition and matrix description 2.1.2. Syndrome decoding 2.1.3. Error detection and correction properties 2.1.4. Hamming codes 2.1.5. Cyclic codes 2.2. ARQ protocols 2.2.1. Stop and wait 2.2.2. Go-back n 2.2.3. Selective repeat
Unit 3. Multiple access channels and local area networks	3.1. Multiple access channels 3.1.1. The multiple access channel: definition and types 3.1.2. MAC protocols: Aloha, CSMA and variants 3.1.3. Performance of MAC protocols 3.2. Local area networks 3.2.1. Wi-Fi networks 3.2.2. Ethernet networks 3.2.3. Switching ethernet 3.2.4. Virtual local networks
Practical sessions (B)	Sessions to solve problems related to the content of the course.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	36	0	36
Previous studies	0	44	44
Problem solving	22	0	22
Autonomous problem solving	0	43	43
Essay questions exam	4	0	4
Problem and/or exercise solving	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Systematic exposition of the theoretical contents of the subject, emphasizing the aims, fundamental concepts and relationships between the different units. Through this methodology the competencies C11, C17, C18, C20, B3 and D2 are developed.
Previous studies	Students will study the theoretical contents of the subject using the textbook and/or further material. Through this methodology the competencies C11, C17, C18, C20, B3 and D2 are developed.

Problem solving	Selected problems and/or exercises will be solved in detail, emphasizing the theoretical concepts involved and the methodology of resolution. Through this methodology the competencies C11, C17, C18, C20, B4 and D3 are developed.
Autonomous problem solving	Students will try to autonomously solve a problems and/or exercises from a proposed collection. Through this methodology the competencies C11, C17, C18, C20, B4 and D3 are developed.

Personalized assistance

Methodologies	Description
Previous studies	Students will receive personalized attention (during the office hours) to resolve doubts that can arise in the autonomous study of the subject. Office hours: Rebeca P. Díaz Redondo: https://moovi.uvigo.gal/user/profile.php?id=11470 Manuel Fernández Veiga: https://moovi.uvigo.gal/user/profile.php?id=11641 Cándido López García: https://moovi.uvigo.gal/user/profile.php?id=11339
Autonomous problem solving	Students will receive personalized attention (during the office hours) to resolve doubts that can arise in the autonomous resolution of exercices. Office hours: Rebeca P. Díaz Redondo: https://moovi.uvigo.gal/user/profile.php?id=11470 Manuel Fernández Veiga: https://moovi.uvigo.gal/user/profile.php?id=11641 Cándido López García: https://moovi.uvigo.gal/user/profile.php?id=11339

Assessment

	Description	Qualification	Training and Learning Results		
Essay questions exam	Two partial examinations. In each one of them we will evaluate all the competencies corresponding to the contents we have seen in class to date of the examination.	80	B3 B4	C11 C17 C18 C20	D2 D3
Problem and/or exercise solving	Two short exams, whose dates will be published at the beginning of the term.	20	B3	C17 C18	D3

Other comments on the Evaluation

A continuous assessment of the learning will be practised. Continuous assessment will consist of two types of tests: two short tests and two partial exams, the first one in the midterm and the second one at the end of the class period. All these tests will not be repeatable and will only be accountable for the ordinary call in the current course. The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester.

The continuous assessment grade will be obtained as the weighted average of the grades of all the mentioned tests: 20% due to all the short tests (equally weighted) and 40% of each one of the partial exams, whenever the average grade of partial exams was not less than 3.5. In other case, the grade of the continuous assessment will be the average grade obtained in the partial exams.

All the students can do a final exam (global assessment), that will include ALL the contents of the subject and that will take place in the exam period scheduled by the Centre. In this case, the final grade of the subject will be the exam grade.

All the students following continuous assessment or taking the final exam will be graded. The students that attend to the second partial exam will be considered following continuous assessment. Once a student has decided to follow the continuous assessment, his/her grade will never be no show ("no presentado").

Those students who do not pass the subject at the ordinary exam have a second one consistent in the realisation of a new final exam (extraordinary exam).

In the endo-of-program exam the assessment will just consist in the realisation of a written exam including ALL the contents of the subject.

Plagiarism is regarded as serious dishonest behaviour. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information

Basic Bibliography

C. López García, M. Fernández Veiga, **Teoría de la Información y Codificación, 2/e**, 2013,

Complementary Bibliography

C. López García, M. Fernández Veiga, **Cuestiones de Teoría de la Información y Codificación**, 2003,

J. F. Kurose, K. W. Ross, **Computer Networking, 7/e**, 2017,

Recommendations

Subjects that continue the syllabus

Computer Networks/V05G301V01210

Subjects that it is recommended to have taken before

Mathematics: Linear algebra/V05G301V01102

Mathematics: Calculus 1/V05G301V01101

Mathematics: Probability and Statistics/V05G301V01107

IDENTIFYING DATA				
Digital Signal Processing				
Subject	Digital Signal Processing			
Code	V05G301V01205			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Alonso Alonso, Ignacio Márquez Flórez, Óscar Willian			
Lecturers	Alonso Alonso, Ignacio Docio Fernández, Laura Márquez Flórez, Óscar Willian			
E-mail	ignacio.alonso@uvigo.es omarquez@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Digital signal processing is nowadays a feature of most everyday communications and entertainment devices. The aim of this course is to equip students with a mathematical grounding in general signal and systems analysis. In subsequent course subjects, this knowledge will be applied to specific applications of signals and systems, including audio, image, video and voice signals. Objectives cover the following areas: Managing signals and systems mathematically and visually, including learning and applying their properties. Studying the different domains for signal and systems analysis: time domain, frequency domain and Z domain. Learning how to transfer a problem in one domain to a domain in which it is easier to solve. Mastering the concept of filter frequency response and learning to interpret the system function. Understanding the relationship between the poles and zeros of the system function and the frequency response. Acquiring basic notions of filter design in the Z domain. Managing specific digital signal processing software. Applying the above knowledge to simple and practical laboratory examples. English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C48	(CE48/T16) The knowledge of the appropriate techniques to develop and exploit signal processing subsystems.
C49	(CE49/T17) The ability to analyze digital signal processing schemes.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Managing specific software for digital signal processing	B3	C48	D3
Applying mathematical knowledge for signal filtering	B4	C49	D2
Mastering filtering operations in frequency domain.	B4	C49	D2
Learning mathematical issues for understanding the processes of sampling and windowing of analog signals.	B3	C48	D3

Analysis of simple processing systems.	B4	C49	D2

Contents

Topic	
Subject 1. Introduction	Concept of signal and system. Mathematical representation
Subject 2. Sinusoids	Sinusoidal signals: Frequency, amplitude and phase. Complex exponentials and phasors. Phasor addition rule.
Subject 3. Spectrum representation	Spectrum of a sum of sinusoids. Mathematical expression and graphical plot. Fourier Series analysis of periodic signals.
Subject 4. Introduction to Sampling and Aliasing	Sampling and digital frequency. Analog frequency vs discrete frequency. Aliasing. The sampling theorem.
Subject 5. FIR Filters	Introduction to discrete-time systems. Difference equation. Filter Coefficients. Block Diagrams. Causality, linearity and time-invariance. LTI systems and convolution. FIR frequency response. Cascaded LTI systems.
Subject 6. Frequency response of FIR filters	Sinusoidal response of FIR systems. Frequency response. Properties. Graphical representation.
Subject 7. Z Transform	Definition and properties. Linear-phase filters.
Subject 8. IIR Filters	Difference equation. Filter Coefficients. Block Diagrams. Impulse response. Relation between the position of poles and zeros of the system function and the frequency response.
Subject 9. Continuous-Time Signals and Systems	Introduction to continuous-time systems. The unit impulse. The unit step. Time delaying. Linearity and time-invariance. Convolution
Subject 10. Continuous-Time Fourier Transform	Definition. Basic pairs. Properties
Subject 11. Sampling and Reconstruction in the Frequency Domain	The sampling theorem in the frequency domain
Project 1. A/D and D/A Conversion	Digitalisation of Continuous-Time Signals. Aliasing.
Project 2. Digital Filters	Digital filters in the time and frequency domains.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Lecturing	32	37	69
Laboratory practical	10	20	30
Problem solving	14	28	42
Discussion Forum	0	2	2
Objective questions exam	1.5	0	1.5
Problem and/or exercise solving	4.5	0	4.5

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Course presentation: programme, reading materials, teaching methodology and assessment system
Lecturing	Instructor presentation of the main concepts of each subject. During the 5 minutes before the lecture, a student will summarize the main concepts presented in the previous session. Students will participate by answering questions during the explanation and by doing exercises. Student will work alone afterwards on the concepts studied in class and on expanding this content using the guidelines provided for each subject. Identification of doubts that need to be resolved in personalized tutorials. Through this methodology the competencies C48, B3, and D3 are developed.
Laboratory practical	Application of Matlab functions and commands for digital signal processing to solve practical exercises. Identification of doubts that need to be resolved in personalized tutorials. Software to be used: MatLab. Through this methodology the competencies C49, B4 and D2 are developed.

Problem solving	Problems and exercises formulated according to the content of the lectures and the guidelines for each subject. Students solve problems and exercises prior to the class in which one or several students explain the solution on the board. Identification of doubts that need to be resolved in personalized tutorials. Through this methodology the competencies C49, B4 and D2 are developed.
Discussion Forum	The website for the course is included in the MooVi platform (https://moovi.uvigo.gal/). Subscription to this platform, including a photograph, is mandatory. The website provides all the information related to the course. It also publishes continuous assessment grades and runs forums for students to exchange ideas and discuss doubts. Through this methodology the competencies C48, C49, B3, B4 , D2 and D3 are developed.

Personalized assistance

Methodologies	Description
Lecturing	Students will have the opportunity to attend one-on-one tutorials at specific times established by lecturers for this purpose at the beginning of the academic year and published on the subject's page, on MooVi (https://moovi.uvigo.gal), within the "Teaching staff and tutorials" section. These tutorials are aimed at resolving student doubts and providing guidance regarding: The content of the lectures and approaches to study. Laboratory projects and the software used. Problems and exercises proposed and solved in the classroom as well as other problems and exercises arising during the course. Online tutorials will be available too by appointment.
Laboratory practical	The same as in the previous section.
Problem solving	The same as in the previous section.

Assessment

	Description	Qualification	Training and Learning Results		
Objective questions exam	These tests are a requirement to pass the subject. See details in the "Other comments and second call" section.	0	B3	C48 C49	D3
Problem and/or exercise solving	These tests are a requirement to pass the subject. See details in the "Other comments and second call" section.	100	B3 B4	C48 C49	D2 D3

Other comments on the Evaluation

ASSESSMENT PROCEDURE:

A. Overview

The acquired skills are assessed by a series of tests grouped into two parts, with different requirements:

1. **Lab assessment**.
2. **Problems assessment**.

To pass the course it is necessary to pass all two parts.

- For each part one or more tests are performed to obtain an independent grade on each.
- There are tests for the two parts both in continuous assessment and in global assessment.
- A pass grade in any part is valid for the entire academic year.
- The final grade for Lab assessment is a numerical mark between 0 and 10. A student needs a grade greater than or equal to 5 to pass the Lab. Moreover, if the Lab exams are carried out during the classes period and the Lab grade for that period is greater than 7, the Lab grade will increase the Course mark (see details below).
- The final grade for the Problem assessment is a numerical mark between 0 and 10.
- The **Course mark** is obtained as follows (for both continuous and global assessment):
  - If you have passed all two parts and your continuous assessment Lab grade (the one obtained during the classes period) is not greater than 7:
    - Course mark=Problems assessment grade.
  - If you have passed all two parts and your continuous assessment Lab grade is greater than 7:

        - Course mark=minimum [10 , Problems assessment grade + [(Continuous Assessment Lab grade-7)/3]]
    - If you have not passed any of the two parts:
        - Course mark=minimum [Problems assessment grade, Lab grade]
    - In case the student has more than one mark for any part, the highest one will be used.

It is also important to note that:

- The course can be passed with full marks from continuous assessment, with no need to sit the final exam.
- Students who have done continuous assessment and have failed any part, in the final exam, only have to sit the part they failed (Lab or Problems).
- Students who sit any of the tests corresponding to Problem assessment will obtain a mark that will be listed in the academic records.

The following sections explain in detail how each part is graded.

B. Details of the assessment procedure

B1. Lab assessment

- Its goal is to determine whether the student has acquired all the knowledge and/or skills corresponding to the laboratory practice, emphasizing the use of MatLab for digital signal processing.
- Content to be assessed: content of the lab manuals and related theory content.
- Type of test: The test consists of a combination of multiple-choice questions and short questions. Students may use MatLab, lab manuals with personal notes, and text book. Students may not use a calculator for this test.
- The final grade for Lab assessment is a numerical mark between 0 and 10. A student needs a grade greater than or equal to 5 to pass the Lab. If the continuous assessment Lab grade is greater than 7 (not a Lab grade obtained in a final exam), the Lab grade will increase the Course mark.
- Assessment method:
    - **Ordinary exam**: Students will have two nonexclusive ways to pass the Lab part.
        1. Two tests in the lab room during the class period (continuous assessment)
            - The test consists of a series of questions at the end of each Lab assignment. The practice that is completed and all the previous ones are evaluated.
            - The tests will be graded between 0 and 10. The lab grade will be obtained as the weigthed average of the grades of both practices, being the weights the 40% and the 60% for practices 1 and 2 respectively. The student will pass this part if he/she gets a weigthed average greater than or equal to 5. It is compulsory to sit the two tests.
            - The schedule of the tests will be approved in the Comisión Académica de Grado (CAG) and it will be announced on the subject web site at the beginning of the lecture period.
        1. A final exam (global assessment). The pass mark for this test is 5 out of 10.
    - **Extraordinary exam or end-of-program exam**: A final exam (global assessment). The pass mark for this test is 5 out of 10.
- Remarks:
    - Once the Lab part has been passed, the Lab grade will be valid for the entire academic year.

B2. Problems assessment

- Its goal is to determine whether the student has acquired all the knowledge and/or skills corresponding to the course and knows how to apply them to solve problems.
- Content to be assessed: as specified in the guidelines document for each topic (available on the subject web) in the section "Content to be assessed". MatLab knowledge is not assessed.
- Type of test: A problem solving test. Students are not allowed to use books or notes. The use of calculators may be granted on an exam basis.

- It will be graded between 0 and 10. The pass mark is 5.
- Assessment method:
  - **Ordinary exam**: Students will have two nonexclusive ways to pass the Problems part.

    1. Three problem solving tests in the classroom during the class period (continuous assessment). Each test will be graded between 0 and 10 and it is mandatory to sit the three tests.

       - The mark will be obtained as : w1* Test1Mark+ w2*Test2Mark + w3*Test3Mark
       - The weight w1 will be 0.25.
       - The weight w2 will be 0.35 if the mark of the second test is higher than or equal to 3 out of 10. Otherwise w2 will be 0.
       - The weight w3 will be 0.40 if the mark of the third test is higher than or equal to 3 out of 10. Otherwise w3 will be 0.
       - Test1: Units 1 to 4. Test2: Units 1 to 7. Test3: Units 1 to 11.
       - The schedule of the tests will be approved in the Comisión Académica de Grado (CAG) and it will be announced on the subject web site at the beginning of the lecture period.

    2. A final exam (global assessment). The pass mark for this test is 5 out of 10.

  - **Extraordinary exam or end-of-program exam**: A final exam (global assessment). The pass mark for this test is 5 out of 10.

- Remarks:

  - Once the Problems part has been passed, the Problems grade will be valid for the entire academic year.
  - A student who has passed the Problems part in the Ordinary exam through the continuous assessment method is allowed to sit the final exam of the Ordinary exam to try to get a better mark.
  - A student who has passed the Problems part in the Ordinary exam is NOT allowed to sit the Problems Part of the final exam of the Extraordinary exam.

C. Other comments

- After the end of the course students will have a single grade of the subject in their academic record:

  - After the Ordinary exam their corresponding grade is registered. If this grade is greater than or equal to 5, it will be the student final grade
  - If a student who has not passed the subject in the Ordinary exam, gets a better grade in the Extraordinary exam, this new grade will be the one that will be included in his academic record. If it is not better the academic record will stay unchanged. In any of these cases, this grade becomes the final grade.

- Continuous assessment tests may not be rescheduled.
- Lab or Problems grades are only valid for the current academic year.
- The use of books, notes or electronic devices such as phones or computers is not permitted in any test or exam. Mobile phones must be turned off and out of reach of the student. If calculator use is permitted, the calculator must be a conventional scientific calculator. Therefore, calculators that allow formulas to be saved or that have libraries that automatically perform operations with complex numbers, calculation of roots, etc. are not allowed under no circumstances.
- Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.
- Throughout the course, during the celebration of the lectures, the teachers of the subject will eventually propose activities or exercises in which students can be rewarded with up to 1 point out of 10. If they receive it, this bonus will be added to the final grade that the students have obtained following the assessment methods previously described.
- English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.

Sources of information

Basic Bibliography

J.H. McClellan y R.W. Schafer, R, **Signal Processing First**, Pearson Prentice Hall,

Complementary Bibliography

A. Quarteroni y F. Saleri, **Cálculo científico con Matlab y Octave**, Springer,

M. J. Roberts, **Señales y Sistemas**, McGraw Hill,

A.V. Oppenheim y R.W. Schafer, **Tratamiento de señales en tiempo discreto**, Prentice Hall,

Recommendations

Subjects that it is recommended to have taken before

Physics: Analysis of Linear Circuits/V05G301V01108
Mathematics: Linear algebra/V05G301V01102
Mathematics: Calculus 1/V05G301V01101
Mathematics: Calculus 2/V05G301V01106

IDENTIFYING DATA				
Electronic technology				
Subject	Electronic technology			
Code	V05G301V01206			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Valdés Peña, María Dolores			
Lecturers	Álvarez Ruiz de Ojeda, Luís Jacobo Raña García, Herminio José Valdés Peña, María Dolores			
E-mail	mvaldes@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This course is dedicated to the utilisation of integrated circuits, in particular operational amplifiers, as well as to the following fields: Electronics of Power, Electrotechnics in the aspects of electrical installations and to the conversion of photovoltaic solar energy and thermal. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B13	CG13 The ability to use software tools that support problem solving in engineering.
B14	CG14 The ability to use software tools to search for information or bibliographical resources.
C14	CE14/T9: The ability to analyze and design combinatory and sequential, synchronous and asynchronous circuits and the usage of integrated circuits and microprocessors.
C16	CE16/T11: The ability to use different energy sources, especially photovoltaic and thermal ones, as well as the fundamentals of power electronics and electronics

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
To know how to analyse and use circuits with operational amplifiers and with other integrated circuits.	B13 B14	C14
To know the foundations of Electrotechnics.		C16
To know the foundations of the Power Electronics and the basic topologies of the power electronic converters.	B13 B14	C16
Ability to use distinct sources of energy and especially photovoltaic solar energy and thermal solar energy.	B13	C16

Contents	
Topic	
Operational amplifiers and other integrated circuits	Introduction to amplifiers: Aspects of frequency response in amplifiers. Bode diagrams. Principles of operation of an operational amplifier. Application circuits for operational amplifiers. Other integrated circuits of general application.
Power Electronics (I)	Introduction to Power Electronics. Power electronic devices .
Power Electronics (II)	DC power supplies. DC-DC converters.
Power Electronics (III)	Single-phase rectifiers. Single-phase inverters.
Electrotechnics	Electrical installations. Protections.
Photovoltaic and thermal solar energy	Photovoltaic and thermal solar installations. Photovoltaic cells. Photovoltaic panels. Photovoltaic systems of energy conversion.
Laboratory sessions	Assembly and simulation of the most important circuits studied in the different theory topics. Transistor based amplifiers. Linear and nonlinear applications of operational amplifiers. Linear regulators for power supplies. Power devices. DC-DC and DC-AC converters. Photovoltaic solar generator.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	24	24	48
Laboratory practical	22	22	44
Problem solving	12	12	24
Essay questions exam	1.5	10	11.5
Problem and/or exercise solving	1.5	10	11.5
Laboratory practice	2	9	11

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The teacher exposes the theoretical contents. This activity is individual. In these activities skills C14 and C16 are developped.
Laboratory practical	They include circuit mounting and testing and computer electronic circuits simulation. Software to be used: ORCAD PSPICE. Some practical classes will also include some web search made by the student, about some technical information about some specific electronic devices used in the practical classes (e.g. some kind of transistors or operational amplifiers). This activity is collective. The students work in teams of two persons in each laboratory position. Through this methodology the competencies C14, C16, B13 and B14 are developed.
Problem solving	The teacher will solve exercises about most of the chapters. This activity is individual. Through this methodology the competencies C14 and C16 are developed.

Personalized assistance

Methodologies	Description
Lecturing	The students may talk to the professor in the office hours published in the course webpage (https://moovi.uvigo.gal/). Questions about the contents of the master classes will be answered in this tutorship time as well as questions about how to prepare their study.
Laboratory practical	The students may talk to the professor in the office hours published in the course webpage (https://moovi.uvigo.gal/). Questions about the contents of the laboratory practices, about how to use the instrumentation or about the implementation of the electronic circuits and the simulation software will be answered in this sessions.
Problem solving	The students may talk to the professor in the office hours published in the course webpage (https://moovi.uvigo.gal/). Questions about the problems or exercises proposed and solved in the classroom will be answered in this tutorship time as well as other problems or exercises that the student can find along the study of the subject.

Assessment

	Description	Qualification	Training and Learning Results	
Essay questions exam	They are part of each partial theory exam. The number of tests and the policy are detailed in 'Other comments' section.	35		C14 C16
Problem and/or exercise solving	They are part of each partial theory exam. The number of tests and the policy are detailed in 'Other comments' section.	35		C14 C16
Laboratory practice	They are carried out in the laboratory. They consist of the type of tasks carried out or prepared during the practices of the subject: the practical tests consist of real assembly of circuits, carrying out measurements on them and questions related to those circuits and/or simulation of circuits equal or similar to those studied in the practices and questions related to that simulation.	30	B13 B14	C14 C16

Other comments on the Evaluation

A continuous assessment (CA) procedure is established based on partial theory and laboratory exams, but students can alternatively opt for a global assessment (GA).

Students are considered to opt for CA from the time they attend the first partial exam, whether it is of the theory or laboratory kind. Students will be able to renounce the CA and opt for the GA until the date in which the first partial exam of laboratory practices is carried out (after the first month of the course).

1. Continuous assessment:

Students who opt for the CA modality will have two assessment opportunities, the ordinary and the extraordinary.

1.1 Ordinary exam for continuous assessment:

The CA is divided into a theory part (70% of the final grade) and another of laboratory practical (30% of the final grade). The planning of the different exams will be published in a shared calendar and will be available at the beginning of the semester.

Regarding the theory part:

- The theoretical part of the subject is evaluated through three exams that will be carried out within the schedule assigned to the subject.
- The weight of each exam is 23,33% of the final grade.
- Student passes this part if they obtain a grade greater than or equal to 4 out of 10 in each of the exams.
- The TG (theory grade) is the average of the three partial exams.

Regarding laboratory exams:

- The practical part of the subject is evaluated through two partial exams that are carried out within the class hours assigned to the laboratories.
- The weight of each exam is 15% of the final grade.
- The attendance to the laboratory sessions is mandatory. Students must complete at least 80% of the sessions.
- This part is passed if a grade greater than or equal to 4 out of 10 is obtained in each of the partial exams.
- The laboratory grade LG is the average grade of the two partials.

Final grade (FG):

The final grade of the continuous assessment is obtained as follows:

FG = (TG*0.7 + LG*0.3) if the grades of all the theory and laboratory partials are greater than or equal to 4 points out of 10 and FG is greater than or equal to 5,

FG = min [(TG*0.7 + LG*0.3), 4.9] otherwise.

On the date of the final exam, it will be possible to recover the failed partial exams, both theory and practical.

1.2 Extraordinary Opportunity of CA:

Students who do not pass one or more of the partial exams of the ordinary opportunity can recover them in the extraordinary one.

The final grade is obtained in the same way as that of the ordinary opportunity.

2. Global assessment (GA):

Students who choose GA will have two assessment opportunities, the ordinary and the extraordinary.

In both cases the evaluation will consist of two exams, one of the theoretical part (TG) of the subject with a weight of 70% and another of the laboratory part (LG) with a weight of 30%.

The final grade (FG) of the continuous assessment is obtained as follows:

FG = (TG*0.7 + LG*0.3) if the grades of all the theory and laboratory partials are greater than or equal to 4 points out of 10 and FG is greater than or equal to 5,

FG = min [(TG*0.7 + LG*0.3), 4.9] otherwise.

3. End-of-program call:

The end-of-program assessment will be the same as that described for the global case.

Other comments:

- Any other information/recommendation regarding the organization of the subject will be published on the subject's website.
- During exams, smart electronic devices must be turned off and out of the reach of students.
- Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information
Basic Bibliography
Hambley, A. R., **Electrónica**, 2ª ed. en español, Prentice-Hall,
Hart, D. W., **Electrónica de potencia**, Prentice-Hall,
Quintáns Graña, C., **Simulación de circuitos electrónicos con OrCAD® PSpice®**, 2.ª edición, Marcombo, 2021
Hambley, Allan R., **Electronics**, 2nd ed., Prentice Hall,
Hart, Daniel W., **Power Electronics**, McGraw-Hill,
Complementary Bibliography
Rashid, Muhammad H., **Electrónica de potencia: circuitos, dispositivos y aplicaciones**, Pearson Education,
Reglamento Electrotécnico para Baja Tensión (REBT) e Instrucciones Técnicas Complementarias (ITC),
Schneider Electric España, S.A., **Guía de diseño de instalaciones eléctricas (PDF de uso libre disponible en www.schneiderelectric.es)**, Schneider Electric España, S.A,
Guirado, R., **Tecnología eléctrica**, McGraw-Hill,
AENOR, **Norma UNE 60617 de Símbolos gráficos para esquemas eléctricos**,
Carta, J. A. y otros, **Centrales de energías renovables: Generación eléctrica con energías renovables**, Pearson-UNED,
Quintáns Graña, C., **Simulación de circuitos con OrCAD 16 DEMO**, 1ª ed., Marcombo,

Recommendations

Subjects that it is recommended to have taken before

Physics: Analysis of Linear Circuits/V05G301V01108
Physics: Fundamentals of electronics/V05G301V01201

IDENTIFYING DATA				
Electromagnetic Transmission				
Subject	Electromagnetic Transmission			
Code	V05G301V01207			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Vera Isasa, María			
Lecturers	Díaz Otero, Francisco Javier Santalla del Río, María Verónica Vera Isasa, María			
E-mail	mirentxu@uvigo.gal			
Web	http://moovi.uvigo.gal			
General description	Fundamentals of electromagnetic guided and unguided transmission. Analysis of the operating principles of different transmission media models and their characterization in telecommunication engineering. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
C9	CE9/T4: The ability to analyze and specify the main parameters of a communications system.
C13	CE13/T8: The ability to understand the electromagnetic and acoustic wave mechanisms of propagation and transmission, and their corresponding receiving and transmitting devices.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Transmissionm line specification: two-wire line, coaxial wire, coaxial models, twisted pair, optical fibre.	B3	C9	
Tension and current waves, E-H fields and stationary wave analysis.	B5	C13	
Proposing impedance matching solutions.	B4		
Antenna radiated field calculation and related parameters: radiation pattern, gain, beam-width, impedance, polarisation, effective area.	B5	C9 C13	
Resolving problems of propagation and reception of electromagnetic waves.	B3 B4		D2 D3

Contents	
Topic	
Introduction	Types of transmission media, advantages and disadvantages, characterisation.

Transmission lines	Getting started with some of the most commonly used transmission lines: two-wire, coaxial cable, twisted pair. Circuit model of distributed parameters ,general equations, characteristic parameters (characteristic impedance, propagation velocity, attenuation and phase constants). Attenuation, dispersion and crosstalk. Transmission line in a circuit (reflection coefficient, standing wave ratio, input impedance). Smith Chart.
Waveguides and optical fibre	Metallic waveguides: modes of propagation, cutoff frequency, single-mode band , attenuation and dispersion. Optical fibre: structure and types, numerical aperture and acceptance cone, attenuation and dispersion, optical sources and receivers.
Radiowaves and antennas	Characteristics of radiowaves: far field, radiation integral. Antenna concept and fundamental parameters (radiation pattern, secondary lobe level, beamwidth, directivity, gain, polarisation, impedance). Reception: power balance in free space (Friis equation), polarization loss factor. Antenna arrays.
Labs	- Measurement and analysis of voltage and current waves and standing waves. - Basic impedance matching technics. - Optical fiber transmission fundamentals. - Measurements with microwave training system (waveguides). - Radiation pattern plots. - Measurement of antenna basic parameters. - Problem resolution.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	1	2
Lecturing	20	30	50
Autonomous problem solving	14	30	44
Laboratory practical	18	12	30
Problem solving	6	12	18
Problem and/or exercise solving	4	0	4
Self-assessment	0	2	2

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Activities focused to take contact and get information about the students and to introduce the subject.
Lecturing	Presentation by the teacher of the contents of the subject of study (theoretical basis). Through this methodology the competencies B3, C9,C13 and D2 are developed.
Autonomous problem solving	Activity in which problems are formulated related to the subject. The student must develop the analysis and solving problems independently. The solutions are provided in ordinary class hours. Through this methodology the competenciesB4, C9 and C13 are developed.
Laboratory practical	Application of knowledge to specific situations and acquisition of basic skills and procedures. They are developed in laboratories with specialized equipment. Software to be used: applets java. Through this methodology the competencies B5 and D3 are developed.
Problem solving	Activity in which problems are formulated related to the subject. The student must develop the analysis and solving problems with the advisor help. Through this methodology the competencies B4, C9 and C13 are developed.

Personalized assistance

Methodologies	Description
Lecturing	In the tutorial schedule, teaching staff will attend the needs and queries of the students related with the study of the subject. See tutorial schedule time in the web of the subject (http://moovi.uvigo.gal)
Laboratory practical	The teaching staff will set the time of the session and will solve the questions about the practical implementation.

Autonomous problem solving	In the tutorial schedule, teaching staff will attend the needs and queries of the students related with the study of the subject. See tutorial schedule time in the web of the subject (http://moovi.uvigo.gal)
Problem solving	In the tutorial schedule, teaching staff will attend the needs and queries of the students related with the study of the subject. See tutorial schedule time in the web of the subject (http://moovi.uvigo.gal)

Assessment

	Description	Qualification	Training and Learning Results	
Problem and/or exercise solving	Test in which the student has to solve a series of problems in a time and conditions established by the teacher, applying the acquired knowledge.	100	B3 B4	C9 C13
Self-assessment	Online tests using the web platform.	0	B3 B4 B5	C9 C13

Other comments on the Evaluation

Following the guidelines of the degree, two evaluation systems will be offered: continuous assessment or global assessment.

Continuous assessment

Continuous assessment includes two types of tasks: self-assessment tasks using the web platform and problem solving tasks with weight in the final grade:

- T1: Decibel problems (5%).
- T2: Transmission line problems (40%).
- T3: Waveguides and fiber optic problems (15%).
- T4: Radio transmission problems (40%).

The time schedule of these tasks (T1 to T4), approved by the CAG, will be available at the beginning of the semester. The planning of the other continuous assessment tasks will be indicated at the beginning of the course. All these tasks are not recoverable, that is, if a student fulfill on time, the teacher has no obligation to repeat them, and they are valid only for the academic year in which they are made.

After the second problem solving exam (T2) the student must decide between continuous assesment or single assesment. Not to attend to this test implies that the choice is global assessment.

To pass the subject through this evaluation system, it is necessary to pass the self-assessment tests and obtain 30% of the maximum grade in tests T2 and T4. If any of these conditions are not met, the official rating will never be higher than 4.5.

Global assessment

Instead of the continuous assessment described above, the student may choose to perform one final problem-solving exam.

Extraordinary exam

It consists of a single problem solving exam.

Students who have chosen continuous assessment and passed all the self-assessment tasks may keep, if they wish, the mark of the T1 to T4 tasks they have passed and repeat the remaining ones.

End-of-program exam

It consists of a single problem solving exam.

Copy

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution

At least 50% in the total qualification must be obtained in any of the assessment systems and calls to pass the subject.

Sources of information
Basic Bibliography
F.T. Ulaby, **Fundamentals of Applied Electromagnetics**, 7ª, Pearson, 2015
S.M. Wentworth, **Applied electromagnetics. Early transmission line approach**, 1ª, Wiley, 2007
D. K. Cheng, **Fundamentos de electromagnetismo para ingeniería**, Addison-Wesley, 1997
Complementary Bibliography
N.N.Rao, **Elements of engineering electromagnetics**, 6ª, Pearson, 2004
J.D. Krauss, **Electromagnetismo con aplicaciones**, McGraw-Hill, 2000
Y.H. Lee, **Introduction to Engineering Electromagnetics**, Springer, 2013
S. Balaji, **Electromagnetics Made Easy**, Springer, 2020

Recommendations

Subjects that it is recommended to have taken before

Mathematics: Calculus 1/V05G301V01101
Mathematics: Calculus 2/V05G301V01106
Physics: Fields and Waves/V05G301V01202

IDENTIFYING DATA				
Signal Transmission and Reception Techniques				
Subject	Signal Transmission and Reception Techniques			
Code	V05G301V01208			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Rodríguez Banga, Eduardo			
Lecturers	Márquez Flórez, Óscar Willian Rodríguez Banga, Eduardo			
E-mail	erbanga@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The course "Signal Transmission and Reception Techniques" is an introduction to the different existing methods for the exchange of information at the physical layer level. Its main focus is on pulse amplitude modulation (PAM) as illustrative example. The main components of a digital transmitter and receiver are described, as well as the different effects caused by the communication channel and the different performance parameters of a digital system. English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
C7	CE7/T2: The ability to use communication and software applications (ofimatics, databases, advanced calculus, project management, visualization, etc.) to support the development and operation of Electronics and Telecommunication networks, services and applications.
C9	CE9/T4: The ability to analyze and specify the main parameters of a communications system.
C10	CE10/T5: The ability to evaluate the advantages and disadvantages of different technological alternatives in the implementation and deployment of communication systems from the point of view of signals, perturbations, noise and digital and analogical modulation systems.
C20	CE20/T15: The knowledge of national, European and international telecommunication regulations and laws.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Differentiate the blocks and functionalities of a complete data transmission sytem	B3	C9 C10	
Identify the minimum requirements for a reliable data communication.	B3 B4	C9 C10	
Distinguish the fundamental parameters of a complete communications system oriented to data transmission.	B3 B4	C9 C10	
Describe, develop and analyse the different blocks of a data transmission system.	B3 B6	C9 C10 C20	D3
Develop and implement basic circuits for modulation and demodulation of signals.	B4 B6	C9 C10 C20	D2
Use applications of communication and computer (text processing, databases, advanced calculus, management of projects, visualisation, etc.) to support the design of data transmission systems.	B4	C7	D2 D3

Recognise the different quality assessment measures of a digital signal.		C9 C10
Statistically analyse the noise and understand its effects.	B3	C9 C10

Contents

Topic	
1. Introduction to digital communication systems	-Basic elements and general description of a communication system. -Analog and digital communications -Description of a digital transmitter -Description of a digital receiver
2. Signals, systems and stochastic processes in communications	-Review of basic concepts: signals and systems. Continuous time Fourier transform. - Deterministic signals: energy-defined and power-defined. Autocorrelation. Spectral density. - Random variables. Stochastic processes: stationarity, autocorrelation, power spectral density, bandwidth. White noise.
3. Frequency conversion and analog processing	-Amplitude modulation (AM) and frequency modulation (FM) -I/Q modulation and demodulation - Transceiver requirements and specifications -Receiver architectures: direct conversion, intermediate frequency. Analog and digital stages.
4. Pulse amplitude modulation (PAM)	- Baseband PAM - Bandlimited channels and intersymbol interferences (ISI) - Nyquist criterion, raised cosine pulses, eye diagram - Matched filtering - Bandpass PAM
5. Modulation and detection in Gaussian channels	- Introduction to the Signal Subspace - Discrete equivalent channel - Maximum A Posteriori (MAP) and Maximum Likelihood (ML) detectors - Probability of error
6. The communication channel	-Transmission media -Signal to noise ratio -Multipath and frequency selectivity -Fading -Doppler effect
Practical content	In this course there is no division between theoretical and practical content. Indeed, practical exercises related to many of the previously described contents are considered.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	34	34	68
Practices through ICT	24	31	55
Problem and/or exercise solving	3	6	9
Problem and/or exercise solving	2	16	18

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Presentation and discussion of the fundamental theory. The explanation will be complemented by the resolution of questions and exercises. Through this methodology, skills C9, C10, C20, B3, B4, B6, D2, D3 are developed.
Practices through ICT	The concepts presented in the class sessions will be further illustrated and developed by means of Matlab-based simulation and signal processing tools. Through this methodology, skills C7, C9, C10, B3, B4, D2 are developed

Personalized assistance

Methodologies	**Description**

Lecturing	Personalized attention will be offered during office hours, which can be consulted on the institutional page of the instructors. Spanish Degree: Óscar Márquez Flórez (https://www.uvigo.gal/es/universidad/administracion-personal/pdi/oscar-willian-marquez-florez) Eduardo Rodríguez Banga (https://www.uvigo.gal/es/universidad/administracion-personal/pdi/eduardo-rodriguez-banga) English Degree: Felipe Gómez Cuba (https://www.uvigo.gal/es/universidad/administracion-personal/pdi/felipe-gomez-cuba) Eduardo Rodríguez Banga (https://www.uvigo.gal/es/universidad/administracion-personal/pdi/eduardo-rodriguez-banga)
Practices through ICT	Beyond the initial explanation to the group, instructors will answer individual students' questions. In addition, instructors will be available to students at office hours.

Assessment

	Description	Qualification	Training and Learning Results		
Problem and/or exercise solving	Three midterm exams will be given during the semester. Their influence on the final grade is detailed in the section "Other comments on the Evaluation".	60	B3 B4 B6	C7 C9 C10 C20	D2 D3
Problem and/or exercise solving	Final examination with questions of any type. It will cover all of the material covered during the course and will take place during the exam period as established by the Center. The influence of the exam on the final grade is described in the section "Other comments on the Evaluation".	40	B3 B4 B6	C7 C9 C10 C20	D2 D3

Other comments on the Evaluation

The final grade will be computed based on the grades obtained in the three midterm exams (P1, P2 and P3, respectively) and the grade in the final exam (EX), all of them in a ten-point scale.

The contribution of the midterm exams to the final grade (P) is obtained as

P = V1*P1 + V2*P2 + V3*P3

where

V1 =0.15 if P1 >= 5, V1 = 0 otherwise

V2 =0.2 if P2 >= 5, V2 = 0 otherwise

V3 =0.25 if P3 >= 5, V3 = 0 otherwise

Then, the final grade (F) will be computed as:

F =min(10, P + EX*(10-P)/(10-0.3*P)) if EX>=3.5

F = min(4, P + EX*(10-P)/(10-0.3*P)) if EX < 3.5

The schedule of the midterm exams will be approved in the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester. These exams are not recoverable, that is to say, if a student does not show up when they take place, the instructors do not have the obligation to repeat them. In each midterm exam, the material covered from the start of the course until the previous week (included) will be evaluated.

For those students who choose to follow global assessment, the final grade will be directly the final exam grade (F = EX).

Students will be graded at the ordinary opportunity of evaluation as long as they take any midterm exam and do not waive the continuous assesment (C.A.) track within a period established by the instructors; this period will last at least for one month and will be included in the period between the publication of the grades of the first midterm exam and the date of the third midterm exam.

For those students following C.A., any not attended midterm exam or final exam will be graded with zero points.

The mark achieved in the three midterm exams (P) will be kept for the second call of evaluation to those students attending the final exam of that call, but not for subsequent years. Regarding this second call, the same rules stated above will apply.

For the end-of-program exam, a comprehensive exam will be given, corresponding to 100% of the final grade.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information

Basic Bibliography

A. Grami, **Introduction to Digital Communications**, 1, 2016

A. Artés, F. Pérez González et al., **Comunicaciones Digitales**, 1,

J. G. Proakis, M. Salehi, **Fundamentals of Communication Systems**, 1,

Complementary Bibliography

Bernard Sklar, **Digital Communications: Fundamentals and Applications**, 2,

C.R. Johnson Jr., W.A. Sethares, **Telecommunication Breakdown**, 1,

B. Razavi, **RF Microelectronics**, 1,

Recommendations

Subjects that continue the syllabus

Principles of Digital Communications/V05G301V01324

Subjects that it is recommended to have taken before

Physics: Analysis of Linear Circuits/V05G301V01108
Mathematics: Probability and Statistics/V05G301V01107
Digital Signal Processing/V05G301V01205

Other comments

Se asume que el/la estudiante posee conocimientos básicos sobre la disciplina del procesado de señal (analógico y digital), así como de probabilidad y estadística.

IDENTIFYING DATA				
Fundamentals of Sound and Image				
Subject	Fundamentals of Sound and Image			
Code	V05G301V01209			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	Spanish			
Department				
Coordinator	Pena Giménez, Antonio Rodríguez Vaqueiro, Yolanda			
Lecturers	González Valdés, Borja Pena Giménez, Antonio Rodríguez Vaqueiro, Yolanda			
E-mail	apena@gts.uvigo.es yrvaqueiro@gmail.com			
Web	http://https://moovi.uvigo.gal			
General description	"Sound & image fundamentals" presents some basic concepts on sound & image nature, the course also deals with some basic processing of these signals.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
C13	CE13/T8: The ability to understand the electromagnetic and acoustic wave mechanisms of propagation and transmission, and their corresponding receiving and transmitting devices.
C48	(CE48/T16) The knowledge of the appropriate techniques to develop and exploit signal processing subsystems.
C49	(CE49/T17) The ability to analyze digital signal processing schemes.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Acquire mathematical tools that allow the understanding of the practical effects of sampling, windowing and time-frequency analysis of sound and image signals.	B3	C48 C49	D3
Apply quantification techniques	B3	C48 C49	D3
Understand the nature, basic properties, generation and capture of sound and image.		C13	D3
Understand and interpret the different levels of measurement present in sound systems.	B5		D3
Review the different processes and systems associated with the treatment of sound and image	B3 B5	C48 C49	D3
Apply the basic rules of the colorimetry.	B3		D3

Contents	
Topic	
Sampling, windowing and quantification of one-dimensional and two-dimensional signals.	- Sampling, Nyquist theorem, reconstruction filter. - 2D sampling, concept of resolution vs. sampling frequency. 2D reconstruction. - Windowing in 1D and 2D. - Uniform quantization. A/D conversion . Quantization noise.
Time-frequency analysis of sound and image signals.	- Sound and image characteristics in time and double spatial dimension, respectively. - Windowing and Discrete Fourier Transform (DFT). DFT in 2D. - Frequency characteristics. Spatial frequencies, physical interpretation.
Basic concepts of light and color.	- The image: numerical nature, colorimetry, visual system basics.

Acoustics: basics. Measurement of acoustic signals.	- The sound: acoustic variables, generation, combination of sources, sound sensations - Measurement levels. - Sound level meter
Sound and image systems and processes: basics.	Filter banks. - Sound capture and calibration. - Specifications and objective quality. - 1D filtering. FIR and IIR filters. Relation between windowing and filtering. - 2D filtering. Separable filters. Point operations and spatial filtering on images.
Practices	Audio -Localized analysis of audio signals -Spectrogram -Calculation of sound pressure levels -Calibration of sound pressure levels Image -Image processing in Matlab -Filtering and restoration of images

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Lecturing	31	39	70
Problem solving	8	12	20
Practices through ICT	19	18	37
Discussion Forum	0	1	1
Objective questions exam	4	2	6
Problem and/or exercise solving	0	2	2
Problem and/or exercise solving	0	2	2
Essay	0	11	11

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Course presentation: programme, reading materials, teaching methodology and assessment system. Developed capabilities: B3, B5, C13, D3, C48, C49.
Lecturing	Exposition by the teacher of the main concepts of each topic, promoting critical discussion. The theoretical foundations of algorithms and procedures used to solve problems are laid. The student should take as reference the content of the exam indicated in the guide document for each topic. Subsequent personal work of the student reviewing the concepts seen in the classroom and expanding the contents taking as reference the notes documents of each topic. Identification of doubts that need to be resolved in personalized tutorials. Developed capabilities: B3, B5, C13, D3, C48, C49.
Problem solving	Problems and exercises formulated according to the content of the lectures and the documents for each subject. Students solve problems and exercises prior to the class. Identification of doubts that need to be resolved in personalized tutorials. Developed capabilities: B3, B5, C13, D3, , C48, C49.
Practices through ICT	Handling of analysis tools and algorithms. Identifying which one must to be used to solve each specific problem. Identification of doubts that need to be resolved in personalized tutorials. Developed capabilities: B3, B5, C13, D3, , C48, C49.

Discussion Forum	The website for the course is included in the platform (https://moovi.uvigo.gal). Subscription to this platform, including a photograph, is mandatory. The website provides all the information related to the course. It also publishes continuous assessment grades and runs forums for students to exchange ideas and discuss doubts. Developed capabilities: B3, B5, C13, D3, C48, C49.

Personalized assistance

Methodologies	Description
Problem solving	Help with problem solving, in the classroom and/or at the office. https://moovi.uvigo.gal/user/profile.php?id=11310 https://moovi.uvigo.gal/user/profile.php?id=11639
Practices through ICT	Help in the classroom and, if necessary at the office or via e-mail. https://moovi.uvigo.gal/user/profile.php?id=11310 https://moovi.uvigo.gal/user/profile.php?id=11639 https://moovi.uvigo.gal/user/profile.php?id=35677
Lecturing	Querry and answer in the classroom and, if necessary, at the office. https://moovi.uvigo.gal/user/profile.php?id=11310 https://moovi.uvigo.gal/user/profile.php?id=11639

Assessment

	Description	Qualification	Training and Learning Results		
Objective questions exam	Made in the platform Moovi or by written tests in the classroom.	20	B3	C48 C49	
Problem and/or exercise solving	Exam with brief questions and problems on the thematic of sound	25	B3	C48 C49	
Problem and/or exercise solving	Exam with brief questions and problems on the thematic of image	25	B3	C48 C49	
Essay	Supervised work related with the contents of the practices	30	B3 B5	C13 C48 C49	D3

Other comments on the Evaluation

On detecting any kind of plagiarism in any of the tests (short test, partial or final exam, lab reports) the final qualification will be FAIL (0) and the fact will be transmitted to school regents for taking the appropriate actions.
There are two kinds of assesment: continuous assesment and global assesment.
The schedule for intermediate evaluation tests will be approved by the CAG (DEGREE ACADEMIC COMMITTEE) and will be published at the beginning of four month period in which this course is delivered.

CONTINUOUS ASSESSMENT

The continuous assessment consists of the tests detailed below in this guide and are not recoverable, that is, if a student cannot take them on the stipulated date, the teacher is not required to repeat them. The evaluable tasks will be valid only for the academic year in which they are carried out. The submission of assignments is not mandatory. Assignments not submitted will be evaluated with zero points
It is understood that the student opts for continuous evaluation once the commitment document that will be offered after the first month si signed, so that work can begin in the corresponding groups. Once signed, the student will be assigned the grade that results from the application of the criteria detailed below, regardless of whether or not they take the final exam.
Types and evaluation of tests:
1. Delivery of two supervised group projects related to the practices (weight 30%). The individual grade of the group work will be determined by means of cross evaluation and personal interview.
2. Resolution of tests or short questions related to the practical contents (Weight: 20%): they are developed throughout the course on the Moovi platform.
3. Test 1: final written test of the sound part (development, Weight: 25%): it takes place approximately halfway through the semester.
4. Test 2: final written test of the image part (development, Weight: 25%): coincides with the date of the final exam of the subject.
In order to guarantee that students acquire a minimum, more or less balanced, of the subject competences, to pass they will need to meet these conditions:
Obtain a minimum of 3.5 in Test 1.Obtain a minimum of 3.5 in Test 2.Get an average of more than 5 in Tests 1 and 2.Obtain an average of more than 5 in supervised group projects.
In case of not fulfilling all the conditions, the final grade (on a scale of 0 to 10) will be the minimum between the overall

grade obtained and the value FOUR.
To participate in the Continuous Assessment, 80% attendance is required for groups A and B. In case of non-compliance, the student will be assessed in the single assessment option.
Any student can be called at any time by the teachers to carry out a review of the work done to date in the works or projects in progress.

GLOBAL ASSESSMENT

If the student does not sign the commitment document, he/she will be evaluated by means of an only exam, in the official date. The grades for this final exam are between 0 and 10 points. It includes all the subjects of the course, including the laboratory works.
In order to ensure that students acquire a balanced minimum on the subject competences, they will pass the course if they meet these two conditions:

1) get a final mark equal to or greater than 5 (on a ten-points scale)

2) and a score equal to or greater than 4 in the questions related with the group B and supervised group projects activities.

If some of these conditions are not fulfilled, then the final grade (on a ten-points scale) will be the minimum between the final mark and the value "4.9".

Extraordinary exam:
⇒ Students evaluated by Continuous Assessment in the ordinary opportunity can opt between two possibilities the same day of the exam:

1. Do again Test 1 and 2 and be evaluated according what is stipulated for the system of Continuous Assessment.
2. Be evaluated with a single final exam in the official date assigned by the Centre. The grades for this final exam are between 0 and 10 points. It includes all the subjects of the course. Non Continuous Assessment rules apply.

⇒ Students not evaluated by Continuous Assessment:

They will be evaluated with a single final exam on the official date assigned by the Center.The grades for this final exam are between 0 and 10 points. It includes all the subjects of the course. Non Continuous Assessment rules apply. No other activities are assessed.
End of program Exam:

In special call exam (end of degree), we will proceed as in the case of students who have not completed the continous assesment.

Sources of information

Basic Bibliography

Finn Jacobsen et al., **FUNDAMENTALS OF ACOUSTICS AND NOISE CONTROL**, Technical University of Denmark, 2001

Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, **Digital image processing using MATLAB**, Gatesmark Publishing, 2009

Günther Wyszecki, W.S. Stiles, **Color science: concepts and methods, quantitative data, and formulae**, John Wiley & Sons,

Complementary Bibliography

Lawrence Kinsler, Austin Frey, Alán Coppens, James Sanders, **FUNDAMENTALS OF ACOUSTICS**, John Wiley &;, 1999

Alan V. Oppenheim, Alan S. Willsky with S. Hamid Nawab, **Signals and systems**, Prentice-Hall, 1997

Alan V. Oppenheim, Ronald W. Schafer., **Discrete-time signal processing**, Pearson Prentice Hall, 2010

Rafael C. Gonzalez, Richard E. Woods, **Digital image processing**, Pearson Prentice Hall, 2018

R.J. Clarke, **Digital compression of still images and video**, Academic Press, 1995

Recommendations

Subjects that continue the syllabus

Room Acoustics/V05G301V01330
Design of audiovisual installations/V05G301V01334
Fundamentals of Acoustics Engineering/V05G301V01327
Fundamentals of Image Processing/V05G301V01333
Sound Processing/V05G301V01328
Interactive Audio Systems/V05G301V01331
Imaging Systems/V05G301V01332

Subjects that it is recommended to have taken before

Physics: Fundamentals of Mechanics and Thermodynamics/V05G301V01103
Digital Signal Processing/V05G301V01205

Other comments

The use of generative artificial intelligence (GAI) is allowed while carrying out the academic activities of this subject. Its use must be ethical, critical and responsible. When using GAI, any result should be critically evaluated, and any citations or references generated should be carefully verified. Likewise, it is recommended to declare the use of the tools used.

IDENTIFYING DATA				
Computer Networks				
Subject	Computer Networks			
Code	V05G301V01210			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	López Ardao, José Carlos			
Lecturers	López Ardao, José Carlos Rivas Costa, Carlos Rodríguez Rubio, Raúl Fernando Sousa Vieira, Estrella			
E-mail	jardao@det.uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	Operating principles, architecture, technology and norms of computer networks, especially of Internet. Design-oriented course, complemented by practical skills			

Training and Learning Results	
Code	
B1	CG1: The ability to write, develop and sign projects in the field of Telecommunication Engineering, according to the knowledge acquired as considered in section 5 of this Law, the conception and development or operation of networks, services and applications of Telecommunication and Electronics.
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C11	CE11/T6: The ability to conceive, deploy, organize and manage networks, systems, services and Telecommunication infrastructures in residential (home, city, digital communities), business and institutional environments, being responsible for launching of projects and continuous improvement like knowing their social and economical impact.
C17	CE17/T12: The knowledge and usage of concepts of communication network architecture, protocols and interfaces.
C18	CE18/T13: The ability to differentiate the concepts of access and transport networks, packet and circuit switched networks, mobile and fixed networks, as well as distributed newtwork application and systems, voice, data, video, audio, interactive and multimedia services.
C19	CE19/T14: The knowledge of methods of networking and routing, as well as the fundamentals of planning and network evaluation based on traffic parameters.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Comprise the general organization and the basic aspects of operation of communication networks, and particularly of computer networks	B3	C17	D2
Identify and know employ the concepts of switching, access and transport networks and wired and wireless networks	B3	C18	
Comprise the principles and the organization of distributed applications and services, either data or media oriented	B3	C17	
Comprise and know how to analyze the operation of the Internet: the architecture, the service model, the data transport, the routing methods and inter-networking, error control and congestion control	B3 B6	C11 C17 C19	D2 D3

Dominate the technical standards and the fundamental protocols of the Internet	B3 B4 B6	C17 C18 C19	
Practical capacity to design, handle and configure computer networks, from the point of view of data switching and transport	B1 B9	C11	D4
Specify common telecommunications infrastructures and structured cabling in buildings	B1 B6	C11	

Contents	
Topic	
1. Introduction	1.1. Network elements, types of links, services and protocols 1.2. Switching techniques: circuits, messages and packets 1.3. Reference models and service modes
2. Packet switching (I): Link Transmission	2.1. Delimitation and transmission of frames 2.2. Multiplexing in the link: Static vs. statistical 2.3. Forwarding techniques. Generalized forwarding. Virtual circuits and Datagrams. 2.4. Packet switching: Delay and losses in a link.
3. Conmutación de paquetes (II): Transmisión en ruta	3.1. Fundamental metrics: delay, losses, equivalent capacity 3.2. Reliable end-to-end transmission (hop-by-hop vs. end-to-end retransmissions) 3.3. Flow control
4. The data plane (I): IEEE 802.x networks	4.1. Link lawyer. Link types 4.2. IEEE 802 project 4.3. Flat addressing in iEEE 802 4.4. Bridges IEEE 802 4.5. IEEE 802.3: Ethernet 4.6. IEEE 802.11: WiFi
5. The data plane (II): IP networks	5.1. Internet and IP 5.2. Hierarchical addressing. Structure of IP addresses 5.3. Routers and forwarding tables 5.4. Correspondence in IP (longest prefix match) 5.5. The IP protocol. IPv4 and IPv6 5.6. Addressing scopes. Private networks 5.7. NAT
6. Interconnection of link networks	6.1. IP as interconnection network 6.2. Routers vs. bridges 6.3. Translation between link and network addresses: NDP/ARP 6.4. Fragmentation in IP
7. The control plane (I): IEEE 802.X networks	7.1. Data and control planes. Distributed and centralized control. 7.2. Control plane in IEEE 802 networks 7.3. Backward Learning 7.4. Spanning Tree Protocol (STP)
8. The control plane (II): IP networks	8.1. The problem of routing. Key elements: Algorithms, protocols, RIB 8.2. Hierarchical routing on the Internet: Autonomous systems and domains 8.3. Format of the RIB. Obtaining the FIB 8.4. Intra-domain routing. Main IGPs: RIP and OSPF 8.5. Inter-AS routing: BGP
9. The Transport Layer	9.1. Multiplexing, reliability and transmission modes 9.2. Transport protocols 9.3. UDP 9.4. TCP: Connection management. Ordered delivery. ARQ and flow control in TCP
10. Congestion control	10.1. The problem of congestion 10.2. Congestion control: objectives, requirements, types of mechanisms 10.3. Congestion Control in TCP. The AIMD algorithm 10.4. Classic implementations: Tahoe, Reno 10.5. Delay-based mechanisms. Vegas
11. Internet Security	11.1. Secure communication systems 11.2. Confidentiality. Symmetric and asymmetric cryptography 11.3. Authenticity and integrity. Hash functions. Digital signatures 11.4. Availability. DDoS Attacks 11.5. Secure Transport: TLS over TCP

Lab Sessions	In the lab sessions we will do practicals using various network tools and utilities (GNS3, WireShark, ping, traceroute, dig, etc.) to reinforce the contents learnt in the lecturing classes. Software to be used: GNS3, WireShark, Java. Besides, there will be several sessions to explain related programming concepts (sockets, network utilities).

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	31	45	76
Problem solving	8	8	16
Laboratory practical	12	6	18
Autonomous problem solving	0	12	12
Practices through ICT	8	12	20
Gamification	0	4	4
Essay questions exam	2	0	2
Objective questions exam	1	0	1
Objective questions exam	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Exposition of the ideas, concepts, technics and algorithms related to the thematic units of the course. With this methodology we will work the competences D2, D3, B3, B4, C11, C17, C18 and C19.
Problem solving	Resolution in the classroom by the professor of problems and exercises related with the contents of the master lessons. With this methodology students work the competences B3, B4, C11, C17, C18 and C19.
Laboratory practical	Networking laboratory practices, using various network tools and utilities (GNS3, WireShark, ping, traceroute, dig, etc.) to reinforce the contents learnt in the lecturing classes. Software to be used: GNS3, WireShark, Java. With this methodology, the competencies B1, B9, C17 and C19 are worked on.
Autonomous problem solving	Completion and delivery, more or less weekly, of online activities. These are self-evaluation tests and small tasks or problems to be carried out before or after the practical classes. It also includes the delivery of a small basic network program, as a training for the final network program. With this methodology we will work the competencies B4, B6, B9, C11, C17, C18, C19, D2, D3, D4
Practices through ICT	The goal is to develop small network programs in an autonomous and individual way. There will be several sessions to explain related programming concepts (sockets, network utilities), and also to solve doubts with the teacher, and to test and debug the programs in the laboratory where they will be evaluated. With this methodology we work with the competencies B1, B6, B9, C11, C17 and C19.
Gamification	In the virtual classroom, a gamification system will be used that includes activity points, mechanics and gamification elements to encourage the performance of online graded activities and to participate in a meaningful way in help forums. This will allow the student to obtain rewards to be used in the exams or in the continuous evaluation. The discussion forums will be the preferred way of answering questions and doubts related to the contents of the subject. The gamification will encourage peer support and collaborative resolution of doubts in the forums. Besides contributing to the increase of motivation, with this methodology we will also work on the competences B9, D3 and D4

Personalized assistance

Methodologies	**Description**
Lecturing	Personalized attention will be given individually, in a face-to-face meeting or by videoconference, during the tutorial schedule that will be made public at the beginning of the course. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teacher of this subject at https://moovi.uvigo.gal/
Problem solving	Personalised attention will be given individually, in a face-to-face meeting or by videoconference, during the tutorial schedule that will be made public at the beginning of the course. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teacher of this subject.
Practices through ICT	Personalised attention will be given individually, in a face-to-face meeting or by videoconference, during the tutorial schedule that will be made public at the beginning of the course. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teacher of this subject.

Autonomous problem solving	In the case of tasks, the detailed solution will be provided in the virtual classroom. In the case of self-assesmemt tests, suitable feedback for the wrong questions will be provided to the student. In any case, personalised attention will be given individually, in a face-to-face meeting or by videoconference, during the tutorial schedule that will be made public at the beginning of the course. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teacher of this subject.
Gamification	In addition to individually personalized face-to-face attention, the professor will be monitor the discussions in the forums making suitable answers when necessary or explaining the answers of the students. The forums in the virtual classroom are the preferred way to request asynchronous attention for doubts and questions related to the contents of the subject.
Laboratory practical	Personalized attention will be given individually, in a face-to-face meeting or by videoconference. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teachers of this subject.

Assessment

	Description	Qualification	Training and Learning Results
Autonomous problem solving	During the course, with an approximately weekly periodicity, tasks, resolution of exercises, questions and self-evaluation tests will be proposed in the virtual classroom that must be carried out by the students individually, autonomously and not presencially, always with a deadline. These tasks have an overall weight of 10% for the student who chooses option B of continuous assessment. Those who choose option A of continuous assessment can do the tasks but the score does not count for the final mark, being only indicative for their self-assessment.	0-10	B4 B6 B9 C11 C17 C18 C19 D2 D3 D4
Practices through ICT	The student must develop several small network programs. There will be several classroom sessions for the explanation of the related programming concepts (sockets, network utilities) and also for tutoring with the teacher and for the development, testing and debugging of the programs in the laboratory, where it will be evaluated. The mark obtained for these programs will be multiplied by the mark obtained in a question about them in the final exam, with a value between 0 and 1.	10	B1 B6 B9 C11 C17 C19
Essay questions exam	Final exam covering the whole subject. It has a weight of 60% but a minimum mark of 4 out of 10 is required to pass the subject.	40	B3 B4 C11 C17 C18 C19 D2
Objective questions exam	One-hour multiple-choice tests to check the progress on the subject. It has a weight of 20% for the students who choose option B of continuous evaluation and 25% for the students who choose option A	20-25	B3 B4 C11 C17 C18 C19 D2
Objective questions exam	One-hour multiple-choice tests to check the progress on the subject. It has a weight of 20% for the students who choose option B of continuous evaluation and 25% for the students who choose option A	20-25	B3 B4 C11 C17 C18 C19 D2

Other comments on the Evaluation

Students can choose the method of Assessment:

Continuous or Global Assessment.

Continuous Assessment (CA)

There will be **two possible ways or options to go through Continuous Assessment, which we call A and B.** Students must choose the option in the subject virtual classroom during first month, one day before the first assessment exam. After this deadline, the chosen continuous assessment option cannot be changed. Students who do not make any explicit choice follow the global assessment.

Given the necessary collaborative and social character of option B, groups that do not reach a minimum of 30 students, will only have option A for continuous assessment.

Continuous Assessment consists of four types of activities or tests:

- **Qualifying activities in the virtual classroom**. During the course, with an approximately weekly periodicity, tasks, resolution of exercises, questions and self-evaluation tests will be proposed in the virtual classroom for the students to carry out after school hours individually, autonomously. All activities will have a strict deadline. The completion of these activities allows students to obtain "merit points" (**MP**) up to a maximum of 100 points (in the case of the correct completion of all of them). **The mark in this part will be calculated as the amount of MP divided by 100**. In order to facilitate the achievement of the maximum number of points, it will be possible to obtain a certain amount of PM through rewards, and in tasks with submissions, peer evaluation will be used, which will allow students to obtain additional PM.

The Merit Points only count for students who have chosen option B of continuous assessment. Those who chose option A of continuous assessment can also do the tasks and tests, but the MP obtained do not count for the final mark, being only indicative of their self-assessment.

- **Network programs (PR):** Students will have to develop several small network programs in an individual and autonomous manner during the course. Several practical sessions will be dedicated to explain the related network programming projects needed to make the programs (sockets, network utilities…), and also to solve doubts with the teacher, and to test and debug the programs in the lab before being delivered for evaluation. The mark obtained by these programs **(PR)**, between 0 and 10, will be multiplied by the mark obtained in a question about the programs that is part of the final exam **(CR)**, with a range between 0 and 1.
- **Two intermediate one-hour multiple-choice tests to assess the progress of the subject (C1 and C2)**. Each control test has a weight of 25% on the final mark (FG) for students who chose option A of continuous assessment and 20% for those who opt for option B. The schedule of the different intermediate evaluation tests will be approved by the *Comisión Académica de Grado* (CAG) and will be available at the beginning of the term.
- **A final exam (FE) covering all contents,** has a weight of 60% of the Final Grade (FG). A minimum qualification of 4 points over 10 is required to pass the subject. Included in the final exam there will be a question about the network programming projects (CR) but its mark, between 0 and 1, will not be part of the final exam and will only be used to ponder the qualification obtained in the network programming projects.

The final mark of the continuous assessment evaluation will be, according to the chosen evaluation method, A or B:

FG-CA-A = 0.25 × (C1+C2) + 0.1 × CR × PR + 0.4 × FE, if FE ≥ 4

FG-CA-A = 0.2 × (C1+C2) + MP/100 + 0.1 × CR × PR + 0.4 × FE, if FE ≥ 4

If FE < 4, the Final Mark will be equal to min{4, FG-CA} where FG-CA would be the final mark of the continuous assessment evaluation calculated before (FG-CA-A or FG-CA-B)

As said above, it is mandatory to choose the CA option, A or B, in the established period, that will be until the day before the C1 control test. Students that do not make any explicit choice will be subjected to global assessment (EA).

Failure to take any of the control tests, C1 or C2, implies a mark of "0" on the test. These tests are not recoverable.

Global Assessment (EA)

Students who do not made any choice of continuous assessment within the stipulated time period are required to take the Global Assessment (EA)

The Global Assessment will consist of the same FE at the end of the term, including the additional question (**CR**) about the network programming projects. The final mark is calculated as:

FG-EA = 0.9 x FE +CR

Extraordinary exam

In the official dates, a new extraordinary exam (FE) will be done only for students that failed in the ordinary call. This exam will also include the question about the network programming projects (CR).

These EF and CR tests of the extraordinary call are an opportunity to raise the mark in these two tests with respect to the ordinary call. In the calculation of the Final Grade, the highest mark obtained in these tests between the two attempts will prevail.

Those students who had chosen continuous assessment and that want to change to global assessment in this extraordinary call, must communicate it to the subject coordinator in written form before 8pm on the day before the review session of the first call. In this case, the conditions to pass the subject will be identical as those of students who had chosen global evaluation on the first place. In particular, it will not be possible to use in the exam any of the rewards obtained during the term as part of the continuous assessment.

The final marks are obtained in the same way as in the first-call evaluation.

End-of-program exam

The same procedure as for the global assessment will be used for the end-of-program call.

Other comments

All students presenting to any FE are considered to be presented to the subject. The marks for all exams, intermediate or final, and activities will only have effects on the current academic year.

The virtual classroom platform has tools to detect possible anomalous and dishonest behaviors in self-assessment tests (tests carried out among several people, previously known answers, etc.), as well as to detect plagiarism in written works or in software programs.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the works/test/exams, including the virtual platform activities, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

All the official communications of the Subject will be published in the News Forum of the virtual classroom, to which all the students are necessarily subscribed by email. It is assumed that all students reads these messages and are properly informed of their content.

In the event of any contradiction that may have occurred between the different versions of this guide, due to any error in the translation, the prevailing version will be the Galician language version, except for English group, for which the English version of the Guide will be considered.

Sources of information
Basic Bibliography
J.F. Kurose, K.W. Ross, **Computer networking: a top-down approach**, 8,
L. Peterson, B. Davie, **Computer networks: a systems approach**, 5,
Complementary Bibliography
C. López, M. Rodríguez, S. Herrería, M. Fernández, **Cuestiones de redes de datos: principios y protocolos**, 1,
Peterson, Brakmo, and Davie, **TCP Congestion Control: A Systems Approach**,
Larry Peterson and Bruce Davie, **Computer networks: a systems approach**, 6.2-dev,

Recommendations

Subjects that it is recommended to have taken before

Data Communication/V05G301V01204

Other comments

To take the course, in order to carry out the network programs, it is very important to have a certain programming skills in an object-oriented language such as Java (or C ++). The skill level obtained after passing the Programming II course is enough.

IDENTIFYING DATA				
Internet Services				
Subject	Internet Services			
Code	V05G301V01301			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	3rd	1st
Teaching language	Spanish			
Department				
Coordinator	Gil Solla, Alberto Burguillo Rial, Juan Carlos			
Lecturers	Álvarez Sabucedo, Luis Modesto Gil Solla, Alberto Rivas Costa, Carlos Rodríguez Estévez, Judith Soledad			
E-mail	jrial@uvigo.es alberto.gil@uvigo.es			
Web	http://http://faitic.uvigo.es			
General description	This subject will provide to the student a global vision of the group of current services of Internet like DNS, email, the WWW, the Web Services, the sharing of resources among peers (P2P), the Semantic Web and the Cloud Computing. Besides, the student will be introduced in the most frequent technologies to develop such services and web applications.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C11	CE11/T6: The ability to conceive, deploy, organize and manage networks, systems, services and Telecommunication infrastructures in residential (home, city, digital communities), business and institutional environments, being responsible for launching of projects and continuous improvement like knowing their social and economical impact.
C18	CE18/T13: The ability to differentiate the concepts of access and transport networks, packet and circuit switched networks, mobile and fixed networks, as well as distributed newtwork application and systems, voice, data, video, audio, interactive and multimedia services.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
To know the basic services of Internet, as well as comprise the basic principles of his operation.	B3 B6	C11 C18	D2 D3 D4
To dominate the main technical standards in the field of development of telematic services.	B6	C11 C18	
To understand the importance of organising the structured information for his suitable utilisation.	B3 B4	C11 C18	D2
To Know the basic concepts of semantic management of the information.		C11	D2
To understand the principles and the general organisation of a web service.	B9	C11 C18	
To improve the skill in the design and development of basic telematic services.	B4 B9		D2 D3 D4

Contents

Topic	
Internet basic services	- DNS - Electronic mail - World Wide Web: architecture, languages, protocols.
Information structure	- HTML - CSS - XML introduction - NameSpaces, - Document Object Model (DOM) - JSON - XML Schema
Server-side development technologies	- RESTful API. - CGI, DSO modules - PHP - Servlets - JSP - XPath, XSLT
Client-side development technologies	- JavaScript - jQuery - Ajax, SSE - WebSockets - Development frameworks
Additional services	- Sharing resources among peers (P2P) - Blockchain - Cloud Computing, Edge computing and hybrid architectures - Metadata

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	2	0	2
Lecturing	24	24	48
Practices through ICT	26	40	66
Discussion Forum	0	4	4
Self-assessment	0	2	2
Essay questions exam	2	10	12
Essay questions exam	2	10	12
Problem and/or exercise solving	1	1	2
Problem and/or exercise solving	1	1	2

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	In the first classes we will describe the activities to be performed along the subject, along the theory and along the practices.
Lecturing	Along the theory classes we will describe the main contents of the subject by means of slides. Theory classes will promote the competences: CT2, CT3 y CT4. Besides, the exam for this part evaluates the competencies: CG3, CG4, CG6, CE11, CE18.
Practices through ICT	The subject also will require the development and delivery of 3 practices that the students will perform individually. The applications to develop in these practices will be done by means of the languages common used in the Internet: Javascript, PHP, Java, etc. These practices evaluate the competences: CG3, CG4, CG6, CG9, CE11, CE18 and promote the competences CT2, CT3 y CT4.
Discussion Forum	During the course we will discuss several topics, related with the concepts seen in theory, in the forums of the subject. This forum will promote the competences: CG3, CG6, CT2, CT3 and CT4.

Personalized assistance

Methodologies	Description

Discussion Forum	In the practical formative activities and tutoring, the professors of the subject will offer personal guidance to each student in the tasks to be performed, with the aim to orient the approach and the methodology. Also they will offer coordination information with other contents and subjects of the study program. It is recommended to consult the doubts with the teachers along the course in order to improve the understanding of the basic concepts, and for performing the tasks and activities to be evaluated. The students will be able to query and request tutoring through MOOVI platform (https://moovi.uvigo.gal).
Practices through ICT	In the practical formative activities and tutoring, the professors of the subject will offer personal guidance to each student in the tasks to be performed, with the aim to orient the approach and the methodology. Also they will offer coordination information with other contents and subjects of the study program. It is recommended to consult the doubts with the teachers along the course in order to improve the understanding of the basic concepts, and for performing the tasks and activities to be evaluated. The students will be able to query and request tutoring through MOOVI platform (https://moovi.uvigo.gal).

Tests	**Description**
Essay questions exam	In the practical formative activities and tutoring, the professors of the subject will offer personal guidance to each student in the tasks to be performed, with the aim to orient the approach and the methodology. Also they will offer coordination information with other contents and subjects of the study program. It is recommended to consult the doubts with the teachers along the course in order to improve the understanding of the basic concepts, and for performing the tasks and activities to be evaluated. The students will be able to query and request tutoring through MOOVI platform (https://moovi.uvigo.gal).
Essay questions exam	In the practical formative activities and tutoring, the professors of the subject will offer personal guidance to each student in the tasks to be performed, with the aim to orient the approach and the methodology. Also they will offer coordination information with other contents and subjects of the study program. It is recommended to consult the doubts with the teachers along the course in order to improve the understanding of the basic concepts, and for performing the tasks and activities to be evaluated. The students will be able to query and request tutoring through MOOVI platform (https://moovi.uvigo.gal).
Problem and/or exercise solving	n the practical formative activities and tutoring, the professors of the subject will offer personal guidance to each student in the tasks to be performed, with the aim to orient the approach and the methodology. Also they will offer coordination information with other contents and subjects of the study program. It is recommended to consult the doubts with the teachers along the course in order to improve the understanding of the basic concepts, and for performing the tasks and activities to be evaluated. The students will be able to query and request tutoring through MOOVI platform (https://moovi.uvigo.gal).
Problem and/or exercise solving	In the practical formative activities and tutoring, the professors of the subject will offer personal guidance to each student in the tasks to be performed, with the aim to orient the approach and the methodology. Also they will offer coordination information with other contents and subjects of the study program. It is recommended to consult the doubts with the teachers along the course in order to improve the understanding of the basic concepts, and for performing the tasks and activities to be evaluated. The students will be able to query and request tutoring through MOOVI platform (https://moovi.uvigo.gal).

Assessment

	Description	Qualification	Training and Learning Results		
Self-assessment	They will do two test of self-evaluation along the subject on the theoretical concepts that the students have learnt up to such point.	0	B3 B4 B6	C11 C18	
Essay questions exam	There will be a theoretical exam in the half of the course about the contents seen so far. It will be composed of short questions, selection of multiple option, and/or questions of development where the student will describe one or several concepts, relating them between yes, and illustrating them with examples.	25	B3 B4 B6 B9	C11 C18	D2 D3 D4
Essay questions exam	There will be a theoretical exam at the end of the course about the contents of the second part. It will be composed of short questions, selection of multiple option, and/or of questions of development where the student will describe one or several concepts, relating them between yes, and illustrating them with examples.	25	B3 B4 B6 B9	C11 C18	D2 D3 D4
Problem and/or exercise solving	The code of the practices will be evaluated by the teachers to check that it works according to the requirements and specifications. In addition, the student must pass a practical test (related to the proposed practices) to verify that he adequately masters his code.	25	B3 B4 B6	C11 C18	D2 D3

Problem and/or exercise solving	The code of the practices will be evaluated by the teachers to check that it works according to the requirements and specifications. In addition, the student must pass a practical test (related to the proposed practices) to verify that he adequately masters his code.	25	B3 C11 D2 B4 C18 D3 B6

Other comments on the Evaluation

The subject consists of a theoretical part and a practical part. Each of them will be valued with 5 points, having to get at least 2.5 in each part to pass the subject.

Following the guidelines of the degree, students who take this subject will be offered two evaluation systems: continuous evaluation (CE) and global evaluation (GE).

EC:

- The student body follows the EC by default, but may renounce it at any time.

- The theoretical part is graded with 5 points and consists of two exams (E1 and E2), the first will be held during the semester and the second during the official exam period (2.5 points each).

A minimum of 1 point will be required in each of the two theory exams to average with the other in order to pass the theoretical part. In addition, the result of said average must reach 2.5 points.

Additionally, students who follow the CE may receive up to 1 extra point based on activities carried out in class and/or on the MOOVI platform (only in first opportunity of CE). If theoretical exams are passed (over 2,5 points) the extra grade will be fully added. If more than 2 points are obtained in the exams, half of such grade will be added. Below 2 points the extra grade will be discarded. Finally, the grade for the theory part will be adjusted to 5 if the result is higher.

- The practical part is graded with 5 points and consists of several practices and a practical exam.

- Practice 1 is worth 0.5 points, it can be delivered at any time throughout the month of October. The students must correct the errors found, at which time they will obtain the indicated grade.

- Practice 2 will be worth 2 points and can be delivered up to a few days before the practical exam (the exact date will be notified at the time). After the delivery, the students must correct the errors identified by the teachers until the practice works correctly, having until the deadline mentioned above. Once the approval of the teachers has been obtained, the students will obtain the indicated mark.

The correction of the errors found by the teachers in practices 1 and 2, depending on their number and importance, may give rise to a penalty in the final grade for the subject.

- The rest of the practices (whose number will be established at the beginning of the course) will be worth 2.5 points and can be delivered from the time the approval of the teachers is obtained for practice 2, and until the end of the classes, or a later date indicated in his moment. These practices will be evaluated as they are delivered, without the possibility of correcting the errors observed.

- Practical test: On the day of the exam, a practical test will be carried out to verify that the students have adequate command of the delivered code.

EG:

Students who have opted for GE must take a final exam out of 5 points and hand in practices 1 and 2 before finishing classes (with possible modifications specified at the time). The students must correct the errors identified by the teachers until they obtain their approval (with the penalty described above depending on their importance). Then you can deliver the rest of the practices, always before finishing classes. In addition, you must also take the practical test.

Passing the subject: Both in the case of EC and EG, to pass the subject, students must obtain at least 2.5 points in each part (theory and practice). In the case of not exceeding the minimum grade in any of the parts, the score obtained by adding both parts will be adjusted to 4.9 points in the case of exceeding said value.

Extraordinary opportunity:

The students must take the same theoretical exam described in the case of the EG, hand in the practices that are specified (published during the month of March), and take the practical test already described.

In the case of suspending only one of the parts, the students will only have to do the other part in the extraordinary opportunity if some conditions are fulfilled:

- The practical grade (passed) will be kept if the theoretical grade (failed) was above 1,5 over 5.

- The theoretical grade will be kept if practices were presented and passed (only practical exam has been failed).

End of career announcement:

It will have the same characteristics as the extraordinary opportunity. The practices may undergo modifications or incorporate additional functionalities that will be communicated in the month of July.

In principle, none of the marks obtained in both parts in the ordinary or extraordinary opportunities are kept for this call. Once the practices of this call have been published, the teaching staff of the following year will decide and inform opportunely about whether or not to keep the grades obtained in the previous calls.

In case of detection of plagiarism in any of the tests, the final grade will be FAIL (0) and the fact will be communicated to the Center's management so that it can take the appropriate effects.

Sources of information

Basic Bibliography

Complementary Bibliography

H.M Deitel et al., **Internet and World Wide Web How to Program: International Edition**, 5, 2012

Robert W. Sebesta, **Programming the World Wide Web**, 8, 2014

Andrew S. Tanenbaum, **Computer Networks**, 5, 2012

Priscilla Walmsley, **Definitive XML Schema, 2/E**, 2, 2012

W. Stallings, **Data and Computer Communications**, 9, 2013

J Murach, M. Urban, **java Servlets and JSP**, 3, Murach, 2014

S. Holzner, **Ajax**, 1, McGraw Hill, 2009

Ethan Brown, **Web Development with Node and Express: Leveraging the JavaScript Stack**, 1, O'Reilly, 2014

Andrew Lombardi, **WebSocket: Lightweight Client-Server Communications**, 1, O'Reilly, 2015

Recommendations

Subjects that it is recommended to have taken before

Programming II/V05G301V01110

IDENTIFYING DATA				
Programmable Electronic Circuits				
Subject	Programmable Electronic Circuits			
Code	V05G301V01302			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	3rd	1st
Teaching language	Spanish Galician			
Department				
Coordinator	Poza González, Francisco			
Lecturers	Álvarez Ruiz de Ojeda, Luís Jacobo Poza González, Francisco			
E-mail	fpoza@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The documentation of the subject may be in English. The objectives of this course are that students learn the general aspects of the architecture of microprocessors, microcontrollers and configurable devices, as well as the adequate design methods and tools, while they acquire the necessary skills to design systems based on these devices.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B13	CG13 The ability to use software tools that support problem solving in engineering.
C7	CE7/T2: The ability to use communication and software applications (ofimatics, databases, advanced calculus, project management, visualization, etc.) to support the development and operation of Electronics and Telecommunication networks, services and applications.
C8	CE8/T3: The ability to use software tools for bibliographical resources search or information related with electronics and telecommunications.
C14	CE14/T9: The ability to analyze and design combinatory and sequential, synchronous and asynchronous circuits and the usage of integrated circuits and microprocessors.
C15	CE15/T10: The knowledge and application of the fundamentals of description languages for hardware devices.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
To understand the basic architecture of microprocessors, microcontrollers and configurable devices (FPGAs).	B3	C14 C15	
To know the methods and techniques of design of integrated hardware/software systems (System on Chip - SoC).	B3	C14 C15	
To know the hardware and software tools for the design of systems based in programmable devices.	B13	C14 C15	
To acquire the skills to use the design tools.		C14 C15	
Ability to design simple integrated systems (System on Chip - SoC) applied to the telecommunications fields.	B3 B4 B13	C7 C8 C14 C15	D2 D3

Contents	
Topic	
LESSON 1 THEORY. CORRECT DESIGN METHODS. SYNCHRONOUS DESIGN.	Digital systems design techniques. Recommendations. Design rules for synchronous sequential systems

LESSON 2 THEORY. DESIGN METHODS OF COMPLEX SYNCHRONOUS DIGITAL SYSTEMS.	Study of a systematic design method for this type of systems.
LESSON 3 THEORY. ANALYSIS OF DIFFERENT TYPES OF DIGITAL CIRCUITS.	Types of digital circuits. Main characteristics. System on Chip (SOC). Types. Characteristics.
LESSON 4 THEORY. FPGAs. APPLICATIONS. ARCHITECTURE OF THE FAMILY USED.	General architecture of FPGAs. Characteristics. Analysis of the family of FPGAs used in the subject.
LESSON 5 THEORY. INTERNAL ARCHITECTURE OF THE MICROPROCESSOR USED IN THE SUBJECT.	Analysis of the internal architecture. Instruction set.
LESSON 6 THEORY. SOFTWARE DEVELOPMENT FOR THE MICROPROCESSOR USED IN THE SUBJECT.	Program syntax. Compilation directives.
LESSON 7 THEORY. EXTERNAL ARCHITECTURE OF THE MICROPROCESSOR USED IN THE SUBJECT.	External architecture of the microprocessor. Signals used for I/O. Connection of I/O peripherals. Interrupts.
LESSON 8 THEORY. DESIGN OF EMBEDDED SYSTEMS. HARDWARE / SOFTWARE CODESIGN.	Hardware/software codesign flow. Partitioning.
LESSON 1 LABORATORY. DESIGN OF A BASIC DIGITAL SYSTEM IN THE CORRECT FORM.	Design of a digital system using VHDL for its implementation in an FPGA, applying the correct design recommendations.
LESSON 2 LABORATORY. DESIGN OF A COMPLEX SYNCHRONOUS DIGITAL SYSTEM.	Design of a complex digital system using VHDL for its implementation in an FPGA, using the systematic design method analyzed in theory.
LESSON 3 LABORATORY. DESIGN OF A BASIC EMBEDDED SYSTEM BASED ON AN FPGA.	Design of the circuits and development of the necessary programs to implement a basic embedded system in an FPGA, using the microprocessor analyzed in theory.
LESSON 4 LABORATORY. DESIGN OF A MEDIUM COMPLEXITY EMBEDDED SYSTEM.	Design of the circuits and development of the necessary programs to implement an embedded system of medium complexity, combining the basic system previously developed with additional circuits and programs that the student must develop.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	2	2	4
Lecturing	12	16	28
Problem solving	12	19	31
Mentored work	6	10	16
Mentored work	6	10	16
Mentored work	6	10	16
Mentored work	8	14	22
Essay questions exam	4	13	17

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Introduction to key topics both theoretical and practical. Through this methodology the competence B3 is developed.
Lecturing	Conventional lectures. Through this methodology the competence B3 is developed.
Problem solving	In these sessions, exercises will be solved by both the teacher and the students. Through this methodology the competences B3, B4, C8, C14 and C15 are developed.
Mentored work	Practical work on the design of a digital system applying the correct design recommendations. With this methodology develop the competences B3, B4, B13, C7, C8, C14, C15, D2 and D3.
Mentored work	Practical work on the design of a complex digital system using the systematic design method analyzed in theory. With this methodology develop the competences B3, B4, B13, C7, C8, C14, C15, D2 and D3.
Mentored work	Practical work on the design of circuits and programs necessary to implement a basic embedded system using the microprocessor analyzed in theory. With this methodology develop the competences B3, B4, B13, C7, C8, C14, C15, D2 and D3.

Mentored work	Practical work on the design of circuits and programs necessary to implement an embedded system of medium complexity using the microprocessor analyzed in theory. With this methodology develop the competences B3, B4, B13, C7, C8, C14, C15, D2 and D3.

Personalized assistance

Methodologies	Description
Introductory activities	In the classes the doubts of the students will be answered. They will also be able to consult with the teachers in the place and at the time published at https://www.uvigo.gal/es/universidad/administracion-personal/pdi/luis-jacobo-alvarez-ruiz-ojeda y https://moovi.uvigo.gal/user/profile.php?id=11302.
Lecturing	In the classes the doubts of the students will be answered. They will also be able to consult with the teachers in the place and at the time published at https://www.uvigo.gal/es/universidad/administracion-personal/pdi/luis-jacobo-alvarez-ruiz-ojeda y https://moovi.uvigo.gal/user/profile.php?id=11302.
Problem solving	In the classes the doubts of the students will be answered. They will also be able to consult with the teachers in the place and at the time published at https://www.uvigo.gal/es/universidad/administracion-personal/pdi/luis-jacobo-alvarez-ruiz-ojeda y https://moovi.uvigo.gal/user/profile.php?id=11302.
Mentored work	In the classes the doubts of the students will be answered. They will also be able to consult with the teachers in the place and at the time published at https://www.uvigo.gal/es/universidad/administracion-personal/pdi/luis-jacobo-alvarez-ruiz-ojeda y https://moovi.uvigo.gal/user/profile.php?id=11302.
Mentored work	In the classes the doubts of the students will be answered. They will also be able to consult with the teachers in the place and at the time published at https://www.uvigo.gal/es/universidad/administracion-personal/pdi/luis-jacobo-alvarez-ruiz-ojeda y https://moovi.uvigo.gal/user/profile.php?id=11302.
Mentored work	In the classes the doubts of the students will be answered. They will also be able to consult with the teachers in the place and at the time published at https://www.uvigo.gal/es/universidad/administracion-personal/pdi/luis-jacobo-alvarez-ruiz-ojeda y https://moovi.uvigo.gal/user/profile.php?id=11302.
Mentored work	In the classes the doubts of the students will be answered. They will also be able to consult with the teachers in the place and at the time published at https://www.uvigo.gal/es/universidad/administracion-personal/pdi/luis-jacobo-alvarez-ruiz-ojeda y https://moovi.uvigo.gal/user/profile.php?id=11302.

Assessment

	Description	Qualification	Training and Learning Results		
Mentored work	Practical work on the design of a digital system applying the correct design recommendations.	15	B3 B4 B13	C7 C8 C14 C15	D2 D3
Mentored work	Practical work on the design of a complex digital system using the systematic design method analyzed in theory.	15	B3 B4 B13	C7 C8 C14 C15	D2 D3
Mentored work	Practical work on the design of circuits and programs necessary to implement a basic embedded system using the microprocessor analyzed in theory.	12	B3 B4 B13	C7 C8 C14 C15	D2 D3
Mentored work	Practical work on the design of circuits and programs necessary to implement a basic embedded system using the microprocessor analyzed in theory.	18	B3 B4 B13	C7 C8 C14 C15	D2 D3
Essay questions exam	This exam will include two types of questions: 1) Multiple choice questions about the theoretical topics of the subject. 2) Design problems about circuits and programs, explaining the work done.	40	B3 B4	C14 C15	

Other comments on the Evaluation

The final mark will be expressed in numerical form ranging from 0 to 10.

The students will be offered two assessment systems: continuous assessment and global assessment.

It is considered that all the students have chosen continuous assessment by default.

Choosing of global assessment must be communicated in writing form to the coordinator within one month of the start of the semester.

All the tasks must be delivered in the date specified by the professor, otherwise they will not be assessed.

In case of detection of plagiarism in any of the tasks (theoretical exam, laboratory practices or autonomous projects) the final qualificationwill be fail (0) and the fact will be communicated to the Head of the faculty for further actions.

The subject is composed of a theoretical part and a laboratory part, with a respective weighting of 40% and 60% of the total mark of the subject.

The theoretical part consists of a final examination. This final examination will be the same for all the students, regardless of the type of assessment they have opted for.

The exam will be on the date of the final exam of the semester, which the faculty will determine.

CONTINUOUS ASSESSMENT (ordinary exam)

Laboratory class attendance is compulsory if the student is following continuous assessment.

The students who are following continuous assessment can only miss 1 laboratory session without justification, as a maximum.

If the number of students in any laboratory group is sufficiently small, the students will carry out the practices and projects individually. Otherwise, students will perform these tasks in groups of 2. In the latter case, the two students will receive the same mark.

Theoretical class attendance is considered crucial to achieve success in continuous assessment, as the experience shows that it has a strong influence on the rate of success in the continuous assessment.

All the tasks have to be delivered on the date specified by the professor, otherwise they will not be assessed. It is also compulsory to sit the theoretical exam in the continuous assessment.

None of the tasks can be done on a different date that the one set up by the professor.

If any of the previous conditions is not met, the student that was in continuous assessment will lose the right to it and will automatically fail.

The total mark will be the weighted sum of the marks obtained in the different tasks of the subject.

To pass the subject, it is necessary that:

· The global mark of the theory (TM) is greater or equal than 4 over 10.

· The global mark of the laboratory (LM) is greater or equal than 4 over 10.

· The global mark of the subject (FM) is greater or equal than 5 over 10.

The laboratory mark is calculated as follows:

LM = 0,25 * LAP1 + 0,25 * LAP2 + 0,20 * LAP3 + 0,30 * LAP4

being:

LAPi = Laboratory Autonomous Projects mark over 10.

In case a student passes all the minimum marks, the final mark (FM) will be:

FM = 0.40 * TM + 0.60 * LM

In case a student does not reach any of the minimum marks (theory mark < 4 or global laboratory mark < 4), the final mark (FM) will be:

FM = minimum [4.9; (0.40 * TM + 0.60 * LM)]

The students that pass the course by means of continuous assessment will not be allowed to repeat any tasks (theory, laboratory) in the global assessment in order to improve the mark.

If the students who are following continuous assessment deliver all the tasks, the mark of the part of the subject (theory, laboratory) in which they have obtained the minimum demanded will be preserved, only until the extraordinary exam of the same academic course.

GLOBAL ASSESSMENT (ordinary and extraordinary exam) and END-OF-PROGRAM EXAM

The students that opt for the global assessment (whether it is the ordinary or extraordinary exam) or for the end-of-program exam will have to do a theoretical exam and a laboratory exam individually.

To be allowed to do the laboratory exam, it is necessary to request it previously on the dates that will be communicated to the students through the Moovi website.

The total mark will be the weighted sum of the marks obtained in the different tasks of the subject.

To pass the subject, it is necessary that:

· The mark of the theoretical exam (TE) is greater or equal to 4 over 10.

· The mark of the laboratory exam (LE) is greater or equal to 4 over 10.

· The global mark of the subject (FM) is greater or equal to 5 over 10.

In case a student passes all the different tasks, the final mark (FM) will be the weighted sum of the marks of each exam:

FM = 0.40 * TE + 0.60 * LE

In case a student does not pass one of the exams (theoretical exam < 4 or laboratory exam < 4), the final mark (FM) will be:

FM = minimum [4.9; (0.40 * TE + 0.60 * LE)]

Theoretical exam

The theoretical exam will include test questions and practical problems on the topics of all the theoretical lessons. The students will have to answer all the exam questions correctly to obtain the maximum mark.

This exam will be held on the date and place that the faculty will determine.

Laboratory exam

The exam will consist of the design of circuits in VHDL and programs for the microprocessor used in the subject. These circuits and programs may be part of a complex peripheral or an embedded system and they will have a similar complexity to the ones designed in the laboratory practical and the autonomous laboratory projects during the continuous assessment.

The students will have to perform the simulations and tests described in the exam in the assigned time.

The teacher may request that the students show them the operation of each of the circuits and programs.

All the sections have to work perfectly to obtain the maximum mark.

The addition of additional functionality to the minimum required will be taken into account.

It is compulsory to deliver the files indicated in the exam.

If this condition is not fulfilled, the corresponding sections will not be assessed.

The correct operation and the correct application of the theoretical concepts to the circuits and programs realised during the exam will be assessed, according to the same assessment criteria for the laboratory practices and the autonomous projects during the continuous assessment.

Sources of information

Basic Bibliography

Chu, Pong P., **FPGA prototyping by VHDL examples: Xilinx MicroBlaze MCS SoC**, 978-1119282747, 2ª, John Wiley & Sons, Inc., 2017

Complementary Bibliography

ÁLVAREZ RUIZ DE OJEDA, L.J., POZA GONZÁLEZ, F., **Diseño de aplicaciones empotradas de 32 bits en FPGAs con Xilinx EDK 10.1 para Microblaze y Power-PC**, 9788499837413, Vision Libros, 2011

ÁLVAREZ RUIZ DE OJEDA, L.J., **Diseño Digital con FPGAs**, Vision libros, 2013

ÁLVAREZ RUIZ DE OJEDA, L.J.,, **Diseño Digital con Lógica Programable**, Editorial Tórculo, 2004

ÁLVAREZ RUIZ DE OJEDA, L. Jacobo, MANDADO PÉREZ, E., VALDÉS PEÑA, M.D., **Dispositivos Lógicos Programables y sus aplicaciones**, Editorial Thomson-Paraninfo, 2002

PÉREZ LÓPEZ, S.A., SOTO CAMPOS, E., FERNÁNDEZ GÓMEZ, S., **Diseño de sistemas digitales con VHDL**, Thomson-Paraninfo, 2002

Recommendations

Subjects that continue the syllabus

Application Design with micro-controllers/V05G301V01406
Design and synthesis of digital systems/V05G301V01408

Subjects that are recommended to be taken simultaneously

Electronic Systems for Signal Processing/V05G301V01312

Subjects that it is recommended to have taken before

Informatics: Computer Architecture/V05G301V01109
Digital electronics/V05G301V01203

Other comments

The students will have previously followed the subject Digital Electronics. It gives the necessary knowledge to understand the topics of this course.

Besides, it is recommended that the students have previously followed the subject Informatics: Computer Architecture. It gives the necessary knowledge to understand some topics of this course.

IDENTIFYING DATA				
Operating Systems				
Subject	Operating Systems			
Code	V05G301V01303			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	Spanish			
Department				
Coordinator	Rivas Costa, Carlos			
Lecturers	Rivas Costa, Carlos			
E-mail	carlos.rivas.costa@gmail.com			
Web	http://moovi.uvigo.es			
General description	The aim of this subject is that the student was able to learn the foundations of the current operating systems and to comprise its importance inside the architecture of a computer.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C33	CE33/TEL7 The ability to program network and distributed applications and services.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Understanding of the basic functions of the operating system as part of a computer system.	B3		D3
Knowledge of the main concepts and the principles of design of the operating systems.	B3		D3
Ability to identify the components of an operating system, recognise its functions and the interrelationships between them.	B3		D3
Knowledge of the lastest advances and tendencies related with operating systems	B3		D3
Knowledge and ability to evaluate the different alternatives for the design of an operating system and its main components.	B4		D2
Acquisition of basic skills for the configuration and the utilisation of operating system services.	B9	C33	D4
Manage and know the operative associated to the administration of current operating systems.	B3		D3

Contents	
Topic	
Introduction and general perspective of the Operating systems	• Concept of operating system. • Structure of an operating system. • Types of operating systems. • Emulation and virtualization.
Processor management.	• Concept of process and thread. • Strategies of allocation of capacity of computation.
Memory management.	• Strategies of contiguous allocation. • Concepts of fragmentation, protection, compactation, relocation and sharing of memory. • Strategies of non-conriguous allocation: paging, segmentation and hybrid methods. • Virtual memory.

Permanent storage of the information.	• Functions of a file system. Concepts of file and directory. • Interface with the file system. • File sharing. • File Protection. • File system implementation. • Free space management. • Methods for allocation of space to files.
Input/Output (I/O) management.	• I/O Controllers. • I/O Interfaces. • Secondary and tertiary storage. • Disk scheduling. • Management of disk. • Replication and consistency of the information. RAID and RAIN technologies.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	18	46	64
Practices through ICT	13	26	39
Workshops	5	30	35
Problem and/or exercise solving	1	0	1
Problem and/or exercise solving	1	0	1
Problem and/or exercise solving	1	0	1
Laboratory practice	1	0	1
Essay	2	6	8

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Presentation of the ideas, concepts, technics and algorithms of each lesson. This activity develops the CG3, CG4, CT2 and CT3 competencies.
Practices through ICT	The students will resolve under the supervision of the professors practical problems that pose in each session of laboratory. This activity develops the CG4, CT2 and CE33 competencies.
Workshops	Each group of students will tackle the design and implementation of a software project with half complexity. This task will be realised in successive steps, that will be discussed and validated in each one of the face-to-face sessions. The aim of this methodology of work is to provide a suitable feedback to improve the proposed solutions. This activity develops the CG4, CG9, CT2 and CT4 competencies.

Personalized assistance

Methodologies	Description
Practices through ICT	The professor will be present during the realisation of the practices, answering all the doubts that can arise to the students. Tutoring: The schedules and mechanisms for requesting tutoring can be consulted through the Moovi platform https://moovi.uvigo.gal
Workshops	The professor will be present during the realisation of the workshops, answering all the doubts that can arise to the students. Tutoring: The schedules and mechanisms for requesting tutoring can be consulted through the Moovi platform https://moovi.uvigo.gal
Lecturing	During the development of the master sessions, the students will be able to interrupt and formulate all the questions or doubts that can arise them. Tutoring: The schedules and mechanisms for requesting tutoring can be consulted through the Moovi platform https://moovi.uvigo.gal

Assessment

	Description	Qualification	Training and Learning Results	
Problem and/or exercise solving	Proof of theoretical contents exposed in the master classes.	20	B3 B4	D2 D3
Problem and/or exercise solving	Proof of theoretical contents exposed in the master classes.	20	B3 B4	D2 D3
Problem and/or exercise solving	Proof of theoretical contents exposed in the master classes.	20	B3 B4	D2 D3

Laboratory practice	Validation of the work realised in the sessions of laboratory.	20	B4	C33	D2
Essay	In the last face-to-face session of workshop, students will deliver and will expose to their mates the design and the proposed solution for their project. This solution will be exposed to debate for students and professors. The professor will do questions to each member of the group, what will allow his individual evaluation.	20	B4 B9		D2 D4

Other comments on the Evaluation

The subject can be surpassed by means of Continuous Assessment according to the following criteria, having opened the possibility to opt by the Exam-only assessment anytime until the beginning of the final examination to celebrate the day fixed to such effect in the official calendar of the EET. All those students that opt by the Continuous Assessment will consider presented if they evaluate of the part of the work in Workshops.

Continuous Assessment:

The final note will result of the sum of the corresponding notes to the three following components:

1. Three tests of type short answer questions to evaluate the contents given in the masterclasses. Each proof will take place in one of the master classes , except the last that will realize in one of the sessions of the Workshop. **Scoring:** Up to 2 points each test. (T=t1+t2+t3)

2. One Practical Test that will realize at the last session of laboratory. **Scoring:** Up to 2 points. (L)

3. Presentation of the Project proposed like work in the sessions of the Workshop. **Scoring:** Up to 2 points. (P)

To pass the subject by Continuous Assessment will have to give the three following conditions: (i) obtain an equal or upper qualification to 2 points in the group of the tests.; (ii) More than 0,75 points in the practical test; and (iii) to attend all the face-to-face sessions and obtain more than 0 points in the presentation of the project. In the case to fulfill the three previous conditions, the final mark of the Continuous Assessment will be the sum of the three components (Mark=T+L+P). If the student does not fulfill any of the three conditions, the mark of the Continuous Assessment will be a fail (Mark=min[4.9, T+L+P]).

Global Assessment:

By means of an examination on 10 points scheduled in the official calendar of the EET.

Extraordinary Exam and End-of-program exam:

It will be governed by the indicated for the Global Assessment.

Sources of information

Basic Bibliography

Abraham Silberschatz, Greg Gagne y Peter B. Galvin, **Operating System Concepts**, 10, Wiley, 2018

Robert Love, **Linux Kernel Development**, 3, Addison-Wesley Professional, 2010

Complementary Bibliography

William Stallings, **Operating Systems: Internals and Design Principles**, 9, Prentice Hall, 2018

Gary Nut, **Operating System : A Modern Perspective**, 3, Adison-Wesley Longman, Inc., 2004

Jesús Carretero, Felix García, Pedro de Miguel y Fernando Pérez, **Sistemas Operativos: Una Visión Aplicada**, 2, McGraw Hill, 2007

Ralf Steinmetz y Klara Nahrstedt, **Multimedia Systems**, 1, Springer, 2004

Frederic Magoules , Jie Pan, Kiat-An Tan y Abhinit Kumar, **Introduction to Grid Computing**, 1, CRC Press, 2009

John Rittinghouse y James Ransome, **Cloud Computing: Implementation, Management, and Security**, 1, CRC Press, 2009

Charles Crowley, **Operating Systems: A Design-Oriented Approach**, 1, McGraw Hill, 1996

Andrew S. Tanenbaum, **Modern Operating Systems**, 4, Prentice Hall, 2014

Daniel P. Bovet y Marco Cesati, **Understanding the Linux Kernel**, 3, O'Reilly Media, 2005

Wolfgang Mauerer, **Professional Linux Kernel Architecture (Wrox Programmer to Programmer)**, 1, Wrox, 2008

Recommendations

Subjects that it is recommended to have taken before

Informatics: Computer Architecture/V05G301V01109
Programming I/V05G301V01105
Programming II/V05G301V01110

IDENTIFYING DATA

Data Networks: Technology and Architecture

Subject	Data Networks: Technology and Architecture			
Code	V05G301V01304			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Rodríguez Pérez, Miguel			
Lecturers	Rodríguez Pérez, Miguel Rodríguez Rubio, Raúl Fernando			
E-mail	miguel@det.uvigo.gal			
Web	http://moovi.uvigo.gal/			
General description	The objective of this subject is to teach our students the technical basics that govern the modern computer networks, regarding topics like new switching paradigms, new access technologies or data transport with quality of service. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results

Code	
B1	CG1: The ability to write, develop and sign projects in the field of Telecommunication Engineering, according to the knowledge acquired as considered in section 5 of this Law, the conception and development or operation of networks, services and applications of Telecommunication and Electronics.
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
C30	CE30/TEL4 The ability to describe, program, assess and optimize communication protocols and interfaces at different network architecture layers .
C32	CE32/TEL6 The ability to design networks and service architectures.
D2	CT2 Understanding Engineering within a framework of sustainable development.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Capacity to apply concepts and recent technologies of transmission, switching and data transport for the design, the operation and the exploitation of heterogeneous networks	B1 B4	C32	
Identify and know how to use specific solutions of switching, data transport and management for the deployment of special purpose networks.	B4 B6	C30	D2
Know and apply the techniques and the mechanisms of engineering of data traffic in packet networks, both in close and open environments.	B4	C30	
Practical capacity for the design, usage and configuration of advances computer networks, from the point of view of switching, quality of service, data transport and telematic services deployment.		C30 C32	D2

Contents

Topic	
LAN Virtualization Technologies	The VLAN Concept Trunks Routing Considerations Practical about VLAN configuration
Network virtualization	Tunnels Overlay networks Remote access (VPNs) Practical about tunneling

Advanced switching mechanisms	Label switching (MPLS) MPLS applications VPNs with provider support Practical about MPLS
IP mobility	Network mobility concepts IPv4 Mobility IPv6 Mobility
Access network technologies	xDSL Cable (HFC, DOCSIS) Optical access networks
Optical switching and transmission	Circuit switching, burst switching and packet switching Transmission on optimal medium

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	21	32	53
Laboratory practical	9	18	27
Mentored work	7	42	49
Presentation	1	0	1
Essay questions exam	2	8	10
Essay questions exam	2	8	10

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The master lectures follow the usual scheme for this way of teaching. We work on competencies CG6, CE32 and CE32 in these master sessions.
Laboratory practical	In the labs the students will face several practical sessionssupervised by the teacherswhere they will settle the concepts learned in the theoretical classes. In such practicals they will use actual network equipment (routers and switches) and/or virtualization software that will allow their instruction and training on their own. The practicals that the teachers will pose will be designed to be done within the respective face-to-face sessions at the School; although the student will be able to reproduce them at home using free software that will allow to virtualize the network hardware used in the laboratory. Software to be used: GNS3, netcat, and SSH client and server. It is recommended to use a Linux distribution running on top of the bare hardware. Also, the teachers may propose optional exercises that the student will be able to do as homework; and review individually in tutorial time. The students should acquire competencies CE30 and CE32 in the lab.
Mentored work	A project with a fairly large magnitude will be posed to be developed as a teamwork during all the semester. This practical work might require in its earliest stage to be set in context doing an additional theoretical study/research. Both works will be supervised by the professors with periodic meetings every 10/15 days (roughly). The tutored works are related with competencies CG1, CG4, CE30, CE32 and CT2.
Presentation	Every group must deliver the right documents where the suggested challenge (project teamwork) have to be explained in a detailed way. Also, the students must prepare a public presentation of the team solution to be defended in front of the rest of the class. The students practice competence CG4 in the presentations.

Personalized assistance

Methodologies	Description
Lecturing	During the tutorial hours the teachers will give personalized attention either individually - to strengthen or guide the student in the understanding of the theoretical concepts explained in the lectures or in the practical demonstration sessions; and to correct or refocus the small optional practical work derived from these laboratory classes - or in a group setting with the follow-up of the work associated with the project of a considerable extent to be undertaken with fellow students. In these group tutorships - which have an attendance component (more or less one hour every fortnight), the solutions proposed by the group members will be discussed and their equal involvement in the final development will be verified and stimulated. Students can ask for tutoring sessions following the instructions provided in the profiles pages of the teachers of this subject: * Miguel Rodríguez Pérez: https://moovi.uvigo.gal/user/profile.php?id=11314 * Raúl F. Rodríguez Rubio: https://moovi.uvigo.gal/user/view.php?id=11315

Laboratory practical	During the tutorial hours the teachers will give personalized attention either individually - to strengthen or guide the student in the understanding of the theoretical concepts explained in the lectures or in the practical demonstration sessions; and to correct or refocus the small optional practical work derived from these laboratory classes - or in a group setting with the follow-up of the work associated with the project of a considerable extent to be undertaken with fellow students. In these group tutorships - which have an attendance component (more or less one hour every fortnight), the solutions proposed by the group members will be discussed and their equal involvement in the final development will be verified and stimulated. Students can ask for tutoring sessions following the instructions provided in the profiles pages of the teachers of the practical part of this subject: * Miguel Rodríguez Pérez: https://moovi.uvigo.gal/user/profile.php?id=11314
Mentored work	During the tutorial hours the teachers will give personalized attention either individually - to strengthen or guide the student in the understanding of the theoretical concepts explained in the lectures or in the practical demonstration sessions; and to correct or refocus the small optional practical work derived from these laboratory classes - or in a group setting with the follow-up of the work associated with the project of a considerable extent to be undertaken with fellow students. In these group tutorships - which have an attendance component (more or less one hour every fortnight), the solutions proposed by the group members will be discussed and their equal involvement in the final development will be verified and stimulated. Students can ask for tutoring sessions following the instructions provided in the profiles pages of the teachers of this subject: * Miguel Rodríguez Pérez: https://moovi.uvigo.gal/user/profile.php?id=11314 * Raúl F. Rodríguez Rubio: https://moovi.uvigo.gal/user/view.php?id=11315

Assessment

	Description	Qualification	Training and Learning Results
Mentored work	The practical teamwork (project) that the student will face will determine one of the mid-term marks, T, of our continuous evaluation. The quantitative value (between 0-10) will be determined by the correctness of the solution presented by the group, the associated presentation and docs, the individual implication of the student in the developed work and the answers given to an individual interview with each member of the group.	40	B1 C32 D2 B4 B6
Essay questions exam	Partial exam (Ef). A written test of theoretical nature about the first four lessos of the subject. It will be evaluated individually between 0 and 10 points.	30	C30 C32
Essay questions exam	Final exam (Ef). A written test of theoretical nature. It will be evaluated individually between 0 and 10 points.	30	C30 C32

Other comments on the Evaluation

Please note that even though utmost care has been placed to ensure the accuracy of this translation, it is possible that some mistakes have been inadvertently made. So, in case of discrepancy between this text and the canonical version available in the Galician language, the latter shall hold.

The assessment of the subject can either be based on a *continuous assessment* or global assessment. Students will choose the *continuous assessment* if they take the midterm written exam (Ep) around the middle of the semester□never before the first month ends□. The percentages shown in the previous section only reflect the maximum weights that any activity (partial mark) can obtain when following the continuous evaluation strategy, and serve only as illustration. The actual assessment procedure follows:

For *continuous assessment*, the *final mark* is the weighted geometric mean between the tutored work grade (T) and the corresponding from the written tests (Y). Mark Y is calculated as the arithmetic mean between the final exam (Ef) and partial exam (Ep) marks.

Y = ½×(Ef+Ep)

FINAL MARK=T^0.4×Y^0.6

Students that opt for the global assessment, must take a final examination that will be made up of two parts: a theory examination, like the final one in the continuous assessment (Ef) and a practical project that must be developed individually (T). The final mark, in this case, will be the weighted geometric mean between the theoretical exam and the project work.

Finally, both the extraordinary exam and the end-of-program call will have the same characteristics as the exam-only assessment just described, but students will be allowed to inherit the partial mark of any activity (T or Ef) if that has been passed during the same academic year, independently of the assessment modality that the student had followed.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

The use of generative artificial intelligence (GAI) is permitted as a tool to complete the academic activities of this subject. Its use must be carried out in an ethical, critical and responsible manner. In the case of using GAI, any result it provides must be critically evaluated, and any citation or reference generated must be carefully verified. It is also recommended to declare the used tools.

Sources of information

Basic Bibliography

Peterson & Davis, **Computer Networks**, 6ª, Morgan Kauffman, 2021

Ina Minei & Julian Lucek, **MPLS-Enabled Applications**, 3ª, Wiley, 2011

Sanjeev Mervana, Chriis Le, **Design and implementation of DSL-based access solutions**, Cisco-press, 2001

Gerd Keiser, **FTTx Concepts and applications**, John Wiley & sons, 2006

Complementary Bibliography

Kurose & Ross, **Computer Networking: A Top-Down Approach**, 8ª, Prentice Hall, 2021

Roderick W. Smith, **Broadband Internet connections: a user guide to DSL and cable**, Addison Wesley, 2007

Walter Goralski, **Tecnologías ADSL y xDSL**, McGraw-Hill, 2000

Biswanath Mukherjee, **Optical WDM networks**, Springer, 2006

G. Papadimitriou, C. Papazoglou & A. Pomportsis, **Optical Switching**, Wiley, 2008

James Farmer, Brian Lane, Kevin Bourg, Weyl Wang, **FTTx Networks: Technology implementation and operation**, 1ª, Morgan Kaufmann Publishers, 2016

Recommendations

Subjects that it is recommended to have taken before

Computer Networks/V05G301V01210

IDENTIFYING DATA				
Network Security				
Subject	Network Security			
Code	V05G301V01305			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	Spanish			
Department				
Coordinator	Fernández Masaguer, Francisco Rodríguez Rubio, Raúl Fernando			
Lecturers	Fernández Masaguer, Francisco Rodríguez Rubio, Raúl Fernando			
E-mail	francisco.fernandez@det.uvigo.es rrubio@det.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	In this subject, the main security problems or threats in networks and telematic services are studied in a unified way, and different techniques are presented to protect them. The topic is first approached from a general point of view, so that the security concepts, services, and techniques studied are applicable to any type of network, telematic service, or information system to be secured. This block consists of topics 1 to 4. This leads to a detailed examination of the three central security topics: the algorithmic part (encryption, digital signature, and integrity), authentication protocols, and key management and negotiation procedures. The objective is for the student to acquire a solid foundation that enables them to understand the specific techniques required by each application as well as to apply them to other areas they may encounter. The topic is then addressed in a somewhat more specific way, reviewing the problems, techniques, and security standards in some of the most prevalent communication environments today. A topic is dedicated to security at the IP level, a central protocol in the Internet architecture, and another topic to web security, given the current relevance of this telematic communication medium, where the student will assimilate the theoretical and practical concepts of the SSL protocol, central to the security of transactions over the web. Due to the increasing use of wireless communications and their particular security issues, a topic is also dedicated to them. The course concludes with an introduction to two other topics of increasing importance: malicious networks and software, and forensic analysis of information systems.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
C28	CE28/TEL2 The ability to apply the techniques that are basis of computer networks, services and applications, such as management, signaling and switching, routing and securing systems (cryptographic protocols, tunneling, firewalls, charging mechanisms, authentication and content protection) traffic engineering (graph theory, queuing theory and teletraffic) rating, reliability and quality of service in both fixed, mobile, personal, local or long distance environments with different bandwidths, including telephony and data.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Understand the foundations of the cryptographic science	B3		
To acquire the necessary knowledges to ensure the security of a computer or telematic system.	B3		
To acquire skills on the process of analysis of the attacks that can suffer a network and the main mechanisms of defence against them.	B4	C28	D3
Know the main architectures of applicable security to the computer and telematic systems.	B4	C28	D3
Know the main ideas of the norms and standard more important in matter of security in computer systems and communication networks.	B6	C28	D2

Contents

Topic	
1 Mathematics foundations of security.	- Basic notions of Complexity Theory. - Basic notions of Number Theory.
2. Cypher, digital signature and hash algorithms	- Types of criptosistems and algorithms. - Integrity and hash algorithms. - Symetric key cryptosistems. Mac functions. Encrytion. Shannon principles. Stream and block cyphers. DES and AES algorithms Cypher modes of operation. - Public key cryptosystems. RSA, DSA and elliptic curves. - Influence of quantum computing on cryptography.
3. Certification and Public Key Infrastructures.	- Security problems of asimetric cryptography. Certification and certificate formats. - Trust models. Flat trust model and PGP. Third partiy trust model and certification authorities. - Certificate Infrastructures. Certification path. - Certificate revocation.
4. Authentication and key agreement protocols.	- Authentication methods. - Threats to an authentication protocol. Countermeasures. - Requirements of a key agreement protocol. Diffie-Hellman protocol. - Authentication in simmetric cryptosistems. Cases of study: GSM and Kerberos. - Authentication in asimetric cryptosistems. Cases of study: X509 and SSL. - Passwords based protocols: SRP, SAE. - Single Sign On (SSO)
5. Security at the network layer	- Threats in the network layer. - IP Security Architecture. - IPsec Protocol. IPsec tunnels. IPsec and NAT. - Key manegement protocols: IKE, ISAKMP and OAKLEY.
6. Security in the Web and electronic commerce.	- Problems of security in the Web. - Protocols: SSL and TLS. - Certification in the Web.
7. Wireless security and AAA protocols.	- Threats to security in wireless environments. - Wireless Application Protocol (WAP). WTLS. Protocols WEP, WPA, WPA2, WPA3. - AAA Protocols: RADIUS.
8. Systems Security.	- Firewalls and systems against intrusions. - Malicious software and networks. - Forensic analysis of systems.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	21	38	59
Autonomous problem solving	0	10	10
Mentored work	6	28	34
Laboratory practical	11	22	33
Laboratory practice	1	0	1
Essay	1	0	1
Essay questions exam	1	5	6
Essay questions exam	1	5	6

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Exhibition by means of powerpoint presentations and blackboard of the theoric contents of the course. They will develop the theoretical subjects of the matter that do not remain covered by the others methodologies employed. In those subjects considered indispensable, will pose and will resolve some exercises that serve of help for the realisation of other similar by the student of autonomous form. With this methodology, student will adquire part of CG3 y CE28 competences.
Autonomous problem solving	The student will solve in an autonomous form the exercises, cuestions or problems of the bulletin not solved in the face-to-face hours. The doubts arisen will be agreed and will be exposed to the tutor in normal tutor time. This methodology is aimed to CG4 and CE28 competences.

Mentored work	Work in group. Several theoretical and practical works to develop will be explained to the students, between which each group will have to choose one. In the C class type, will expose to each group the aims of the work, hardware and software tools to use, form to tackle it and will realise a follow-up to each group. This methodology, is aimed to adquire part of CG4,CG6, CE28, CT2 and CT3 competences.
Laboratory practical	Work in group. The group will developed some practices in the laboratory, focused to mature and carry to practice the theoretical concepts , as to improve his ability for the engineering of secure networks and services. This methodology, is aimed to CG6, CE28, CT2 and CT3 competences.

Personalized assistance

Methodologies	Description
Laboratory practical	Individualized monitoring of each group work. Comments of diverse options, recommendations and strategies for the good development of the project. Reviews with each group the level of understanding and advance of the project, particular doubts that can arise, design and Java coding errors. Help for the understanding of the JCA/JCE and JSSE packages. Individualized help for instalation of the keystore management tool and of the basic Java code of the practice. On the subject's website at Moovi (https://moovi.uvigo.gal), you can find instructions on how to request tutoring.
Mentored work	Individualized monitoring of each student in the group. General comments to the group of recommendations and strategies for the good development of the project. Reviews with each group of the level of understandings and advance of the project, particular doubts that can arise, design or approach errors and options of improvement. On the subject's website at Moovi (https://moovi.uvigo.gal), you can find instructions on how to request tutoring.
Autonomous problem solving	Reviews and comments of the diverse exercises proposed. The student will have in Faitic with the solucion to some of the proposed exercises. On the subject's website at Moovi (https://moovi.uvigo.gal), you can find instructions on how to request tutoring.

Assessment

	Description	Qualification	Training and Learning Results		
Laboratory practice	Proof of group in which the teacher will value laboratory practises, reviewing his operation with the members of the group. This proof will be made in the last or previous to last week of the four-month period as it will be published in Moovi platform in the firsts weeks of the four-month period. All the members of the group have to be present at the moment of the presentation. The teacher will do an authorship interview of which the level of participation of each student will be deduced and of which, together with the correct operation, the individual mark of each student will be determined.	25	B6	C28	D3
Essay	Assessment of the tutored project or work realised by the group (type C). The group will do a demonstration to the teacher of the project or work done and results obtained. This proof will be made in the last or previous to last week of the four-month period as it will be published in Moovi platform in the firsts weeks of the four-month period. All the members of the group have to be presents in the moment of the presentation. The teacher will do an authorship interview of which the level of participation of each student in the proyect will be deduced and of which, together with the correct operation, the individual mark of each student will be determined.	25	B4 B6	C28	D2 D3
Essay questions exam	Final exam of the course. This exam will consist of a group of exercises/questions on the contents given in the course.	25	B3 B4	C28	
Essay questions exam	Partial exam of the course, neccesary for students that follow continuos evaluation. This exam will consist of a group of exercises/questions on the contents given until aproximately the middle of the theoretic course.	25	B3 B4	C28	

Other comments on the Evaluation

- CHOICE OF CONTINUOUS ASSESMENT.

  By default, it will be assumed that the students opt for continuous assessment (CA). If a student wishes to opt for global assessment (GA), they must inform the teaching staff before the end of week 5 of the semester. The communication must be made via email to the teaching staff.

- **ORDINARY OPPORTUNITY.**

  Continuous Assessment. The continuous assessment (CA) will be formed by:

  1. Laboratory Assignment B, representing 25% of the grade. This assignment must be submitted via Moovi. The specific submission date will be posted on Moovi in the first weeks of the semester, following a coordination meeting with the other subjects.

  2. Project C, representing 25% of the grade. This project must be submitted via Moovi. The specific submission deadline will be posted on Moovi in the first weeks of the semester, following a coordination meeting with the other subjects.

  3. Midterm exam covering the content taught up to approximately the middle of the semester, representing 50% of the total theory grade. This exam will be averaged with the final exam if the student scores a minimum of 4 out of 10 points. If the student scores below this, they will need to be reassessed on this part in the final exam.

  4. The scheduling of the different interim assessment tests will be approved by a Degree Academic Committee (CAG) and will be available at the beginning of the semester.

  5. Final theoretical exam, on the date agreed upon in the School Board meeting. There will be two cases:

     - Students who have passed the minimum grade on the midterm exam. This exam will cover topics taught from approximately the middle of the semester to the end. It will account for 25% of the total grade. To pass the course, students must achieve a minimum score of 4 out of 10 on this exam.
     - Students who have not achieved the minimum grade on the midterm exam. This exam will cover all topics covered in the theoretical course. It will account for 50% of the total grade. To pass the course, students must achieve a minimum score of 4 out of 10 on this exam, with at least 4 points in each of the two parts of the exam.

  Global Assessment. The global assessment (GA) will be formed by:

  1. A final theoretical exam worth 75% of the grade, consisting of two parts, will be held on the same day and time as the CA exam.
  2. Lab practices B, which will account for the remaining 25%, must be submitted via Moovi, with the deadline on the same day as the CA exam.
  3. To pass the course, students must achieve a minimum of 4.5 points out of 10 in each of the two parts of the theoretical exam. They must also earn at least 1 point out of 2.5 in lab practices B.

  The final exam will be the same for all students, both those opting for continuous assessment and those opting for global assessment.

- **EXTRAORDINARY OPPORTUNITY.**

  For students who have opted for continuous assessment during the semester, the total grade will be determined as follows:

1. 50% from the theoretical part, 25% from lab practices B, and 25% from project C.
2. From the regular opportunity, the grades of the partial and final theoretical exams (provided they have met the minimum grade), lab practice B (provided the minimum has been met), and project C will be retained.
3. All students who have not achieved the minimum theoretical grade in either part of the regular opportunity must take the theoretical exam in this retake. However, they only need to take the part or parts where they did not meet the minimum. It is mandatory to score a minimum of 4 out of 10 in any part taken to pass the course.
4. Students who did not submit lab practice B in the regular opportunity or did not achieve the minimum grade in this part must complete and submit the same lab practice as in the regular opportunity. The deadline for submission will be the same as the day and time of the theoretical exam. It is mandatory to score a minimum of 1 point out of 2.5 in this part to pass the course.
5. Students who did not submit project C in the regular opportunity must take a written test on the same day as the theoretical exam, which will contribute 25% to the total grade. Therefore, there will be no actual submission of project C.

For students who have chosen global assessment in the regular opportunity, there will be a final exam worth 75%, along with lab work B representing 25%. The grade from the theoretical exam in the regular opportunity (provided it meets the minimum of 4.5 points) and lab work B (provided it meets the minimum of 1 out of 2.5 points) will be retained.

- **OTHER OBSERVATIONS.**
    - An student will be marked as "Not Present" if they have not followed continuous assessment and have not attended the final theoretical exam. Similarly, if a student is on CA and does not attend any exam (A, B, and C), they will be considered "Not Present."
    - Grades obtained in lab practice B and project C will only be valid during the academic year in which they are completed.
    - If the total grade is equal to or greater than 5 but the minimum grade has not been reached in any part, the final grade will be 4.9 points (fail).
- **ANNOUNCEMENT OF END OF CAREER.**
    - The evaluation in the end-of-degree session will consist of:
        - Theoretical exam (50%): Individual exam covering the course content, representing 50% of the total grade. Students must achieve a minimum score of 4 points (in each of the two parts of the exam) out of 10 to pass the course.
        - Lab work B (25%): Represents 25% of the grade, with a minimum requirement of 1 point out of 2.5.
        - Project C (25%): Represents 25% of the grade.

Sources of information
Basic Bibliography
F. Fernandez Masaguer, **Apuntes de Seguridad en Redes y Sistemas de Informacion,**, 1ª ed., 2024
William Stallings, **Cryptography and Network Security. Principles and practice.,**, 8ª, Pearson, 2020
Complementary Bibliography
Joseph Migga Kizza,, **Guide to Computer Network Security**, 4ª Ed, Springer, 2015
M. Laurent Maknavicius, **Wireless and Mobile Network Security**, 1ª Ed, Wiley, 2014
R.Perlman, C. Kaufman, M.Speciner, **Network Security: Private communications on a public world,**, 2ª Ed, Prentice Hall, 2002
Enisa, **Botnets: Detection; Measurement, Disinfection & Defence,**, Enisa, 2011

Recommendations

Subjects that are recommended to be taken simultaneously

Architectures and Services/V05G301V01310
Internet Services/V05G301V01301

Subjects that it is recommended to have taken before

Programming II/V05G301V01110

IDENTIFYING DATA				
Distributed and Concurrent Programming				
Subject	Distributed and Concurrent Programming			
Code	V05G301V01306			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish			
Department				
Coordinator	García Duque, Jorge			
Lecturers	García Duque, Jorge			
E-mail	jgd@det.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The main goal of this subject is to provide the foundations of the synchronisation and communication among processes in centralised and distributed systems.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C33	CE33/TEL7 The ability to program network and distributed applications and services.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Ability to design and develop concurrent and distributed systems.	B4 B9	C33	
Understanding of the main theoretical concepts of the concurrent and distributed systems.	B3		D2 D3 D4
Knowledge of the main tools and surroundings for the development of concurrent and distributed systems.	B4 B9	C33	

Contents	
Topic	
Introduction to Concurrent Programming	Concepts of concurrence, parallelism and multitasking. Interleaving of atomic instructions. Precedence graphs.
The critical section problem	The definition of the problem. Busy waiting. Starvation Deadlock. Dekker´s algorithm. Peterson´s algorithm

Concurrent Programming Constructs	Semaphores. The problem of the producer-consumer. The problem of the philosophers. Monitors. Variables of Condition. The problem of the readers-writers.
Deadlock	Introduction and definition of deadlock. Necessary conditions. Deadlock prevention. Deadlock avoidance. Detection and Recovery
Communication among processes	Message Passing. Remote Procedure Call (RPC).
Distributed Programming	Introduction to Distributed Systems. Distributed mutual exclusion Ricart-Agrawala Algorithm. Token ring Algorithms. Consensus: Crash Failures. Byzantine Failures.

Planning

	Class hours	Hours outside the classroom	Total hours
Workshops	5	30	35
Practices through ICT	13	26	39
Lecturing	20	46	66
Objective questions exam	0.25	0	0.25
Laboratory practice	1	0	1
Essay	2	6	8
Objective questions exam	0.25	0	0.25
Objective questions exam	0.25	0	0.25
Objective questions exam	0.25	0	0.25

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Workshops	Each group of students will tackle the design and implementation of a project software of half complexity. Said task will make in different successive steps, that will be discussed and validated in each one of the face-to-face sessions. This methodology of work has like aim provide a suitable *realimentación for, if it is timely, improve the solutions posed. This methodology is oriented to purchase the competitions *CG4, *CG9 and *CT4
Practices through ICT	The students will resolve under the supervision of the *profesorado the practical problems that pose in each session of laboratory. This methodology is oriented to purchase the competitions *CE33/*TEL7 and *CT3
Lecturing	Exhibition of the ideas, concepts, technical and algorithms of each lesson of the *temario. This methodology is oriented to purchase the competitions *CG3 and *CT2

Personalized assistance

Methodologies	Description
Lecturing	By means of tutoring https://moovi.uvigo.gal/user/profile.php?id=11338
Workshops	Part of the sessions devote to resolve individual questions with each student by means of individual questions so much by part of the professor as of the student https://moovi.uvigo.gal/user/profile.php?id=11338
Practices through ICT	Of complete way for the students that do the practices of individual way, and by means of the resolution of individual questions with each student by means of questions *individualizadas so much by part of the professor as of the student https://moovi.uvigo.gal/user/profile.php?id=11338

Assessment

	Description	Qualification	Training and Learning Results		
Objective questions exam	Proof of theoretical contents exposed in the master classes.	12.5	B3 B4	C33	D2

Laboratory practice	Evaluation of the work carried out in each one of the sessions of laboratory For the individual evaluation of each student, personalised questions will be asked in each one of the sessions.	20	B3 B4	C33	D2 D3
Essay	In the last face-to-face session of workshop, students will deliver and will expose to their mates the design and the proposed solution for their project. This solution will be exposed to debate for students and professors For the individual evaluation of each student will realise personalised questions in each one of the sessions.	30	B9	C33	D3 D4
Objective questions exam	Proof of theoretical contents exposed in the master classes.	12.5	B3 B4	C33	D2
Objective questions exam	Proof of theoretical contents exposed in the master classes.	12.5	B3 B4	C33	D2
Objective questions exam	Proof of theoretical contents exposed in the master classes.	12.5	B3 B4	C33	D2

Other comments on the Evaluation

The subject can surpass by means of Continuous Assesment according to the criteria that indicate more advance, having opened the possibility to opt by the Exam-only assessment anytime until the beginning of the final examination to celebrate the day fixed to such effect in the official calendar of the *EET.

All those students that opt by the continuous evaluation will consider presented in the part of the work in Workshops.

Continuous assesment:

The final note will result of the sum of the corresponding notes to the three following components:

1. Four proofs of type Test to evaluate the contents given in the masterclasses. Each proof will take place in one of the sessions *magistrales, except the last that will carry out in one of the sessions of the Workshop.

Score: Until 1,25 points each proof.

2. Six Practical Proofs that will carry out when finalising each one of the sessions of laboratory and that will consist in the **validation of the results obtained during the said session.

Score: Until 1/3 points. Each proof.

3. Presentation of the Project proposed like work in the sessions of the Workshop.

Score: Until 3 points.

To approve the subject by Continuous Evaluation will have to give the three following conditions:

(*i) Obtain an equal or upper qualification to 2 points in the group of the tests.;
(*ii) Upper qualification to 0 points in, at least, four of the six practical proofs; and
(*iii) Assist to all the face-to-face sessions of workshop and obtain more than 0 points in the presentation of the project.

In case of not fulfilling any of said condition, the final note of the student will be limited to a maximum of 4,9 points.

Global assessment:

By means of an examination on 10 points fixed in the official calendar of the *EET.

Extraordinary exam and End-of-program exam:

It will govern by the indicated for the Global assessment.

Sources of information

Basic Bibliography

M. Ben-Ari, **Principles of Concurrent And Distributed Programming**, Second Edition,

Complementary Bibliography

George Coulouris, Jean Dollimore, Tim Kindberg and Gordon Blair, **Distributed Systems Concepts and Design**, Fifth Edition,

William Stallings, **Operating Systems: Internals and Design Principles, 6/E**, Eight Edition, Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, **Operating system concepts**, Ninth Edition,

Lea, Douglas, **Programación concurrente en Java : principios y patrones de diseño**, Second Edition,

Recommendations

Subjects that it is recommended to have taken before

Programming I/V05G301V01105

Programming II/V05G301V01110

IDENTIFYING DATA				
Network and Switching Theory				
Subject	Network and Switching Theory			
Code	V05G301V01307			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish			
Department				
Coordinator	Suárez González, Andrés			
Lecturers	López García, Cándido Antonio Suárez González, Andrés			
E-mail	asuarez@det.uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The objective pursued with this course is that students acquire mastery of the basic methods of analysis for predicting the performance of networks, services and telecommunication systems, in terms of the amount of traffic they carry, the physical structure of the system and the way it is interconnected, the capacity of its constituent network elements and the algorithms used in them.			

Training and Learning Results	
Code	
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
C28	CE28/TEL2 The ability to apply the techniques that are basis of computer networks, services and applications, such as management, signaling and switching, routing and securing systems (cryptographic protocols, tunneling, firewalls, charging mechanisms, authentication and content protection) traffic engineering (graph theory, queuing theory and teletraffic) rating, reliability and quality of service in both fixed, mobile, personal, local or long distance environments with different bandwidths, including telephony and data.
C31	CE31/TEL5 The ability to follow the technological progress of transmission, switching and processing to improve computer networks and services.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
Ability to apply mathematical methods of queueing theory to the analysis and design of telecommunication networks and systems.	B5	C28 C31
Ability to understand the basic compromises in designing telecommunication networks and systems in function of the parameters of traffic.	B5	C28 C31
Ability to use methods of discrete mathematics to resolve problems of routing and interconnection of networks, reliability, quality of service and distribution of contents in wired and wireless networks, fixed and mobile networks, access and transport networks.	B5	C28 C31
Mastery of the necessary basic concepts to resolve problems of resource optimization in networks.	B5	C28 C31

Contents	
Topic	
Queuing Theory	One-server systems. Finite queue systems. Systems with congestion: models of Erlang and Engset. Reversibility. Networks of queues with product solution. Applications: design of link capacity; design of buffer size; congestion in cellular networks; analysis of systems with priorities; provision of ARQ; provision of multiaccess networks.

Graph theory	Graph traversal and connectivity. Minimum cut, maximum flow. Tree coverage and expansion. Minimum cost trees. Graph coloring. Results and uses. Regular and irregular random graphs: small world networks, scale-free networks. Applications: Network topology design, the web graph, message broadcasting in wired networks and ad hoc networks.
Network Optimization	Utility Maximization. NUM decomposition problems. Applications.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	19	42	61
Practices through ICT	4	6	10
Problem solving	8	12	20
Project based learning	7	35	42
Essay questions exam	2	6	8
Problem and/or exercise solving	2	7	9

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	It will present a systematic theoretical approach to the subject, highlighting the objectives, key concepts and relationships between different topics. Students should assimilate knowledge to enable them in the CG5, CE28/TEL2 and CE31/TEL5 competencies.
Practices through ICT	Guided practice where it is intended to study problems by both by applying analytical techniques and by using software tools, providing a training in the use of the latter. So students should acquire practical training in the CE28/TEL2 competency.
Problem solving	Resolution in detail of a series of selected problems and/or exercises, focused on both the theoretical concepts involved and the methodology to be employed. Students should assimilate knowledge to enable them in the CE28/TEL2 competency.
Project based learning	Group work focused on studying and solving a real problem using the techniques studied in theory and the software tool seen in practice. So students should gain practical experience that will enable them on the CE31/TEL5 competency.

Personalized assistance

Methodologies	**Description**
Lecturing	The student may consult individually in the tutoring aid (https://moovi.uvigo.gal/user/profile.php?id=11340 and https://moovi.uvigo.gal/user/profile.php?id=11339) all doubts that arise in the study of the theoretical content.
Practices through ICT	The student may consult individually both in the practice time and in the tutoring aid (https://moovi.uvigo.gal/user/profile.php?id=11340 and https://moovi.uvigo.gal/user/profile.php?id=11339) all doubts that arise in the use of the software tools of the practices.
Project based learning	The student may consult individually in the tutoring aid (https://moovi.uvigo.gal/user/profile.php?id=11340) all doubts that arise both in applying the theoretical concepts and in the use of the software tools used in the projects.

Assessment

	Description	Qualification	Training and Learning Results	
Project based learning	Group work, presentation and defense of the resolution of a typical real-world problem by applying both theoretical knowledge as using, where appropriate, the software tools used in practical classes.	20		C28 C31
Essay questions exam	Test over part of the subject themes. Questions and problems either of conceptual, logical, analytical or applied character. It will be a half and an hour long written test.	40	B5	C28 C31

Problem and/or exercise solving	Test over part of the subject themes. Questions and problems either of conceptual, logical, analytical or applied character. It will be a half and an hour long written test.	40	B5	C28 C31

Other comments on the Evaluation

It is left to the discretion of the students two alternative evaluation methods in the subject: continuous assessment and exam-only assessment.

Selection of continuous assessment involves conduct of a no-scoring short test (15 minutes) of basic knowledge. It will take place during the first two weeks of class. In addition to this short test, the continuous assessment will consist of the group development of one project and the individual resolution of two partial tests (40% of the overall grade each). The individual qualification in the project will depend as much on the joint qualification of the report of the project as on personal interviews (arranged from the delivery on) to the members of the group. The qualification of the project and of the exercises is effective only in the course they are done, including the extraordinary call at the end of the academic year. In any case, the score on the continuous assessment evaluation (once the requirement at the beginning of this paragraph is met) is given by: either score_1 = 0.2 x project + 0.4 x partial_1 + 0.4 x partial_2) if both partial scores are higher than 2.5 or failed score with score_2 = minimum(4.9, score_1) if not.

The exam-only assessment (only choice on end-of-program call) will consist of a written examination on the contents of the subject. The final grade will be the score obtained in this exam. This exam will include (exam-only assessment) one or several questions about the computer tools presented in the laboratory, evaluating a minimum on the CE28/TEL2 competency.

All students who have either attended both partial tests or a final exam will be subjected to a final qualification in that call. Exam-only assessment is selected for whenever either the project is not submitted or the final exam is attended. Those who fail the course at the ordinary call opportunity at the quarter end have an extraordinary one at the end of the academic year, similar to the first call.

Sources of information

Basic Bibliography

Pazos Arias, J.J., Suárez González, A., Díaz Redondo, R.P., **Teoría de colas y simulación de eventos discretos**, 2003,

M.J. Newman, **Networks**, 2012,

Complementary Bibliography

Villy B. Iversen, **TELETRAFFIC ENGINEERING and NETWORK PLANNING**, 2011,

Boyd, S., Vandenberghe, L., **Convex Optimization**, 2009,

Recommendations

Subjects that it is recommended to have taken before

Mathematics: Probability and Statistics/V05G301V01107
Data Communication/V05G301V01204
Computer Networks/V05G301V01210

IDENTIFYING DATA

Multimedia Networks

Subject	Multimedia Networks			
Code	V05G301V01308			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Herrería Alonso, Sergio			
Lecturers	Herrería Alonso, Sergio López García, Cándido Antonio			
E-mail	sha@det.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This subject presents the main specific technologies for distributing multimedia contents over telecommunication networks. English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results

Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
C30	CE30/TEL4 The ability to describe, program, assess and optimize communication protocols and interfaces at different network architecture layers .
C33	CE33/TEL7 The ability to program network and distributed applications and services.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
The understanding of the basics of digital audio and video coding, and the knowledge of the standards in the field.	B3 B6		
The knowledge and understanding of the main problems raised in the transmission of multimedia content.	B3	C30	D3
The knowledge and understanding of the main mechanisms used to provide quality of service in the Internet.	B3	C30	D3
In-depth study and analysis of IP telephony networks, mainly in the field of signaling, coexistence with the traditional telephone service and integration with the latest generation of cellular networks.		C30 C33	

Contents

Topic	
Digital Audio and Video Encoding	a) Digital audio (PCM). Audio compression b) Digital video. Intraframe and interframes compression
Multimedia Applications	a) Classes. Quality of service requirements b) Impact of delay and packet losses c) Content distribution. Multicast. CDN d) IP telephony: architecture, codecs, softphones
Multimedia Protocols	a) Transport protocols: TCP/UDP, RTP, HTTP b) Adaptive streaming. MPEG-DASH c) Session protocols: SIP, H.323, RTSP
Quality of Service in the Internet	a) Monitoring and policing techniques b) Scheduling and resource allocation c) Differentiated Services (DiffServ) d) Integrated Services (IntServ). RSVP

Asterisk IP PBX	a) Installation and basic configuration b) Configuration of the dialplan c) Functionalities: voicemail, interactive menus, music on hold

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	20	40	60
Practices through ICT	10	20	30
Mentored work	6	24	30
Problem and/or exercise solving	1.5	6	7.5
Project	3	12	15
Problem and/or exercise solving	1.5	6	7.5

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Exhibition of the ideas, concepts and techniques of each topic of the course. In these sessions, students must acquire competences CG3, CG6 and CE30.
Practices through ICT	Practical learning of basic tools for the distribution of multimedia contents on computer networks. Group activity. In these sessions, students must acquire competences CE30, CE33 and CT3.
Mentored work	Configuration, with the teacher's guidance, of a basic IP PBX. Group activity. This work should help students to acquire competences CE33 and CT3. Software to be used: Asterisk.

Personalized assistance

Methodologies	**Description**
Lecturing	Personalized assistance will be provided in person and/or remotely by email, Moovi forums or Campus Remoto. Sergio Herrería Alonso: https://moovi.uvigo.gal/user/profile.php?id=11341 Cándido López García: https://moovi.uvigo.gal/user/profile.php?id=11339
Practices through ICT	Personalized assistance will be provided in person and/or remotely by email, Moovi forums or Campus Remoto. Sergio Herrería Alonso: https://moovi.uvigo.gal/user/profile.php?id=11341
Mentored work	Personalized assistance will be provided in person and/or remotely by email, Moovi forums or Campus Remoto. Sergio Herrería Alonso: https://moovi.uvigo.gal/user/profile.php?id=11341

Assessment

	Description	Qualification	Training and Learning Results		
Problem and/or exercise solving	A midterm exam covering some of the content of the subject. Questions and problems of conceptual, logical, analytical or applied nature. A written exam of one and a half hours duration.	35	B3 B6	C30	
Project	Evaluation of the features and performance of the IP PBX configured during the course.	30		C33	D3
Problem and/or exercise solving	A midterm exam covering some of the content of the subject. Questions and problems of conceptual, logical, analytical or applied nature. A written exam of one and a half hours duration.	35	B3 B6	C30	

Other comments on the Evaluation

Students are offered two different methods of assessment: continuous assessment and global assessment.

Students opting for continuous assessment will be required to complete three assignments: two midterm exams (each worth 35% of the final score) and a project involving the configuration of a basic IP PBX (30% of the final score). In any case, a minimum score of 3 (out of 10) in each of the assignments is required to pass. Students who score more than five points in the overall score but less than the minimum score in any of the tasks will receive a FAIL (4.9). The score of the project will depend on the functionality and performance of the developed IP PBX (60%) and the answers to a practical exam solved individually by each member of the group (40%). None of the three assignments are recoverable and all are valid only for the current course.

Students can also opt for a global assessment, in which case they will be evaluated by means of just one final exam covering all the contents of the subject at the end of the course. In this case, the final score of the subject will be the score obtained on that exam.

Students will be considered to have opted for continuous assessment if they take the first midterm exam or the IP PBX project. Only students who take the second midterm exam (or the final exam in case of global assessment) will be considered presented to the subject.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the three tasks, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Those who have not passed the subject after the ordinary opportunity will have to take, for the extraordinary opportunity, a written exam that will cover all the contents of the course. For this opportunity, the score obtained in the project can be kept, with the same weighting as in the ordinary opportunity.

For the end-of-program exams the assessment will just consist in the realization of a written exam covering all the contents of the course.

The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester.

Sources of information
Basic Bibliography
I. Vidal, I. Soto, A. Banchs, J. García-Reinoso, **Multimedia Networking: Technologies, Protocols and Architectures**, 1ª ed., Artech House Publishers, 2019
Z. Li, M. Drew, J. Liu, **Fundamentals of Multimedia**, 2ª ed., Springer, 2014
Kun I. Park, **QoS in packet networks**, 1ª ed., Springer, 2005
R. Bryant, L. Madsen, J. Van Meggelen, **Asterisk: the definitive guide**, 5ª ed., O'Reilly Media, 2019
Complementary Bibliography
J. F. Kurose, K. W. Ross, **Computer networking: a top-down approach**, 8ª ed., Pearson, 2021
H. W. Barz, G. A. Bassett, **Multimedia networks: protocols, design, and applications**, 1ª ed., Wiley, 2016
M. Barreiros, P. Lundqvist, **QoS-enabled networks: tools and foundations**, 2ª ed., Wiley, 2016
Bruce Hartpence, **Packet Guide to Voice over IP**, 1ª ed., O'Reilly Media, 2013
Alan B. Johnston, **SIP: Understanding the Session Initiation Protocol**, 4ª ed., Artech House Publishers, 2015

Recommendations
Subjects that continue the syllabus
Multimedia services/V05G301V01401

Subjects that it is recommended to have taken before

Fundamentals of Sound and Image/V05G301V01209
Computer Networks/V05G301V01210

IDENTIFYING DATA				
Information Systems				
Subject	Information Systems			
Code	V05G301V01309			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish			
Department				
Coordinator	García Duque, Jorge			
Lecturers	García Duque, Jorge			
E-mail	jgd@det.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The aim of this subject is to introduce to the student in the main technologies to process and store the information, like central element of the telematic services			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C27	CE27/TEL1The ability to construct, operate and manage telecommunication networks, services, processes and applications considered as systems to receive, transport, represent, process, store, manage and present multimedia information from the computer services point of view.
C29	CE29/TEL3 The ability to build, operate and manage computer services using planning, sizing and analytical tools
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Know the main mechanisms of organisation of the information for their storage and process.		C27	
Know the main mechanisms of research, recovery and presentation of the information.		C27	
Comprise the concept of metainformatión and its main applications in the new telematic services.		C27	
Capacity to design and implement a database using current models.		C29	
Comprise the importance of information management like a basic support element for telematic services.	B3	C29	D3
Skill to select the mechanisms of information management more suitable for a problem.	B4 B6	C27	D2
Capacity to build telematic services based in stored information.	B4 B6 B9	C29	D2 D4

Contents	
Topic	
Introduction and general perspective of the Systems of Information.	- Concepts of system of information and database. - Types of systems of information. - Concept of Managing System of Databases. - Models of databases. - The process of design of a database.

Design of Relational Databases: Conceptual Model.	- Aims of the conceptual design. - Conceptual models of databases. - The E-A model.
Design of Relational Databases: Logical Model.	- Concept of the logical design. - Logical models of databases. - The relational model. - Relational algebra. - Normalisation of databases.
Database Management Systems.	- Physical storage of the data. - Organisation of data in files. - Indexes and associations. - Management of the integrity of the data. - Consistency. - Concepts related with the security. - Optimisation of queries.
Other information systems.	- No relational databases. - Semistructured information Processing. - No-structured information Processing. - Semantic information processing.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	20	46	66
Practices through ICT	13	26	39
Workshops	5	30	35
Objective questions exam	0.33	0	0.33
Laboratory practice	1	0	1
Essay	2	6	8
Objective questions exam	0.33	0	0.33
Objective questions exam	0.33	0	0.33

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Presentation of the ideas, concepts, technics and algorithms of each lesson. This activity develops CG3, CG4, CG6, CT2 and CT3 competencies.
Practices through ICT	The students will resolve practical problems under supervision of teachers. This activity develops CG4, CT2, CE29 and CE27 competencies.
Workshops	Each group of students will tackle the design and implementation of a software project with half complexity. This task will be realised in successive steps, that will be discussed and validated in the face-to-face sessions. The aim of this methodology is to provide a suitable feedback to improve the proposed solutions. This activity develops CG4, CG9, CT2, CT4 and CE27 competencies.

Personalized assistance

Methodologies	**Description**
Workshops	The professor will be present during the realisation of the workshops, answering all the doubts that can arise to the students. https://moovi.uvigo.gal/user/profile.php?id=11338
Practices through ICT	The professor will be present during the realisation of the practices, answering all the doubts that can arise to the students. https://moovi.uvigo.gal/user/profile.php?id=11338
Lecturing	In the development of the master sessions, the students will be able to interrupt and formulate all the questions or doubts that can arise them. https://moovi.uvigo.gal/user/profile.php?id=11338

Assessment

	Description	Qualification	Training and Learning Results		
Objective questions exam	Proof of theoretical contents exposed in the master classes.	16.66	B3 B4 B6		D2 D3
Laboratory practice	Evaluation of the work carried out in the sessions of laboratory.	20	B4	C27 C29	D2

Essay	In the last face-to-face session of workshop, students will deliver and will expose to their mates the design and the proposed solution for their project. This solution will be exposed to debate for students and professors. The professor will do questions for each member of the group, what will allow his individual evaluation.	30	B4 B9	C27	D2 D4
Objective questions exam	Proof of theoretical contents exposed in the master classes.	16.66	B3 B4 B6		D2 D3
Objective questions exam	Proof of theoretical contents exposed in the master classes.	16.68	B3 B4 B6		D2 D3

Other comments on the Evaluation

The subject can be surpassed by means of Continuous Evaluation according to the following criteria. All those students that opt by the continuous evaluation will consider presented if they assisted in the practical proofs of the Laboratory.

Continuous assesment:

The final mark will result of the sum of the corresponding notes to the three following components:

1. Three proofs of type short answer questions to evaluate the contents given in the masterclasses. Each proof will take place in one of the master classes , except the last that will carry out in one of the sessions of the Workshop.

Score: Up to 5/3 points each proof. (T=t1+t2+t3)

2. One Practical Proofs that will carry out at the last session of laboratory.

Score: Up to 2 points. (L)

3. Presentation of the Project proposed like work in the sessions of the Workshop.

Score: Up to 3 points. (P)

To pass the subject by Continuous Evaluation will have to give the three following conditions: (i) obtain an equal or upper qualification to 2 points in the group of the tests.; (ii) Upper qualification to 0.75 points in the practical proof; and (iii) to attend all the face-to-face sessions and obtain more than 0 points in the presentation of the project. In the case to fulfil the three previous conditions, the final mark of the continuous evaluation will be the sum of the three components (Mark=T+L+P). If the student does not fulfil any of the three conditions, the mark of the continuous evaluation will be the minimum of the marks obtained in each one of the three components (Mark=min(T,L,P)), as long as it does not exceed five points in the overall Mark, in which case it will be graded with a score of 4.9 points in the Fail category.

Global assessment:

By means of an examination on 10 points scheduled in the official calendar of the EET.

Extraordinary exam and End-of-program exam:

It will be governed by the indicated for the Global assessment.

Sources of information

Basic Bibliography

Abraham Silberschatz, Henry Korth y S. Sudarshan, **Database System Concepts**, 6, McGraw-Hill, 2010

Anthony Molinaro, **SQL Cookbook**, 1, O'Reilly Media, 2005

Complementary Bibliography

Ramez Elmasri y Shamkant Navathe, **Fundamentals of Database Systems**, 6, Addison Wesley, 2010

Hector Garcia-Molina, Jeffrey D. Ullman y Jennifer Widom, **Database Systems: The Complete Book**, 2, Prentice Hall, 2008

Jeffrey D. Ullman y Jennifer Widom, **A First Course in Database Systems**, 3, Prentice Hall, 2007

Chris J. Date, **An Introduction to Database Systems**, 8, Addison Wesley, 2003

Chris J. Date, **Database Design and Relational Theory: Normal Forms and All That Jazz**, 1, O'Reilly Media, 2012

Clare Churcher, **Beginning Database Design: From Novice to Professional**, 1, Apress, 2007

Rick A Morelan, **Beginning SQL Joes 2 Pros: The SQL Hands-On Guide for Beginners**, 1, BookSurge Publishing., 2009

Recommendations

IDENTIFYING DATA				
Architectures and Services				
Subject	Architectures and Services			
Code	V05G301V01310			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Mikic Fonte, Fernando Ariel			
Lecturers	Mikic Fonte, Fernando Ariel			
E-mail	mikic@det.uvigo.es			
Web	http://moovi.uvigo.es			
General description	This course focuses on the architectonic solutions for the design of telematic services. More specifically, the course is oriented to scenarios based on services (service-oriented architectures) and the deployment of SOA and RESTful solutions by means of Web Services Technologies. Taking the Web Services as our techonological layout, the course focuses on the description, discovery and invocation of services in SOA and ReSTful. Finally, the course introduces models for services composition in SOA and RESTful (again using Web Services as deployment technology). This subject will be taught in Spanish and Galician.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
C29	CE29/TEL3 The ability to build, operate and manage computer services using planning, sizing and analytical tools
C32	CE32/TEL6 The ability to design networks and service architectures.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
To know the main architectures for telematic services of medium & high complexity.	B3 B6	C29 C32	D2 D3
To understand the concept of middleware as a supporting element for services, and to know the main models used today.	B3	C29 C32	
To understand the importance and utility of web services for the development of telematic services.	B6	C29 C32	
To know the main technologies to build complex services by combining other services.	B6	C29 C32	
To master the basic concepts and technologies associated with the management of telematic services.	B3	C29 C32	
To acquire skills to build complex telematic services.	B4		D2 D3

Contents	
Topic	
Theory: Infrastructure for distributed computing	Distributed systems and y Middleware. Types of distributed systems. Architectural patterns. Inter-process communication.

Theory: SOA and Web Services / WSDL	SOA Web Services. WSDL.
Theory: SOAP (Simple Object Access Protocol)	History. Core items. Messages. Coding and interaction. Error management.
Theory: RESTful Web Services	JSON. REST. Node.js. Non-SQL Databases. Angular.
Theory: Microservices	Case study: Netflix. Architectures. Decomposition of monolithic systems into microservices. Design. Communication between microservices. Data management. Deployment.
Practice: Creating and managing RESTful web services using the MEAN stack.	Installation. Development and deployment of a web service. Development and deployment of web microservices.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	15	45	60
Project based learning	14	20	34
Presentation	1	2	3
Workshops	2	1	3
Gamification	2	2	4
Project based learning	6	38	44
Objective questions exam	1	0	1
Objective questions exam	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Classes that will expose the concepts to be treated in the subject. The aim is to encourage discussion and reinforce the acquisition of skills (B3, C29, C32).
Project based learning	The students, in groups, will develop a software system with specific requirements. The follow-up of the project will be carried out during the B and C sessions (B4, B6, C29, C32, D2, D3).
Presentation	Each workgroup will justify in a presentation the adopted solution for the course project and its performance (B4, D2, D3).
Workshops	Introductory workshop on technologies commonly used in the companies (B3, B6, C32, D2).
Gamification	Test-type exercises to carry out formative assessment (not taken into account for the final grade of the subject), and promote participation and attendance in class (B3, D3).
Project based learning	The students, in groups, will develop a software system with specific requirements. The follow-up of the project will be carried out during the B and C sessions (B4, B6, C29, C32, D2, D3).

Personalized assistance

Methodologies	Description
Lecturing	Tutorships: https://moovi.uvigo.gal/user/profile.php?id=11299
Project based learning	The students, organized in groups, develop a project that addresses the design and implementation of a service-oriented architecture. Personalized attention related to these projects will take place in the sessions type C in the course. In each session of personalized attention, groups would discuss with the teacher the following questions concerning the progress of the project: What work has been addressed since the previous meeting? What problems have been found? What problems have not been solved? and What is the planning of future work?
Workshops	The students, individually, will carry out the installation and different tests and developments of a technology used in the companies. All this with the help of the teacher who will act as a guide in each of the steps of the process.

Gamification	Realization of a kind of multiple choice exam on the contents seen in each topic of the subject, in which different types of elements of gamification are included. The teacher may offer, individually to each student, explanations about the answers made.

Assessment

	Description	Qualification	Training and Learning Results
Project based learning	Each working group will deliver a preliminary part of the project of the subject. The delivery will consist of design, implementation and documentation. After each delivery, a practical test will be carried out on the part implemented by each of the groups. This test will be individual, including modifications of the delivered project.	15	B4 C29 D2 B6 C32 D3
Presentation	Each workgroup will justify in a presentation the solution adopted in the project. They also will give to the teachers an explanation about the project. Questions will be asked to each member of the group individually to verify the involvement of each student in the project.	5	B4 D2 D3
Project based learning	Each working group will deliver the final project of the subject. The delivery will consist of design, implementation and documentation. After each delivery, a practical test will be carried out on the part implemented by each of the groups. This test will be individual, including modifications of the delivered project.	30	B4 C29 D2 B6 C32 D3
Objective questions exam	An individual exam will take place in the date indicated by the Comisión Académica de Grado (CAG) . The exam may include the following types of questions: problem solving, short questions to be solved by applying the theoretical concepts explained in class, reasoned justification if one or more statements are true or false, small tests on theoretical and application aspects. Books, class notes and other material will not be allowed during the exam. The number and combination of these questions will be set for each particular exam.	15	B3 C29 C32
Objective questions exam	An individual exam will take place in the date indicated in the official calendar of exams. The exam may include the following types of questions: problem solving, short questions to be solved by applying the theoretical concepts explained in class, reasoned justification if one or more statements are true or false, small tests on theoretical and application aspects. Books, class notes and other material will not be allowed during the exam. The number and combination of these questions will be set for each particular exam.	35	B3 C29 C32

Other comments on the Evaluation

In ordinary exam students can follow up a continuous assessment or a global assessment model. Once a student selects continuous assessment (joining a group of the practical part) his/her grade will never be not taken. In case of choosing continuous assessment, a period of 1 month is offered from that moment to be able to renounce it.

Final grade will be the sum of the grades obtained in the theoretical and practical part: (i) theoretical part (5 points) and (ii) practical assignments (5 points).

To pass the course, a final grade greater than or equal to 5 points is required, with a minimum grade for each of the parts (theoretical and practical) of 1.5 points. In the case of achieving a final grade greater than or equal to 5 points but the established minimum grades are not met, the final grade will be that corresponding to the maximum score within the Fail category (4.9).

- Theoretical part:
  1. Continuous assessment: EC1 exam (1.5 points) + EC2 exam (3.5 points).
  2. Global assessment: Final exam (5 points).
- Practical assignments:
  1. Continuous assessment: Practices Score * (Weighting factor / 10). Grade will be individual. Practices are mandatory.
     - Practices Score = Partial delivery of the project (1.5 points) + Presentation (0.5 points) + Project: design and final implementation (3 points).
     - Weighting factor = Follow-up by the teacher about the work carried out by each student observed in the classroom (0-10).
  2. Global assessment: Delivery of the project (5 points).

In extraordinary exam and end-of-program exam scheme is exactly the same as the global assessment (with the possible modifications of the project that will be specified at the convenient time).

The schedule of the intermediate exams/assignments will be approved in the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester. The EC2 exam and the Final exam will take place on the date published in the official calendar for the exam of the subject.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution

Sources of information

Basic Bibliography

Michael Papazoglou, **Web Services; SOA: Principles and Technology**, 1, Pearson Education, 2012

Valentin Bojinov, **RESTful Web API Design with Node.js**, 1, Packt Publishing, 2015

Bruno Joseph Dmello, **What You Need To Know About Node.js**, 1, Packt Publishing, 2016

Robert Daigneau, **Service Design Patterns: Fundamental Design Solutions for SOAP/WSDL and RESTful Web Services**, 1, Addison-Wesley Professional, 2011

Shannon Bradshaw, Eoin Brazil, Kristina Chodorow, **MongoDB: The Definitive Guide 3e: Powerful and Scalable Data**, 3, O'Reilly Media, Inc, USA, 2019

Adam Freeman, **Pro Angular 9: Build Powerful and Dynamic Web Apps**, 4, Apress, 2020

Complementary Bibliography

George F. Coulouris, **Distributed Systems: Concepts and Design**, 5, Addison Wesley, 2011

Harvey M. Deitel, Paul J. Deitel, B. DuWaldt, L. K. Trees, **Web Services: A Technical Introduction**, 1, Prentice Hall, 2002

Michael Rosen, **Applied SOA: Service-Oriented Architecture and Design Strategies**, 1, Wiley, 2008

Basarat Syed, **Beginning Node.js**, 1, Apress Ed., 2014

Recommendations

Subjects that it is recommended to have taken before

Internet Services/V05G301V01301

IDENTIFYING DATA				
Analogue Electronics				
Subject	Analogue Electronics			
Code	V05G301V01311			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Raña García, Herminio José			
Lecturers	Quintáns Graña, Camilo Raña García, Herminio José			
E-mail	hrana@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This subject studies the feedback concept, and its applications to amplifiers. The opamps and their applications are also studied. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
C42	(CE42/SE4): The ability to apply electronics as support technology in other fields and activities and not only in information and communication technologies.
C43	(CE43/SE5): The ability to design analogical and digital electronics circuits of analogical to digital conversion and vice versa, of radiofrequency, of feeding and electrical energy conversion for computing and telecommunication engineering.
C44	(CE44/SE6): The ability to understand and use feedback theory and electronic control systems.

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Knowledge of the techniques for feed-back amplifiers and oscillators.	C43 C44
Knowledge of the internal structures of the operational amplifiers and their structures.	C43 C44
Knowledge of the design of circuits based on operational amplifiers.	C43 C44
Knowledge of the design of power-supplies.	C42 C43 C44

Contents	
Topic	
Feedback amplifiers I	Feedback concept. Sample and mix networks. Feedback topologies. Feedback law.
Feedback amplifiers II	Negative and positive feedback. Parameters for the study of feedback. Benefits and draws of feedback. Effect on the uniform of gain. Effect on the harmonic distortion. Effect on the input and output impedances.
Feedback amplifiers III	Methods for the analysis: Simple or using matrix. Topology identifying. Amplifier without feedback, but with the load effect of the feedback network. The gain of the feedback amplifier. The input and the output impedances of the feedback amplifier.

Feedback amplifiers IV	Effect of the feedback on the frequency response. Bandwidth and stability. The effect of poles on the amplifier (one pole, two poles and three poles). Gain and phase margins. Nyquist criteria. Root places. Compensation methods.
Sine waveform oscillators	Barkhausen criteria. Design of a sinusoidal oscillator. RC oscillator. LC oscillator. Oscillator based on quartz crystals.
Operational amplifiers I	Internal structure of an operational amplifier. Current mirrors. Active loads. Voltage references. Technologies for the operational amplifiers: bipolars, bifet, cmos.
Operational amplifiers II	Analysis of the operational amplifier in the non inverting mode, using feedback. Voltage follower. Converters I-V and V-I. Integrator. Derivator. Applications.
Operational amplifiers III	Half-wave inverter rectifier . Full-wave inverter rectifier. Relaxation oscillator. Generator of triangle waves. Sinusoid oscillators based on the operational amplifier.
Power amplifiers	Output stages in class A, B and A-B. Full amplifier in class B. Full amplifier in class A-B. Introduction to the class-D amplifiers.
Regulated power supplies	Linear regulated power supplies. Protection to over current. Low drop-out (LDO).
Lab work 1	The effect of the feedback on a two-stage amplifier .
Lab work 2	Linear applications. Voltage-to-current converter. Integrator.
Lab work 3	Half-wave inverter rectifier. Full-wave inverter rectifier. Peack detector. Slope detector.
Lab work 4	Operational-based relaxation oscillator. Operational-based sinusoidal oscillator.
Lab work 5	Power amplifiers. Class B. Class A-B.
Lab work 6	Design of an active load. Design of a voltaje regulated supply.

Planning

	Class hours	Hours outside the classroom	Total hours
Mentored work	7	20	27
Laboratory practical	12	38	50
Lecturing	15	27.5	42.5
Problem solving	4	22.5	26.5
Objective questions exam	1	0	1
Problem and/or exercise solving	2	0	2
Laboratory practice	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description

Mentored work	***The lecturer will lead the students in order to design an amplifier. For simulation: software to be used: ORCAD CIS Lite. *** This activity is collective. The students work in teams of two persons. Competencies C42, C43 and C44 (CE42, CE43 and CE44) will be addressed in these sessions.
Laboratory practical	***Simulations and real assembled circuits will be tested. For simulation: software to be used: ORCAD CIS Lite. *** This activity is collective. The students work in teams of two persons in each laboratory position. Competencies C42, C43 and C44 (CE42, CE43 and CE44) will be addressed in these sessions.
Lecturing	The lecturer will show some theoretical contents related to the subject. This activity is individual. Competencies C42, C43 and C44 (CE42, CE43 and CE44) will be addressed in these sessions.
Problem solving	The lecturer will solve some exercises related to the subject. This activity is individual. Competencies C42, C43 and C44 (CE42, CE43 and CE44) will be addressed in these sessions.

Personalized assistance

Methodologies	**Description**
Problem solving	The teacher will resolve the doubts of the students at the schedule established and published on the school website. (https://moovi.uvigo.gal/user/profile.php?id=11318).
Mentored work	The teacher will resolve the doubts of the students at the schedule established and published on the school website. (https://moovi.uvigo.gal/user/profile.php?id=11317).
Laboratory practical	The teacher will resolve the doubts of the students at the schedule established and published on the school website. (https://moovi.uvigo.gal/user/profile.php?id=11318).
Lecturing	The teacher will resolve the doubts of the students at the schedule established and published on the school website. (https://moovi.uvigo.gal/user/profile.php?id=11318).

Assessment

	Description	Qualification	Training and Learning Results
Mentored work	The students have to write a document about the assigned work. A single document for the group of two persons that work together in this job. The grade for both students in this job is the same. Competencies CE42, CE43 and CE44 will be assessed in these works.	10	C42 C43 C44
Objective questions exam	Multiple choice test. Competencies CE42, CE43 and CE44 will be assessed in these tests.	30	C42 C43 C44
Problem and/or exercise solving	Exercise test. Competencies CE42, CE43 and CE44 will be assessed in this test.	30	C42 C43 C44
Laboratory practice	Laboratory-work exam based on simulations and real circuits. Competencies CE42, CE43 and CE44 will be assessed in this test.	30	C42 C43 C44

Other comments on the Evaluation

CONTINUOUS ASSESSMENT OPTION:

The subject is evaluated in a continue way, by means of two partial exams. These exams cover the theoretical aspects. In addition, there is an exam for the lab-work and a tutored work.

This first partial exam includes themes from one to five. The second partial exam includes themes from six to ten. The weight of both partials is 60% from the total mark.

The two partials take place in the classroom, within the class time. These partials are approximately 90 minutes long. The first 30 minutes will be dedicated to a multiple-choice test. The other 60 minutes will be dedicated to exercises.

Inside each partial exam, the 60 minutes exam and the 30 minutes exam have the same weight.

In order to pass a partial exam (the first or the second), the student is required to obtain at least a mark of 5 over 10.

The student that passes only one partial will only have to try the other one at the final exam, which is the same for the students who do that exam as a recovery exam for the continuous assessment and for the students who do that exam as their global assessment.

The lab-work is evaluated using a unique exam, in the laboratory. The weight is 30%.

The weight of the tutored work in the continuous assessment is 10% of the total mark.

When a student attends the first partial, he or she accepts to follow the continuous assessment. Students that do not attend to the first partial will be assessed by means of a unique assessment, *** except in the case of the student's waiver of continuous assessment, a step for which in this matter the term is not restricted beyond what is established by the general regulations: regarding this matter, the waiver of continuous assessment is accepted at any moment.***

The mark that a student obtains in the lab-work is maintained until the extraordinary exam, except if the student does not want. In this case, the student will have to do partials and lab exams in the extraordinary exam.

In order to pass the subject, once partial exams have been passed, the student has to obtain a global mark (GM) of at least 5 points out of ten. The global mark is calculated acording to the following expression if the student has more than 5 points in each partial exam:

GM = 0.6 * TM + 0.3*LM + 0.1*RM

where

TM (Theory Mark) = Mean value of the partial marks; LM = lab mark; RM = report mark

If the mark of the student in any of the two partial theory exams is less than 5, then the value of GM is the minimum between 4 and 0.6*TM+0.3*LM+0.1*RM.

The lab exam will take place in the lab, the day of the last lab session.

GLOBAL ASSESSMENT OPTION:

The students that do not follow the continuous assessment will be assessed by means of a global assessment. The global assessment will consist of an exam with three parts: the first part covers the themes 1 to 5, the second part covers the themes 6 to 10 and the third part is a lab-work in the laboratory.

In order to pass the subject, the student has to obtain a mark of at least 5 points over ten for the first and second parts. In this case, the global mark (GM) is calculated according to the following formula:

GM = 0.6 * TM + 0.4*LM

where:

TM = Average mark of the first and second part of the exam; LM = lab mark

If the student does not obtain a mark of at least 5 in the first part or in the second part, the global mark would be the minimum between 4 and 0.6*TM + 0.4*LM.

IMPORTANT. MANDATORY ENROLLMENT.

If a student did not enter the continuous assessment mode but is interested in participate in the global assessmente, he or she must enroll in this assessment by talking to the professors at least two weeks before the day of the exam. Contact can be by e-mail. This helps in the organization of the lab work exam.

EXTRAORDINARY EXAM AND END OD FROGRAM EXAM

The extraordinary exam and the end of program exam have the same exam structure and the same rules (calculation of the mark and mandatory enrollment) as for the global assessment.

Sources of information
Basic Bibliography
Hambley, Allan R., **Electrónica**, 2ª ed., Pearson-Prentice Hall, 2001
Quintáns Graña, C., **Simulación de circuitos electrónicos con OrCAD® PSpice®**, 2.ª edición, Marcombo, 2021

Sergio Franco, **Design with operational amplifiers and analog integrated circuits**, third edition, McGraw-Hill,

Complementary Bibliography

Paul Horowitz y Winfield Hill, **The Art of Electronics**, Cambridge Univ. Press,

Horenstein, Mark N., **Microelectrónica**, 2ª ed., Prentice Hall, 1997

Malik, Norbert, **Circuitos electrónicos**, Prentice Hall, 1996

Rashid, Muhammad, **Circuitos microelectrónicos**, Thomson, 2002

Sedra, Adel, **Circuitos microelectrónicos**, 5ª ed., McGraw-Hill, 2006

Recommendations

IDENTIFYING DATA				
Electronic Systems for Signal Processing				
Subject	Electronic Systems for Signal Processing			
Code	V05G301V01312			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Valdés Peña, María Dolores			
Lecturers	Valdés Peña, María Dolores			
E-mail	mvaldes@uvigo.es			
Web	http://moovi.uvigo.gal/course			
General description	This subject introduces the basic concepts of digital signal processing systems from the point of view of its hardware implementation. Emphasis is put on FPGAs-based solutions, using professional software design tools and hardware supports. The nature of the course is mainly practical. It promotes the development of collaborative projects whose ultimate goal is the design of electronic signal processing systems. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B13	CG13 The ability to use software tools that support problem solving in engineering.
C39	(CE39/SE1): The ability to construct, exploit and manage the receiving, transporting, representation, processing, storage, manage and presentation multimedia information from the electronic systems point of view.
C45	(CE45/SE7): The ability to design interface, data capturing and storage devices, and terminals for services and telecommunication systems.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Understand the fundamental design principles of the signal processing hardware systems.	B6 B13	C39 C45	
Ability to decide different design strategies depending on the application.	B4	C39 C45	D2
Ability to choice the most suitable hardware architecture for each application.	B4 B6	C39 C45	
Ability to design basic circuits for audio and image processing.	B4 B6 B9 B13	C39 C45	D4
Acquire skills in the use of design, simulation and implementation tools of signal processing systems.	B13	C39 C45	
Acquire skills to verify the proper operation of complex hardware systems.	B6 B13	C39 C45	
Acquire skills to combine different software tools and hardware platforms.	B13	C39 C45	
Ability to document hardware design projects.	B4 B9		D4

Contents	
Topic	
Theory: Theme 1. Introduction	- Basic architecture of electronic signal processing systems: signal conditioning, sampling, conversion, and reconstruction.
Theory: Theme 2. Types of signal processing	-Different hardware and software solutions: DSP and FPGAs. -Processing types: Serial/Parallel, Hardware/Software. -Hardware cost of regular signal processing circuits. Logical resources used. Processing rate.
Theory: Theme 3. Arithmetic in DSP	-Data types. -Data modification: quantification and overflow. -Arithmetic operations and associated circuits. -Associated concepts: critical path, pipeline and latency.
Theory: Theme 4. Signal conditioning and sampling	- Example of a real signal conditioning and sampling system using a FPGA-based development board.
Theory: Theme 5. Design and Implementation of Digital Filters	- Implementation of digital filters in FPGA. - Analysis of full parallel and semi-parallel solutions: hardware costs, operation rates.
Theory: Theme 6. Design of audio processing systems	- Examples of audio processing systems. - Analysis of required hardware resources. - Implementation and performance analysis.
Theory: Theme 7. Design of image processing systems	- Examples of basic image processing systems. - Analysis of hardware resources required. - Implementation and performance analysis.
Labs: Design of basic signal processing systems.	- Design, implementation and verification of basic signal processing systems using VHDL: digital filters, communication applications, image processing, audio processing. - Using the ISE and/or Vivado design tool from Xilinx and MATLAB from MathWorks.

Planning			
	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Lecturing	14	14	28
Laboratory practical	14	14	28
Project based learning	9	48	57
Presentation	0	6	6
Problem and/or exercise solving	2	6	8
Laboratory practice	0	14	14
Project	1	3	4
Presentation	1	3	4

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Introductory activities	The teacher will present the theoretical ad practical key topics of the subject, as well as the projects to be developed during the course. B6, C39 and C45 competencies will be worked on. It is an individual activity.
Lecturing	The theoretical content of the course and the introductory activities of both the theoretical and practical contents will be presented. B6, C39 and C45 competencies will be worked on. It is an individual activity.
Laboratory practical	The students will implement basic signal processing systems using FPGAs platforms. B6, B9, C39, C45 and B13 competencies will be worked on. It is a group activity. Software to be used: Matlab, ISE and/or Vivado

Project based learning	Working groups of two or more students will be established. Each group will develop one project along the course. This project will address the design of a signal processing system of medium complexity. Additionally, small groups (Groups Type C) will be available allowing supervising the project developed during the course. Activities to be developed in C groups: Activity 1. Analysis and discussion of the system designed in the project. Activity 2. Demonstration of the operation of the designed system. Analysis and discussion of the results. B6, B9, C39, C45, B13, D2, B4 and D4 competencies will be worked on. It is a group activity. Software to be used: Matlab, ISE and/or Vivado
Presentation	Exhibition by the students to the teacher and to the rest of the students of the results of the developed project. B4, B9 and D4 competencies will be worked on. It is a group activity. Software used: Power Point or any other presentation tool.

Personalized assistance

Methodologies	Description
Lecturing	The teacher will personally attend student□s doubts and queries related to theoretical contents. Students will have the opportunity to attend individual or group tutorials upon request and confirmation via email. The professor's contact data are accessible at https://moovi.uvigo.gal/user/profile.php?id=11303
Laboratory practical	The teacher will personally attend student□s doubts and queries related to laboratory practices. Students will have the opportunity to attend individual or group tutorials upon request and confirmation via email. The professor's contact data are accessible at https://moovi.uvigo.gal/user/profile.php?id=11303
Project based learning	The teacher will personally attend student□s doubts and queries related to the projects. Students will have the opportunity to attend individual or group tutorials upon request and confirmation via email. The professor's contact data are accessible at https://moovi.uvigo.gal/user/profile.php?id=11303

Assessment

	Description	Qualification	Training and Learning Results		
Problem and/or exercise solving	There will be a short-answer test on the theoretical issues of the course. More information is provided in the "Other Comments" section below. This test will assess competencies C39 and C45.	20		C39 C45	
Laboratory practice	Laboratory practices will be evaluated based on the continuously work carried out during the laboratory hours (Type B hours) and on a final report of the practices. These practices will assess competencies B4, B6, B13, C39, C45 y D4.	35	B4 B6 B13	C39 C45	D4
Project	The students will develop a project focused on the design of a signal processing system of medium complexity. More information is provided in the "Other Comments" section that follows. This project will assess competencies B4, B6, B9, B13, C39, C45, D2 and D4.	40	B4 B6 B9 B13	C39 C45	D2 D4
Presentation	The project will be presented orally. More information is provided in the "Other comments" section. This activity will assess competencies B4, B9 and D4.	5	B4 B9		D4

Other comments on the Evaluation

According to the guidelines for the degree programme, two evaluation systems will be offered to students: continuous assessment (CA) and global assessment (GA).

It is considered that a student opts for CA when he/her takes more than two laboratory practices. In no case can the final grade of a student who opts for CA be "No Submitted". However, the CA may be waived and the GA may be opted for, upon request by email, within a maximum period of one month before the end of the semester.

1.- Continuous assessment

The continuous assessment, both the ordinary and the extraordinary call, consists of a theoretical exam, a set of laboratory practices, a theoretical-practical work (project)and the oral presentation of the project.

The schedule of the assessment activities will be published in a shared calendar and will be available at the beginning of each academic semester.

1.1 Theoretical exam (NExam):

The theoretical exam will include all the theoretical contents of the course and will take place at the end of the term. The weight of this assessment will be 2 points out of 10.

1.2 Laboratory practices (NPrac):

The laboratory practices will be performed in groups of two or more students. The evaluation of the labs will take in to account both, the work in the laboratory as well as a final report. The weight of this assessment is 3.5 point out of 10. The work in the laboratory will be individually evaluated and represent the 60% of the score. The remaining 40% correspond to the final report and will be the same for all the members of a working group.

Laboratory practices are compulsory. To cualify for a practical mark, students must attend at least 80% of the practices.

1.3 Theoretical-practical work (NPro):

The theoretical-practical work will be conducted in type B and C hours, in groups of two or more students. As a result of the work a writing report and the implemented system must be delivered. The weight of this assessment is 4 points out of 10.

To carry out the theoretical-practical work individual and cooperative tasks will be assigned to the students. The weight of the individual work will be the 60% of the maximum score of the project and the weight of the cooperative work will be the 40%. The 40% of the score corresponding the cooperative work will be the same for all the members of a working group.

1.4 Oral presentation of the theoretical-practical work (NPre):

The students must present the results of the theoretical-practical work. The weight of this activity is 0.5 points out of 10. The oral presentation will be at the end of the semester, on the same date as the theoretical exam.

1.5 Final grade (Final_grade):

The final grade for the continuous assessment correspond to:

Final_grade = (0.2*NExam + 0.35*NPrac + 0.4*NPro + 0.05*NPre) if Nexam, NPrac and NPro are greater or equal to 4 and Final_grade is greater or equal to 5;

Final_grade = min[(0.2*NExam + 0.35*NPrac + 0.4*NPro + 0.05*NPre), 4.9] in any other case.

Students who fail any of the assessment activities in the ordinary call will have the possibility to repeat it/them in the extraordinary call. In this case the students would be evaluated only of the part they have not pass (theoretical exam, laboratory practices and/or project). The grade obtained in the extraordinary call will replace the previous one.

2.- Global assessment and End-of-program exam

Students who opt for the global assessment or for the end-of-program exam must pass two assessments, a theoretical one covering all the contents of the subject and a practical one.

2.1 Theoretical exam (NExam_G):

The theoretical examination would include short answer questions, problems, and/or system design exercises.

2.2 Practical exam (NPra_G):

The practical examination will consist in the final test of a previously designed and simulated system. One week before the date established for the exam the student must submit a writing report of the designed system as well as the simulation results. During the practical exam the student will validate the system designed in the hardware.

Both the theoretical and the practical exam will weigh 50% of the final grade.

2.3 Final grade (Final_grade_G):

The final grade of the global assessment and the end-of-program exam will correspond to:

Final_grade_G = (0.5*NExam_G + 0.5*NPrac_G) if Nexam_G and NPrac_G are greater or equal to 4 and Final_grade_G is greater or equal to 5;

Final_grade_G = min[(0.5*NExam_G + 0.5*NPrac_G), 4.9] in any other case.

Students who opt for the global assessment and do not pass the subject in the ordinary call, will have another opportunity in the extraordinary call. In this case, only the part(s) they have failed (theory and/or practice) will be evaluated

3.- Other comments

- The students can use the Spanish, English or Galician to answer the exam an for the reports, works or presentations.
- The grades obtained from the continuous assessment or for the global assessment are only valid for the current academic year.
- The use of books, notes or electronic devices such as phones or computers is not permitted in any classroom test or exam. Mobile phones must be turned off and be out of reach of the student.
- Plagiarism is regarded as serious dishonest behavior. If any form of plagirism is detected in any of the test or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.
- In the event that a student leaves a work group or commits plagiarism, his/her final grade will be FAIL (0), but it will not affect the grade of the rest of the group.

Sources of information

Basic Bibliography

U. Meyer-Baese, **Digital signal processing with Field Programmable Gate Arrays**, 3th ed., Springer-Verlag, 2007

James H. McClellan, Ronald W. Schafer, Mark A. Yoder, **Signal processing first**, 1st ed., Pearson Education International, 2003

XUP, University of Strathclyde and Steepest Ascent, **DSP for FPGA Primer**, 2011

Complementary Bibliography

John G. Proakis, Dimitris G. Manolakis, **Digital signal processing**, 4th ed., Pearson Education International, 2007

John G. Proakis, **Tratamiento digital de señales : principios, algoritmos y aplicaciones**, 4ª ed., Prentice Hall, 2007

Recommendations

Subjects that it is recommended to have taken before

Digital electronics/V05G301V01203

IDENTIFYING DATA				
Engineering of Electronic Equipment				
Subject	Engineering of Electronic Equipment			
Code	V05G301V01313			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	López Sánchez, Óscar			
Lecturers	López Sánchez, Óscar Nogueiras Meléndez, Andres Augusto			
E-mail	olopez@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	This course shows the basics concepts about RAMS (Reliability, Availability, Maintainability and Safety) of electronic components and electronic systems, as well as techniques to follow for a study of this type or design a system that meets specifications RAMS. the basics concepts about the sources of electromagnetic interference and their minimization are also discussed. English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B1	CG1: The ability to write, develop and sign projects in the field of Telecommunication Engineering, according to the knowledge acquired as considered in section 5 of this Law, the conception and development or operation of networks, services and applications of Telecommunication and Electronics.
B2	CG2: The knowledge, comprehension and ability to apply the needed legislation during the development of the Technical Telecommunication Engineer profession and aptitude to manage compulsory specifications, procedures and laws.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B8	CG8: To know and apply basic elements of economics and human resources management, project organization and planning, as well as the legislation, regulation and standarization in Telecommunications.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C41	(CE41/SE3):The ability to make the specification, implementation, documenting and tuning of electronic systems and equipment (both instrumentation and control oriented), considering the corresponding technical aspects and the regulations.
C47	(CE47/SE9): The ability to analyze and solve interference and electromagnetic compatibility problems .
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Knowledge of the applicable standards in the design of the electronic systems	B6		
Ability for the specification of components and electronic systems		C41 C47	
Knowledge and application of techniques to meet EMC standards		C47	
Knowledge of techniques and tools for the design and manufacture of an electronic system based on dependability specifications	B2 B6 B8		
Ability to design, implement and manage a dependability system	B1		
Ability to manage the knowledge of the organization	B9		D4

Contents
Topic

Introduction to the reliability	Definitions and basic concepts. RAMS Technologies. Parameters of the reliability of electronic components. Prediction of reliability. Related technical standards.
Reliability of electronic systems	Series, parallel and redundant systems. Optimization of redundancies.
Maintenance and security	Definitions, type and parameters of the maintenance. Availability. Definitions of electronic systems for safety applications. Safety levels of systems.
Analysis of failures	Failure Mode and Effects and Criticality Analysis (FMECA). Failure Tree Analysis (FTA). Markov's models. Mathematical models of Arrhenius, Eyring, Reverse power and Coffin-Manson.
Electromagnetic interferences	Definitions. Basics of electromagnetic interferences. Sources of interferences.
Design for electromagnetic compatibility	Basics of electronic devices design. Componentes to minimize interferences. Techniques for eliminate interferences.
Electromagnetic compatibility standards	CE marking. Directive of electromagnetic compatibility. Organisms for standardization. Electromagnetic compatibility standards.
Laboratory exercises	Several simulation practices and measurements will be carried out in the laboratory. Accounting will be calculated using specific software and measurements of conducted and radiated emissions will be made.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	14	28	42
Problem solving	7	18	25
Case studies	7	0	7
Mentored work	0	60	60
Laboratory practical	14	0	14
Essay questions exam	1	0	1
Objective questions exam	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Presentation of the contents of the subject by the teaching staff. Examples and problems will be solved to illustrate properly the topic under study. The students may submit all doubts and questions deemed appropriate, during the session. We will promote the more active participation of the student possible. They Will work the competences B1, B2, B6, B8, B9, C41 and C47.
Problem solving	Teaching activities with problems develop, case studies and exercises related to the subject. Also it be used to show existing doubts and also for feedback to teachers. Competences trained: B1, B2, B6, C47 and C41.
Case studies	The groups are conducted with a small number of students and are used for the development of group work and learning methodologies teamwork. Group activity. Competencies B1, B2, C41 and D4 are used.
Mentored work	Autonomous works related with the contents of the subject. Students will work on the competences B6, B8, B9, C41, C47 and D4.
Laboratory practical	Reliability calculation calculation using specific software. Measurement of emitted and radiated emissions. Students will work the competences B2, C41 and D4.

Personalized assistance

Methodologies	Description
Lecturing	Teachers will personally address doubts and queries of the students about theoretical and practical issues. The schedule and the appointed procedure will be published in the online learning platform. Students can appoint for tutorial at the website of the University of Vigo: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/oscar-lopez-sanchez, https://www.uvigo.gal/es/universidad/administracion-personal/pdi/andres-augusto-nogueiras-melendez.

Assessment

	Description	Qualification	Training and Learning Results		
Mentored work	The students will realize one or several works about the contents of the subject. The works can be individual or in group and they will be qualified individually. It cannot be retaken.	15	B6 B8 B9	C41	D4

Laboratory practical	Students will carry out various practical simulations and measurements in the laboratory. They will be done in groups. The correct execution of the practical exercises in the laboratory and the memory of the results will be assessed. Non-attendance or non-delivery of the report of results will be qualified as suspended (0). They cannot be retaken.	15	B2 B6 B8 C41 C47 D4
Essay questions exam	First partial test. Written test with theoretical questions on part of the content of the subject. It will be held on the date and place set by the center. It can be retaken in the extraordinary assessment call.	35	B1 B2 B6 B8 B9 C41 C47 D4
Objective questions exam	Second partial test. Written test with theoretical questions, problems and exercises on the contents of the subject not included in the first partial test. It will be held on the date and place set by the center. It can be retaken in the extraordinary assessment call.	35	B1 B2 B6 B8 B9 C41 D4

Other comments on the Evaluation

Choosing of global assessment must be communicated in writing to the coordinator within one month of the start of the semester.

The end-of-program exam will be by global assessment.

The global assessment will consist of an individual written test with theoretical questions, problems and exercises that will evaluate all the content of the subject (85%) and a practical exam that will be carried out in the laboratory (15%).
In case of detection of copying or any form of plagiarism is detected in any of the tests or exams, the final grade will be fail (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information

Basic Bibliography

T.I. Bajenescu, M.I. Bâzu, **Reliability of Electronic Components**, Springer-Verlag, 1999

P. Kales, **Reliability**, Prentice-Hall, 1998

David J. Smith, **Reliability, Maintainability and Risk**, 8ª, Butterworth Heinemann, 2011

Kececioglu, Dimitri, **Reliability Engineering Handbook**, DEStech, 2002

Antonio Creus Solé, **Fiabilidad y seguridad: Su aplicación en procesos industriales**, Marcombo, 2005

Henry W. Ott, **Electromagnetic Compatibility Engineering**, Wiley, 2011

J. Balcells, F. Daura, R. Esparza e R. Pallás, **Interferencias Electromagnéticas en Sistemas Electrónicos**, Marcombo, 1991

Milton Ohring, **Reliability and Failure of Electronic Materials and Devices**, 2ª, Elsevier, 2015

Complementary Bibliography

ISO, **UNE-EN ISO 9000:2005: Sistemas de gestión de la calidad. Fundamentos y vocabulario.**, AENOR, 2005

ISO, **UNE-ISO 55000:2015: Gestión de activos. Aspectos generales, principios y terminología.**, AENOR, 2015

I. Fernández, A. Camacho, C. Gasco, A.M. Macías, M.A. Martín, G. Reyes, J. Rivas, **Seguridad Funcional en Instalaciones de Proceso: Sistemas Instrumentados de Seguridad y Análisis SIL**, ISA, 2012

Cherry Bhargava, **AI Techniques for Reliability Prediction for Electronic Components**, 1ª, IGI Global, 2020

Recommendations

Subjects that are recommended to be taken simultaneously

Data Acquisition Systems/V05G301V01314

Subjects that it is recommended to have taken before

Digital electronics/V05G301V01203
Physics: Fundamentals of electronics/V05G301V01201
Electronic technology/V05G301V01206

Other comments

This version in English of the guide is a translation of the original one in Galician. In the case that, by mistake, there exists differences between them the original one in Galician is what prevails.

IDENTIFYING DATA				
Data Acquisition Systems				
Subject	Data Acquisition Systems			
Code	V05G301V01314			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Poza González, Francisco			
Lecturers	Poza González, Francisco			
E-mail	fpoza@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This subject is about data acquisition, including instrumention amplifiers, analog switches, active filters, S&H and converters.			

Training and Learning Results	
Code	
C43	(CE43/SE5): The ability to design analogical and digital electronics circuits of analogical to digital conversion and vice versa, of radiofrequency, of feeding and electrical energy conversion for computing and telecommunication engineering.
C45	(CE45/SE7): The ability to design interface, data capturing and storage devices, and terminals for services and telecommunication systems.

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Knowledge of instrumentation amplifiers, and control about its use.	C43 C45
Knowledge of the different topologies of active filters.	C43 C45
Knowledge of the different types of electronic analog switches, and control about its use.	C43 C45
Knowledge of Sample&Hold circuits and their applications in data acquisition.	C43 C45
Knowledge of the operation of different D/A and A/D converters, and control about its use.	C43 C45
Knowledge of the design of data acquisition systems using the previous elements.	C43 C45

Contents	
Topic	
Unit 1. Introduction to data acquisition systems (DAS)	1.1. Introduction 1.2. Components of DAS 1.3. Control systems
Unit 2. Auxiliary circuits	2.1. Level shifter circuits 2.2. Voltage reference 2.3. Voltage-to-current converters
Unit 3. Analog switches and multiplexers	3.1. Analog switches 3.2. Analog multiplexers
Unit 4. Amplification in data acquisition	4.1. Instrumentation amplifiers 4.2. Programmable gain amplifiers 4.3. Isolation amplifiers
Unit 5. Active filters	5.1. Introduction 5.2. First and second order transfer functions 5.3. Transfer functions aproximation 5.4. Active filters synthesis

Unit 6. Sample and hold circuits	6.1. Introduction 6.2. Base circuit 6.3. Practical architectures 6.4. Real parameters 6.5. Commercial devices
Unit 7. Digital-to-analog and analog-to-digital converters	7.1 Digital-to-analog converters (DAC) 7.1.1. Introduction 7.1.2. Transfer function 7.1.3. Parameters and errors 7.1.4. Classification 7.1.5. DAC architectures 7.2. Analog-to-digital converters (ADC) 7.2.1. Introduction 7.2.2. Transfer function 7.2.3. Parameters and errors 7.2.4. Classification 7.2.5. ADC architectures
Practice 0. Introduction	Introduction to laboratory concepts and tools.
Practice 1. Auxiliary circuits	Experimental test and analysis of auxiliary circuits used in signal conditioning stages.
Practice 2. Instrumentation amplifier	Experimental test and analysis of instrumentation amplifiers.
Practice 3. Isolation amplifier	Experimental test and analysis of linear optical isolation amplifiers built from discrete components.
Practice 4. Active filters	Experimental test and analysis of active filter topologies.
Practice 5. Digital-to-analog conversion	Experimental test and analysis of a digital-to-analog converter (DAC) built from discrete components.
Practice 6. Analog-to-digital conversion	Experimental test and analysis of an analog-to-digital converter (ADC) based on an ADC integrated circuit.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	14	37.5	51.5
Problem solving	4	22.5	26.5
Laboratory practical	14	28	42
Mentored work	7	20	27
Problem and/or exercise solving	1	0	1
Problem and/or exercise solving	1	0	1
Problem and/or exercise solving	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The lecturer will show some theoretical contents related to the subject. Competences C43 and C45 will be addressed in these sessions.
Problem solving	The lecturer will solve some exercises related to the subject. Competences C43 and C45 will be addressed in these sessions.
Laboratory practical	Simulations and real assembled circuits will be tested. Software to be used: LabVIEW and Multisim from National Instruments Competences C43 and C45 will be addressed in these sessions.
Mentored work	The lecturer will lead the students in a data acquisition system design. Competences C43 and C45 will be addressed in these sessions.

Personalized assistance

Methodologies	Description
Lecturing	In the classes the doubts of the students will be answered. They will also be able to consult with the teacher in the place and at the time published at https://moovi.uvigo.gal/user/profile.php?id=11302.
Problem solving	In the classes the doubts of the students will be answered. They will also be able to consult with the teacher in the place and at the time published at https://moovi.uvigo.gal/user/profile.php?id=11302.
Mentored work	In the classes the doubts of the students will be answered. They will also be able to consult with the teacher in the place and at the time published at https://moovi.uvigo.gal/user/profile.php?id=11302.
Laboratory practical	In the classes the doubts of the students will be answered. They will also be able to consult with the teacher in the place and at the time published at https://moovi.uvigo.gal/user/profile.php?id=11302.

Assessment			
	Description	Qualification	Training and Learning Results
Laboratory practical	The lecturer will check the level of compliance of the students with the goals related to the laboratory skills. The final mark of laboratory, FML, will be assessed in a 10 points scale. For the evaluation of the laboratory sessions, the lecturer will assess the group work (the same mark for each member), the individual preliminary tasks and the answers to personalized questions for each session.	30	C43 C45
Mentored work	The lecturer will consider the results and the quality of the analysis performed in the developed work. The tutored work mark, TWM, will be assessed in a 10 points scale. For the evaluation of the work, the lecturer will assess the group work (the same mark for each member) and the individual answers to personalized questions (individual mark).	20	C43 C45
Problem and/or exercise solving	First partial theory test. The lecturer will check the level of compliance of the students with the goals related to the theory skills. The final mark will be assessed in a 10 points scale.	16.66	C43 C45
Problem and/or exercise solving	Second partial theory test. The lecturer will check the level of compliance of the students with the goals related to the theory skills. The final mark will be assessed in a 10 points scale.	16.66	C43 C45
Problem and/or exercise solving	Third partial theory test. The lecturer will check the level of compliance of the students with the goals related to the theory skills. The final mark will be assessed in a 10 points scale.	16.66	C43 C45

Other comments on the Evaluation

1. Continuous assessment in ordinary exam

According to the guidelines of the degree and the agreements of the academic commission, a continuous assessment learning scheme will be offered to the students.

It is considered that all the students have chosen continuous assessment by default.

Choosing of global assessment must be communicated in writing form to the coordinator within one month of the start of the semester.

The subject comprises three different parts: theory (50%), laboratory (30%) and tutored work (20%). Once a task has been assessed, the students can not do/repeat the task at a later date. The marks are valid only for the current academic course.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

1.a Theory

Three exercises and troubleshooting tests are scheduled. The exercises and troubleshooting tests (ETT1, ETT2 and ETT3) will be respectively performed after unit 4, 5 and 7, in the usual weekly scheduling of the theoretical classes. The first test (ETT1) of the themes 1 to 4, the second test (ETT2) of the theme 5 and third test (ETT3) of the themes 6 and 7.These tests are approximately 60 minutes long.

Marks for each test will be assessed in a 10 points scale. The minimum mark required to pass this part is of 4 (ETTi>=4). The final mark of theory (FMT) is calculated as the arithmetic mean of the individual marks:

FMT = (ETT1 + ETT2 + ETT3) / 3

1.b Laboratory

Seven laboratory sessions are scheduled. Each session lasts approximately 120 minutes and the students will work in pairs. The first session is mandatory but will not be assessed. The following seasons (practice 1 to 6) will be assessed by continuous assessment. The lecturer will consider the proposed individual tasks, the work in the laboratory as well as the student's behavior. Each session will be only evaluated according to the developed work at the schedule date.

Marks for each laboratory session (LSM) will be assessed in a 10 points scale. A mark of 0 will be obtained for missing sessions. The final mark of laboratory (FML) is calculated as the arithmetic mean of the individual laboratory session marks:

FML = (LSM1 + LSM2 + LSM3 + LSM4 + LSM5 + LSM6) / 6

1.c Tutored work

In the first session lecturer will present the objectives and the schedule of the project. They also assign a specific project to each group. The students will work in pairs whenever possible.

In order to assess the work, the lecturer will consider the results, their analysis and presentation, and the quality of the written report. The tutored work mark (TWM) will be assessed in a 10 points scale.

1.d Final mark of the subject

The weighted points from all assessed parts are added together to calculate the final mark (FM). The following weightings will be applied: 50% theory (FMT), 30% laboratory (FML) and 20% tutored work (TWM). In order to pass the subject, students will be required to pass the theory (ETT1>=4, ETT2>=4 , ETT3>=4 and FMT>=5), the laboratory (FML >= 5) and the tutored work (TWM >= 5). In this case the final mark (FM) will be:

FM = 0.5·FMT + 0.3·FML + 0.2·TWM.

However, when the students do not pass the theory (ETT1 < 4, ETT2 < 4 , ETT3 < 4 or FMT < 5), the laboratory (FML < 5) or the tutored work (TWM < 5), the final mark will be:

FM = min{4.9 ; (0.5·FMT + 0.3·FML + 0.2·TWM)}.

A final mark higher than five points (FM >= 5) should be achieved in order to pass the subject.

If the students who are following continuous assessment deliver all the tasks, the mark of the part of the subject (theory, laboratory and tutored work) in which they have obtained the minimum demanded will be preserved, only until the extraordinary exam of the same academic course.

2. Global assessment (ordinary and extraordinary exam) and end-of-program exam

The students who prefer a different educational policy can attend an exam on a scheduled date and deliver a tutored work the same date. Dates will be specified in the academic calendar. This exam will comprise two parts: theory and laboratory exam.

The theory exam will consist on three exercises and troubleshooting tests (ETT1, ETT2 and ETT3): the first test of the themes 1 to 4, the second test of the theme 5 and third test of the themes 6 and 7. These tests are approximately 60 minutes long. Marks for each test will be assessed in a 10 points scale. The minimum mark required to pass this part is of 4 (ETTi>=4). The final mark of theory (FMT) is calculated as the arithmetic mean of the individual marks:

FMT = (ETT1 + ETT2 + ETT3) / 3

The laboratory exam will consist on the resolution of a practical exercise in the laboratory. This practical exercise will be similar to those made in the laboratory sessions. The final mark of laboratory (FML) will be assessed in a 10 points scale. In order to attend the laboratory exam, the students have to contact to the lecturer at least two weeks before the exam. This way, the organization of the laboratory exam will be simpler.

In order to pass the subject, students will be required to pass the theory (ETT1>=4, ETT2>=4 , ETT3>=4 and FMT>=5), the laboratory (FML >= 5) and the tutored work (TWM >= 5). In this case the final mark (FM) will be:

FM = 0.5·FMT + 0.3·FML + 0.2·TWM).

However, when the students do not pass the theory (ETT1 < 4, ETT2 < 4 , ETT3 < 4 or FMT < 5), the laboratory (FML < 5) and the tutored work (TWM < 5), the final mark will be:

FM = min{4.9 ; (0.5·FMT + 0.3·FML + 0.2·TWM)}.

A final mark higher than five points (FM >= 5) should be achieved in order to pass the subject.

Sources of information

Basic Bibliography

Paul Horowitz y Winfield Hill, **The Art of Electronics**, Cambridge Univ. Press.,

Sergio Franco, **Design with Operational Amplifiers and Analog Integrated Circuits**, WCB/McGraw-Hill,

Franco Maloberti, **Data Converters**, ISBN 978-0-387-32485-2,

Complementary Bibliography

Analog Devices Library,
hhtp;//www.analog.com/library/analogDialogue/archives/43-09/EDCh%206%20Converter.pdf, Capitulos 6.1,6.2,6.3,

Recommendations

Subjects that are recommended to be taken simultaneously

Electronic Instrumentation and Sensors/V05G301V01316

Subjects that it is recommended to have taken before

Digital electronics/V05G301V01203
Analogue Electronics/V05G301V01311

Other comments

I recommend the students to search the web for information about this subject. Electronic devices factories show interesting information. Many universities around the world hung interesting notes in the Internet. And many of them for free.

IDENTIFYING DATA

Power Electronics

Subject	Power Electronics			
Code	V05G301V01315			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Doval Gandoy, Jesús			
Lecturers	Doval Gandoy, Jesús			
E-mail	jdoval@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The main goal of this subject is to provide students with the knowledge about the basics of power electronics. Contents include power semiconductor and magnetic devices, ac-dc converters, dc-dc converters, dc-ac converters and basic concepts about the control of these power converters. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results

Code	
C43	(CE43/SE5): The ability to design analogical and digital electronics circuits of analogical to digital conversion and vice versa, of radiofrequency, of feeding and electrical energy conversion for computing and telecommunication engineering.
C44	(CE44/SE6): The ability to understand and use feedback theory and electronic control systems.

Expected results from this subject

Expected results from this subject	Training and Learning Results
Knowledge about power electronics semiconductor devices.	C43
Knowledge about the operation of the basic topologies of electronic converters used in conversion of electrical energy.	C43
The ability to understand and analyse power electroncis circuits.	C43 C44
The ability to analyse and design the control loop of power electronics converters.	C43 C44
The ability to design basic circuits used in power electronic converters.	C43 C44

Contents

Topic	
Chapter 1: Introduction to power electronics	Introduction, overview of power electronics, applications.
Chapter 2: Power electronic devices	Diode, MOSFET, IGBT. Switching, drivers, thermal analysis, association of devices, electrical protection.
Chapter 3: Magnetics in power electronics	Basics, inductors, transformers, magnetic materials.
Chapter 4: AC to DC power conversion	Three phase rectifiers. Non-controlled rectifiers, controlled rectifiers. Resistive load, inductive load, capacitive filter.
Chapter 5: DC to AC power conversion	Basics of DC to AC power conversion. Single phase and three phase inverters. Square wave inverters, PWM inverters. Modulation techniques.
Chapter 5: DC to DC power conversion	Basic DC to DC converter topologies. Converters without isolation and with isolation. Control in DC to DC power converters.
Laboratory exercise 1. Power electronic semiconductor devices.	MOSFET transistor, switching characteristics. Current and voltage characteristics.
Laboratory exercise 2. AC to DC power conversion	Non-controlled three phase rectifier, controlled three phase rectifier. Input/ output current and voltage.
Laboratory exercise 3. DC to AC power conversion	DC to AC converter. Input/ output current and voltage.
Laboratory exercise 4. DC to DC power conversion	Non-isolated and isolated DC to DC converter. Input/ output current and voltage.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	21	42	63
Laboratory practical	12	24	36
Autonomous problem solving	7	28	35
Problem and/or exercise solving	2	14	16

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Presentation by the professor of the contents of the subject, guidelines for the work to be developed by the student. Work will be focused on Competencies CE43 and CE44.
Laboratory practical	Practical application of the theoretical concepts. Work will be focused on Competencies CE43 and CE44.
Autonomous problem solving	Proposal of problems and/or exercises related with the subject contents. Students have to obtain the correct solutions. The professor will support and will help students to solve the problems. Work will be focused on Competencies CE43 and CE44.

Personalized assistance

Methodologies	Description
Lecturing	The students can attend tutorials in the professor office on dates and hours published in the web of the subject. (www.moovi.uvigo.gal)
Laboratory practical	The students can attend tutorials in the professor office on dates and hours published in the web of the subject. (www.moovi.uvigo.gal)
Autonomous problem solving	The students can attend tutorials in the professor office on dates and hours published in the web of the subject. (www.moovi.uvigo.gal)

Assessment

	Description	Qualification	Training and Learning Results
Laboratory practical	The laboratory practices are evaluated in a continuous way (session to session) taking into account their previous preparation and the execution in the laboratory.	10	C43 C44
Autonomous problem solving	The execution of several tasks and the corresponding reports are requested.	10	C43 C44
Problem and/or exercise solving	Exams consist of exercises and problems related to the theoretical and practical contents of the subject..The maximum grade for each of the exams will be 40% of the total for the subject.	80	C43 C44

Other comments on the Evaluation

For the ordinary and extraordinary exam, it will be possible to choose between continuous assessment and global assessment. Students that select global assessment should notify this to the teachers during the very first month of classes of the subject.

The end-of-program exam will be by single evaluation.

The dates and classrooms of the written tests will be those approved and published by the Academic Commission of the Degree of the school.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be fail (0), and the incident will be reported to the corresponding academic authorities for prosecution

1. Continuous evaluation

It consists of the realization of several weekly tasks, the preparation and execution of the laboratory practices, and the realization of two tests of partial evaluation.

1.1 Weekly tasks

Along the course, the execution of several individual tasks and the corresponding written report will be requested. These tasks will be no retakeable. By the correct realization of these tasks, it will be possible to obtain up to 10% of the final qualification of the subject.

1.2 Laboratory practices

There will be four sessions of laboratory practices in groups of two students, which will be both graded individually. The laboratory practices will be no retakeable. By the correct preparation and execution of the practices, it will be possible to obtain up to 10% of the final qualification of the subject.

1.3 Tests of partial evaluation

There will be two individual written tests of partial evaluation, in which will be possible to obtain up to 40% of the final qualification of the subject in each one of them. It will be possible to retake these tests in the extraordinary call.

1. **First partial test:** it will evaluate the contents taught to date of the test.
2. **Second partial test:** it will evaluate the remaining contents of the subject that were not included in the first test.

2. Global evaluation

It will be an individual written test consisting of theoretical questions, problems and exercises that will evaluate all the contents, theoretical and practical, of the subject.

Sources of information
Basic Bibliography
Mohan, Ned, **Electrónica de Potencia. Convertidores, Aplicaciones y Diseño**, 3, Mc Graw Hill, 2009
Barrado, Andrés, **Problemas de electrónica de potencia**, Pearson Prentice Hall, 2007
Rashid, Muhammad H., **Electrónica de potencia: circuitos, dispositivos y aplicaciones**, Pearson Education, 2004
Hart, Daniel W., **Electrónica de potencia**, Prentice-Hall, 2001
Complementary Bibliography

Recommendations

Subjects that it is recommended to have taken before

Physics: Analysis of Linear Circuits/V05G301V01108
Mathematics: Linear algebra/V05G301V01102
Mathematics: Calculus 1/V05G301V01101
Mathematics: Calculus 2/V05G301V01106
Physics: Fundamentals of electronics/V05G301V01201
Electronic technology/V05G301V01206
Analogue Electronics/V05G301V01311

Other comments

This version in English of the guide is a translation of the original one in Galician. In the case that, by mistake, there exists differences between them the original one in Galician is what prevails.

IDENTIFYING DATA				
Electronic Instrumentation and Sensors				
Subject	Electronic Instrumentation and Sensors			
Code	V05G301V01316			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Costas Pérez, Lucía			
Lecturers	Costas Pérez, Lucía Pastoriza Santos, Vicente			
E-mail	lcostas@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The main purpose of the subject is to provide the theoretical and practical skills for the design and characterization of electronic instrumentation systems, and the range of sensors which provide analogical and digital signal in the input stage of said instrumentation systems. Course outline: + Analysis of sensor parameters. + Basic concepts about the physical principles of the sensors. + The most important application of sensors in electronic instrumentation. + Electronic instrumentation architectures, from the simplest point to point systems to the most complex distributed systems. International standards for electronic instrumentation are presented. + Design of programmable instrumentation: GPIB, VXI and PXI buses. + Classification of architectures for electronic instrumentation. Introduction of wired and wireless field buses. The documentation of the course will be in Spanish. It will be taught in Galician and Spanish. It will be assessed in Spanish.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
C42	(CE42/SE4): The ability to apply electronics as support technology in other fields and activities and not only in information and communication technologies.
C46	(CE46/SE8): The ability to specify and use electronic instrumentation and measurement systems.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Knowledge of the distinct types of sensors and his applications.	B3	C42 C46	D2 D3
Capacity for the development of electronic circuits of conditioning of signal.	B4 B5	C42 C46	D2 D3
Knowledge and utilisation of computer tools for treatment of data and representation of the information.	B4 B5	C42 C46	
Knowledge of the basic principles of the programmable instrumentation and his utilisation.	B3	C42 C46	D2 D3

Contents
Topic

Unit 1: Introduction to sensors.	Energy conversions. Concepts of sensor, transducer and actuator. Dynamic and static features. Other features. Selection of sensors.
Unit 2: Temperature resistive sensors. Strain gauges.	Temperature resistive sensors: General features. Types. Conditioning . Application examples. Strain gauges: Basic principles. General features. Types of using. Conditioning . Application examples.
Unit 3: Photoresistive and Optoelectronic. Other resistive sensors.	Photoresistive and Optoelectronic: Basic principles. General features. Encoders. Conditioning. Application examples. Other resistive sensors: Gas sensors. Magnetoresistors. Potentiometers. Basic principles. General features. Conditioning . Application examples.
Unit 4: Capacitive sensors. Inductive and magnetic sensors.	Capacitive sensors: Introduction. Measurements principles. Features. Conditioning. Proximity sensors. Application examples. Inductive and magnetic sensors: Introduction. Basic principles. Variable transformer types. Features. Conditioning. Hall effect sensors. Application examples.
Unit 5: Thermocouples. Other sensors.	Thermocouples: Basic principles. General features. Calibration scales. Conditioning. Application examples. Other sensors: Pyroelectric. Ultrasounds. Magnetostrictive.
Unit 6: Programmable instrumentation. Standards on programmable instrumentation	Programmable instrumentation. Standards on programmable instrumentation. General features.
Practice 1: Introduction to the LabVIEW Application Development Environment	Introduction to LabVIEW environment by means of basic examples of programming.
Practice 2: Temperature sensors. NTC thermistor.	Signal conditioning and virtual instrument development for measurement
Practice 3: Optoelectronic sensors. PIN photodiode.	Spectral response analysis.
Practice 4: Capacitive sensors. Accelerometer.	Signal analysis and post-processing, and virtual instrument developing for tilt measurement.
Practice 5: Programmable Instrumentation I.	Frequency response test of two RC circuits via the programmable control of the laboratory instrumentation. The programmable control will realise through a USB connection from the PC to each instrument.
Practice 6: Programmable Instrumentation II.	To develop an application that verify the frequency response of a RC circuit by means of the programmable control of some of the instruments situated in a VXI chassis. The programmable control of each instrument from the PC will realise through a LAN connection and using a GPIB - Ethernet gateway .
Groups C: Work of documentation on thematic of interest that are not included in the contents of the theoretical parts-practical of the matter.	(*)

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	2	1	3
Lecturing	16	26	42
Laboratory practical	14	28	42
Mentored work	7	29	36
Objective questions exam	3	24	27

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Subject presentation. Presentation of laboratory sessions, instrumentation and software resources to be used. Individual task. In these sessions, the skills B3, B4, B5, C42, C46, D2 and D3 (DCG3, CG4, CG5, CE42, CE46, CT2 and CT3) will be worked.

Lecturing	The lecturer will explain in the classroom the main contents of the subject. The students, individually, have to manage the proposed bibliography to carry out a self-study process in a way that leads to acquire the knowledge and the skills related to the subject. The lecturer will answer the students questions in the classroom or at the office. In these sessions, the skills B3, B4, B5, C42, C46, D2 and D3 (DCG3, CG4, CG5, CE42, CE46, CT2 and CT3) will be worked.
Laboratory practical	Small-group activities designed to apply the main concepts and definitions of the subject. The student will be asked to acquire the basic skills to manage the laboratory instrumentation, software tools and components in order to construct and test electronic circuits. The student has to develop and demonstrate autonomous learning and collaborative skills. He/she is supposed to be able to manage bibliography and recently acquired knowledge. Possible questions can be answered in the laboratory sessions or at the lecturers office. Software to be used: National Instruments (NI) LabVIEW and NI Multisim. In these practises, the skills B3, B4, B5, C42, C46, D2 and D3 (DCG3, CG4, CG5, CE42, CE46, CT2 and CT3) will be worked.
Mentored work	The students have to manage basic concepts to search and select information in order to get a deeper understanding in some specific fields related to the subject. This is a group activity. The lecturer will propose in the classroom the topic of this group task and monitor the students work in personalized attention sessions. In these sessions, the skills B3, B4, B5, C42, C46, D2 and D3 (DCG3, CG4, CG5, CE42, CE46, CT2 and CT3) will be worked.

Personalized assistance

Methodologies	Description
Lecturing	The/ace students will have occasion to attend to tutoring sessions personalised or in groups. The information can find published in the web page: https://moovi.uvigo.gal/user/profile.php?id=11301. In said tutoring sessions will attend doubts and queries and will orient on how tackle their study.
Laboratory practical	The/ace students will have occasion to attend to tutoring sessions personalised or in groups. The information can find published in the web page: https://moovi.uvigo.gal/user/profile.php?id=11330. In said tutoring sessions will attend doubts and queries on the development of the practices of laboratory, the handle of the instrumentation, the setting of circuits and the tools of programming.
Mentored work	The/ace students will have occasion to attend to tutoring sessions personalised or in groups. The information can find published in the web page: https://moovi.uvigo.gal/user/profile.php?id=11301. Teachers will attend doubts and queries on the work mentored work proposed.

Assessment

	Description	Qualification	Training and Learning Results
Laboratory practical	The lecturers will check the level of compliance of the students with the goals related to the laboratory skills. They will consider the work of the students carried out before the practical session to prepare the proposed tasks, the attendance, and the quality of the work done. Marks for each session (LSM: Laboratory Session Mark) will be assigned in a 10 points scale. Final mark of laboratory, FML, will be assessed in a 10 points scale. For the evaluation of these sessions, the lecturer will assess the group work (the same mark for each member), the individual preliminary tasks and the answers to personalised questions for each session. In these works, the skills B3, B4, B5, C42, C46, D2 and D3 (DCG3, CG4, CG5, CE42, CE46, CT2 and CT3) will be evaluated.	35	B3 B4 B5 C42 C46 D2 D3
Mentored work	The lecturers will consider the quality of results obtained, their presentation and analysis, and the quality of the final report. The tutored work mark, TWM, will be graded in a 10 points scale. For the evaluation of the project, the lecturer will assess the group work (the same mark for each member). In these works, the skills B3, B4, B5, C42, C46, D2 and D3 (DCG3, CG4, CG5, CE42, CE46, CT2 and CT3) will be evaluated.	15	B3 B4 B5 C42 C46 D2 D3
Objective questions exam	The lecturers will check the level of compliance of the students with the goals related to the theory skills. Marks for each test will be assessed in a 10 points scale. Final mark of theory, FMT, will be assessed in a 10 points scale. In these tests, the skills B3, B4, B5, C42, C46, D2 and D3 (DCG3, CG4, CG5, CE42, CE46, CT2 and CT3) will be evaluated.	50	B3 B4 B5 C42 C46 D2 D3

Other comments on the Evaluation

1. Continuous Assesement

According to the guidelines of the degree and the agreements of the academic commission, a continuous assessment learning scheme will be offered to the students.

It understands that the students that assist to the two first activities evaluated just after a month from the beginning of the classes **opts by the Continuous Assesment** of the subject.

The subject comprises three different parts: theory (50 %), laboratory practical (35%) and tutored work (15%). The marksare valid only for the current academic course. The final grade for the students which have selected this option, may not be "no standing".

Any one of the activities following this evaluation type is not recoverable, except that they are properly justified following the criteria billed in the rule approved by the Claustro of the University on 18 April 2023.

1.a Theory

Two partial testing (PT) are scheduled. The first exam will be performed after unit 5, in the usual weekly scheduling of the theoretical classes. The second exam will be performed during the examination period in the date specified in the academic calendar.

Each theory exam will be comprised short answer tests and long answer development. Marks for each theory exam will be assessed in a 10 points scale.

The final mark of theory (FMT), will be the arithmetic mean of the two parts:

FMT = (PT1 + PT2)/2

The minimum mark required to pass the theory is of 5 for each test (PTi>=5).

1.b Laboratory

Seven laboratory sessions are scheduled. Each session lasts approximately 120 minutes and the students will work in small groups. This part also will be assessed by continuous assessment. Marks for each laboratory session (LSM) will be assessed in a 10 points scale.

The final mark of laboratory (FML) is calculated as the arithmetic mean of the individual laboratory session marks.

In order to pass the laboratory part the students can not miss more than one practical sessions and the minimum mark required is of 5 (FML>=5).

1.c Tutored work

In the first session of C hours, lecturers will present the objectives and the schedule of the work. They also assign a specific work to each group. After that, the most important part of the workload will be developed outside the classroom hours. The lecturers will monitor the group work and the individual student work in the following sessions of C hours. The students will be duly informed by the lecturer about the deadline for the report submission.

The minimum mark required to pass this part is of 5, TWM (Tutored Work Mark) >=5, and the students are only allowed to miss one tutored work session.

2. Global Assesment

The students who prefer a different educational policy can attend an exam on a scheduled date. This exam will comprise three parts (similar to the activities completed by the continuously assessed students): theory exam, practical exam and tutored work. Dates will be specified in the academic calendar. In order to attend the practical exam and to assign the tutored work, the students have to contact to the lecturer according to an established procedure. The procedure will be published in advance.

The theory exam will be comprised two exams (PT) each one with short answer tests and long answer development. Marks for each test will be assessed in a 10 points scale. The final mark of theory (FMT) is calculated as the arithmetic mean of the individual marks:

FMT = (PT1 + PT2)/2

The practical exam will include the implementation of electronic circuits developed in the laboratory sessions as well as some short answer questions related to these sessions. The practical exam will be assessed in a 10 points scale and this mark will be the final mark of aboratory (FML).

The student will also do a tutored work and prepare a written report to be handed in just before the exam.

3. Final mark of the subject
In order to pass the subject, students will be required to pass the three parts:

theory: FMT>=5 with PT1>=5 and PT2>=5

and laboratory: FML>=5

and tutored work: TWM>=5

In this case the final mark (FM) will be:

FM = 0.5·FMT + 0.3·FML + 0.15·TWM

However, when the students do not pass all parts, the final mark will be:

FM = min({ 4.9; 0.5·FMT + 0.3·FML + 0.15·TWM })

A final mark higher than five points (FM>=5) should be achieved in order to pass the

4. Extraordinary opportunity and End-of-program exam

The assessment policy in these calls will follow the scheme described in the single assessment: a theory exam, a practical exam and a tutored work. Dates will be specified in the academic calendar. In order to attend the practical exam and to assign the tutored work, the students have to contact to the lecturer according to an established procedure. The procedure will be published in advance.

The marks obtained during the current academic year in the first opportunity are kept in the second one for those parts in

which the student has not attended. Moreover, in the second opportunity, the students can not take an exam or a tutored work task if they have got a pass previously in the first opportunity.

The final mark will be calculated as it has described in section 3.

Sources of information
Basic Bibliography
Black, J. (editor), **The system engineering handbook: a guide to building VME bus and VXI bus Systems**, Academic Press, 1992
Mariño, P., **Las comunicaciones en la empresa: normas, redes y servicios**, 2ª ed., RAMA, 2002
Norton, H., **Sensores y analizadores**, Gustavo Gili D.L., 1984
Pérez García, M.A., **Instrumentación Electrónica**, 1ª ed., Ediciones Paraninfo, S.A., 2014
Pérez García, M.A., Álvarez Antón, J.C., Campo Rodríguez, J.C., Ferrero Martín, F.J., y Grillo Orteg, **Instrumentación Electrónica**, 2ª ed., Thomson, 2004
Complementary Bibliography
del Río Fernández, J., Shariat-Panahi, S., Sarriá Gandul, S., y Lázaro, A.M., **LabVIEW: Programación para Sistemas de Instrumentación**, 1ª ed., Editorial Garceta, 2011

Recommendations

Subjects that are recommended to be taken simultaneously
Programmable Electronic Circuits/V05G301V01302 Analogue Electronics/V05G301V01311 Data Acquisition Systems/V05G301V01314

IDENTIFYING DATA				
Microelectronics Design				
Subject	Microelectronics Design			
Code	V05G301V01317			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Cao Paz, Ana María			
Lecturers	Cao Paz, Ana María Rodríguez Pardo, María Loreto			
E-mail	amcaopaz@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The main purposes of this course are for the students: 1) To get acquainted with integrated circuits (ICs) and micro-electro-mechanical systems (MEMs) fabrication technologies. 2) To get acquainted with CMOS fabrication processes for ICs and MEMs. 3) To analyze the physical structure of passive components and active devices in CMOS technology. 4) To get acquainted with the basic aspects of MEMs design. 5) To work with CAD tools for the design.of CMOS ICs English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B13	CG13 The ability to use software tools that support problem solving in engineering.
C42	(CE42/SE4): The ability to apply electronics as support technology in other fields and activities and not only in information and communication technologies.
C43	(CE43/SE5): The ability to design analogical and digital electronics circuits of analogical to digital conversion and vice versa, of radiofrequency, of feeding and electrical energy conversion for computing and telecommunication engineering.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
To know and understand fabrication process of integrated circuits (ICs) and micro-electro-mechanical systems (MEMs) in CMOS technology, as well as design methodologies and steps for the specification of an IC.	B6	C42 C43	
To understand and be able to analyze the physical structure of resistors, capacitors, and transistors for inclusion in CMOS technology ICs.	B6 B9	C43	D4
To be capable of working with CAD tools for the design of CMOS ICs.	B6 B9 B13		D4
To know and understand the basic aspects of analog ICs design and their basic structures in CMOS technology.		C42	

Contents	
Topic	
Chapter 1: Introduction (1h)	Course introduction. Purposes and planning of the course. Basic concepts in the design of integrated circuits (ICs) and micro-electro-mechanical systems (MEMs).

Chapter 2: Fabrication steps for ICs and MEMs (2h)	Introduction to ICs and MEMs fabrication. Planar technology. Micromachining and micromolding technologies. CMOS IC fabrication steps. Structure of MOS transistors. Fabrication example: CMOS inverter. Layout. MEMs fabrication steps: bulk micromachining, surface micromachining, and LIGA.
Chapter 3. ICs and MEMs fabrication processes (3h)	Silicon wafers. Epitaxial layers. Dielectric layers. Oxidation. Deposition. Semiconductor layers. Dopant diffusion. Ion implantation. Photolithography. Etching. Metalization.
Chapter 4. Modeling of MOS transistors (3h).	MOS transistors: analytical model. Higher-order effects. Fundamentals of Spice modeling and simulatin. Spice models of MOS transistors.
Chapter 5. Physical structure of basic elements (2h)	Specification of the physical structure of a MOS transistor. Specification of the physical structure of a resistor. Specification of the physical structure of a capacitor. Types of physical specifications. Influence of physical design in the behavior of a device. Design rules. Design methodologies and tools.
Chapter 6. Resistor layout strategies (1h)	Lateral diffusion. Effective geometric dimensions. Influence of the terminals. Long resistors. Unit resistors. Stacked resistors. Neighborhood effects. Dummies. Interdigited and common centroid structures.
Chapter 7. Capacitor layout strategies (1h)	Oxide thickness gradient, lateral diffusion, and neighborhood effects. Area and perimeter unit capacitances.
Chapter 8. Transistor layout strategies (2h)	Transistor with high aspect ratio. Stacked transistors. Interdigited structures.
Chapter 9. Physical design case studies (3h)	Basic current mirror. Self-biased differential amplifier.
Lab assignment 1. Introduction to IC design tools (2h)	Introduction to physical design tools. Basic layout elements and individual nMOS and pMOS transistors. Design Rule Check (DRC). Predesigned elements and transistors.
Lab assignment 2. CMOS inverter (4h)	Schematic design of a CMOS inverter. Corrections for symmetrical response. Simulation with capacitive loads. Layout design and DRC. Layout Versus Schematic (LVS). Post-layout simulation (without and with capacitive load). Comparison with schematic simulation.
Lab assignment 3. MOS transsitor layout strategies (2h)	Layout of pMOS and nMOS transistors. Snake, stacked, and interdigited structures. Dummy structures.
Lab assignment 4. Physical design of analog functional blocks: current mirror and differential pair (3h)	Layouts of a basic curent mirror and a self-biased pMOS differential amplifier.
Lab assignment 5. Passive components layout strategies (2h)	Layouts of resistors and capacitors. Linear, snake, stacked and interdigited structures. Dummy structures.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	18	45	63
Practices through ICT	13	19.5	32.5
Project based learning	6	27	33
Presentation	1	2.5	3.5
Problem and/or exercise solving	1	3.5	4.5
Problem and/or exercise solving	2	7	9
Laboratory practice	1	3.5	4.5

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The professor will present the relevant concepts of the course. Before each lecture, students must carry out a preparatory analysis of the topics to be addressed, aiming at their active participation. Practical examples and case studies will be developed and analyzed. Attendance will be recorded. Competencies C42 and C43 will be addressed in these sessions
Practices through ICT	Students will work using IC CAD tools. All relevant steps in the physical design of an IC will be practically studied. Attendance will be recorded, and performance of each group in each lab assignment will be evaluated. Software to be used: Electric and LTSpice. Competencies C43 and B13 will be addressed in these sessions

Project based learning	Students will work in small teams (C-type groups) in the physical design and characterization of a circuit consisting of active devices and passive components, under the close guidance of professors. Attendance will be recorded. The activities to be developed by each team are: - Analysis of possible solutions and design alternatives. - Critical analysis of the design process developed. - Demonstration of the circuits designed in the project. - Preparation of a report where results are presented, analyzed, and discussed. Competencies C43, B6, B9, B13, and D4 will be addressed in these sessions.
Presentation	Each group of students will publicly present their project to professors and the other students in the group. Anyone in the audience will be allowed to ask questions about the project. Competencies C43, B6, B9, and D4 will be addressed in these sessions.

Personalized assistance

Methodologies	**Description**
Lecturing	Professors will personally assist students with doubts and questions they may have about either theoretical contents. Office hours will be scheduled for both individual and group sessions. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: María Loreto Rodríguez Pardo: https://moovi.uvigo.gal/user/view.php?id=11332 Ana María Cao Paz: https:// moovi.uvigo.gal/user/view.php?id=11331
Practices through ICT	Professors will personally assist students with doubts and questions they may have about lab assignments. Office hours will be scheduled for both individual and group sessions. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: María Loreto Rodríguez Pardo: https://moovi.uvigo.gal/user/view.php?id=11332 Ana María Cao Paz: https:// moovi.uvigo.gal/user/view.php?id=11331
Project based learning	Professors will personally assist students with doubts and questions they may have about the development of the projects. Office hours will be scheduled for both individual and group sessions. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: María Loreto Rodríguez Pardo: https://moovi.uvigo.gal/user/view.php?id=11332 Ana María Cao Paz: https:// moovi.uvigo.gal/user/view.php?id=11331
Presentation	Professors will personally assist students with doubts and questions they may have about the preparation of the public presentations. Office hours will be scheduled for both individual and group sessions. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: María Loreto Rodríguez Pardo: https://moovi.uvigo.gal/user/view.php?id=11332 Ana María Cao Paz: https:// moovi.uvigo.gal/user/view.php?id=11331

Assessment

	Description	Qualification	Training and Learning Results	
Project based learning	Each group of students will deliver the design carried out in the project in the format of the integrated circuit design tool. To pass the course, the design must meet technological standards and it shall comply the required specifications. In addition, each group must submit a detailed project report, with explicit information about the contribution of each of them to the whole, as well as the methodology followed for the distribution and coordination of tasks. Based on this division of tasks, it can be assigned an individual mark to each of the group members. The evaluation of the projects will be based on a list of items provided previously. Reports must be submitted on the date indicated in the planning of the course and it will be at least two days prior to the public presentation. To pass the course, students must achieve at least a mark of 5 or higher in a scale of 0-10 in the project (design and reporting). Competencies C43, B6, B9, B13, and D4 will be assessed in these projects.	25	B6 B9 B13	C43 D4

Presentation	Each student must provide an individual 5-minute public presentation of the part of the project he/she carried out (including planning / coordination tasks, if applicable). Presentations will be scheduled in the last (1-hour) classroom session of the corresponding group. At the end of each presentation, the student must give suitable replies to questions from the audience, which will consist of professors and the other students in the group, who must attend the whole session. Evaluation will be based on the content, formal issues, and deliverance of the presentation, as well as on the way the student replies to que questions from the audience. Students asking relevant questions will get additional score for them. The mark obtained in the public presentation consists of two parts, a common part for tasks carried out jointly and an individual part of the exposition of each student of his or her work as well as the appropriate interventions at the end of the exposure of other groups. To pass the course, the student must achieve in his/her presentation (plus additional score if applicable) a mark of 5 or higher in a 0-10 scale. Competencies C43, B6, B9, and D4 will be assessed in these presentations.	5	B6 B9	C43 D4
Problem and/or exercise solving	As part of the continuous assessment, two written individual tests are conducted. The first evaluation 1-hour written test will be held during one of the classroom sessions, covering course contents lectured so far. The test will consist of short answer questions, accounting for 20% of the global mark. The second written test will be held at the end of classroom sessions, covering the remaining classroom contents and accounting for 5% of the global mark. This test will be held in conjunction with the test of design problems or exercises more fully described below. The test will last for about an hour, including written test and design problems (or exercises) test. To pass the course, students must achieve in each of the tests a mark or 4 or higher in a 0-10 scale. Competencies C42 and C43 will be assessed in these tests	25		C42 C43
Problem and/or exercise solving	An exam of troubleshooting and / or exercises will be carried out as part of the continuous assessment, accounting for 15% of the global mark. This exam will be held in conjuction with the second written test described in the previous section and it will last for about an hour as a whole. To pass the course, students must achieve in this exam a mark or 4 or higher in a 0-10 scale. Competencies C42 and C43 will be assessed in this test.	15		C42 C43
Laboratory practice	All students, in continuous evaluation or not, must submit the files of the Lab practices. Deadline for submissions will be communicated sufficiently in advance. These submissions account for 10% of the global mark. All students, in continuous evaluation or not, must submit a complete report based in Lab Assignments 1 and 2 with the achieved results and conclusions according to the indications of the teaching staff. The report is due the indicated date in the planning. The corresponding report account for 10% of the global mark. A continuous evaluation 1-hour lab exam using an IC CAD tool will be held in the last scheduled lab session. Another similar exam will be held in the date of the final exam. It is compulsory for students not in continuous evaluation. Lab tests account for 10% of the global mark. To pass the course, students must achieve a mark or 4 or higher in a 0-10 scale in each part: lab files submissions, Lab Report and the lab test. Competencies C43 and B13 will be assessed in this part.	30	B13	C43

Other comments on the Evaluation

Continous assesment:

The planning of the different tests of intermediate evaluation will be approved by the "Comisión Académica de Grado" (CAG) and it will be available at the beginning of the semester.

In order to pass the course, students must achieve a global mark of 5 or higher in a 0-10 scale. The global mark will be obtained as the weighted summation of the scores obtained in the different parts of the course. A minimum score is required in each of these parts. For students not achieving the minimum score in any of the parts, the global mark will be the lower value between 4.5 and the weighted summation of scores.

Global assessment:

Students not in continuous evaluation will be evaluated as follows:

- Final written and lab tests will account for the same percentage of the global mark as in the case of students in continuous assessment.
- They must develop a project and deliver the corresponding report and public presentation (in the same sessions and with

the same criteria as students in continuous assessment). Reports are due two days before public presentation.
- They must complete all the lab practice files submissions and deliver the Lab written report with the achieved results and conclusions.
Minimum scores in the different parts for students in global assessment are the same as for students in continuous assessment.
The deadline to renounce to continuos assessment will be one month before the end date of the semester, according to the calendar of the center. The procedure will be by sending an email to the teaching staff requesting the renounce of continuous assessment.

Extraordinary call and End-of-program call.

Requirements to pass the course in these calls will be the same as in the continuos assessment, in terms of the minimum scores. Students must complete the two written tests and the lab test. The practice files, the lab report and the memory of the project must be submitted 7 days before the date of the exam.

Sources of information

Basic Bibliography

José Antonio Rubio Solà, **Diseño de circuitos y sistemas integrados**,
Stephen A. Campbell, **Fabrication Engineering at the Micro-and Nanoscale**, 4ª,
J. Franca, Y. Tsividis (eds.), **Design of analog VLSI circuits for telecommunications and signal processing**,

Complementary Bibliography

Recommendations

Subjects that it is recommended to have taken before

Digital electronics/V05G301V01203
Physics: Fundamentals of electronics/V05G301V01201
Electronic technology/V05G301V01206

Other comments

All conclusions achieved both in the written tests and in the projects must be adequately justified. Non-trivial concepts cannot be assumed but they have to be explained. The methodologies used by the student will be taken into account in the computation of his/her marks. No auxiliary resources, including but not limited to documentation, can be used in the written tests.

In case of detection of plagiarism in any of the evaluation tests or assignment submissions, the final grade will be SUSPENSE (0) and the fact will be reported to the corresponding academic authorities for prosecution.

IDENTIFYING DATA				
Electronic Systems for Digital Communications				
Subject	Electronic Systems for Digital Communications			
Code	V05G301V01318			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Machado Domínguez, Fernando			
Lecturers	Machado Domínguez, Fernando			
E-mail	fmachado@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The overall objective of this course is to provide the theoretical and practical skills for the analysis and design of electronic systems for digital communications. To achieve this, several wire and wireless communication standards will be reviewed and the basic architectures of digital communication systems, the design of the electronic circuits that compose these systems and their functionality will be studied.			

Training and Learning Results	
Code	
B11	CG11 To approach a new problem considering first the essential and then the secondary aspects
B13	CG13 The ability to use software tools that support problem solving in engineering.
C40	(CE40/SE2): The ability to select electronic circuits and devices specialized in transmission, forwarding or routing, and terminals for fixed and mobile environments.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
Knowledge of transmission-reception principles and general considerations on the transmission-reception (transceivers) and routing circuits.		C40
Knowledge of the basic digital communication systems architecture and the functional design of these systems.	B11	C40
Ability to design different basic subcircuits that compose the transmision-reception circuits of a digital communication system.	B11 B13	C40
Ability to evaluate the possibilities of diferent interconnection standards for the design of communications systems.		C40
Knowledge of the terminals used in digital communications systems.		C40

Contents	
Topic	
Unit 1. Introduction	Introduction and review of the basic concepts of transmission-reception and general considerations on the transmission-reception circuits. Basic architecture of digital communications systems. Different hardware and software implementations: ASIC, DSP and FPGA.
Unit 2. Wired communication systems	Introduction to serial communication systems. Transmission media, signals and bit encoding. Transceiver circuits. Medium access methods.
Unit 3. Asynchronous serial communication systems	Asynchronous serial communication protocols. Standards and practical implementations.
Unit 4. Synchronous serial communication systems	Synchronous serial communication protocols. Standards and practical implementations.
Unit 5. High-speed synchronous serial communication systems	High-speed synchronous serial communication protocols. Differential technologies. Standards and practical implementations.
Unit 6. Wireless communication systems	Wireless communication protocols. Wiireless networks characteristics and configurations.
Unit 7. Short range wireless communication systems	Wireless communication protocols of short range and low consumption. WPAN Networks. Characteristics and analysis of the wireless sensors networks. Standards and practical implementations.
Unit 8. Radio frequency identification systems. Near-field communications	RFID technology. Near-field communications. Standards and practical implementations.
Laboratory	Laboratory sessions and project.

Block 1. Wired asynchronous serial communication circuits	Design, implementation and test of an asynchronous serial communication circuit. Transceivers.
Block 2. Wired synchronous serial communication circuits	Design, implementation and test of a synchronous serial communication circuit. Clock recovery.
Block 3. Wireless communication circuits	Design, implementation and test of a wireless communication circuit. Using and configuring communication modules.
Block 4. Project: Design and implementation of a digital communications system	Design, implementation and test of a digital communication system. Applying theoretical and practical concepts.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	12	12	24
Problem solving	4	4	8
Laboratory practical	8	20	28
Project based learning	15	45	60
Report of practices, practicum and external practices	0	15	15
Objective questions exam	1.5	6	7.5
Problem and/or exercise solving	1.5	6	7.5

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The lecturer will explain in the classroom the main contents of the subject. The students have to manage the proposed bibliography to carry out a self-study process in a way that leads to acquire the knowledge and the skills related to the subject. The lecturer will answer the students questions in the classroom or in the office. In these sessions the students will develop the skills C40 and B11 ("know").
Problem solving	Activities designed to apply the main concepts of the subject to solve problems and exercices. The lecturer will explain a set of problems and the students have to solve diferent take-home sets of problems. The lecturer will answer the students questions in the classroom or in the office. In these sessions the students will develop the skill C40 ("know").
Laboratory practical	Activities designed to apply the main concepts and definitions of the subject. The student will be asked to acquire the basic skills to manage the laboratory instrumentation, software tools and components in order to construct and test electronic circuits. The student has to develop and demonstrate autonomous learning and collaborative skills. Possible questions can be answered in the laboratory sessions or in the lecturers office. In these sessions the students will develop the skills C40 and B13 ("know how").
Project based learning	Students have to develop a group project, as long as it is possible to form groups, that goes on over a period of time and addresses a specific problem. They have to design, schedule and carry out a set of tasks to achieve a solution. Each group will present the proposed solution and a project report. In these sessions the students will develop the skills C40, B11 and B13 ("know how").

Personalized assistance

Methodologies	**Description**
Lecturing	The lecturer will answer the students questions and also give instructions to guide the studying and learning process. The students can go to the lecturers office (individually or in a group). The timetable will be available on the school website at the beginning of the term. The timetable and/or the mechanism to request tutoring sessions will be available on the subject's website on the Moovi online-teaching portal (https://moovi.uvigo.gal/).
Problem solving	The lecturer will answer the students questions and also give instructions to guide the studying and learning process. The students can go to the lecturers office (individually or in a group). The timetable will be available on the school website at the beginning of the term. The timetable and/or the mechanism to request tutoring sessions will be available on the subject's website on the Moovi online-teaching portal (https://moovi.uvigo.gal/).
Laboratory practical	The lecturer will help students understand the work to be developed in the laboratory (components, circuits, instrumentation and tools). The students can go to the lecturers office (individually or in a group). The timetable will be available on the school website at the beginning of the term. The timetable and/or the mechanism to request tutoring sessions will be available on the subject's website on the Moovi online-teaching portal (https://moovi.uvigo.gal/).
Project based learning	The lecturer will be available to help students in order to deal with the project. The timetable will be available on the school website at the beginning of the term. The timetable and/or the mechanism to request tutoring sessions will be available on the subject's website on the Moovi online-teaching portal (https://moovli.uvigo.ga/).

Assessment			
	Description	Qualification	Training and Learning Results
Laboratory practical	The lecturer will check the level of compliance of the students with the goals related to the laboratory skills. The final mark of laboratory, FML, will be assessed in a 10 points scale. For the evaluation of the laboratory sessions, the lecturer will assess the group work (the same mark for each member), as long as it was possible to form groups, the individual preliminary tasks and the answers to personalized questions for each session.	20	B13 C40
Project based learning	The lecturers will consider the work done during the laboratory sessions, the presentation of results and functionality. This mark (FUN) will be assessed in a 10 points scale and will represent 80% of the group project mark and 40% of the final mark of the subject. For the evaluation of the project, the lecturer will assess the group work (the same mark for each member) and the individual work during the laboratory sessions and the presentation of the developed project.	40	B11 C40 B13
Report of practices, practicum and external practices	The lecturers will consider the quality of the project report and the presentation and analysis of the results. This mark (REP) will be assessed in a 10 points scale and will represent 20% of the final mark project and 10% of the final mark of the subject. For the evaluation of this part, the lecturer will assess the group work (the same mark for each member) and the individual presentation of the developed project.	10	B11 C40 B13
Objective questions exam	The lecturer will check the level of compliance of the students with the goals related to the theory skills. The final mark of theory, FMT, will be assessed in a 10 points scale.	15	C40
Problem and/or exercise solving	The lecturer will check the level of compliance of the students with the goals related to the theory skills. The final mark of theory, FMT, will be assessed in a 10 points scale.	15	C40

Other comments on the Evaluation

1. Continuous assessment (ordinary call)

According to the guidelines of the degree and the agreements of the academic commission, a continuous assessment learning scheme will be offered to the students.

*When the students perform the first short answer test or attend any laboratory sessions one month after the start of the semester, **they will be assessed by continuous assessment**.*The final grade of students who have chosen this path cannot be "not presented".

The subject comprises three different parts: theory (30 %), laboratory (20%) and group project (50%). The marks of the assessed tasks are valid only for the current academic course.

The planning for the different sessions will be available at the beginning of the semester. Students who are occasionally unable to attend any of the assessment tasks could repeat it, whenever it was possible within the subject academic schedule and only if the absence is duly justified.

1.a Theory

Two short answer tests (SAT) are scheduled. The first intermediate test (SAT1) will be performed during the classes. The scheduling of the intermediate test will be approved by the Academic Committee of the Degree (CAG) and will be available at the beginning of the semester. The second test (SAT2) will be performed during the examination period in the date specified in the academic calendar.

Marks for each test will be assessed in a 10 points scale. The minimum mark required to pass this part is of 4 (SATi>=4). The final mark of theory (FMT) is calculated as the arithmetic mean of the individual marks:

FMT = (SAT1 + SAT2)/2.

The students cannot do the tests at a later date.

If the minimun mark in the first test is not achieved (SAT1 less than 4), the students can repeat this part in the same date of the second test.

1.b Laboratory

Four laboratory sessions are scheduled. Each session lasts approximately 120 minutes and the students will work in groups. This part also will be assessed by continuous assessment. The lecturer will consider the work of the students carried out before the laboratory session to prepare the proposed tasks, the work in the laboratory to deal with them as well as the student's behavior.

Marks for each laboratory session (LSM) will be assessed in a 10 points scale. In order to pass the laboratory part the students can not miss more than one laboratory sessions. The final mark of laboratory (FML) is calculated as the arithmetic mean of the individual laboratory session marks.

1.c Project

In the first session lecturers will present the objectives and the schedule of the project. They will also assign a specific project to each group, as long as it was possible to form groups. After that, the most important part of the workload and the project supervision will be developed in the remaining sessions: six hours of B laboratory sessions and six hours of C laboratory sessions.

In order to assess the project, the lecturer will consider: the work done during the laboratory sessions, functionality and presentation of results (FUN), and the quality of the project report (REP). Each of these parts will be scored on a 10 points scale. The group project mark (GPM) will be the weighted sum of the marks for each part:

GPM = 0.8·FUN + 0.2·REP

The project will be assessed in a 10 points scale. The minimum mark required to pass this part is of 4 (GPM>=4). The students are only allowed to miss one project session and only if this absence is duly justified.

1.d Final mark of the subject

The weighted points from all assessed parts are added together to calculate the final mark (FM). The following weightings will be applied: 30% theory (FMT), 20% laboratory (FML) and 50% group project (GPM).

In order to pass the subject, students will be required to pass the theory, laboratory and group project parts. In this case the final mark (FM) will be:

FM = (0.3·FMT + 0.2·FML + 0.5 GPM).

However, when the students do not pass both parts (FMT or GPM less than 4) or do not reach the minimum mark of 4 required to pass each short answer test or miss more than 1 laboratory sessions or miss more than 1 project sessions, the final mark grade can never be higher than 4.9:

FM = min{4.9 ; (0.3·FMT + 0.2·FML + 0.5 GPM)}.

A final mark higher than five points (FM >= 5) should be achieved in order to pass the subject.

2. Global assessment (ordinary call)

The students who prefer a different educational policy can attend an exam on a scheduled date. The date will be specified in the academic calendar. This exam will comprise three parts: theory exam, laboratory exam and project. The student will prepare a written project report to be handed in just before the exam. The final project must be presented within one week of delivery of reports. In order to assign the project, the student has to contact to the lecturer at least four weeks before the exam.

The theory exam will be assessed in a 10 points scale. The minimum mark required to pass this part is of 4 (FMT>=4).

The laboratory exam will be assessed in a 10 points scale. The minimum mark required to pass this part is of 4 (FML>=4).

In order to assess the project, the lecturer will consider the results and the quality of the written report. The project will be assessed in a 10 points scale. The minimum mark required to pass this part is of 4 (GPM>=4).

In order to pass the subject, students will be required to pass each part (FMT>=4, FML>=4 and GPM>=4). In this case the final mark (FM) will be:

FM = (0.3·FMT + 0.2·FML + 0.5 GPM).

However, when the students do not reach the minimum mark of 4 required (FMT or FML or GPM less than 4), the final mark can never be higher than 4.9:

FM = min{4.9 ; (0.3·FMT + 0.2·FML + 0.5 GPM)}.

A final mark higher than five points (FM >= 5) should be achieved in order to pass the subject.

3. Extraordinary call and end-of-program call

The assessment policy in extraordinary call and end-of-program call will follow the scheme described in the previous section. Dates will be specified in the academic calendar. This exam consist on a theory exam, a laboratory exam and a project. In order to assign the project, the student has to contact to the lecturer at least four weeks before the exam.

The final mark will be calculated as it has described in section 2.

In extraordinary call, the marks obtained in the previous continuous or global assessment are kept for those parts in which the student has not attended.

Sources of information

Basic Bibliography

F. Machado, V. Pastoriza, F. Poza, **Sistemas Electrónicos para Comunicaciones Digitales**, Curso 2016/2017,

P. Mariño, **Las comunicaciones en la empresa. Normas, redes y servicios**, 2ª Ed.,

S. Mackay, E. Wright, D. Reynders, J. Park., **Practical industrial data networks : design, installation and troubleshooting**, 1ª Ed.,

Complementary Bibliography

R. Faludi, **Building wireless sensor networks**, 2011,

H. Lehpamer, **RFID design principles**, 2012,

B. Sklar, **Digital communications. Fundamentals and applications**, 2ª Ed.,

Recommendations

Subjects that it is recommended to have taken before

Digital electronics/V05G301V01203

Programmable Electronic Circuits/V05G301V01302

IDENTIFYING DATA				
Radio Frequency Circuits				
Subject	Radio Frequency Circuits			
Code	V05G301V01319			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Torío Gómez, Pablo			
Lecturers	Torío Gómez, Pablo			
E-mail	ptorio@uvigo.es			
Web	http://moovi.uvigo.gal/course/view.php?id=286			
General description	Main radio system circuits are studied. In this matter main characteristics and structure are treated. The evaluation of this circuits is studied too. International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B8	CG8: To know and apply basic elements of economics and human resources management, project organization and planning, as well as the legislation, regulation and standarization in Telecommunications.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C24	CE24/ST4 The ability to select circuits, subsystems and systems of radiofrequency, microwaves, broadcasting, radio link and radio determination.
C25	CE25/ST5 The ability to select transmission antennas, equipment and systems, propagation of guided and non-guided waves, with electromagnetic, radiofrequency and optical media, and their corresponding radio electric spectrum management and frequency designation.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
- Learn to understand the specifications of a subcircuit and the impact these specifications have on the system as a whole. From these specifications, learn how to develop a circuit that complies with them by proposing engineering solutions in which prices, deadlines, availability, etc. are of paramount importance. - Learn the effect that each parameter of the specifications of a circuit has on the complete system. - Learn to analyse the priorities of the parameters as appropriate.	B4 B6 B8 B9	C24 C25	D2 D4

Contents	
Topic	
Main radiocommunication systems characteristics.	Non linear effects
Use of radiofrequency laboratory equipment.	Use and understanding of laboratory equipment: Spectrum analyzer Network analyzer Signal source
Filtros	Theorical and practical principles of radiofrequency filters.
Study of amplifiers.	Main characteristics Noise in amplifiers

Oscillators	Non linear treatment Oscillators measurement Voltage controlled oscillators (VCO) Phase noise
Frequency synthesizers	Based in PLL. Direct digital synthesis.
Mixers	Basic approach Main mixers structures

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	17	24	41
Practices through ICT	12	4	16
Laboratory practical	7	2	9
Problem and/or exercise solving	2	27	29
Problem and/or exercise solving	2	27	29
Problem and/or exercise solving	2	24	26

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Lecturing	Exhibition by part of the faculty of the contents of the matter, boosting the critical discussion of the concepts. They seat the theoretical bases of algorithms and procedures used to resolve problems.
Practices through ICT	Cooperative work in computer classroom, with software of simulation
Laboratory practical	Cooperative work in a reduced group, with instrumental of measure, in conditions of laboratory.

Personalized assistance

Methodologies	Description
Lecturing	In the established tutorial classes the teacher will attend the doubts that can arise. These tutorial classes will be made individually or in reduced groups. They will be attended after previous appointment that will be requested by email or in moovi.uvigo.gal.
Laboratory practical	In the established tutorial classes the teacher will attend the doubts that can arise. These tutorial classes will be made individually or in reduced groups. They will be attended after previous appointment that will be requested by email or in moovi.uvigo.gal.
Practices through ICT	In the established tutorial classes the teacher will attend the doubts that can arise. These tutorial classes will be made individually or in reduced groups. They will be attended after previous appointment that will be requested by email or in moovi.uvigo.gal.
Tests	**Description**
Problem and/or exercise solving	In the established tutorial classes the teacher will attend the doubts that can arise. These tutorial classes will be made individually or in reduced groups. They will be attended after previous appointment that will be requested by email or in moovi.uvigo.gal.
Problem and/or exercise solving	In the established tutorial classes the teacher will attend the doubts that can arise. These tutorial classes will be made individually or in reduced groups. They will be attended after previous appointment that will be requested by email or in moovi.uvigo.gal.
Problem and/or exercise solving	In the established tutorial classes the teacher will attend the doubts that can arise. These tutorial classes will be made individually or in reduced groups. They will be attended after previous appointment that will be requested by email or in moovi.uvigo.gal.

Assessment				
	Description	Qualification	Training and Learning Results	
Practices through ICT	Assistance to practical sessions in computer classroom, justified by the report of each practice	4.8	B4 B6 B9	C24 C25
Laboratory practical	Active assistance to practical sessions of laboratory, justified by the report of each practice	10	B4 B6	C24 C25
Problem and/or exercise solving	Examination written of evaluation, with questions and problems referents to the contents of the sessions *magistrales 1	30	B4 B6	C24 C25

Problem and/or exercise solving	Examination written of evaluation, with questions and problems referents to the contents of the sessions *magistrales 2	30	B4 B6	C24 C25
Problem and/or exercise solving	Examination written on the practical sessions in the computer classroom	25.2	B4 B6 B9	C24 C25

Other comments on the Evaluation

Following the specific guidelines of the qualification, two assessment systems will be offered to those studying this subject: Continuous assessment, which is the recommended method and around which teaching activities are organized, and a Global assessment option, that is recommended only in those situations where it is impossible to follow the suggested system.
Types and rating of sections: * Master sessions. Individual rating (Weight: 60%)* Practices in computer science classes. Individual rating (weight: 30%)* Laboratory practices. Individual rating (weight: 10%)
CONTINUOUS ASSESSMENTA person is considered to be following the continuous assessment procedure when he or she submits to a punctuable test or continuous assessment examination.If the continuous assessment is chosen, the final rating may not be not present.
The ongoing assessment consists of the tests described below in this guide.* Examinations on the content of master sessions.* Practices in computer science classes. Their assessment is based on active assistance justified by the report of each practice and a final examination.* Lab practices. Their assessment is based on active assistance justified by the report of each practice.
In order to ensure that all competences in the subject matter are acquired, approval will require the following two conditions to be met together:1) Get a score equal to or greater than a 4 (on a scale of 0 to 10), in each type of activity.2) Obtain an overall score, calculated as the sum of the activities scores weighted by the corresponding weight, equal to or greater than 5 (on a scale of 0 to 10)If only condition 2) and not condition 1) is met, the overall score for the subject will be 4.9.
Continuous assessment practices and examinations are not recoverable.The continuous assessment reviews have no impact beyond the continuous assessment procedure.A person who has not completed at least 50% of the practices may not take the continuous assessment procedure.
CONTINUOUS ASSESSMENTThose who do not opt for continuous assessment will be assessed through a single final examination on the official date assigned by the Centre, at which the content of all activities will be assessed, in such a way that it is demonstrated that they have acquired the same competences as those who opted for the continuous assessment.In order to ensure that all competences in the subject matter are acquired, approval will require the following two conditions to be met together:1) Get a score equal to or greater than a 4 (on a scale of 0 to 10), in each of the different sections in which the examination is divided. These sections correspond to the types of activity described above.2) Obtain a overall score in the examination equal to or greater than a 5 (on a scale of 0 to 10).
EXTRAORDINARY OPPORTUNITY CALLThe person who has been assessed by Continuous Assessment can choose between two options on the same day of the examination:* Maintain the qualification corresponding to their attendance to the practices and take all the Continuous Assessment exams on the official date assigned by the Centre.* Be assessed with a single final examination at the official day assigned to the Centre, as stipulated for the comprehensive assessment system The person who has NOT been assessed by Continuous Assessment will be assessed with a single final examination on the official date assigned by the Centre, as stipulated for the global assessment system.
FINAL CALLIn the end-of-career call, the student will be assessed with a single final examination on the official date assigned by the Centre, as stipulated for the Global Assessment System.
In case of detection of plagiarism in any of the tests or works, the final rating will be FAIL (0) and the fact will be communicated to the management of the Centre for the appropriate purposes.
ENGLISH FRIENDLYThe international students will be able to request to the professor material and bibliographic references for the follow-up of the subject, attend the tutorials, proofs and evaluations in English.

Sources of information

Basic Bibliography

Apuntes de la asignatura, **F. Isasi**, 1,

Complementary Bibliography

Electrónica de comunicaciones, **M. Sierra y otros**, 1,
Solid state radio engineering, **Kraus, Bostian y Raab**, 1,
James W. Nilsson, Susan A. Riedel, **Circuitos eléctricos**, 7,

Recommendations

Subjects that continue the syllabus

Microwave Circuits/V05G301V01322
Wireless Systems and Networks/V05G301V01326

Subjects that it is recommended to have taken before

Physics: Analysis of Linear Circuits/V05G301V01108
Mathematics: Calculus 1/V05G301V01101
Mathematics: Calculus 2/V05G301V01106
Signal Transmission and Reception Techniques/V05G301V01208
Electronic technology/V05G301V01206
Analogue Electronics/V05G301V01311

Other comments

Studens should be skillful in network analisys and know the small signal equivalent circuits.
Electronics subjects around the transistor must be reviewed.

IDENTIFYING DATA				
Radio Communication Systems				
Subject	Radio Communication Systems			
Code	V05G301V01320			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	Spanish			
Department				
Coordinator	Rubiños López, José Óscar			
Lecturers	Arias Acuña, Alberto Marcos Rubiños López, José Óscar			
E-mail	oscar@com.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This course is devoted to the study of the fundamentals of radio communications systems, including the antennas, the link budget as well as those factors that limit the correct recepction such as noise and interference.			

Training and Learning Results	
Code	
B2	CG2: The knowledge, comprehension and ability to apply the needed legislation during the development of the Technical Telecommunication Engineer profession and aptitude to manage compulsory specifications, procedures and laws.
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C21	CE21/ST1 The ability to construct, exploit and manage telecommunication networks, services, process and applications, considered as systems of receiving, transporting, representation, processing, storage, management and presentation of multimedia information from the point of view of transmission systems.
C22	CE22/ST2 The ability of applying the basic techniques of telecommunication networks, services and applications for mobile and fixed environments, personal, local or long distance, with different bandwidth, including telephony, radio broadcasting, TV and data, from the point of view of transmission systems.
C25	CE25/ST5 The ability to select transmission antennas, equipment and systems, propagation of guided and non-guided waves, with electromagnetic, radiofrequency and optical media, and their corresponding radio electric spectrum management and frequency designation.
D2	CT2 Understanding Engineering within a framework of sustainable development.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Ability to apply the techniques underlying radio communications systems in fixed and mobile communication services in local or long-distance links at different bandwidths.	B4	C22	D2
Ability to understand the concept of systems limited by noise, as well as the types of noise and interferences.	B2		D2
Ability to understand the mechanisms of propagation and how to model the propagation channel.	B2	C25	
Ability to understand the foundations of antennas. Ability to know and characterize the different types of antennas.	B2	C25	
Ability to understand and specify the foundations of terrestrial and satellite broadcast services.	B2	C21	
Ability to understand the foundations of the radio links.	B2	C21	
Ability to understand the concept of coverage and to apply it to the radio link and broadcasting services.	B2	C22 C25	D2
Ability to analyse the coverage in order to specify the quality of service.	B4	C21	D2

Contents	
Topic	
1. RADIATION FUNDAMENTALS (theoretical-practical)	1.1 Electromagnetic Fundamentals 1.2 Antenna parameters in transmission 1.3 Antenna parameters in reception 1.4 Types of antennas

2. LINK BUDGET (theoretical-practical)	2.1 Friis transmission equation 2.2 Propagation losses. 2.3 Band frequencies.
3. NOISE (theoretical-practical)	3.1 Thermal noise. 3.2 Noise in antennas. 3.3 Noise factor and noise-equivalent temperature of a receiver.
4. INTERFERENCE (theoretical-practical)	4.1 Concept and types of interference 4.2 Characterization of interference
5. AVAILABILITY (theoretical-practical)	5.1 Concepts of availability, fading and diversity 5.2 Noise-limited Systems 5.3 Interference-limited Systems
6. RADIOWAVE PROPAGATION (theoretical-practical)	6.1 Propagation at very low frequencies 6.2 Surface wave propagation 6.3 Ionospheric propagation 6.4 Tropospheric Propagation
0. MEASUREMENTS (practical)	0.1 Introduction 0.2 Measurements with the field meter 0.3 Measurements with the spectrum analyzer

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	11	11	22
Problem solving	7	7	14
Laboratory practical	7	14	21
Introductory activities	1	1	2
Case studies	10	50	60
Report of practices, practicum and external practices	0	15	15
Problem and/or exercise solving	4	8	12
Essay questions exam	2	2	4

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Presentation, by the professor, of the contents of the course (theoretical basis, guidelines for solving exercises/problems or developing a radio communication project). The competencies B2, C21, C22, C25, D2 are worked with this methodology. In group.
Problem solving	Resolution, by the student, of problems and/or exercises related with the course. The student not only has to get the suitable or correct solutions by the application of the theory previously explained but also has to interpret correctly the results. The competencies B4, C21, C22, C25, D2 are worked with this methodology. Individual.
Laboratory practical	Application of knowledge to specific situations and acquisition of basic skills and procedures in the related field. They are developed in laboratories with specialized equipment. The competencies B4, C21, C22, C25 are worked with this methodology. In group.
Introductory activities	Review of necessary contents in that class that had previously been explained in previous classes and / or subjects. The competences B2, B4, C21, C22, C25, D2 are worked with this methodology. Group activity
Case studies	Study and analysis of problems based on real events in order to know them, think about them, interpret them, generate hypothesis, constrast data ... and train in the use of different procedures of solution. The competencies B4, C21, C22, C25, D2 are worked with this methodology. Individual.

Personalized assistance

Methodologies	Description
Lecturing	In this methodology, all the questions that each student can ask will be answered. (https://www.uvigo.gal/universidade/administracion-persoal/pdi/jose-oscar-rubinos-lopez)
Problem solving	Each student will be attended in an individual way. (https://www.uvigo.gal/universidade/administracion-persoal/pdi/jose-oscar-rubinos-lopez)
Case studies	Each student will be attended in an individual way. (https://www.uvigo.gal/universidade/administracion-persoal/pdi/jose-oscar-rubinos-lopez)
Laboratory practical	Each student will be attended in an individual way. (https://www.uvigo.gal/universidade/administracion-persoal/pdi/jose-oscar-rubinos-lopez)

Assessment

	Description	Qualification	Training and Learning Results
Case studies	Technique that consists of monitoring the student, who will be assessed from his autonomously solving of the proposed tasks (case studies / analysis of situations). The professor will provide help students if necessary.	3	B2 C25 D2 B4
Report of practices, practicum and external practices	Evaluation of: - the preparation and development of the lab practices, - the reports and memories on lab practices. The professor will provide help students if necessary.	7	B4 C21 D2 C22 C25
Problem and/or exercise solving	Continous assessment: two examinations in which the student has to solve (in an autonomous way) a number of exercises by applying the acquired knowledge in the time and conditions established by the professor. The student can take them during the course or together with the final examination, depending on the evaluation system chosen.	50	B2 C22 B4
Essay questions exam	Global examination: evaluation of the skills acquired by the student. He/she has to develop, relate, organise and present the knowledge acquired in the course in an autonomous way.	40	B2 C22 B4 C25

Other comments on the Evaluation

The student can choose between two evaluation systems: continuous assessment or exam-only examination. Previously to the global examination (or at the entrance of the session), the student will decide the evaluation system. Before permorming each task or delivery, the procedure and dates for the review of the qualifications will be published within a reasonable period of time.

1. The CONTINUOUS ASSESSMENT includes a series of tasks performed during the course. They are not recoverable, i.e., if a student can not fulfilled them in the time established, the professor is not bound to repeat them. The obtained qualification will be valid only for the current academic course.

The continuous assessment consists of:

a) two examinations;

b) delivery (in the last weeks of the course) of memories of the lab and autonomous-ICT practices (recommended, but not mandatory) ;

c) autonomous tasks (case studies / analysis of situations) (recommended, not mandatory);

d) the global examination.

2. GLOBAL ASSESSMENT at the end of the semester. It is mandatory for all students.

3. FIRST CALL

E1=score obtained in the mandatory part of the global examination (up to 10 points).

PM=score obtained in the lab practices (attendance, quality of the reports...) (up to 10 points).

PEC=score obtained in both exams (continous assessment) (up to 10 points).

S=score obtained in the autonomous tasks (case studies / analysis of situations) (up to 10 points).

Continuous assessment:

If PEC < 4 points, Qualification = PEC

If PEC >= 4 points, Qualification = 0.4 * E1 + 0.5 * PEC + 0.07 * PM + 0.03 * S

Exam-only assessment: Qualification = E1

4. SECOND CALL. Previously to the exam (or at the entrance of the session) the students choose between continous or exam-only assessment. The qualification formulas are the same (as those of the first call).

5. END-OF-PROGRAM EXAM. Only exam-only-assesment.

6. STUDENTS PRESENTED AT THE COURSE. A student is considered "presented" if he/she receives the final exam or both exercises of the continuous assessment.

7. Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution

Sources of information

Basic Bibliography

Marcos Arias Acuña, Oscar Rubiños López, **Radiocomunicación**, 1ª, Andavira Editora, 2011

José María Hernando Rábanos, **Transmisión por Radio**, 7ª, Editorial Universitaria Ramón Areces, 2013

Complementary Bibliography

Constantine A. Balanis, **Antenna Theory. Analysis and design**, 4th, Wiley, 2016

John Griffits, **Radio Wave Propagation and Antennas. An Introduction**, 1st, Prentice Hall, 1987

Angel Cardama, L. Jofre, J.M. Rius, S. Balnch, M. Ferrando, **Antenas**, 2ª, Ediciones UPC, 2002

Maral, G. / Bousquet M. / Zhili Sun, **Satellite communications systems: systems, techniques and technology**, 6th, Wiley, 2020

Hernando Rábanos J.M., Mendo Tomás L. y Riera Salís, J.M., **Comunicaciones móviles**, 3ª, Editorial Universitaria Ramón Arecesº, 2015

Thomas A.Milligan, **Modern Antenna Design**, 2nd, Wiley, 2005

Robert E. Collin, **Antennas and Radiowave Propagation**, 1st, Mc Graw Hill, 1985

ITU-R, **Recommendations**,

Recommendations

Subjects that it is recommended to have taken before

Mathematics: Probability and Statistics/V05G301V01107
Physics: Fields and Waves/V05G301V01202
Electromagnetic Transmission/V05G301V01207

IDENTIFYING DATA				
Multimedia Signal Processing				
Subject	Multimedia Signal Processing			
Code	V05G301V01321			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Cardenal López, Antonio José			
Lecturers	Cardenal López, Antonio José			
E-mail	cardenal@gts.uvigo.es			
Web	http://Moovi.uvigo.gal			
General description	Multimedia signal processing is now a fundamental part of any modern information, communication, learning, and entertainment system. Once the main Digital Signal Processing concepts and bases have been introduced in the second year, this course prepares students for the analysis and processing of deterministic and random signals, before encoding and transmission of multimedia information. In related courses both on this and next academic year, the knowledge acquired shall be applied to voice, audio, image and video signals and systems,. The main goals of the course are: - Analyze digital signal processing schemes. - Design digital filters according to prescribed specifications. - Analyze and specify the basic parameters of communication subsystems from the point of view of signal processing. - Apply statistical filtering in coding, processing and transmission of multimedia information. To help in reaching these goals, the course is divided into four major topics: DFT and Fast Fourier Transform, Fundamentals of statistical signal processing, digital filter characterization and multirate signal processing. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C26	CE26/ST6 The ability to analyze, codify, process and transmit multimedia information using analogical and digital signal processing techniques.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Analyze digital signal processing diagrams.	B3	C26	
Design digital filters from specifications.	B4	C26	D2
Analyze and specify the fundamental parameters of the communication subsystems from the point of view of digital signal processing.	B4	C26	
Statistical analysis and filtering applied to the coding, processing and transmission of multimedia information.	B3 B4	C26	D3

Contents
Topic

Topic 1 Fourier Transform of discrete signals: DFT.	Formulation and properties of the DFT. Efficient computation of the DFT (FFT). Linear Filtering Methods using DFT. Effects of the time and frequency sampling. Windowing and spectral resolution.
Practice 1 Fourier Analyses through DFT.	Linear Filtering using DFT. Effects of the temporal and frequency sampling. Windowing and spectral resolution
Topic 2 Filter Design and implementation.	Z transform: a review. Implementation of FIR and IIR filters from difference equations. Block Diagramas. Structures for digital filters. FIR and IIR Design.
Practice 2 Digital Filters Design and implementation.	FIR filters Design. IIR filters Design.Implementation of digital filters.
Topic 3 Introduction to Statistical signal processing.	Random signals. Correlation and spectra for stationary signals. Random signals and linear systems. Optimal Linear Filters. Wiener filter. Introduction to adaptive filtering: LMS algorithm. Spectral Estimation.
Practice 3 Adaptive Filtering.	Wiener Filter. LMS.
Topic 4 Multirate signal processing.	Decimation and Interpolation. Spectral interpretation of interpolation and decimatio. FIR Filter Structures Based on Polyphase Decomposition. Filter Banks.
Practice 4 Multirate signal processing.	Decimation and Interpolation. Polyphase Filter Banks.

Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	3	6	9
Laboratory practical	3	6	9
Laboratory practical	3	6	9
Laboratory practical	3	6	9
Mentored work	7	35	42
Lecturing	21	42	63
Essay questions exam	2	7	9

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Laboratory practical	Application of MatLaB commands and functions to digital signal processing practical exercises. Through this methodology the competencies B4, C26, D2 and D3. are developed. (Individual)
Laboratory practical	Application of MatLaB commands and functions to digital signal processing practical exercises. Through this methodology the competencies B4, C26, D2 and D3. are developed. (Individual)
Laboratory practical	Application of MatLaB commands and functions to digital signal processing practical exercises. Through this methodology the competencies B4, C26, D2 and D3. are developed. (Individual)
Laboratory practical	Application of MatLaB commands and functions to digital signal processing practical exercises. Through this methodology the competencies B4, C26, D2 and D3. are developed. (Individual)
Mentored work	Group work on a project centered in a practical application of signal processing. Through this methodology the competencies B3, B4, C26, D2 and D3 are developed. (Group)
Lecturing	Presentation of main topics in class. Multimedia material will be made available in Moovi before classes take place. Personal study. Support from the instructors through tutorial help. Through this methodology the competencies B3, C26, D2 and D3. are developed. (Individual)

Personalized assistance

Methodologies	**Description**
Lecturing	Lectures take place within a continuous interaction framework in which students may answer questions formulated by the teacher. They could also solve their particular doubts during the sessions. Tutoring hours will be available at https://www.uvigo.gal/universidade/administracion-persoal/pdi/antonio-jose-cardenal-lopez.
Laboratory practical	In practical sessions students are required to carry on their own the assigned task. The instuctorr will be available during the session to solve any problems/questions students may have.
Mentored work	Tutored works are carried out in small working groups. The follow up of the work in progress takes place in regular meetings between the groups and the instructor, in which students may formulate any questions related to the work to be done.
Laboratory practical	In practical sessions students are required to carry on their own the assigned task. The instuctorr will be available during the session to solve any problems/questions students may have.
Laboratory practical	In practical sessions students are required to carry on their own the assigned task. The instuctorr will be available during the session to solve any problems/questions students may have.

Laboratory practical	In practical sessions students are required to carry on their own the assigned task. The instuctorr will be available during the session to solve any problems/questions students may have.

Assessment

	Description	Qualification	Training and Learning Results		
Laboratory practical	Individual drill related with the laboratory content. Will be taken in laboratory time, and will last 30 minutes. Fourier Analysis through DFT.	10	B3 B4		D3
Laboratory practical	Individual drill related with the laboratory content. Will be taken in laboratory time, and will last 30 minutes. Design and implementation of FIR and IIR filters.	10	B3 B4		D3
Laboratory practical	Individual drill related with the laboratory content. Will be taken in laboratory time, and will last 30 minutes. Adaptive filtering.	10	B3 B4		D3
Laboratory practical	Individual drill related with the laboratory content. Will be taken in laboratory time, and will last 30 minutes. Multirate Filter Banks.	10	B3 B4		D3
Mentored work	Projects to be carried out in groups. Different gradings according to levels of participation that will be assessed through cross- evaluation surveys among students.	20		C26	D2
Lecturing	Written exam encompassing all the material exposed in the classroom and laboratory . Students will receive support to clarify any questions about the written exam.	40	B3 B4		

Other comments on the Evaluation

Evaluation

Students shall be offered two evaluation systems: continuous assessment and global assessment.

CONTINUOUS ASSESSMENT

The continuous assessment of the course will consist in:

- Four 30-minutes drills related to the laboratory work, that will account for 40% of the final grade.
- One project to be carried out in a group that will account for 20% of the final grade. Each student's individual grade may be weighted using the results of cross-assessments carried out throughout the course.
- A written exam encompassing all the material exposed in the classroom and laboratory. Will take place on the dates scheduled by the School. The exam shall help in gauging the level of understanding of the four-course topics. The exam will feature exercises and questions to be answered in two hours. Students may bring to the exam books, laboratory and classroom notes, and any other materials downloaded from Moovi. The exam will account for 40% of the final grade.

The final qualification of the student will be computed as a weighted sum (40%, 20%, and 40%, respectively) of the qualifications of the laboratory, group project, and final exam. However, in order to pass the course, the grade of the final exam must not lie below 25 out of 100 points. If that grade is lower than 25, the final qualification will be the minimum among the aforementioned weighted sum and 4.5.

None of these tests is recoverable, and your grade may be kept throughout the current academic year. The final grade is determined in a 60% by the tests carried out throughout the course. Only attendance at the written exam will be considered mandatory.

The contents and weights of each continuous assessment exercises are the following:

- Laboratory drill 1 (10 %):

Fourier Analysis through DFT.

- Laboratory drill 2 (10 %):

Design and implementation of FIR and IIR filters.

- Laboratory drill 3 (10 %)

Adaptive filtering.

- Laboratory drill 4 (10 %):

Multirate Filter Banks.

- Project: (20%) practical application of concepts mastered in the course.

The planning of the different intermediate evaluation tests will be approved in an Academic Committee of Degree (CAG) and will be available at the beginning of the semester.
GLOBAL ASSESSMENT

Should a student decide not to be graded through continuous assessment , she will have a written examination opportunity that will take place the same day of the final exam for all the students. Before taking the exam though, the student shall sign a form in which he states his decision to dispense with continuous assessment .
This written exam will last three hours and will be composed of 5 exercises encompassing all the material mastered in the classroom, laboratory, and tutorial sessions, under the same conditions specified for the students that take the final exam at the end of the continuous assessment process.

Grading Periods

Ordinary exam (December-January)

If the student passes the course in this period, her grade will be final and will be recorded in her academic file.

If the student does not pass the course, a provisional fail shall be posted in his academic file.

If the student do not attend the written exam, her grade will be "Not presented".

Extraordinary exam (June-July)

In June-July only the written exams shall be offered. If a student wants to dispense with continuous assessment in this period, the student will be able to take the final exam reserved for those cases. Before taking the exam though, a form shall be signed, in which the student formulates the decision to dispense with continuous assessment .

If the student do not attend the written exam and was graded as "Not presented" in the ordinary exam, will mantain the same grading.

The provisional fail will become definitive should the student not take any of the written exams in this second period.

END-OF-PROGRAM EXAM

The student will have a written examination for the 100% of the final grade. This written exam will last three hours and will be composed of 5 exercises encompassing all the material mastered in the classroom.

Sources of information

Basic Bibliography

Sanjit K. Mitra., **Digital Signal Processing: A Computer Based Approach.**, Ed. McGraw-Hill,

Complementary Bibliography

John G. Proakis, Dimitris G. Manolakis., **Tratamiento Digital de Señales**, Prentice Hall,
Alan V. Oppenheim, Ronald W. Schafer, **Discrete-Time Signal Processing**, Prentice Hall,

Recommendations

Subjects that it is recommended to have taken before

Digital Signal Processing/V05G301V01205

IDENTIFYING DATA				
Microwave Circuits				
Subject	Microwave Circuits			
Code	V05G301V01322			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Fernández Barciela, Mónica			
Lecturers	Fernández Barciela, Mónica Rodríguez Rodríguez, José Luis			
E-mail	monica.barciela@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	This subject provides the student with the basic tools to analyze components and analog subsystems (active and passive) that operate in the band of the microwaves, as well as to evaluate his specifications and performance. The microwave subsystems are part, among others, of the modern communications systems transceivers (cellular telephony, wireless networks, satellite communications, and so on), thus the importance for the student to get some knowledge and background about these components. On the other hand, this subject complements the knowledge the student has, due to previous subjects, in electronics for communications, since when working in the microwave range, we need to use different tools for an accurate circuit analysis and design. English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C23	CE23/ST3 The ability to analyze the components and their specifications for guided and non-guided communications systems
C24	CE24/ST4 The ability to select circuits, subsystems and systems of radiofrequency, microwaves, broadcasting, radio link and radio determination.
C25	CE25/ST5 The ability to select transmission antennas, equipment and systems, propagation of guided and non-guided waves, with electromagnetic, radiofrequency and optical media, and their corresponding radio electric spectrum management and frequency designation.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
To learn how to analyze microwave active and passive circuits and components, and to evaluate their specifications and performance. The student will learn how to use S-parameters, electronic instrumentation for measurements in the microwave range and circuit simulators for that purpose.	B3 B5	C23	
To learn how to solve exercises, how to perform measurements, how to elaborate and present reports, how to work in a technical team and to transfer knowledge in the field. To learn how to handle technical documentation and scientific bibliography, both in English.	B4 B5 B9	C24 C25	D3 D4

To learn how to select, analyze and apply semiconductor active devices in circuits for microwave communications subsystems.	B5	C23 C24 C25	
To learn how to analyze and select microwave circuits for optical transmitters and receivers.	B5	C23 C25	
To learn how to evaluate and select microwave subsystems. To propose solutions for applications at the different frequency bands for guided (coaxial cable, waveguide) and wireless transmissions.	B3 B5	C24 C25	D2

Contents

Topic	
1.Introduction to microwave circuits.	A. Microwaves and their advantages for communications. B. Microwave Subsystems. Solutions for applications in the different frequency bands for wave guided and wireless transmissions. C. Integrated technologies for high frequencies. MICs.
2. Basic concepts.	A. Transmission Lines Theory. Travelling waves, characteristic impedance and reflection coefficient. B. Smith Chart. C. Coaxial cable and planar transmission lines.
3. S-parameters.	A. Definition and properties. B. Signal Flow Charts. C. Power and Gain. D. Stability.
4. Impedance Matching.	Basic matching networks (discreet and distributed) for narrowband applications.
5. Microwave passive components.	Filters, couplers, phase shifters and resonators.
6. Microwave active devices for integrated circuits.	A. Semiconductors for microwave active devices. Heterostructures. B. High Frequency Diodes c. Bipolar and FET Transistor technologies for high frequencies.
7. Circuits for microwave transceivers.	A. Linear microwave amplifiers. B. Circuits for optical receivers and transmitters.
8. Linear analysis of microwave active and passive components, and circuits with a commercial simulator.	a. Practice to analyze basic microwave components: microwave transistor equivalent circuit, matching networks, etc. b. Practice to analyze attenuators and various types of couplers. c. Practice to analyze linear amplifiers.
9. RF measurements of microwave devices and circuits. Microwave lab instruments.	a. Coaxial wires and adapters. b. Vector Network Analyzer. Calibration. c. RF measurements using a Vector Network Analyzer. d. Analysis of the RF performance of various microwave components

Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	7	14	21
Practices through ICT	12	36	48
Introductory activities	0	7	7
Lecturing	19	38	57
Problem and/or exercise solving	1	3	4
Problem and/or exercise solving	1.5	5	6.5
Problem and/or exercise solving	1.5	5	6.5

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Laboratory practical	The work will be performed individually or in pairs of students. With the aid of different microwave measurement instruments/components, there will be analyzed passive and active microwave devices / circuits mostly in microstrip technology. It will be defined and evaluated different figures of merit and other tools that will be used in the experimental characterization of these components. An introduction to Vector Network Analyzers with be provided to the student, besides description of their use and calibration procedure . Students will find in Moovi support documentation. These practises are designed to aid in adquiring competencies CG3, CG4, CG5, CG9, CE23, CE24, CE25, CT2, CT3 y CT4.

Practices through ICT	The work will be performed individually or in small teams of 2 students. With the aid of a commercial microwave circuits simulator, there will be analyzed different passive components (matching networks, filters, couplers, etc.) and active semiconductor devices (diodes and transistors), and simple amplifier circuits, in agreement with Chapter 8. There will be defined and evaluated diverse figures of merit and other tools that will be in used in the analysis of these components. Also, exercise resolution will be described, to complete the one described in the lectures. Students will find in Moovi support documentation and files. Besides, they will have available a procedure to obtain a simulator licence for their PCs, through an agreement between UVIGO and the simulator provider. These practises are designed to help in adquiring competencies: CG3, CG5, CE23, CE24 y CE25.
Introductory activities	The student will have available documents about concepts from previous subjects that the student need to recall.
Lecturing	It will be given in a classroom with the aid of a slate board and a video projector. Most of the concepts in the subject Topics will be described in detail and explained. Application of these concepts will be supplied through exercises resolution, during lectures, and in the practices (ICT and laboratory). Students will find in Moovi support documentation. These sessions are designed to help in adquiring competencies CG3, CG5, CG4, CE23, CE24 y CE25.

Personalized assistance

Methodologies	Description
Lecturing	During master sessions, the professor will answer the questions addressed by the students regarding the content of the subject or the assessment tests. Besides, in office hours, the professor will also be available to the students, providing answers to their questions in a more personalized way. Office hours appointement: https://moovi.uvigo.gal/user/profile.php?id=11321
Laboratory practical	During laboratory practises, the professor will guide the work of each student, and answer those questions he/she may ask regarding the work and the assessment test/s. Office hours appointment: https://moovi.uvigo.gal/user/view.php?id=11322&course=9898
Practices through ICT	During practises, the professor will guide the work of each student, and answer those questions he/she may ask regarding the work and the assessment test/s. Office hours appointement: https://moovi.uvigo.gal/user/profile.php?id=11321

Assessment

	Description	Qualification	Training and Learning Results
Laboratory practical	In the case of Continuous Assessment: During or outside the designated time for experimental practices, the student will perform one or several short examinations, individually (or in small groups), involving short questions/exercises and/or circuit implementations. This evaluation may involve a team presentation of the work performed. Besides, in the short exam 3, the work performed in theses practices may be also evaluated, through questions/exercises. In the case of Exam-only Assessment, the work performed in these practices may also be evaluated, though questions/exercises and/or some experimental implementation/test.	10	B3 C23 D2 B4 C24 D3 B5 C25 D4 B9
Practices through ICT	In the case of Continuous Assessment: During or outside practice hours, the student will have one/several examinations in which will answer/solve individually some proposed questions/exercises with the aid of the simulator. Besides, in the short exam 3, the work performed in the practices may be similarly evaluated. In the case of Exam-only Assessment, the work performed in the practices may be evaluated in the Exam through questions/exercises with the aid of the simulator.	10	B3 C23 B5 C24 C25
Problem and/or exercise solving	Continuous Assessment: There will be one short partial examination (Exam 1), containing exercises resolution. Moreover, it may contain a set of short questions related to the master sessions. In the case of Exam-only Assessment, problem/exercise solving will be an important part of the Exam.	15	B3 C23 B4 C24 B5 C25

Problem and/or exercise solving	Continuous Assessment: There will be one short partial examination (Exam 2), containing exercises resolution. Moreover, it may contain a set of short questions related to the master sessions. In the case of Exam-only Assessment, problem/exercise solving will be an important part of the Exam.	25	B3 C23 B4 C24 B5 C25
Problem and/or exercise solving	Continuous Assessment: There will be one (almost global) examination (Exam 3), containing exercises resolution. Moreover, it may contain a set of short questions related to the master sessions and the practices, both experimental or CAD-based. In the case of Exam-only Assessment, problem/exercise solving will be an important part of the Exam.	40	B3 C23 B4 C24 B5 C25

Other comments on the Evaluation

It is convenient that all students participate in the practices, both experimental and computer aided ones, to acquire all the required skills of this subject.

A) If the student selects Continuous Assessment (CA):

The schedule of the different assessments events will be approved by the Grade Academic Commission (CAG) and it will be available at the Term beginning. These assessments tests will not have available second chance ones.

1. In order that his/her work in the practices (computer aided and/or experimental) is evaluated, his/her presence in at least 80% of the corresponding practices will be mandatory. Besides, he/she must perform all the assessment events scheduled related to these practices. The maximum grade the student might obtain in the joint evaluation of all these types of practices is 20 % of the Total Available Course Grade (TACG).

2. The rest of the student work will be evaluated by means of 3 Short Examinations that will mainly contain exercises resolution, but may also include short questions. These 3 short examinations, as a whole, add up to 80% of the TACG.

The First and Second Short Examinations may last around 1 hour; the First corresponds to 15% of the TACG and the Second to the 25% of the TACG.

It is assumed that students performing the Second and/or Third Short Examination do choose Continuous Evaluation. In this case, the final grade cannot be "Not Presented".

The Third Short Examination will take place simultaneously with the Final Examination, performed by those students who do not follow CA. This short examination is the most important one, it involves all of the subject Topics and corresponds to a 40 % of the TACG.

B) In the case of the students who choose E*xam-only Assessment*, the Final (extended) Examination corresponds to 100% of the TACG. In this examination it will be evaluated exercises resolution, with and without the aid of the simulator, answers to short questions related to the course theoretical and experimental parts (Lab) and computer/simulator aided practices (ICT practices). In this Exam, the weight of Topics 8 and 9 will be in total of 20% of TACG.

Extraordinary Exam:

In it the students who have previously failed must perform a similar Final Examination than in option B, with similar characteristics as the ones described previously.

In particular, those students who followed CA in the first call may opt now between option B and option A.

If they choose option A, all their grades in the first call, with respect to the First and Second short Examinations, and the practices (both experimental and computer aided) will be preserved; hence, it will add up as a whole to 60% of the TACG. Moreover, these students must solve an exam similar to the Third one in option A (corresponding to 40 % of the TACG). The student must send a written communication to the course coordinator about his/her decision with respect to the desired type of evaluation (A or B) in this Call, deadline up to 3 days before this Examination takes place,.

In the End-of-Program Exam, evaluations will be similar to the Extraordinary Exam.

In case of plagiarism detection in any of the student works/tests, the grade obtained by the student in this course will be a failing grade (0) and the course professor will communicate this issue to the school Board of Directors so they may take those measures deemed appropriate.

Sources of information

Basic Bibliography

D.M. Pozar, **Microwave Engineering**, 3,

J.M. Miranda y otros, **Ingeniería de Microondas**, 1,

Guillermo González, **Microwave Transistor Amplifiers: Analysis and Design**, 1,

Enrique Sánchez, **Introducción a los dispositivos y circuitos semiconductores de microondas**, 1,

Complementary Bibliography

R.E. Collin, **Foundations for Microwave Engineering**, 2,

P.A. Rizzi, **Microwave Engineering, Passive Circuits**, 1,

S. Y. Liao, **Microwave Devices and Circuits**, 3,

Recommendations

Subjects that it is recommended to have taken before

Physics: Analysis of Linear Circuits/V05G301V01108
Physics: Fundamentals of electronics/V05G301V01201
Electronic technology/V05G301V01206
Electromagnetic Transmission/V05G301V01207

IDENTIFYING DATA				
Radio Spectrum Management				
Subject	Radio Spectrum Management			
Code	V05G301V01323			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	García Sánchez, Manuel			
Lecturers	García Sánchez, Manuel Torío Gómez, Pablo			
E-mail	manuel.garciasanchez@uvigo.es			
Web	http://moovi.uvigo.es			
General description	Radio spectrum management pursues the most efficient use of the radio spectrum (a natural, limited and scarce resource), by applying effective processes that facilitate the implementation of communication systems and guarantee minimum interference between them. Engineering, planning and management tools, as well as measurement equipment and techniques to survey the use of the radio spectrum are needed to acomplish these objectives. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B7	CG7: The ability to analyze and assess the social and environmental impact of technical solutions.
B8	CG8: To know and apply basic elements of economics and human resources management, project organization and planning, as well as the legislation, regulation and standarization in Telecommunications.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C21	CE21/ST1 The ability to construct, exploit and manage telecommunication networks, services, process and applications, considered as systems of receiving, transporting, representation, processing, storage, management and presentation of multimedia information from the point of view of transmission systems.
C25	CE25/ST5 The ability to select transmission antennas, equipment and systems, propagation of guided and non-guided waves, with electromagnetic, radiofrequency and optical media, and their corresponding radio electric spectrum management and frequency designation.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Understand the concepts of frequency allocation, allotment and assignment.	B6	C21	
Apply concepts of base station certification.	B6 B7 B8	C21	
Propose solutions for fulfilment the broadcast limits.	B5 B6 B7 B8	C25	
Interference analysis	B5 B6 B8 B9	C21 C25	D4
Field measurements	B5 B9	C21 C25	D4

Contents

Topic	
Introduction	Introduction to the matter. General concepts.
Spectrum management	National and international regulatory bodies International management and coordination National management The Telecommunications Law National telecommunication Plans CNAF
Spectrum engineering	Specifications of telecommunication equipment. Radio wave propagation. Coverage. Interferences. Re-use distance. Techniques to share the spectrum.
Modulations	Definitions The radio channel Objective of the modulation Types Analog Modulations: AM, FM Digital Modulations Wideband Modulations MIMO
Frequency planning	Trellis method List method Other methods Examples
Technical surveillance	The spectrum analyzer The wideband sounder Measurement procedures for radioelectric base station certification

Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	15	30	45
Practices through ICT	6	9	15
Lecturing	19	19	38
Objective questions exam	1	15	16
Objective questions exam	1	35	36

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Laboratory practical	Activities of application of the acquired knowledge to particular situations. Acquisition of basic skills related with the matter. Specific measurement equipment as Spectrum Analysers , Field level sounders, etc, will be used. Through this methodology the competencies CG5, CG6, CG8, CG9, CE21, CE25 and CT4 are developed. Group activity.
Practices through ICT	The student, alone or in a small group with other students, elaborates a report on a given subject. This includes the search of the information, reading, writting, etc Through this methodology the competencies CG9 and CT4 are developed. Group activity.
Lecturing	Field activities. Activities of application of the acquired knowledge to particular situations. Acquisition of basic skills related with the matter. Specific measurement equipment as Spectrum Analysers , Field level sounders, etc, will be used. Through this methodology the competencies CG5, CG6, CG7, CG8, CG9, CE25 and CT4 are developed. Group activity.

Personalized assistance

Methodologies	Description
Lecturing	The students will be able to resolve doubts and questions during the activity, in the scheduled tutoring hours or by means of email (www.teleco.uvigo.es).

Laboratory practical	The students will be able to resolve doubts and questions during the activity, in the scheduled tutoring hours or by means of email (www.teleco.uvigo.es).
Practices through ICT	The students will be able to resolve doubts and questions during the activity, in the scheduled tutoring hours or by means of email (www.teleco.uvigo.es).
Tests	**Description**
Objective questions exam	The students will be able to resolve doubts and questions during the activity, in the scheduled tutoring hours or by means of email (www.teleco.uvigo.es).
Objective questions exam	The students will be able to resolve doubts and questions during the activity, in the scheduled tutoring hours or by means of email (www.teleco.uvigo.es).

Assessment

	Description	Qualification	Training and Learning Results		
Laboratory practical	These practices are made in groups. In some cases the qualification of each student will be the one of the group and in others by means of an individual exam about the practice.	30		C21 C25	
Practices through ICT	Calculation of the coverage area of an AM radio station. This practice is made in groups but will be evaluated individually by means of the assistance, the performance during the realisation and by means of the memory of the practice delivered by the group.	10	B6 B9	C21 C25	D4
Objective questions exam	Individual exam with questions and problems from the contents of the lectures.	20	B5 B6 B7 B8	C21 C25	
Objective questions exam	Individual exam with questions and problems from the contents of the lectures.	40	B5 B6 B7 B8	C21 C25	

Other comments on the Evaluation

1) Ordinary call. We offer students two ways of assessment: continuous assessment and global assessment. Students will have to opt by one of them. After one moneth, the delivery of a report or participation in anyone of the exams of continuous evaluation means that you opt by this type of assessment and your qualification could not be "not presented". The attendance to, at least, 70% of the practices is compulsory if you opt by continuous assessment.

1.a) Continuous assessment. Assessment will be made according to the results of the report of the computer practice, the tests of the lab practices and the two exams about the lecture contents. One of these exams will be conducted at the middle of the lecture period and will encompass the matter delivered till the date of the exam. The other exam, about all the matter, will take place after the end of the lectures. The assessment of the practical work will have a weight of 40% in the final grade and the assessment of the theory will have the other 60%. These tasks are not recoverable and only are valid for the current course.

In order to guarenteee that all the competences are acquired, three conditions should be met¡ to pass the matter:

1) Get a qualification equal or larger than 5 (over 10) in the theory part.

2) Get a qualification equal or larger than 5 (over 10) in the practice part.

3) Get a final qualification, calculated as weighted sum of the activitiies marks, equal or larger than 5 (over 10).

If condition 3) is met, but not 1) or 2), the final qualification will be 4.9

1.b) Global assessment. Students that do not opt by continuous assessment will have an exam about the lectures contents (60%) and another one about the practices (40%) in the official exam date fixed by the School.

In order to guarenteee that all the competences are acquired, three conditions should be met¡ to pass the matter:

1) Get a qualification equal or larger than 5 (over 10) in the theory part.

2) Get a qualification equal or larger than 5 (over 10) in the practice part.

3) Get a final qualification, calculated as weighted sum of the activitiies marks, equal or larger than 5 (over 10).

If condition 3) is met, but not 1) or 2), the final qualification will be 4.9

2) Extraordinary call. Students that opted previously by continuous assessment will have the chance to repeat just the exam about the lecture contents (60%) or take a full exam of the subject (100%), including lectures (60%) and practices (40%). They will have to tell to the coordinator of the subject about the option they choose before the official date of the exam. The rest of the students will take a full exam of the subject (100%), including lectures (60%) and practices (40%).

In order to guarenteee that all the competences are acquired, three conditions should be met¡ to pass the matter:

1) Get a qualification equal or larger than 5 (over 10) in the theory part.

2) Get a qualification equal or larger than 5 (over 10) in the practice part.

3) Get a final qualification, calculated as weighted sum of the activitiies marks, equal or larger than 5 (over 10).

If condition 3) is met, but not 1) or 2), the final qualification will be 4.9

3) End-of-program call. Full exam of the subject (100%), including lectures (60%) and practices (40%).

In order to guarentee that all the competences are acquired, three conditions should be met¡ to pass the matter:

1) Get a qualification equal or larger than 5 (over 10) in the theory part.

2) Get a qualification equal or larger than 5 (over 10) in the practice part.

3) Get a final qualification, calculated as weighted sum of the activitiies marks, equal or larger than 5 (over 10). If condition 3) is met, but not 1) or 2), the final qualification will be 4.9

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information
Basic Bibliography
International Telecomunication Union, **National Spectrum management Manual**, 2005,
Complementary Bibliography
International Telecomunication Union, **ITU-R recommendations**,
International Telecomunication Union, **Radiocomunication Rules**, 2012,
Gretel-COIT, **La evolución de la gestión del espectro radioeléctrico**, 2007,
SETSI, **Cuadro Nacional de Atribución de Frecuencias**, 2013,

Recommendations

IDENTIFYING DATA				
Principles of Digital Communications				
Subject	Principles of Digital Communications			
Code	V05G301V01324			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Comesaña Alfaro, Pedro			
Lecturers	Comesaña Alfaro, Pedro Gómez Cuba, Felipe Pérez González, Fernando			
E-mail	pcomesan@gts.uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The basic aims of the subject are the following: - Apply optimisation criteria for the realisation of diagrams of estimate and synchronisation in digital receptors of communications. - Differentiate the blocks and the functionalities of a data transmission system. - Use digital signal processing to transmit and receive analog waveforms. - Apply the basic mechanisms of reduction of the impact of noise in a communications system. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B11	CG11 To approach a new problem considering first the essential and then the secondary aspects
C26	CE26/ST6 The ability to analyze, codify, process and transmit multimedia information using analogical and digital signal processing techniques.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Apply criteria of optimisation for the realisation of diagrams of estimate and synchronisation in digital receptors of communications	B3	C26	
Differentiate the blocks and the functionalities of a system of transmission of complex data	B11	C26	D2
Use the processed digital of signals to transmit and receive forms of analog wave	B3 B4		D3
Apply the basic mechanisms of reduction of the impact of noise in a system of communications		C26	D2

Contents	
Topic	
1. Introduction to digital communications	- Historical evolution of wireless communication systems. - Basic blocks of a digital communications system. - Review of impairments in a communications channel. - Introduction to the course.

2. Discrete equivalent channel and Nyquist pulses	- Baseband equivalent channel. - Discrete equivalent channel. - Nyquist pulses. - Square root raised cosine pulses. - Application and implementation of Nyquist pulses. - Introduction to polyphase structures.
3. Symbol synchronization	- Motivation. - Phase Locked Loops (PLL). - PLLs and steepest descent. - Maximum output energy criterion. - Interpolation-based symbol synchronization. - Adaptive symbol synchronization.
4. Frame synchronization	- Review of Least Squares (LS) estimation. - Motivation for frame synchronization. - Data-aided frame synchronization. - Design of training sequences.
5. Phase and carrier recovery	- Decision-directed phase recovery. - Non-decision-directed phase recovery. - Motivation for carrier recovery. - Coarse carrier synchronization. - Fine carrier synchronization.
6. Estimation and equalization in flat channels	- Maximum likelihood detection. - Equalization through estimation. - Direct equalization. - Adaptive equalization. - The LMS algorithm.
7. Frequency selective channel equalization	- Multipath, bandwidth and frequency selectivity. - Zero-forcing equalization. - Least squares equalizer. - LMS algorithm derivation for selective channels. - Unconstrained equalizers.
8. Introduction to advanced digital communications.	- Principles of OFDM. - Introduction to MIMO systems.
Theoretical-practical contents.	The contents of chapters 2 to 7 are considered both at theoretical lectures and practical sessions.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	19	28.5	47.5
Problem solving	2	8.5	10.5
Project based learning	7	35	42
Laboratory practical	12	36	48
Problem and/or exercise solving	2	0	2

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Presentation and discussion of the fundamental concepts associated to the different blocks that constitute a digital communications system. This methodology works competencies: B4, B11, D2, D3.
Problem solving	In A hours the doubts remaining after the publication of the solutions of the proposed problems will be discussed. Furthermore, 3 exercises will be proposed for assessment; some of them will be completed in A hours, while the remaining one(s) will be completed at home. All these 3 exercises will be used as midterm exams and they will completed individually. This methodology works competencies: B3, B4, B11, C26.

Project based learning	In C hours practical projects will be proposed; the students will develop a digital communications system that shows its good operation in the proposed application. The projects will be implemented in small groups. All the members of the group have to understand the operation of all the blocks of the complete system that will be submitted at the end of the course. This methodology works competencies: B3, B4, B11, C26, D2, D3. Software to be used: Matlab.
Laboratory practical	In B hours the students will work on the lab to create a software defined radio receptor that uses all the basic functionalities studied in the subject. They will be implemented in small groups. This methodology works competencies: B4, B11, C26. Software to be used: Matlab.

Personalized assistance

Methodologies	Description
Lecturing	The teacher will solve the doubts that each student formulates during the presentation realised in the master session, beyond the availability at office hours. Information on the latter can be found at the following links: - Fernando Pérez González (https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-perez-gonzalez) - Pedro Comesaña Alfaro (https://www.uvigo.gal/es/universidad/administracion-personal/pdi/pedro-comesana-alfaro) - Felipe Gómez Cuba (https://www.uvigo.gal/es/universidad/administracion-personal/pdi/felipe-gomez-cuba)
Laboratory practical	The students will work in small groups and the teacher will solve the doubts that each group might have, both at the lectures and office hours.
Project based learning	The students will work in small groups and the teacher will solve the doubts that each group might have, both at the lectures and office hours.

Assessment

	Description	Qualification	Training and Learning Results		
Problem solving	Short exercises (partial tests) related to the contents explained during the masterclasses and in the laboratory. 3 exercises (midterm exams) will be proposed for assessment; some of them will be completed in A hours, while the remaining one(s) will be completed at home. All these 3 exercises will be completed individually. The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester. Each exercise will have a weight of 10% in the final mark for the students assessed by continuous assessment.	30	B3 B4 B11	C26	
Project based learning	Realisation of a practical project in groups, that will be assessed individually. The deadline for delivering this project will be the same for both students following continuous and global assessment, and it will be included at the midterm exam schedule approved at the CAG. The assessment of this project includes an interview; for continuous assessment students this interview will be performed in the last session of group C, whereas for global assessment students it will be perform in the date of the final exam. This is a mandatory activity for both those students who follow continuous assessment, and those who follow exam-only assessment, yielding in both cases the 40% of the final mark.	40	B3 B4 B11	C26	D2 D3
Problem and/or exercise solving	Final exam, where the student will have to solve some exercises; this exam will be the fourth test for those students who chose continuous assessment. The weight will be 60% for those students that do not follow continuous assessment, and 30% for those who do.	30	B3 B4 B11	C26	

Other comments on the Evaluation

For those students that choose continuous assessment the final note will be obtained as:

If final exam mark (out of 10) < 3.5, min(4, Nmidterms + Nproject + Nexam) (1.a)
If final exam mark (out of 10) >= 3.5, Nmidterms + Nproject + Nexam (1.b)

where Nmidterms denotes the mark accumulated in the midterms exams, up to 3 points; Nproject denotes the mark obtained in the practical project, up to 4 points; and Nexam denotes the mark of the final exam up to 3 points. The midterms exams will not be repeated.

For those students who choose global assessment, the final mark will be obtained as:

If final exam mark (out of 10) < 3.5, min(4, Nproject + Nexam) (2.a)
If final exam mark (out of 10) >= 3.5, Nproject + Nexam (2.b)

where Nproject denotes the mark obtained in a practical project specifically designed for exam-only assessment students, up to 4 points; and Nexam denotes the mark of the final exam up to 6 points.

The final exam for those students who chose global assessment might have more exercises than the exam of those students who chose continuous assessment.

The student has to inform if s/he choose to follow continuous or global assessment in a time interval defined by the teachers; this time interval will last at least for one month and will be within the period between the publication of the marks of the first midterm exam and the date of the third midterm exam. In case s/he does not inform about it and s/he does not make the third midterm exam, it will be considered that s/he chooses global assessment.

The mark in the midterm exams will be considered for the second call, but not for subsequent years. In the second call those students who chose to follow continuous assesment in the first call can choose to keep their midterm exams' mark and be qualified according to (1.a) and (1.b), or be qualified according to (2.a) and (2.b). Those students who in the first call chose to follow global assessment, will be qualified according to (2.a) and (2.b).

In the end-of-program call, the assessment will be only based on an exam.

A mark in a given call will be given (i.e., the student will be considered as "presentado") to those students who follow continuous assesment, and also to those who follow global assessmet and do the final exam of that call.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism or extensive use of AI tools is detected in any of the projects, tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information
Basic Bibliography
A. Artés Rodríguez, F. Pérez González y otros,, **Comunicaciones Digitales**, 2007
R. W. Heath Jr., **Introduction to Wireless Digital Communication: A Signal Processing Perspective**, 2017
Complementary Bibliography
J.R. Barry, E. A. Lee y D. G. Messerschmitt, **Digital communication**, 3rd edition, 2004

Recommendations
Subjects that continue the syllabus
Digital Communications/V05G301V01414
Subjects that it is recommended to have taken before
Signal Transmission and Reception Techniques/V05G301V01208 Multimedia Signal Processing/V05G301V01321

IDENTIFYING DATA				
Optical Telecommunication Infrastructures				
Subject	Optical Telecommunication Infrastructures			
Code	V05G301V01325			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish			
Department				
Coordinator	Fraile Peláez, Francisco Javier			
Lecturers	Fraile Peláez, Francisco Javier			
E-mail	fj_fraile@com.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Firstly, we explain the physical foundations of the optical fibre technology. This includes concepts of electromagnetism in dielectric dispersive materials that may be nonlinear, the theory of the optical reception and noise, and the theory of the optical sources and optical modulators. Then, we describe the different transmission systems that use fibre, and we present optical networks. Special emphasis is made on the analysis and design of these optical systems.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
C21	CE21/ST1 The ability to construct, exploit and manage telecommunication networks, services, process and applications, considered as systems of receiving, transporting, representation, processing, storage, management and presentation of multimedia information from the point of view of transmission systems.
C25	CE25/ST5 The ability to select transmission antennas, equipment and systems, propagation of guided and non-guided waves, with electromagnetic, radiofrequency and optical media, and their corresponding radio electric spectrum management and frequency designation.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
1. To understand the origin and motivation of the optical transmission systems.	B3 B5		D3
2. To learn the physical foundations of the optical transmission systems and optical information processes. In particular, those concepts that deviate most from the classical technics such as, for instance, the optical generation and photonic detection.	B3 B5		D3
3. To know the basic theory of optical devices and optical subsystems like, for example, LEDs and lasers, photodetectors, modulators, fibre amplifiers and optical filters.	B3 B5		D3
4. To be able to specify the type of optical fibres and other necessary optoelectronical components that are needed for a certain optical link. Also, to understand their physical and technological limitations.		C25	D3
5. To be able to develop models for optical links and to evaluate the impact that the different transmission subsystems and transmission formats have on their performance.		C25	D3
6. To know the foundations, topologies and switching technologies of optical networks, as well as those of the current proposals of FTTH		C21	

Contents	
Topic	
1. Introduction to optical communications	1.1. Reasons for the optical transmission 1.2. Digital transmission in multimode fibres

2. Electromagnetism in dielectrics	2.1. Maxwell equations in dielectrics 2.1. Wave equations in dielectrics 2.3. Refraction index and losses 2.4. Dispersion
3. Monochromatic propagation in flat guides	3.1. Solution to the wave equation in flat guides 3.2. Guided modes: TE and TM 3.3. Modal power 3.4. Normalised parameters
4. Monochromatic propagation in step index fibres	4.1. Solution to the wave equation in step index fibres 4.2. Guided modes 4.3. Modal power 4.4. Weakly guiding fibres 4.5. Losses; transmission windows
5. Propagation of pulses in single-mode fibres	5.1. Pulse distortion in optical fibres 5.2. Propagation of gaussian pulses in single-mode fibres 5.3. Propagation of analog signals in single-mode fibres 5.4. Dispersion minimisation in single-mode fibres
6. Detection of the luminous radiation	6.1. Light detection in semiconductors 6.2. p-i-n photodiodes and APDs 6.3. Photonic noise 6.4. Quantum efficiency and equivalent noise power
7. Sources and optical amplifiers	7.1. Photonic emission: basic concepts 7.2. Light emitting diodes (LEDs) 7.3. Semiconductor lasers (LDs) 7.4. External modulation of the laser 7.5. Doped fibre and semiconductor optical amplifiers
8. Digital optical links	8.1. Basic concepts of digital transmission in fibre optics 8.2. Digital receiver: a simplified model. The quantum limit 8.3. Optical amplifiers 8.4. Nonlinear effects 8.5. Penalties
9. Coherent systems	9.1. Homodyne and heterodyne receivers 9.2. Coherent modulations 9.3. I-Q Systems
10. Introduction to WDM and to optical networks	10.1. Introduction 10.2. WDM systems 10.3. Optical networks 10.4. Basic topologies of optical networks 10.5. FTTH
Laboratory exercise 1. Measuring the numerical aperture of a multimode fibre	Here we will measure the numerical aperture of a multimode fibre
Laboratory exercise 2. Acousto-optic modulator (AOM)	Here we will built a free-space optical link that uses an AOM together with an He-Ne laser.
Laboratory exercise 3. Optical amplifier	Here we will characterise an erbium doped fibre amplifier (EDFA)
Laboratory exercise 4. Dispersion in a link.	Characterization of chromatic and intermodal dispersion in a gradual index fiber link.
Laboratory exercise 5. Digital link based on graded index fibres	Here we will characterise a LED and a FP laser. Also, we will analyse the effects that losses and noise have on a digital link based on graded index fibres
Laboratory exercise 6. WDM systems	Here we will characterise the performance of WDM systems working at 1310/1550nm

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Lecturing	18	27	45
Problem solving	0	12	12
Laboratory practical	12	9	21
Project based learning	6	39	45
Presentation	1	3	4
Problem and/or exercise solving	2	8	10
Essay questions exam	2	10	12

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Presentation of the subject: program, bibliography, educational methodology and assessmentsystem.
Lecturing	The professor introduces the main contents of each chapter to the students. Note, however, that these lectures do not cover all the contents of each subject. For that reason, the students have to review the supplementary notes provided in class. It is also expected that the students review the concepts introduced in the classroom and expand on their contents using the guide of each chapter, together with the recommended bibliography, as a reference. Through this methodology the competencies CG3, CG5, CE21 and CE25 are developed.
Problem solving	The students can solve problems and/or exercises given by the professor. These exercises are related to the contents presented in the class. It is an individual activity. Through this methodology the competencies CG3, CG5 and CE21 are developed.
Laboratory practical	The lectures include some exercises in the lab involving different optical devices and optical communication systems. The students have to read the lab notes provided by the professor before the lab starts. At the beginning of each exercise the professor might request that the students summarise the main concepts related to the exercise. Any doubt can be solved using the office hours of the professor. The realisation of the laboratory exercises is a group activity. Through this methodology the competencies CG3, CG5 and CE25 are developed.
Project based learning	The students will have to complete several small projects proposed by the professor. These projects require the correct planning, design and realisation of a series of activities and are performed in groups of students. Each project has to be turned over on a given deadline. It is a group activity. Through this methodology the competencies CG3, CG5, CE21, CE25 and CT3 are developed.
Presentation	The students will give a small presentation of the completed projects in front of the professor and possibly other students. It is a group activity. Through this methodology the competency CG5 is developed.

Personalized assistance

Methodologies	Description
Lecturing	The students can use the office hours of the professor to solve doubts related to the subject. The timetable of these office hours will be available at the beginning of the semester and is published on the website of the course.
Laboratory practical	The students can use the office hours of the professor to solve doubts related to the subject. The timetable of these office hours will be available at the beginning of the semester and is published on the website of the course.
Project based learning	The students can use the office hours of the professor to solve doubts related to the subject. The timetable of these office hours will be available at the beginning of the semester and is published on the website of the course.
Tests	**Description**
Essay questions exam	The professor who teaches the group A will help the students to solve any doubt related to the exams and tests.

Assessment

	Description	Qualification	Training and Learning Results		
Project based learning	The students will have to deliver a report for each of the realised projects. Also, the students shall give a presentation of the results obtained within a certain timeframe and follow the conditions established by the professor.	30	B3 B5	C21 C25	D3
Problem and/or exercise solving	Before the lab starts, the students will perform a test (7% of the final mark) about the contents of the the lab notes. Likewise, when finalising the lab, the students will perform a test (23% of the final mark) about the lab exercises.	30	B5	C21 C25	
Essay questions exam	At the end of the semester, the students will perform a final test that covers all the contents of the course.	40	B3 B5	C21 C25	

Other comments on the Evaluation

We will offer to the students two possible assessment systems: continuous assessment or exam-only assessment at the end of the semester.

It will be considered that the students choose continuous assessment unless they specifically request the profesor to follow an exam-only assessment. Such request should be done in the third week of the semester. A request after three weeks may lead to the student being considered as a no-show.

Continuous assessment:

The continuous assessment comprises a series of tasks that the student has to realise along the semester (55%), together with a long answer test (45%) that he/she performs at the end of the semester. These tasks include the completion of two short answer tests about the lab (30%), and the realisation of several projects (25%). The projects will be conducted in groups of students and the mark for each student for this task will be the mark of the group. The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester. All these tasks may not be retaken at another point in time. That is to say, if a student cannot fulfill them within the time stipulated by the professor, there is no possibility to fulfil them afterwards. Also, they are only valid for the present academic year.

Those students who decide to opt for a continuous assessment will have to fulfill these conditions in order to pass the course: (a) perform at least 5 out of the 6 lab exercises; (b) obtain, at least, 10 points out of 25 in the projects; (c) obtain, at least, 18 points out of 45 in the long answer test; and (d) obtain a minimum of 50 points in total (i.e., taking all the activities into account). The final mark of those students who do not fulfill these minimum requirements will be calculated as follows. It will be the minimum between: (i) the total number of points obtained by the student in all the activities of the course, and (ii) 40 points. That is to say, the maximum mark obtainable for these students is 40 points.

The choice of a continuous assessment necessarily implies that the student is counted as present at the final evaluation, independently of whether or not the student has performed the long answer test.

Exam-only assessment:

In addition to the system of continuous assessment described above, the student can opt for a exam-only assessment. This exam-only assessment covers all the contents of the subject. The professor may demand the student to deliver some additional tasks, which will be notified by the fourth week of the course. These tasks have to be delivered on the day of the exam. To pass the course the student will have to obtain, at least, 50 points out of 100 in the exam together with the additional tasks.

Extraordinary exam:

Those students who opted for a continuous assessment and fulfill the requirements of (a) and (b) above, will be able, if they so wish, to keep the mark obtained in the tasks performed during the continuous assessment (55%). In such a case, they will only take a long answer test (45%). To pass the course, these students will have to obtain, at least, 18 points out of 45 in the long answer test, and obtain a minimum of 50 points in total.

Alternatively, these students can also opt for a exam-only assessment, which covers all the contents of the course. In this case, the students will have to inform the professor one month prior to the final exam. Otherwise, it will be understood that the student opts for continuous assessment.

The rest of students (i.e., those that opted for a system of continuous assessment and do not fulfil the requirements of (a) and (b) above, and those students that opted for a exam-only assessment) will be evaluated by a exam-only assessment, which covers all the contents of the course.

In the case of choosing a exam-only assessment, the professor may demand the student to deliver some additional tasks, which will be notified by one month before the exam. These tasks have to be delivered at the day of the exam. To pass the course the student will have to obtain, at least, 50 points out of 100 in the final exam together with the additional tasks.

End-of-program exam:

It follows the same rules as the evaluation in the second call.

Ethical code:

Plagiarism is regarded as serious dishonest behaviour. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information
Basic Bibliography
J. Capmany, F. J. Fraile Peláez y J. Martí, **Fundamentos de Comunicaciones Ópticas**, 2ª Edición, Síntesis, 2001
J. Capmany, F. J. Fraile Peláez y J. Martí, **Dispositivos de Comunicaciones Ópticas**, 1ª Edición, Síntesis, 1999

Complementary Bibliography

G. P. Agrawal, **Fiber-Optic Communication Systems**, 4ª Edición, Wiley-Interscience, 2010

G. Keiser, **Optical Fiber Communications**, 5ª Edición, McGraw-Hill, 2014

Recommendations

IDENTIFYING DATA

Wireless Systems and Networks

Subject	Wireless Systems and Networks			
Code	V05G301V01326			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Pérez Fontán, Fernando			
Lecturers	Pérez Fontán, Fernando			
E-mail	fpfontan@uvigo.es			
Web	http://www.uvigo.gal/en/university/administration-staff/pdi/fernando-perez-fontan			
General description	(*)(*) A general overview of current wireless communications systems will be provided including standards and dimensioning issues.			

Training and Learning Results

Code	
B2	CG2: The knowledge, comprehension and ability to apply the needed legislation during the development of the Technical Telecommunication Engineer profession and aptitude to manage compulsory specifications, procedures and laws.
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B7	CG7: The ability to analyze and assess the social and environmental impact of technical solutions.
C21	CE21/ST1 The ability to construct, exploit and manage telecommunication networks, services, process and applications, considered as systems of receiving, transporting, representation, processing, storage, management and presentation of multimedia information from the point of view of transmission systems.
C22	CE22/ST2 The ability of applying the basic techniques of telecommunication networks, services and applications for mobile and fixed environments, personal, local or long distance, with different bandwidth, including telephony, radio broadcasting, TV and data, from the point of view of transmission systems.
C25	CE25/ST5 The ability to select transmission antennas, equipment and systems, propagation of guided and non-guided waves, with electromagnetic, radiofrequency and optical media, and their corresponding radio electric spectrum management and frequency designation.
D2	CT2 Understanding Engineering within a framework of sustainable development.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Cellular and wireless network specifications.	B7	C22	
To apply previously acquired knowledge on wave propagation for the planning of radio networks.		C21	
To specify the various elements (antennas, transmitters and receivers) which make up a global system.	B2	C25	D2
Provide access solutions to communications systems.	B4	C22	
Develop roll-out models which minimize the social and environmental impact of the radio communication networks, understanding the ethic and moral responsibilities involved in such work.	B2	C22	D2

Contents

Topic	
Theory 1. Introduction to radiocommunications	Basic concepts Current situation
Theory 2. Cellular systems	Fundamental concepts The radio propagation channel Multiple access techniques Interference Network sizing up Countermeasures Medium access control. Security and access control. Network management. Mobility management. Quality of service.
Theory 3. Review of cellular and wirelss lan standards and other proposals	Cell network generations. Evolution for the technological solutions in each generation.

Tutored work 1. Introduction to multipath effects	Reproducing multipath fading Doppler effect Narrow and wideband channel
Lab. 1. Introduction tho the radio channel	Statistical representation.
Lab 2. Channel effects on 3G	DS-SS
Lab 3. Introduction to 4G standard LTE	OFDMA

Planning

	Class hours	Hours outside the classroom	Total hours
Mentored work	7	14	21
Problem solving	6	18	24
Practices through ICT	14	28	42
Introductory activities	1	0	1
Lecturing	12	0	12
Objective questions exam	1	0	1
Report of practices, practicum and external practices	0	8	8
Problem and/or exercise solving	1	0	1
Essay	0	14	14

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Mentored work	INDIVIDUAL. Simulation work to be carried out in Matlab language will be proposed to C class gropus where they will go deeper into specific issues discussed in less detail in the theoretical classes. Through this methodology the competencies CG2, CG4, CG7, CT2 and CE21
Problem solving	INDIVIDUAL.The theoretical treatment of the various topics studied in theoretical classes will be complemented by performing numerical calculations relative to radio network dimensioning. Through this methodology the competencies CG2 and CE22
Practices through ICT	INDIVIDUAL. In laboratory sessions (type B) various Matlab simulations will be proposed to the students in order to study specific topics which are more suitably aproached this way. Through this methodology the competencies CE21, CE22 and CE25
Introductory activities	In the course of the explanations provided in the lectures as well as during lab work or supervised work mention will be made to concepts already presented in earlier lectures from previous years
Lecturing	INDIVIDUAL. In classroom lectures the more theoretical issues will be presented. Through this methodology the competencies CE21, CE22, CE25 and CT2

Personalized assistance

Methodologies	**Description**
Lecturing	The student will be able to consult individually during tutoring hours all his/her doubts arising during the study of the theoretical contents as well as in the resolution of numerical exercises, laboratory work and supervised projects
Mentored work	The student will be able to consult individually during tutoring hours all his/her doubts arising during the study of the theoretical contents as well as in the resolution of numerical exercises, laboratory work and supervised projects
Problem solving	The student will be able to consult individually during tutoring hours all his/her doubts arising during the study of the theoretical contents as well as in the resolution of numerical exercises, laboratory work and supervised projects
Practices through ICT	The student will be able to consult individually during tutoring hours all his/her doubts arising during the study of the theoretical contents as well as in the resolution of numerical exercises, laboratory work and supervised projects
Introductory activities	In the same way as with the above points, personalized attention will be provided to the students in all aspects related to introductory activities.

Assessment

	Description	Qualification	Training and Learning Results	
Objective questions exam	Adequate knowledge of the theoretical materials of the lecture will be assessed by means of short response questions during an Intermediate Test and at the Final Exam. Each of these tests has a weight of 1/2. Continued class attendance will be evaluated.	20	C21 C22 C25	D2

Report of practices, practicum and external practices	For each lab assignment, the students individually, will present a written report. The evaluation will be carried out by means of (1) reports, (2) an specific mid-term test and (a) at the final exam. The weights of these 3 parts will be 1/3. Continued class attendance will be evaluated.	30		C21 C22 C25	D2
Problem and/or exercise solving	In a mid-term test and at the final exam, there will be a part containing various short numerical problems. Each of these 2 tests will weight 1/2. Continued class attendance will be evaluated.	30	B2	C21 C22 C25	
Essay	The evaluation of supervised group work (C classes) will be carried out through (1) a report, (2) a specific min-term test and (3) a specific test at the Final Exam. Each of these two evaluation mechanisms has a weight of 1/2. That is 1/2 for the reports and 1/4 for the specific mid term test and 1/4 for the final exam test. Continued class attendance will be evaluated.	20	B4 B7	C21 C22 C25	

Other comments on the Evaluation

English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.
If possible all skills pertaining to this subject will be evaluated in all the various tests and exercises proposed: short answer tests, lab reports, problem solving and projects**ORDINARY EXAM**

For the Ordinary Opportunity, the Continuous Assessment option will be carried out according to the Table above. Note that should one chose Continuous Evaluation, it will be compulsory to carry out all the Lab Work proposed (Groups B) and the Supervised Projects (Groups C). A mid-term exam will be taken consisting of 4 Intermediate Tests: Short Questions, Problems, Groups B and Groups C. The overall value of this exam will be 40% of the overall mark. For the Final Exam the same 4-test structure will be followed. Again, the overall weight of this exam will be 40% of the overall mark. Further, the overall mark will be complemented with the assessment of the Lab Work and Supervised Project Reports, both with a weight of 10%.

Those who chose Global Evaluation will be assessed through a Final Exam with a weight of 100% of the overall mark with 4 different parts similar in structure to the Intermediate Test and Final Test for the Continuous Evaluation case. For this option, it is not compulsory to carry out the Lab Work and Supervised Projects.

The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester.

The marks achieved for the Lab Work and Supervised Project Reports are only valid during the current academic year.

Should the student chose the Global Evaluation option, this will be reported to the professor, otherwise it will be assumed by default that the student has opted for the Continuous Evaluation option. The student going for this Conunyuous Evaluation option must carry out all Lab Work and Supervised Project tasks proposed. Change to Global Evaluation can b chosen at any time during the semester. This should be duly notified to the professor.

EXTRAORDINARY AND END-OF-PROGRAM EXAM

Extraordinary Exam will involve a Final exam for all option: Continuous and Global Evaluation, as well as for End-of-Term. In the case of Continuous Evaluation, the marks for the Lab Work and Supervised Project Reports will be added to the overall mark.

ETHICS CODE

Should a case of plagiarism be detected in any of the various activities and tests , the final mark will be FAILED (0) and the school direction team will be advised on the fact.

Sources of information

Basic Bibliography

José María Hernando Rábanos, **Comunicaciones Móviles. 2ª ed.**, Ed. Centro de Estudios Ramón Areces, S.A., 2014

F.Pérez-Fontán and P.Mariño Espiñeira, **Modeling of the wireless propagation channel. A simulation approach with Matlab**, Wiley, 2008

Oriol Sallent Roig, Jordi Pérez Romero, **Fundamentos de diseño y gestión de sistemas de comunicaciones móviles celulares**, UPC, 2014

Complementary Bibliography

Fernando Pérez Fontán, Sigfredo Pagel Lindow, **Introducción a las. Comunicaciones Móviles**, Servicio de Publicaciones. Universidad de Vigo, 1997

José María Hernando Rábanos, **Comunicaciones Móviles de Tercera Generación**, Telefónica Móviles, 2000

Simon R. Saunders, **Antennas and Propagation for Wireless Communications Systems**, Wiley, 2007

José María Hernando Rábanos, Fernando Pérez Fontán, **Introduction to Mobile Communications Engineering**, Artech House, 1999

Ramón Agustí Comés, **LTE: nuevas tendencias en comunicaciones móviles**, Fundación Vodafone, 2010

Recommendations

Subjects that it is recommended to have taken before

Radio Frequency Circuits/V05G301V01319

Radio Communication Systems/V05G301V01320

IDENTIFYING DATA				
Fundamentals of Acoustics Engineering				
Subject	Fundamentals of Acoustics Engineering			
Code	V05G301V01327			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	Spanish			
Department				
Coordinator	González Valdés, Borja			
Lecturers	González Valdés, Borja			
E-mail	bgvaldes@uvigo.es			
Web	http://https://moovi.uvigo.gal			
General description	Concepts covered by the subject: vibratory systems related to the acoustic wave equation, radiation and propagation, mechanisms of acoustic-mechanical-electrical transduction, behaviour and design of speakers and microphones. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B11	CG11 To approach a new problem considering first the essential and then the secondary aspects
C34	CE34/SI1The ability to construct, exploit and manage telecommunication services and applications, such as receiving, digital and analogical treatment, codification, transporting and representation, processing, storage, reproduction, management and presentation of audiovisual and multimedia information services.
C37	CE37/SI4 The ability to carry out acoustic engineering projects related to: acoustical isolation and conditioning of rooms, loudspeaker installations, specification, analysis and selection of electro acoustical transducers, measurement, analysis and control of radio vibration systems, environmental acoustics, submarine and acoustical systems.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
* Understand the basic mechanisms of vibration of distinct elements and interpret his relation with the production of sound. * Know the bases of the linear acoustics and understand the concepts of pressure, speed of particle, intensity, power and impedance. * Understand the phenomena of propagation of the sound and to analyse the influence of the medium. * Understand the phenomenon of the radiation of acoustic waves. * Understand the basic mechanisms of the *transducción mechanical-acoustic.	B3 B11	C34 C37
* Analyse electro-mechanical-acoustic systems by the use of analogies which are based on circuit theory. * Design acoustic systems by using speakers, acoustic boxes and horns. * Analyse different types of microphones from the point of view of their technical specifications and their possible applications. * Comprender los principios básicos y aplicaciones concretas de los ultrasonidos. * Understanding of basic principles and specific applications of ultrasounds * Understanding of basic principles and specific applications of underwater acoustics	B3 B5 B11	C34 C37

* Interpret technical specifications within working teams. * Apply norms of measuring. * Elaborate trial procedures. * Develop trial procedures. * Process data obtained from trials * Program processing algorithms. * Value technical results. * Write trial reports.	B6 B9 B11	C34 C37	
* Cooperate and collaborate in working groups to carry out technical projects. * Adapt to new surroundings. * Accept the role allocation in a group. * Contribute to the resolution of conflicts.			D3 D4

Contents

Topic	
1. Sound power measurement tests.	Acoustic variables. Sound field. Propagation. Uses of intensity and power. Sound intensity probes. Power measurement standards using acoustic pressure or intensity.
2. Models of radiation sources.	Directivity. Acoustic impedance. Monopole. Dipole. Monopole on infinite baffle. Baffled circular piston. Directivity measurement standards.
3. Vibrating systems.	Damped and forced oscillatory motion. Vibration of strings, bars, membranes and plates. The sound in tubes. Sound sources. Acoustic filters.
4. Specifications and measurement of electroacoustic systems.	Introduction to loudspeakers: baffles and crossovers. Acoustic measurement tests: measurement of speakers. Measurement of noise and nonlinear distortion.
5.Analogies and transduction.	Electro-mechano-acoustic systems. Equivalent circuits. Transduction
6. Speakers, horns and cabinets.	Equivalent model of an infinite baffle loudspeaker. Equivalent model of a cabinet with speaker. Horns.
7. Cabinet design.	Techniques and design criteria of acoustic boxes
8. Microphones.	A microphone equivalent model. Tank circuits.
9. Submarine acoustics and ultrasounds	Submarine acoustics. Ultrasounds

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	17	38	55
Autonomous problem solving	0	44	44
Practices through ICT	13	0	13
Laboratory practical	6	6	12
Problem solving	0	20	20
Problem and/or exercise solving	2	0	2
Objective questions exam	1	0	1
Problem and/or exercise solving	1	0	1
Problem and/or exercise solving	2	0	2

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Oral speech, promoting the critical discussion of the concepts. Theoretical bases of algorithms and procedures used to solve problems are presented. CG3, CG5, CG11, CE34, CE37.
Autonomous problem solving	Individual resolution of exercises as a practical application of the theoretical bases and procedures described in the master sessions. Given a specific situation, the student has to obtain the suitable solution, in a reasoned way, by properly choosing the appropriate formulas and coming to a valid solution. CG3, CG5, CG11, CE34, CE37.
Practices through ICT	Handle and adjustment of tools of analysis and algorithms, in group, identifying which is appropriate for a given situation. CG3, CG5, CG6, CG9, CG11, CE34, CE37, CT3, CT4.
Laboratory practical	Cooperative and collaborative work with measuring equipment in reduced groups, and registering of acoustic magnitudes, in laboratoy environments. CG3, CG5, CG6, CG9, CG11, CE34, CE37, CT3, CT4.
Problem solving	Give solution to exercises, relative to practice sesions. CG3, CG5, CG6, CG11, CE34, CE37.

Personalized assistance

Methodologies	Description
Lecturing	Doubts may be solved in the tutorial classes. These will take place in the following way: - Individually or in small groups (typically with a maximum of 2-3 people). - Unless the contrary is specified, previous appointment with the professor will be required. The appointment will be requested and acknoledged by email or at moovi.uvigo.gal. Place and time will preferrably be as officially scheduled.
Practices through ICT	Doubts may be solved in the tutorial classes. These will take place in the following way: - Individually or in small groups (typically with a maximum of 2-3 people). - Unless the contrary is specified, previous appointment with the professor will be required. The appointment will be requested and acknoledged by email or at moovi.uvigo.gal. Place and time will preferrably be as officially scheduled.
Problem solving	Doubts may be solved in the tutorial classes. These will take place in the following way: - Individually or in small groups (typically with a maximum of 2-3 people). - Unless the contrary is specified, previous appointment with the professor will be required. The appointment will be requested and acknoledged by email or at moovi.uvigo.gal. Place and time will preferrably be as officially scheduled.
Autonomous problem solving	Doubts may be solved in the tutorial classes. These will take place in the following way: - Individually or in small groups (typically with a maximum of 2-3 people). - Unless the contrary is specified, previous appointment with the professor will be required. The appointment will be requested and acknoledged by email or at moovi.uvigo.gal. Place and time will preferrably be as officially scheduled.
Laboratory practical	Doubts may be solved in the tutorial classes. These will take place in the following way: - Individually or in small groups (typically with a maximum of 2-3 people). - Unless the contrary is specified, previous appointment with the professor will be required. The appointment will be requested and acknoledged by email or at moovi.uvigo.gal. Place and time will preferrably be as officially scheduled.

Assessment

	Description	Qualification	Training and Learning Results		
Practices through ICT	Attendance to the practices at computer classroom.	1.5	B3 B5 B6 B9 B11	C34 C37	D3 D4
Laboratory practical	Attendance to the laboratory practices	2.5	B3 B5 B6 B9 B11	C34 C37	D3 D4
Problem and/or exercise solving	Written exam, with brief questions and problems 1	30	B3 B5 B11	C34 C37	
Objective questions exam	Exam on the work done in the computer classroom.	13.5	B3 B5 B6 B11	C34 C37	
Problem and/or exercise solving	Exam on the exercises of the laboratory practices.	22.5	B3 B5 B6 B11	C34 C37	
Problem and/or exercise solving	Written exam, with brief questions and problems 2	30	B3 B5 B11	C34 C37	D3 D4

Other comments on the Evaluation

Following the guidelines of the studies, two assessment systems will be offered to the students inscribed on this subject:

Continuous assessment (the preferred method, academic activities are linked to this system) and exam-only assessment (not recommended).

Weighting:

* Magister sessions. Individual assesment. (weight: 60%)

* Practises in computer rooms. Individual assesment. (weight: 15%)

* Laboratory practises. Individual assesment. (weight: 25%)

*** Students who choose continuous assessment:**

Students will follow the continuous assessment system if they sit for any examination after the first course month.

Asessment activities:

* Short answer tests of magister sessions.

* Practices in computer rooms. The assessment will be done twofold: Attendance, and exam.

* Laboratory practices. The assessment will be done twofold: Attendance, and exam.

To ensure that all competencies are acquired, it will be necessary to jointly fulfill these two conditions to pass:

1) To obtain a grade equal to or greater than 4 (on a scale of 0 to 10), in the set of activities of each type.

2) To obtain an overall mark, calculated as the sum of the scores of activities weighted correspondingly, equal to or greater than 5 (on a scale of 0 to 10)

In the event that only condition 2) is fulfilled, and not condition 1), the global mark in the subject will be 4.9.

Missed exams and/or lab classes will not be rescheduled.

The exams in continuous assessment are only valid for the ordinary continuous assessment call.

*** Students who choose for exam-only assessment:**

The possibility of a final examination will be provided to students who do not opt for the continuous assessment. This final exam will cover all the activities of the subject.

To ensure that all competencies are acquired, it will be necessary to jointly fulfill these two conditions:

1) To obtain a grade equal to or greater than 4 (on a scale of 0 to 10), in each of the sections in which the test is divided.

2) To obtain an overall grade in the examination equal to or greater than 5 (on a scale of 0 to 10).

SECOND CALL

Two different situations:

=> Students that are evaluated using continuous assessment:

Two options to choose:

* To keep the practice attendance grades and take all of the continuous assessment exams on the official date assigned by the Center.

* To be evaluated with the same final exam as stated in the above section Students who choose for exam-only assessment.

=> Students who choose for exam-only assessment:

A final examination will be provided to students who do not opt for the continuous assessment. This final exam will be assessed as stated in the above section Students who choose for exam-only assessment.

END OF PROGRAM CALL

End of program calls will be assessed as stated in the above section Students who choose for exam-only assessment.

In the event of copycatting at any proof or work, the final assessment will be FAIL (0) and the event will be communicated to the Centre headmaster in order to conduct appropriate measures.

Additional comments

The use of generative artificial intelligence (GAI) is allowed in the realization of the academic activities of this subject. Its use must be carried out in an ethical, critical and responsible manner. In the case of using GAI, any result it provides must be critically evaluated, and any citation or reference generated must be carefully verified. It is also recommended to declare the use of the tools used.

Sources of information
Basic Bibliography
Basilio Pueo Ortega, Miguel Romá Romero, **Electroacústica : altavoces y micrófonos**,
W. Marshall Leach, Jr., **Introduction to electroacoustics and audio amplifier design**,
Finn Jacobsen et al., **FUNDAMENTALS OF ACOUSTICS AND NOISE CONTROL**,
Complementary Bibliography
Lawrence E. Kinsler, **Fundamentals of acoustics**,
Vance Dickason, **Loudspeaker Design Cookbook**,

Recommendations

IDENTIFYING DATA				
Sound Processing				
Subject	Sound Processing			
Code	V05G301V01328			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	Spanish			
Department				
Coordinator	Rodríguez Banga, Eduardo			
Lecturers	Rodríguez Banga, Eduardo			
E-mail	erbanga@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This course describes the main techniques of the sound processing, with special emphasis on real applications. Students are shown the basic principles of these techniques and how the same principles may give rise to different algorithms or systems depending on the type of signal to process (speech or audio, for instance). This course also makes an introduction to Speech Technologies and their applications.			

Training and Learning Results	
Code	
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
C34	CE34/SI1The ability to construct, exploit and manage telecommunication services and applications, such as receiving, digital and analogical treatment, codification, transporting and representation, processing, storage, reproduction, management and presentation of audiovisual and multimedia information services.
C38	CE38/SI5 The ability to create, modify, manage, broadcast and distribute multimedia contents taking into account the use and accessibility criteria to audiovisual, broadcasting and interactive services.
D2	CT2 Understanding Engineering within a framework of sustainable development.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Understand some basic techniques for speech and audio processing.	B4	C34 C38	
Development of basic speech and audio coders.	B4	C34 C38	
Analyse speech and audio specifications and standards.	B4 B6	C34 C38	D2
Understand some basic techniques used in Speech Technologies.	B4	C34 C38	
Ability to adapt learned techniques to other applications.	B4		D2

Contents	
Topic	
Voice production and perception	Voice generation. Physiology. General characteristics of a speech signal. Perception. Auditive physiology.
Analysis of speech and audio signals	Sampling, interpolation and decimation. Short-term analysis. Time and spectral parameters. Linear prediction techniques. Cepstrum. Psychoacoustic principles: critical bands and masking.
Speech coding	Waveform coding. Parametric coding. Hybrid coding. Standards. Applications.
Audio Coding	Main characteristics of an audio signal. Psychoacoustic models. Time-frequency analysis: filterbanks and transforms. Coding. Standards. Applications.
Speech Technologies	Speech Recognition, Speech Synthesis and related applications.
Practical content	In this subject there is no division between theoretical and practical content. Indeed, practical exercises related to many of the previously described contents are considered.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	20	42	62
Practices through ICT	10	9	19
Mentored work	7	57	64
Problem and/or exercise solving	3	0	3
Problem and/or exercise solving	2	0	2

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The instructor makes a presentation of some relevant contents of the subject. Some concepts may be illustrated by means of computer simulation. Students are encouraged to make questions and discuss some proposed problems and exercises. The main objective of these sessions is to provide the students with the theoretical background so that they can develop all the subject competences. Therefore, every subject competence is developed in these sessions.
Practices through ICT	Students will carry out computer simulations using Matlab, which will help them to better understand the concepts introduced in the theory sessions and to discover new ones. All the subject competences are developed in these sessions.
Mentored work	The students will be grouped into teams which will develop one or several tasks proposed by the instructor. The number of students in a team will be established taking into account the number of students enrolled and the complexity of the proposed tasks. Each team work will be supervised by the instructor who, in addition to evaluate the team work, may establish procedures for self and cross evaluation. Tutored works are thought to develop B4 and B6 competences, as well as C34, C38 and D2.

Personalized assistance

Methodologies	Description
Practices through ICT	The instructor will establish mechanisms to determine the degree of understanding of the main concepts by the students.
Lecturing	Personalized attention will be offered during office hours. Further information at Moovi: https://moovi.uvigo.gal
Mentored work	At the regular team meetings the instructor will track the work of each student. In addition , the instructor will establish additional mechanisms such as, for instance, cross-evaluation of the student work by his/her team mates.

Assessment

	Description	Qualification	Training and Learning Results
Mentored work	The assessment of teamwork will be carried out by collecting evidence throughout its execution, both at the group and individual levels. It will involve the delivery of a final report with the results and a presentation and/or test of knowledge regarding the work performed. The assessment will take into account the work carried out and the understanding of concepts at both the group and individual levels. The final report will be delivered around week 13 of the course term. The exact date will be communicated at the beginning of the term. The section "Other comments on the evaluation" provides more details about the mentored work and its influence (TG grade) on the final grade F.	35	B4 C34 D2 B6 C38
Problem and/or exercise solving	There will be three midterm tests during the course term: two related to the contents of the mentored work and one to the contents taught in the lectures and practicals. The section "Other comments on the evaluation" provides more details about these midterm tests and their impact on the final grade.	25	B4 C34 D2 B6 C38
Problem and/or exercise solving	Final exam with questions of any kind, covering the contents taught in the course. The section "Other comments on the evaluation" provides more details about the final exam and its impact on the final grade.	40	B4 C34 D2 B6 C38

Other comments on the Evaluation

The calculation of the final mark (F) for continuous assessment (C.A.) is based on the marks obtained jointly by the group in the mentored work (TG), in two midterm tests related to the tasks of the mentored work (T1 and T2), in a midterm test related to contents of the first parts of the course (P1) and the final exam (EX). All marks are given on a scale of 0 to 10. The three midterm tests will be taken individually.

The mark of the mentored work (TR) is calculated as

TR= min(10, 0.7*TG*W+ 0.3*(T1+T2)/2)

where W is a weighting factor, usually of value 1, which is explained below.

A fully individual mark (NI) is calculated as

NI= max(EX, 0.8*EX+0.2*P1)

and the final mark as

F=0.5*TR+0.5*NI   if TR>=4 and NI>=4

F=min(4, 0.5*TR+0.5*NI) if TR < 4 or NI < 4

In order to pass, a grade of F>=5 is required. According to the previous expression, in case the grades TR or NI do not reach four points, the maximum final grade will be F=4.

The TG grade will be determined based on the evaluation of submitted tasks and a final presentation conducted by the entire group to their instructor in the last C group meeting, with questions to its different members.

The TG mark will be weighted by the factor W according to the results of the cross-evaluations and the instructor's opinion about the student's personal contribution to the group work. Normally the weighting factor will be 1, although factors less than 1 will be applied to students that hinder the normal progress of the group or show poor participation or understanding in the tasks of the mentored work. Likewise, the instructor might reward those students who stand out significantly for their contribution to the teamwork with a weighting factor of up to 1.2, especially in case of unexpected difficulties.

Failure to attend the final presentation, unless justified, will result in W=0. In the case of a justified absence, the student must promptly contact his/her instructor to schedule an interview and demonstrate his/her understanding of the group's work.

The final exam will contain a set of questions related to the mentored work tasks for students who have chosen global assessment. The grade obtained in this set of questions will be considered as TR. The grade corresponding to the remaining questions of the exam will be considered as NI. From TR and NI, the final mark F will be calculated according to the expressions described above for C.A.

Students attending the second-call exam, with independence of the assesment track followed, will be able to choose, before starting the exam, to maintain the grade obtained either in TR or NI in the first call if equal or higher than 4. In that case, they will only answer the group of questions corresponding to the part whose score they do not wish to keep. However, students should be aware of the influence of this decision on their final grade.

The end-of-program call will consist of a final exam with a single set of questions (without differentiated groups) related to any content of the course. In this case the final grade F will be directly the grade of the exam.

To ensure that students do not disadvantage their potential teammates, they will be given a period to decide whether or not to follow the C.A. track. This decision must be made within one month from the beginning of the course term. Opting for the C.A. track means that the student will be graded in the first call.

In exceptional cases, such as long-term justified reasons that unable to follow the C.A. procedure or to take essential assessment tests within the foreseen period, the instructor will decide whether or not it is appropriate to allow the student to change from C.A. to global assessment or to consider him/her 'no show'.

The different evaluation tests are not recoverable in case a student does not show up when they take place, with the exception of non-attendance due to any of the justified reasons listed in the University regulations.

Attendance to group C meetings, corresponding to the mentored group work, is mandatory in case of following the C.A. track.

Plagiarism is regarded as serious misconduct. If any form of plagiarism is detected in any test or work, according to the circumstances, the final grade of the course might be FAIL (0) and the corresponding academic authorities informed about the fact in order to take further measures.

The solution to any possible inconsistency, discrepancy or difference of interpretation that may arise from this guide, as well as any error or any other not considered case, will be discussed between the instructor and the concerned students and, in case of no agreement, the matter will be referred to the competent higher bodies.

Sources of information

Basic Bibliography

Andreas Spanias, Ted Painter and Venkatraman Attii, **Audio Signal Processing and Coding**, Wiley, 2007

Wai C. Chu, **Speech Coding Algorithms: Foundation and Evolution of Standardized Coders**, Wiley, 2004

Douglas O'Shaughnessy, **Speech Communications. Human and Machine**, Second edition, Wiley-IEEE Press, 1999

Boss, M. and Goldberg, R. E., **Introduction to digital audio coding and standards**, Kluwer Academic Publishers, 2003

Ian Vince McLoughlin, **Speech and Audio Processing: A MATLAB Based Approach**, Cambridge University Press, 2016

Complementary Bibliography

Dutoit, T. and Marqués F., **Applied signal processing : a matlab-based proof of concept**, Springer, 2009

Paul Taylor, **Text-to-Speech Synthesis**, Cambridge University Press, 2009

Recommendations

Subjects that it is recommended to have taken before

Fundamentals of Sound and Image/V05G301V01209

Digital Signal Processing/V05G301V01205

Other comments

It is assumed that the student has some basic skills in Matlab.

IDENTIFYING DATA				
Video and Television				
Subject	Video and Television			
Code	V05G301V01329			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Martín Rodríguez, Fernando			
Lecturers	Martín Rodríguez, Fernando Obelleiro Basteiro, Fernando			
E-mail	fmartin@uvigo.es			
Web	http://https://moovi.uvigo.gal/			
General description	(*)(*) This subject develops nowadays available video technology: video saving on magnetic and/or optic media, digital television over different transmission media (terrestrial, satellite, cable and IP) and television networks. English Friendly subject, International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
C34	CE34/SI1The ability to construct, exploit and manage telecommunication services and applications, such as receiving, digital and analogical treatment, codification, transporting and representation, processing, storage, reproduction, management and presentation of audiovisual and multimedia information services.
C35	CE35/SI2 The ability to analyze, specify, carry out and maintain systems, equipments, heads and installations of TV, audio and video for mobile and fixed environments.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
Analyzing the influence of coding parameters on compression and quality results. Making calculations necessary for the design and installation of TV networks of different types.	B6	C34 C35
Choosing appropriate saving formats for each need. Choosing appropriate equipment to work with such formats.	B5	C34 C35
Choosing the most suitable formats for image and video.	B6	C34 C35
Writing intra-building video distribution projects and monitoring their installation process. Testing and correcting problems in existing systems.	B6	C34 C35
Designing and implementing interactive TV projects.	B6	C34 C35
Applying and analyzing different multimedia systems: videoconferencing, streaming, audiovisual databases, synchronization, metadata processing, multimedia content exchange.	B5	C34 C35

Contents	
Topic	
Still image and video formats.	- Still Image: JPEG. - Intra-Frame video formats. - Simple video formats: H.261 & MPEG. - Contemporary video formats. H.26x, MPEG-x. - Video saving: file formats, multimedia containers, magnetic tape formats, optical formats. - 3D formats.

Video distribution.	- Video on the Internet: smartTV and interactive TV, HBBTV, real-time protocols: RTP, RTCP, SRTP, RTSP. - Digital Video Broadcasting (DVB): DVB-S, DVB-T, DVB-C, DVB distribution networks.
Practical content 1.	Practical work based on informatics/programming and about themes from the course. Probably, it will be divided into several exercises.
Practical content 2.	Desing of an intra-building TV network for a real example.

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	21	42	63
Practices through ICT	12	9	21
Mentored work	7	49.5	56.5
Objective questions exam	0.5	1.5	2
Report of practices, practicum and external practices	0	6	6
Essay questions exam	1.5	0	1.5

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Lecturing	Professor makes presentation of contents, encouraging critical discussion. Algorithm and procedures teoretical basis are exposed. Related competencies: CG5, CG6, CE34, CE35.
Practices through ICT	Small projects are suggested. Work in pairs. Well founded solutuions must be obtained, choosing appropriate methods and coming to a valid solution. Related competencies: CG5, CG6, CE34, CE35. Software to be used: MATLAB, free CAD application.
Mentored work	A project of a different type is proposed. It will be designed to be carried out by a small group. Work takes into account both the technical aspects of the project and the group organization issues. Skills worked: CG5, CG6, CE34, CE35.

Personalized assistance

Methodologies	Description
Lecturing	Query and answer in the classroom and, if necessary, at the office. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-martin-rodriguez
Practices through ICT	Query and answer in the classroom and, if necessary, at the office (previous appointment). Help via e-mail. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-martin-rodriguez
Mentored work	Query and answer at the office (with previous appointment). Help via e-mail. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-martin-rodriguez

Assessment				
	Description	Qualification	Training and Learning Results	
Mentored work	These are small projects that are subject to follow-up meetings in C groups. In these meetings the status of the work is analyzed, including the qualification that they would deserve at that time. Improvements will be proposed that can be carried out in non presentrially.	25	B5 B6	C34 C35
Objective questions exam	Multiple choice tests, performed on finishig each theory unit.	10	B5 B6	C34 C35
Report of practices, practicum and external practices	Final version of works carried out in computer lab. sessions (groups B).	25	B5 B6	C34 C35
Essay questions exam	Final written exam in time and place according to school official scheduling.	40	B5 B6	C34 C35

Other comments on the Evaluation

Students can decide if they want only a final exam (global evaluation) or continuous evaluation (according to the procedure described above). The decision can be taken at the time for final exam: students can sign to resign from their continuous evaluation marks. At the time of joining a C group to carry out the supervised work, they must send an e-mail to record their decision to opt for continuous evaluation.

In the extraordinary call, they can again choose between continuous assessment and the final exam, but taking into account that::

- The qualification from test and lab reports is the same of the first call.

- That qualification is only valid within the present academic year.

End of Grade Call: in this exam call, we will proceed as in the case of students that have not fulfilled the continuous assesment process.

In case of detecting any kind of plagiarism in any of the tests (short tests, partial and final exams, lab. reports), the qualification will be FAIL (0) and this fact will be communicated to the school regents for taking the appropriate actions.

Sources of information
Basic Bibliography
Ulrich Reimers, **DVB: the family of international standards for digital video broadcasting**, 2, Springer, 2005
José Luis Fernández Carnero, Antonio Suárez Perdigón, **Televisión y radio analógica y digital : sistemas para la recepción y distribución de las comunicaciones y los servicios en edificios y viviendas**, 1, Televés, 2004
Complementary Bibliography
Tomás Perales Benito, **Radio y Televisión Digitales: Tecnología de los Sistemas DAB, DVB, IBUC y ATSC**, 1, Creaciones Copyright, 2005
Mark Massel, **Digital Television: Dvb-T Cofdm And Atsc 8-Vsb**, 2, Digitaltvbooks.com, 2008
Walter Fischer, **Digital video and audio broadcasting technology : a practical engineering guide**, 3, Springer, 2010
Iain E. G. Richardson, **H.264 and MPEG-4 video compression : video coding for next generation multimedia**, 1, Wiley, 2003

Recommendations

Subjects that it is recommended to have taken before

Fundamentals of Sound and Image/V05G301V01209
Digital Signal Processing/V05G301V01205

IDENTIFYING DATA				
Room Acoustics				
Subject	Room Acoustics			
Code	V05G301V01330			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish English			
Department				
Coordinator	Sobreira Seoane, Manuel Ángel			
Lecturers	Sobreira Seoane, Manuel Ángel			
E-mail	msobre@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Architectural acoustics, develops the fundamental theoretical principles of the architectural acoustics, in the fields of room acoustics and acoustic isolation. The aims of the subject are: provide a sufficient theoretical background that allow the understanding of the behaviour of the sound filed in rooms; define the parameters that allow to evaluate the acoustic quality of rooms; develop the techniques of design that allow to optimise the acoustic behaviour of rooms; detail the parameters that allow to evaluate the acoustic isolation in buildings and introduce the problematic of the calculation of the acoustic insulation in the buildings and building elements. International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B2	CG2: The knowledge, comprehension and ability to apply the needed legislation during the development of the Technical Telecommunication Engineer profession and aptitude to manage compulsory specifications, procedures and laws.
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
C36	CE36/SI3 The capacity to implement projects at places and installations for the production and recording of audio and video signals.
C37	CE37/SI4 The ability to carry out acoustic engineering projects related to: acoustical isolation and conditioning of rooms, loudspeaker installations, specification, analysis and selection of electro acoustical transducers, measurement, analysis and control of radio vibration systems, environmental acoustics, submarine and acoustical systems.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
Knowledge on the theoretical fundamentals of room acoustics.	B2	C36
Ability to analyse the acoustic behaviour of rooms and identify acoustic problems.	B5	C37
Capacity to design solutions to acoustic problems in rooms.		
Capacity to write expert technical reports on room acoustics measurement test and analysis.		
Ability to check and assess the acoustic quality of rooms.		
Capacity to design different kind of rooms matched to the specific acoustic requirements (recording studios, control rooms, conference rooms and classrooms).		

Contents	
Topic	
Introduction	Basic concepts in acoustics. Acoustic power, sound pressure, sound intensity. Levels and decibels.
Statistital theory in acoustics.	Average sound pressure in rooms. Reverberation time: Sabine and Eyring equations. Measurement of reverberation time and absorption coefficient.
Absorbents and Acoustic Diffusers.	Porous absorbing materials. Membrane and Helmhotz resonators. Acoustic diffusers.
Wave theory in rooms.	Three dimensional wave equation.Resonant frequencies and resonant modes in rooms. Modal density. Frequency response of rooms. The influence of dimension relations and frequency response.
Geometrical theory.	Method of the virtual image. Reflections in flat surfaces. The acoustic behaviour of curved surfaces

Acoustic design of rooms.	Descriptors of room acoustics. Echoes in rooms. Focalization effects in rooms. Acoustic behaviour of audience: seat dip. Geometrical design of rooms. Design of conference rooms and classrooms. Recording studios: LEDE and Non-Environment design techniques. Measurement of acoustic quality of rooms and practical work on acoustic design of small spaces.
Acoustic insulation.	Introduction to the acoustic insulation. Acoustic isolation of single panels. Insulation of double walls. Introduction to the flanking transmission evaluation in buildings. Noise control in buildings.

Planning

	Class hours	Hours outside the classroom	Total hours
Mentored work	7	28	35
Practices through ICT	12	9	21
Previous studies	0	15	15
Lecturing	19	38	57
Problem and/or exercise solving	2	10	12
Problem and/or exercise solving	2	8	10

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Mentored work	The students will have to develop and write a report on three small projects: 1. Design and building Helmholtz and membrane resonators. 2. Design and acoustic measurements on scale models. 3. Software to calculate acoustic reflectors and diffusers Through this methodology the general competencies CG2, CG5 and the specific competency CE36 and CE37 are developed.
Practices through ICT	During practical sessions, the student will learn the use use of software to measure and analyse the impulse response of rooms. Through this methodology the general competencies CG5 and the specific competency CE36 and CE37 are developed.
Previous studies	The students must study and prepare with the sources of information given before the lectures and the practical sessions. Through this methodology the general competencies CG2, CG5 and the specific competency CE36 and CE37 are developed.
Lecturing	Lectures will be given, developing the main theoretical concepts of the subject. Through this methodology the general competencies CG2, CG5 and the specific competency CE36 and CE37 are developed.

Personalized assistance

Methodologies	**Description**
Lecturing	Lectures are develop within a continuous interaction framework, where students can answer questions delivered by the teacher. They could also solve their particular doubts during the sessions. In any case the students will be able to contact the teacher to request tutoring through the platform of the subject (www.moovi.gal).
Mentored work	Tutored works are developed in small working groups. The works are followed during meetings between the groups and the teacher. In those meetings the students can interact and ask their questions to the teacher.
Practices through ICT	In practical sessions, each student must solve his/her own tasks. The teacher will be available during the session to solve any problem/question or doubt the student may have.

Assessment

	Description	Qualification	Training and Learning Results
Mentored work	Tutored practical project, with the delivery of a final report. The learning aims containing the develompent of the ability to develop projects are assesed through this practical tutored works. Each student will give a final presentation on its contribution to the group.	35	C36 C37

Practices through ICT	Practical tasks, solved in a computer lab with specific acoustic software.	15	B2 B5
Problem and/or exercise solving	Written examination, solving calculation problems. Evaluation of the learning aims, mainly in those aspects related to "know how to carry calculations out" in the field of room acoustics. To be done at the end of the semester in the dates agreed and published by the Degree Academic Comitee (Comisión Académica de Grado-CAG).	25	B5
Problem and/or exercise solving	Short answers related to the theoretical content of the subject. Evaluation of the knowledge of regulations in the matter of room acoustics. To be done at the mid of the semester in the dates agreed and published by the Degree Academic Comitee (Comisión Académica de Grado-CAG).	25	B2

Other comments on the Evaluation

Following the guidelines of the degree, two systems of evaluation are offered: continuous assessment (recommended) and a final examination. Evaluation with only a final examination will be only allowed in situations in which it is imposible to follow the system recommended.

CONTINUOUS ASSESSMENT:

The continuous assessment will be based in the evaluation of practical task, projects and two tests. By default it's assumed all students follow the continuous assessment process unless a written notice of resignation is presented after the first month. The final degree will be obtained by a weighted average of the grades obteined in the methodologies/tests described.

Some considerations on the continous assessment process:

- Tutored works are developed in groups. The final grade will be weighted taking into account the results of a cross assesment survey and the individual final presentation of each student's contribution to the work. To consider as "satisfactory" the contribution of each student to the group a minimum grade of 2 over 5 points is stablished.
    - During the presentation of the work the competences related to analysis, synthesis, mastering of the specific vocabulary of the specialty and his/her presentation and oral exchange skills will be evaluated. 25% of the final grade will be assigned on the basis of the individual presentation of each student.
- The studenst have to show good skills in all the learning outcomes, therefore, four points over a ten points scale must be obtained in all the learning outcomes evaluated during the continuous evaluation process.
- The final grade will be obtained through a weighted average, with the weights included in the qualification column of the methodologies/tests section, once the minimum grade is obtained in each activity.
- In case the final overage is greater than 5 over 10 points, but any of the requirements are not met, the final grade will be 4.9-FAILED.

Final examination: The final examination, (both, ordinary and extraordinary exams) will include two parts:

- A written examination covering a short anwer tests and a troubleshouting part.
- Practical activities: practical questions and delivering the reports of a practical work the teacher may ask.
- The final examination will be develpoped on the official dates published by the accademic staff.

Those students who have passed the subject following the continuous assessment proccess, will have the chance to attend the final examination in order to get a higher grade (either in the written part or the practical activities or both).
Those students who did not succeed in some of the parts of the evaluation proccess, will have the chance to do only the part of the final examination required to fullfill the requirement.
If the subject is passed in first chance, there is no chance to attend the second opportunity to improve the final grade.

The subject is assessed in a 0 to 10 points scale and it is considered "passed" if the final grade obtained is equal or greater than 5.

NON CONTINUOUS ASSESSMENT:

If a student does not sign the agreement to follow the continous assesment proccess, he/she will be evaluated through the final examination, with the same structure as commented before. The student have to show he/she has got the same skills as the students who have followed the continuous assessment proccess. The final grade will be obtained by averaging the grades of each part (written examination+ practical questions and reports) provided at least of 4 over 10 points have been obtained en each part. The final grade should be greater than 5 over 10 points.

EXTRAORDINARY CALL:

The same criteria as the established in case of non continuous assessment will be followed for the extraordinary call.

Sources of information

Basic Bibliography

Higini Arau, **ABC de la acústica arquitectónica**,

Heinrich Kuttruff, **Room Acoustics**, 5,

Manuel A. Sobreira, **Acústica Arquitectónica (Apuntes de la Asignatura)**,

Complementary Bibliography

Phillip R. Newell, **Recording Studio Design**, 3,

Lothar Cremer, **Principles and applications of room acoustics**,

Recommendations

Subjects that it is recommended to have taken before

Fundamentals of Sound and Image/V05G301V01209

Fundamentals of Acoustics Engineering/V05G301V01327

IDENTIFYING DATA				
Interactive Audio Systems				
Subject	Interactive Audio Systems			
Code	V05G301V01331			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Pena Giménez, Antonio			
Lecturers	Pena Giménez, Antonio			
E-mail	apena@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Interactive systems are discussed, from human perception to user experience and user interfaces, considering audiovisual quality. Interactive sound mixing is revised in comparison to traditional linear sound mixing. A project using a game engine is developed. English Friendly subject, International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B12	CG12 The development of discussion ability about technical subjects
C34	CE34/SI1The ability to construct, exploit and manage telecommunication services and applications, such as receiving, digital and analogical treatment, codification, transporting and representation, processing, storage, reproduction, management and presentation of audiovisual and multimedia information services.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject	
Expected results from this subject	Training and Learning Results

Results of learning (SI1.2): -> Describe sound and image human perception using Physiology and Psychology of Perception. Understand the concept 'quality' in a given audio/image application -> Understand which aspects influence audiovisual quality. -> Understand the basics of spatial audition and vision. -> Know and understand the operation of dynamic range processors and its application in a chain of audio systems. -> Apply equalization techniques and other processes. -> Schedule and carry out a mixture of sounds from the technical point of view, either a linear mix or an event-driven mix in interactive environments. -> Know and understand which properties an user interface must hold, specially related to sound and image. -> Design and develop a virtual environment using a game engine.	B3 B5 B6 B12	C34	D3
Results of learning Organize a working group to carry out a project, including the following: -> technical ability to collect information, interpret technical specifications, discuss several options and select a combination of audio systems. -> Write progress reports, minutes of meetings and a final technical report . -> Technical meetings, discussion of partial results and oral presentation of the final work in front of a demanding audience. -> Adaptation to new environments , internal management roles in the group and dispute resolution. -> Internalize the importance of the human relationship with the client , preserving a fluent contact.	B9 B12	C34	D3 D4

Contents

Topic	
Virtual environment in a graphic engine.	Graphic engine management. C# programming.
Dynamic range and processes.	Dynamic range. Compressors and expansors. Filtering. Effects.
Mixture of sounds.	Lineal mixture of sounds. Event-controlled sound mixture for interactive systems.
Audiovisual quality.	Quality of sound and image systems. Audiovisual quality
Perception.	Sound and image human perception systems. Hearing and vision in three-dimensional environments.
User interface and User eXperience (UX).	User interface (UI). User eXperience (UX).

Planning

	Class hours	Hours outside the classroom	Total hours
Practices through ICT	14	10.5	24.5
Studies excursion	0	7	7
Project based learning	7	52.5	59.5
Flipped Learning	0	10	10
Lecturing	19	24	43
Problem and/or exercise solving	2	0	2
Objective questions exam	0	4	4

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description

Practices through ICT	Handle and adjustment of tools of analysis and algorithms, identifying which is appropriate for a given situation. Through this methodology, competencies CT3, CG3 and CE34 are developed.
Studies excursion	Visits to places where the concepts discussed are applied (radio studio, recording studio, etc.). Due to availability and funding. Through this methodology, competency CE34 is developed.
Project based learning	Collaborative work in reduced groups. A complex design with a regular monitoring agenda. Role assignments, working in common, planning, technical reports and oral presentation. Through this methodology, competencies CT3, CT4, CG3, CG12, CG5, CG6, CG9, CE34 are developed.
Flipped Learning	Written and/or audiovisual material is provided to study and prepare an online test. This activity is prior to the master class or practice in computer rooms where doubts will be resolved and challenges will arise. Through this methodology, competencies CG3 and CE34 are developed.
Lecturing	Oral speech, promoting the critical discussion of the concepts. Theoretical bases of algorithms and procedures used to solve problems are presented. Through this methodology, competencies CT3, CG3, CG12, CE34 are developed.

Personalized assistance

Methodologies	Description
Lecturing	Tutoring to solve issues related to master sessions or lab practice is implemented: -> Individually or -> in reduced groups (no more than 2-3 students). E-mail confirmation to match the date of the appointment is needed.
Practices through ICT	Tutoring to solve issues related to master sessions or lab practice is implemented: -> Individually or -> in reduced groups (no more than 2-3 students). E-mail confirmation to match the date of the appointment is needed.
Project based learning	During group projects an individualized tracking of the student is developed. Cross-avaliation within the group and autoavaliation may be used.

Assessment

	Description	Qualification	Training and Learning Results		
Practices through ICT	Work assessment in the computer room.	10	B3	C34	D3
Project based learning	Assessment of different tasks in a collaborative work, developed along the semester, including a written report and oral presentation.	45	B3 B5 B6 B9 B12	C34	D3 D4
Problem and/or exercise solving	Written test with short questions and problems to solve.	35	B3 B12	C34	
Objective questions exam	Automatic corrected online test.	10	B3	C34	

Other comments on the Evaluation

Following the guidelines of the studies, two evaluation systems will be offered to the students inscribed on this subject: continuous assessment (the preferred method, academic activities are linked to this system) and global assessment (not recommended).

*** "Students who choose continuous assessment" conditions:**
A student follows the continuous assessment system if she/he assigns a document that will be delivered and collected after week 4.
If a student has participated in continuous assessment and does not pass the course he/she will receive a grade of fail.

<u>BONUS SYSTEM (used or not depending on the number of students)</u>
* Group: a weekly score of the groups is publicly published. * Individual: a monthly score of the students is privately published.

Up to a maximum of 1.5 points may be added to the final group mark.In no case, this bonus is negative.Details will be given at the beginning of the course.

<u>CONDITIONS TO PASS THE SUBJECT</u>

Once bonus points are added, in order to ensure that students acquire a balanced minimum on the subject competences, they will pass the course if they meet these three conditions:
1) get a final mark equal to or greater than 5 (on a ten-points scale)
2) a score equal to or greater than 4 (on the same scale) in the written exam mark,
3) and a score equal to or greater than 5 (on the same scale), in the collaborative group mark.

If some of these conditions are not fulfilled, then the final grade (on a ten-points scale) will be the minimum between the final mark and the value 4,9.
Time planning of intermediate evaluation exams will be approved by the Comisión Académica de Grado (CAG) and will be available at the beginning of the semester.
*** "Students who choose for global assessment" conditions:**
The possibility of a final examination will be provided to students who do not opt for the continuous assessment.
In order to ensure that students acquire a balanced minimum on the subject competences, they will pass the course if they meet both these two conditions:
1) get a final mark equal to or greater than 5 (on a ten-points scale)
2) and a score equal to or greater than 4 (on the same scale) in each of the sections of the exam. These sections, respectively, correspond with:
* contents included in all activities* project developed in group, including group internals, management, writing of technical reports and oral presentations.
If some of these conditions are not fulfilled, then the final grade (on a ten-points scale) will be the minimum between the final mark and the value 4,9.

--- EXTRAORDINARY EXAM

Two different situations:
=> Students that are evaluated using continuous assessment:
Two options to choose (just before the exam begins):
* repeat the written exam included in the continuous assessment planning an be evaluated under the "Students who choose continuous assessment" conditions, described above.
* be evaluated with the same final exam of students who choose for global assessment, under the "Students who choose for global assessment" evaluation conditions, described above. No other activities are considered.
=> Students who choose for global assessment:
A final examination will be provided to students who do not opt for the continuous assessment, and are evaluated under the "Students who choose for exam-only assessment" conditions, described above. No other activities are considered.

In case of detection of plagiarism in any of the exams or assignments, the final grade will be SUSPENSE (0) and the fact willbe communicated to the management of the Center for the corresponding effects.

Sources of information
Basic Bibliography
Bruce and Jenny Bartlett, **Practical recording techniques**, Ed. 7, Focal press, 2016
George Mather, **Foundations of Sensation and Perception**, Ed. 3, Psychology Press, 2016
Complementary Bibliography
Unity Technologies, **Unity web: API description, tutorials and more. (https://unity3d.com),**,
fmod studio, **fmod web: API description, tutorials and more. (https://www.fmod.com/)**,
Francis Rumsey and Tim McCormick, **Sound and recording**, Ed. 7, Focal press, 2014
Durant R. Begault, **3-D sound for virtual reality and multimedia (https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20010044352.pdf)**, NASA, 1994
Steven M. LaValle, **Virtual Reality (http://vr.cs.uiuc.edu/vrbooka4.pdf)**, Ed. 1, University of Illinois, 2017

Recommendations
Subjects that continue the syllabus
Video games and virtual reality/V05G301V01417

Subjects that are recommended to be taken simultaneously
Design of audiovisual installations/V05G301V01334

Subjects that it is recommended to have taken before
Programming II/V05G301V01110
Fundamentals of Sound and Image/V05G301V01209

Other comments
The use of generative artificial intelligence (GAI) is allowed while carrying out the academic activities of this subject. Its use must be ethical, critical and responsible. When using GAI, any result should be critically evaluated, and any citations or references generated should be carefully verified. Likewise, it is recommended to declare the use of the tools used.

IDENTIFYING DATA				
Imaging Systems				
Subject	Imaging Systems			
Code	V05G301V01332			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Martín Herrero, Julio			
Lecturers	Martín Herrero, Julio			
E-mail	julio@uvigo.es			
Web	http://moovi.uvigo.es			
General description	The study of several families of systems of generation of images, including artificial vision, remote sensing and medical image. English Friendly subject: International students may request from the teacher: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B7	CG7: The ability to analyze and assess the social and environmental impact of technical solutions.
B10	CG10 The ability for critical reading of scientific papers and docs.
C34	CE34/SI1The ability to construct, exploit and manage telecommunication services and applications, such as receiving, digital and analogical treatment, codification, transporting and representation, processing, storage, reproduction, management and presentation of audiovisual and multimedia information services.
C66	(CE66/OP9) The ability for selection of circuits, subsystems and systems of remote sensing.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
Know most common imaging (capture) systems for medical diagnosis, essay and remote sensing.	B3 B10	C34 C66
Understand the principles of operation of such systems.	B3 B10	C34 C66
Knowledge about the most common applications of such systems.	B3 B10	C34 C66
Knowledge about the capabilities and limitations of such systems.	B3 B10	C34 C66
To understand the role of the engineer as a generator of technology on the basis of scientific advances	B3 B4 B7	

Contents	
Topic	
Computer vision systems	Illumination systems (LED, laser, fluorescent), monochrome cameras, Bayer and 3 CCD color cameras, matrix and line cameras, framegrabbers, multicamera systems (mono/stereo)
Medical image and non destructive testing (NDT) systems	Generation and processing of echography, X-ray, computerized axial tomography, nuclear magnetic resonance, and positron emission scanner.
Satellital, airborne and proxy remote sensing	Acquisition, processing and applications of panchromatic images, monoband, multispectral, and hyperspectral, active and passive in UV / VIS / SWIR / NIR / FIR / Thermal / GHz, Radar and Lidar.

Planning			
	Class hours	Hours outside the classroom	Total hours
Practices through ICT	17.6	35.2	52.8

Mentored work	0	35.2	35.2
Lecturing	21	21	42
Essay questions exam	2	8	10
Systematic observation	0.01	0	0.01
Presentation	2	8	10
Essay	0.01	0.01	0.02

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Practices through ICT	Handling and tuning analytic tools and algorithms, identifying which ones to use in different scenarios. We will work mainly in C/C++. Competencies: CG3, CG10, CE34, CE66.
Mentored work	Personal work on the fundamentals, functioning and state of the art of a given imaging system. All competences are addressed.
Lecturing	Master talks by the teacher on central topics, promoting critical discussion of concepts. All learning aims are addressed.

Personalized assistance

Methodologies	Description
Practices through ICT	Doubts can be solved in the teacher's office hours, individually or in small groups. Except otherwise noted, upon previous appointment with the teacher via email, preferably in the schedules and location officially reserved.

Assessment

	Description	Qualification	Training and Learning Results	
Essay questions exam	All teaching aims specified in the corresponding section of this guide are evaluated.	100	B3 B10	C34 C66
Systematic observation	Personalized follow-up of the work of the student in the laboratory, with feedback. All competences are evaluated.	50	B3 B10	C34 C66
Presentation	Presentation to the classroom of the personal work, and attitude and participation in the presentations of their classmates.	25	B3 B10	C34 C66
Essay	Content and quality of the personal work.	25	B3 B10	C34 C66

Other comments on the Evaluation

The assistance to class under continuous evaluation is compulsory, unless exceptional circumstances concur. Continuous evaluation is used for assessment, based on the work of the student. There is a final exam in the official date marked by the Board of School in May, for those students that have not passed the continuous evaluation. This final exam will be marked between 0 and 10 points. It covers all the subjects seen during the semester. To approve, the student has to obtain, at least, five points. Students wishing to improve their continuous evaluation marks can also attend the final exam: in this case the mark of this exam will be the final mark. The students that have passed the continuous evaluation and are satisfied with their mark do not need to attend the final exam. Along the semester the students will receive feedback on their progress, and the final mark of continuous evaluation will be communicated to the students well before the final exam. The delivery of the personal work the last week of class will imply the official participation in continuous evaluation. The extraordinary evaluation of July will be an extraordinary final exam, for those students that have not passed neither the continuous evaluation neither the final exam in May. The final mark will be the mark of the extraordinary final exam in both cases. This extraordinary final exam will be marked between 0 and 10 points, and covers all the subjects. To approve, the student has to obtain, at least, five points. Note that there are two final exams, but both correspond to a single and the same call ("convocatoria").

Sources of information

Basic Bibliography

Erik Reinhard et al., **Color Imaging: Fundamentals and Applications**, 1ª, A K Peters, 2008

John Robert Schott, **Remote Sensing: The Image Chain Approach**, 1ª, Oxford University Press, 2007

Michael Vollmer and Klaus-Peter Möllmann, **Infrared Thermal Imaging: Fundamentals, Research and Applications**, 1ª, Wiley-VCH, 2010

Arnulf Oppelt, **Imaging Systems for Medical Diagnostics**, 2ª, Wiley-VCH, 2005

Complementary Bibliography

Oleg S. Pianykh, **Digital Imaging and Communications in Medicine (DICOM)**, 2ª, Springer, 2012

Recommendations

Subjects that are recommended to be taken simultaneously

Fundamentals of Image Processing/V05G301V01333

Other comments

Simultaneously taking the subject Fundamentals of Image Processing is highly recommended.

Abundant digital bibliographic material will be provided to the students through the subject's web, covering all the subject matter in the program.

IDENTIFYING DATA				
Fundamentals of Image Processing				
Subject	Fundamentals of Image Processing			
Code	V05G301V01333			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Martín Herrero, Julio			
Lecturers	Martín Herrero, Julio			
E-mail	julio@uvigo.es			
Web	http://moovi.uvigo.es			
General description	Introduces to the student the basics of digital image processing. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B10	CG10 The ability for critical reading of scientific papers and docs.
C34	CE34/SI1The ability to construct, exploit and manage telecommunication services and applications, such as receiving, digital and analogical treatment, codification, transporting and representation, processing, storage, reproduction, management and presentation of audiovisual and multimedia information services.
C38	CE38/SI5 The ability to create, modify, manage, broadcast and distribute multimedia contents taking into account the use and accessibility criteria to audiovisual, broadcasting and interactive services.
D2	CT2 Understanding Engineering within a framework of sustainable development.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Understand the nature and organisation of digital images	B3 B10	C34 C38	
Learn to process digital images	B3 B4 B10	C34 C38	D2
Learn how to program a computer to process a digital image	B3 B4 B10	C34 C38	D2
Understand how the fundamental technics of image processing work	B3 B10	C34 C38	
Apply fundamental processing technics to solve specific problems with images or groups of images	B3 B4	C34 C38	

Contents	
Topic	
GUI programming	.
Basic preprocessing.	.
Image restoration.	.
Global and local operators.	.
Linear and nonlinear filters.	.
Segmentation	.
Mathematical morphology.	.

Planning

	Class hours	Hours outside the classroom	Total hours
Practices through ICT	19.6	78.4	98
Lecturing	21	21	42
Systematic observation	0.01	0	0.01
Laboratory practice	2	8	10

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Practices through ICT	Handling and tuning analytic tools and algorithms, identifying which ones to use in different scenarios. All learning aims are addressed.
Lecturing	Master talks by the teacher on central topics, promoting critical discussion of concepts. All learning aims are addressed.

Personalized assistance

Methodologies	Description
Practices through ICT	Implementation of image processing methods within an image processing and visualization framework with graphic user interface, programming in C and C++. Doubts are solved in the classroom and in private sessions.

Assessment

	Description	Qualification	Training and Learning Results		
Practices through ICT	Personalised monitoring of the student's work, with feedback. All teaching aims specified in the corresponding section of this guide are evaluated.	100	B3 B4 B10	C34 C38	D2
Systematic observation	Personalised monitoring of the student's work, with feedback. All teaching aims specified in the corresponding section of this guide are evaluated.	100	B3 B4 B10	C34 C38	D2
Laboratory practice	Final exam.	100	B3 B4 B10	C34 C38	D2

Other comments on the Evaluation

The assistance to class under continuous evaluation is compulsory, unless exceptional circumstances concur. Continuous evaluation is used for assessment, based on the work of the student. There is a final exam in the official date marked by the Board of School in May, for those students that have not passed the continuous evaluation. This final exam will be marked between 0 and 10 points. It covers all the subjects seen during the semester. To approve, the student has to obtain, at least, five points. Students wishing to improve their continuous evaluation marks can also attend the final exam: in this case the mark of this exam will be the final mark. The students that have passed the continuous evaluation and are satisfied with their mark do not need to attend the final exam. Along the semester the students will receive feedback on their progress, and the final mark of continuous evaluation will be communicated to the students well before the final exam. The delivery of the personal work the last week of class will imply the official participation in continuous evaluation.

The extraordinary evaluation of July will be an extraordinary final exam, for those students that have not passed neither the continuous evaluation neither the final exam in May. The final mark will be the mark of the extraordinary final exam in both cases. This extraordinary final exam will be marked between 0 and 10 points, and covers all the subjects. To approve, the student has to obtain, at least, five points.

Note that there are two final exams, but both correspond to a single and the same call ("convocatoria").

Sources of information

Basic Bibliography

Rafael C. Gonzalez, Richard E. Woods, **Digital Image Processing**, 3ª, Prentice Hall,

Complementary Bibliography

Robert Laganière, **OpenCV Computer Vision Application Programming Cookbook**, Packt Publishing, 2014

Jasmin Blanchette, Mark Summerfield, **C++ GUI Programming with Qt 4**, Prentice Hall, 2008

Recommendations

Subjects that are recommended to be taken simultaneously

Imaging Systems/V05G301V01332

Subjects that it is recommended to have taken before

Programming I/V05G301V01105
Programming II/V05G301V01110

Other comments

Simultaneously taking the subject Imaging Systems is emphatically recommended. You also should have passed the subject Programming, or have some notions of, at least, C programming.

IDENTIFYING DATA				
Design of audiovisual installations				
Subject	Design of audiovisual installations			
Code	V05G301V01334			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Torres Guijarro, María Soledad			
Lecturers	Martín Rodríguez, Fernando Torres Guijarro, María Soledad			
E-mail	soledadtorres@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	In this subject the student will learn to design audiovisual systems,with respect to sound take and sound reinforcement, image take and visual coating, synchronisation, wiring, connections and supply. Indoor and outdoor applications of audiovisual networks, as well as distinct multimedia platforms, will be analysed. English Friendly curse: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B1	CG1: The ability to write, develop and sign projects in the field of Telecommunication Engineering, according to the knowledge acquired as considered in section 5 of this Law, the conception and development or operation of networks, services and applications of Telecommunication and Electronics.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B12	CG12 The development of discussion ability about technical subjects
C35	CE35/SI2 The ability to analyze, specify, carry out and maintain systems, equipments, heads and installations of TV, audio and video for mobile and fixed environments.
C36	CE36/SI3 The capacity to implement projects at places and installations for the production and recording of audio and video signals.
C37	CE37/SI4 The ability to carry out acoustic engineering projects related to: acoustical isolation and conditioning of rooms, loudspeaker installations, specification, analysis and selection of electro acoustical transducers, measurement, analysis and control of radio vibration systems, environmental acoustics, submarine and acoustical systems.
C38	CE38/SI5 The ability to create, modify, manage, broadcast and distribute multimedia contents taking into account the use and accessibility criteria to audiovisual, broadcasting and interactive services.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
Knowing the different types of existing amplifiers from a systemic and usage point of view, knowing how to interpret the technical specifications in order to be able to evaluate them	B6	C35
Selecting a sound pick-up configuration to be applied in different situations		C35 C36 C37
Explain interconnection elements and protocols to prepare the transport and synchronisation of audio signals	B6	C35
Analyse lens systems		C35 C36
Choose the most appropriate image capture and presentation systems		C35 C36
Design an image capture and visual overlay system given an enclosure, comparing different subsystems and elements	B1 B6	C35 C36
Design a system of sound take and sound reinforcement given a certain enclosure, comparing different subsystems and elements.	B1 B6	C36 C37

Create atmospheres addressing acoustic and visual appearances		C35 C36	
Design the wiring and connections of an audiovisual network for his control and supply	B1 B6	C35 C36 C37 C38	
Analyse different indoor and outdoor applications of Audiovisual Networks.		C35 C36 C38	
Organize a working group to carry out a project, including the following: * technical ability to collect information, interpret technical specifications of equipment, discuss different options and select a combination of certain equipment. * use of theoretical calculations and simulation software tools to support the design of sound systems and visual coating. * conduction of meetings, discussion of partial results and oral presentation of a definitive work in front of a demanding audience. * writing of progress reports, minutes of meetings and a final technical report. * adaptation to new environments, management of internal roles in the group and conflict resolution.	B6 B9 B12		D4

Contents	
Topic	
Sound reinforcement (electro-acoustic aspects)	Technical specifications in audio. Take. Amplification. Dimensioning and distribution. Sound field calculation exercises and computer simulation of the sound field
Visual overlay	Cameras, image sensors and lenses (exercises). Capture parameters, exposure, focus, depth of field. Field of view calculation Indoor and outdoor imaging technologies. Working with 3D modelling and scenario recreation applications.
Control systems, wiring and power supply	Design of cabling and wiring of an audio-visual network and its power supply. Synchronisation of audio and video signals in an audiovisual network. Control systems. Power supply.
Audiovisual networks	Indoor and outdoor applications.

Planning			
	Class hours	Hours outside the classroom	Total hours
Practices through ICT	12	0	12
Project based learning	7	57	64
Lecturing	21	42	63
Problem and/or exercise solving	1	0	1
Report of practices, practicum and external practices	0	9	9
Objective questions exam	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Practices through ICT	Use and adjustment of analysis tools and algorithms, identifying which one should be used in each situation. Software to be used: EASE Focus 3, Blender With this methodology they work the CE36 and CE37 competences, individually or in couples.
Project based learning	Collaborative work in reduced groups on a complex design that applies several topics covered in the subject. The work is periodically followed-up and it fosters working in group, role sharing, information sharing, planning and public defending of results. With this methodology they work the CG1, CG6, CG9, CG12, CE35, CE36, CE37, CE38 and CT4 competences.
Lecturing	Presentation by the teacher of the contents of the subject, fostering the critical discussion of the concepts. The theoretical grounds of algorithms and procedures used to resolve problems are given. With this methodology they work the CG1, CG6, CG12, CE35, CE36, CE37, and CE38 competences.

Personalized assistance

Methodologies	Description

Lecturing	Doubts can be solved in the rests of the classes and in the teacher tutorial sesions. These tutorial sessions will be done individually or in short groups (with a maximum of 2-3 students). The tutorial sessions are typically agreed with the professor. The meetng requests can be done personally or by email.
Practices through ICT	In the classes of practices is a good moment to consult doubts with the professor. The professor moves between the tables and some students take advantage of the proximity of the professor to consult doubts of the own class or punctual doubts of other classes.
Project based learning	The projects have its own classes of C group in which the students of each team consult their doubts about the project and the professor is with them helping to define the project and giving them support for the development of their particular project. They are classes with a very pleasant interaction.

Assessment

	Description	Qualification	Training and Learning Results
Project based learning	Assessment of a project, developed through the four-month period, including the preparation and public presentation of a report. The corresponding individual mark to the works done in group is obtained as a ponderated sum of: 1) the common mark of the group (60%); 2) the individual mark (40%), obtained from one or various of the following methods of evaluation: cross-evaluation by the other members of the group, oral questions during the presentations of the works, written questions about the content of the work.	40	B1 B6 B9 B12 C35 C36 C37 C38 D4
Problem and/or exercise solving	Written evaluation tests, with brief questions and problems.	40	B1 B6 B12 C35 C36 C37 C38
Report of practices, practicum and external practices	Assessment of a written inform that describes the work of several weeks in the computer classroom.	10	C36 C37
Objective questions exam	Tests	10	B1 B6 B12 C35 C36 C37 C38

Other comments on the Evaluation

Following the guidelines of the degree, two systems of evaluation are offered: continuous assessment (recommended) and global assessment. Global assessment will be only allowed in situations in which it is imposible to follow the recommended system.

In case of detection of plagiarism in any of the tests (short tests, reports of the laboratory practices, reports of the directed works or final exam), the final grade will be of FAIL (0) and the fact will be communicated to the Centre Management for the opportune effects.

ORDINARY EXAM

A) CONTINUOUS ASSESSMENT:

The continuous assessment will be based on the evaluation of practical task, projects and a test. Once a student has signed a document of agreement with the process of continuous assessment, and if not communicated otherwise within one month, it will be understood that the student has submitted to the call, and the final degree will be obtained by the application of the criteria described bellow, regardless of whether or not the final exam is taken.

The subject is assessed in a 0 to 10 points scale and is considered "passed" if each activity is graded equal or greater than 4, and the final grade obtained is equal or greater than 5. The final grade with be obtained from the weighted sum of the grade obtained in the following tasks with the given weights. If in anyof the activities the grade does not reach 4 but the average exceeds 5, thefinal grade will be 4.9.

Types and weights of the activities:

1. Tutored works: 40 % of the final grade. Two reports will be delivered: the first during Halfway through the term and the second at the end. The individualized part of the assessment will be done through cross-evaluation, oral questions during presentations, and written exam questions.
2. Reports of practical tasks (Weight: 10 %).

3. Written evaluation tests: there will be two tests, each with a weighting of 20% of the final mark, one in the middle and one at the end of the term. Several short tests will also be undertaken, with a global weighting of 10%.

A grade of 4 points will be required for an activity to be considered passed. Failed activities can be made up on tje date of the final exam.

B) GLOBAL ASSESSMENT

A final examination is available for those students that for some reason could not follow the continuous evaluation assessment process. In this case the final examination will consist in a written test, and some additional questions related with the practical tasks and projects. The subject is assessed in a 0 to 10 points scale and it is considered "passed" if the final grade obtained is equal or greater than 5.

EXTRAORDINARY EXAM:

There is a scheduled date for a second call examination, for those students that either dropped out during the semester or failed. Prior the examination, a student can choose to follow the continuous assessment or the exam-only assessment. In the former selection, the grades obtained in the projects and practical tasks will be taken into account and the student will only answer to the written test. If the later, (exam-only assessment), the student will also have to answer a full examination as described before.

END-OF-PROGRAM EXAM:

The exam will consist of a written test. This final exam will be rated between 0 and 10 points. It includes all the topics of the course. To pass, at least five points are needed. No other activity is valued.

USE IF GENERATIVE ARTIFICIAL INTELLIGENCE

The use of generative artificial intelligence (GAI) is permitted in the academic activities of this subject. Its use must be carried out in an ethical, critical and responsible manner. In the case of using GAI, any output it provides must be critically evaluated, and any citations or references generated must be carefully checked. It is also necessary to declare the use of the used tools.

Sources of information
Basic Bibliography
John Eargle, **JBL Sound system design reference manual**, 3, JBL, 1999
Complementary Bibliography
John Eargle, Chris Foreman, **Audio Engineering for Sound Reinforcement**, Hal Leonard, 2002
Gary Davis and Ralph Jones, **Sound Reinforcement Handbook**, Hal Leonard, 1989
Philip Giddings, **Audio Systems Design and Installation**, Focal Press, 1990
Hilary Wyatt y Tim Amyes, **Postproducción de Audio para TV y Cine**, Escuela de Cine y Video de Andoain, 2005
Rüdiger Ganslandt, Harald Hofmann, **Handbook of Lighting Design**,
José Luis Sánchez Bote, **Sistemas de refuerzo sonoro**, Universidad Politécnica de Madrid, 2013
José María Mellado, **Fotografía de alta calidad: las técnicas y métodos definitivos.**, CS6. Anaya multimedia, 2013
Ben Simonds, **Blender master class : a hands-on guide to modeling, sculpting, materials, and rendering**, No Starch Press, 2013

Recommendations

Subjects that are recommended to be taken simultaneously

Room Acoustics/V05G301V01330
Imaging Systems/V05G301V01332

Subjects that it is recommended to have taken before

Fundamentals of Sound and Image/V05G301V01209
Fundamentals of Acoustics Engineering/V05G301V01327
Interactive Audio Systems/V05G301V01331
Video and Television/V05G301V01329

IDENTIFYING DATA				
Multimedia services				
Subject	Multimedia services			
Code	V05G301V01401			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Blanco Fernández, Yolanda			
Lecturers	Blanco Fernández, Yolanda Rodríguez Estévez, Judith Soledad			
E-mail	yolanda@det.uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The aim of this subject is to provide the students with the theoretical foundations and the practical skills that allow them to understand the basic principles of the digital treatment of the multimedia information. To this aim, the main standards in the field of the audiovisual content processing are presented, as well as the mechanisms available for the transmission of data through different types of networks and the different types of services that can be offered to the end user, with special attention to digital terrestrial TV broadcasting (DTTV) and transmission over IP networks (IPTV). The practical part of the subject will allow the students to experiment with the design and development of telematic services based on the transmission of multimedia streams, along with the programming of interactive services about digital television broadcasting and video-on-demand. The documentation of the subject will be available in English. English Friendly subject. International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
C84	(CE84/OP27) The ability to apply the techniques based on computer, networks and distributed applications and services, in the broadcasting and interchange of audiovisual information.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Understand the basic foundations of the digital treatment of the multimedia information.	B6		
Know the main standards in the field of the processing of the multimedia information.	B3	C84	
Understand the foundations and the main mediums adopted in digital TV broadcasting.	B6	C84	
Know the basic foundations of the transmission of audiovisual information through telematic networks.	B6	C84	D3
Acquire skills in the design and development of telematic services based on exchanging audiovisual contents.	B6	C84	D3
Acquire skills for the programming of telematic services in the scope of interactive digital television.		C84	

Contents	
Topic	
1. Multimedia systems: Foundations and basic concepts	a. Digitalization of audio and video signals. b. Format for storage of audio and video signals. c. Conditional access and digital rights management.

2. Terrestrial Digital TV broadcasting	a. Architecture b. Transport of bitstreams c. Signaling d. Middlewares e. Mobile Digital Television
3. IP Television and video-on-demand	a. Architecture b. Data distribution. VoD and nVoD. c. Broadcasting, multicasting and P2P d. Systems and protocols e. Signaling
Practical contents.	The first of the B practices will address the contents of theory topic 1. The second B practice will focus on the contents explained in theory topic 2. The project developed in C hours will revolve around concepts from topic 3.

Planning			
	Class hours	Hours outside the classroom	Total hours
Project based learning	5	31	36
Practices through ICT	5	18	23
Practices through ICT	9	20	29
Presentation	2	4	6
Lecturing	20	35	55
Objective questions exam	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Project based learning	The students, organized in groups of 2-3 people (as per professor's criteria), will implement the project planned for group classes. The goal is to boost a collective discussion to identify the key points when it comes to developing the functionalities of each project. These methodologies will assess the skills B3, B6 and D3.
Practices through ICT	The professor will propose practices in which the students will deal with the main concepts explained in the subject, putting the focus on the coding formats adopted in the transmission of multimedia information. The doubts arisen during the autonomous work of the students will allow to promote the debate of the group to agree the best solution for each problem. These methodologies will assess the skills C84 and B3.
Practices through ICT	The professor will propose practices in which the students will deal with the main concepts explained in the subject, putting the focus on possible applications in the realm of Terrestrial Digital TV and transmission of television over IP. The doubts arisen during the autonomous work of the students will allow to promote the debate of the group to agree the best solution for each problem. These methodologies will assess the skills C84, B3 and B6.
Presentation	The students, organized into groups of 2-3 people (as per professor's criteria), will expose to their mates the main design decision and implementation details of the Project planned for group classes, besides showing how it works. The aim is to argue the advantages and problems of each model, promoting the debate around the proposal of each group. These methodologies will assess the skills B3, B6 and D3.
Lecturing	Classes where the main theoretical concepts of the subject will be explained, by proposing examples and possible application scenarios in the context of the transmission of multimedia streams. These methodologies will assess the skills B3 and B6.

Personalized assistance

Methodologies	**Description**
Lecturing	The professor will address the doubts raised by each student during the public presentation of the contents that will be explained in master sessions. Students will be able to consult and request tutorials through the Moovi platform (https://moovi.uvigo.gal/).

Project based learning	In the computer room, the professor will carry out a personalized follow-up of the member of each group, with the goal of fixing possible deficiencies and guiding right decisions when facing design and implementation of the project. Students will be able to consult and request tutorials through the Moovi platform (https://moovi.uvigo.gal/).
Practices through ICT	The personalized attention will be based on following-up the work of each student, by tracking the solutions proposed for each problem proposed in the practices in the computer room. Students will be able to consult and request tutorials through the Moovi platform (https://moovi.uvigo.gal/).
Practices through ICT	The personalized attention will be based on following-up the work of each student, by tracking the solutions proposed for each problem proposed in the practices in the computer room. Students will be able to consult and request tutorials through the Moovi platform (https://moovi.uvigo.gal/).
Presentation	The personalized attention will be based on following-up the work of each group, by tracking the solutions proposed for the system developed during type C-teaching. Students will be able to consult and request tutorials through the Moovi platform (https://moovi.uvigo.gal/).

Assessment

	Description	Qualification	Training and Learning Results		
Project based learning	The students, organized in groups of 2-3 people (according to the criterion of the professor), will develop a project about Digital TV broadcast or video streaming over IP. This project must include the code and the necessary documentation to justify the main design decisions and implementation details. The mark of each member of the group will depend on the following criteria: (i) the quality of the documentation related to the part of the project this student has made, and (ii) the relevance and usefulness of the developed functionalities.	20	B3 B6		D3
Practices through ICT	The students, organized in groups of 2 people, will deliver a report in which they will describe the solution proposed for a first practice in B sessions, which will be about the main formats of coding adopted in the transmission of the multimedia information over telematic networks. In case to be necessary, the submission will include the software used in the development of the solution proposed.	15	B3	C84	
Practices through ICT	The students, organized in groups of 2 people, will deliver a report that describes properly the solution proposed for the second of the practical proposals in B sessions, which will be about Digital TV broadcast.	15	B3 B6	C84	
Presentation	The students, organised in groups of 2-3 people (according to the criterion of the professor), will describe the main decisions of design and details of implementation of the project proposed in C sessions. Each member of the group must identify which part of the project has developed, showing its real-time functioning during the presentation. The mark of each member will depend on the following criteria: (i) the particular level of knowledge about his/her contribution, (ii) its complexity, and (iii) his/her personal performance during the exhibition.	10	B3 B6		D3
Objective questions exam	Each student will take --individually and without material of support-- an exam including multiple-choice tests and short-answer questions, which is aimed at assessing his level of understanding on the theoretical concepts explained in the subject. The minimum required grade is 1.5 points out of 4.	40	B3 B6		

Other comments on the Evaluation

Lessons will be explained in Spanish, although the material about the subject will be available in English.

There exist two mechanisms for the assessment of students in this subject: continuous assessment (CA) and global assessment (GA). Regardless of the considered assessment mechanism, the pass mark for the subject is 5 out of 10.

The students must choose one of the possible mechanisms by bearing in mind the following conditions:

- CA includes the 5 tests described above.
- By the submission of the first B practice (end of October), the student makes a commitment to be assessed via CA, thus renouncing the GA mechanism. In virtue of this commitment, the final remark of these students cannot be "Not taken".
- Students who do not submit the first practice renounce to the CA, thus being assessed through the GA mechanism. Note that it will not be possible to join the CA in the next tests.

- The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester.
- CA tests will be carried out only in the dates defined by the professors. These CA tests cannot be repeated later.
- The grades obtained in the CA and other exams and practical projects are only valid for the current academic year.
- CA will be just considered in the ordinary exam. In the extraordinary exam and in the end-of-program exam only GA will be valid.
- Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Students who sit CA in the ordinary exam will be assessed as follows:

- CA tests will be 100% of the final remark of the student. This assessment mechanism consists of five CA tests that have been previously described (a multiple-choice test with a minimum required grade of 1.5 points out of 4., two practices during B sessions, delivery of code and documentation of the practical project proposed for group classes, and the presentation of its main design and implementation decisions, including a real-time demo of its functioning). Note that the student makes a commitment to follow-up CA by submitting the first practice of B sessions, thus renouncing the GA mechanism.

Students who sit GA in the ordinary exam will be assessed as follows:

- A final exam that these students will take in the official date published at http://www.teleco.uvigo.es. This test will include short-answer questions and/or multiple-choice tests, along with problems and practical use cases to be analyzed and resolved. The weight of this exam in the final remark is 50%. Note that support materials are not allowed. The minimum required grade is 3.75 points out of 5.
- Submission of a practical project that will include software and documentation to justify design decisions and describe implementation details. The weight of this project in the final remark is 50%. Note that that each student must submit this project individually.

Students who did not pass the subject in the ordinary exam will have an **extraordinary exam** where they cannot be assessed via CA, so that **only GA is valid**. Therefore, these students must (i) take the final exam (in the official date published at http://www.teleco.uvigo.es) and (ii) submit individually the practical project (in the date published by professors at Moovi platform), as described above for the GA mechanism. The weight of each part in the final remark will be 50%. The same assessment mechanism is valid for the **end-of-program exam**.
Students who achieved at least 5 points but did not meet the minimum requirement in the theory part of the subject will be assessed as failed with a score of 4.9. This applies to any call.
During the execution of the academic activities for this subject, the use of generative artificial intelligence (GAI) is permitted. Its use must be ethical, critical, and responsible. If using GAI, any result it provides must be critically evaluated, and any generated citation or reference must be carefully verified. Additionally, it is recommended to declare the use of the tools employed.

Sources of information
Basic Bibliography
Wes Simpson, **Video over IP IPTV, Internet video, H.264, P2P, Web TV, and streaming: a complete guide to understanding the technology**, Elsevier, 2008
Frantisek Korbel, **FFmpeg Basics: Multimedia handling with a fast audio and video encoder**, CreateSpace, 2012
Yolanda Blanco Fernández, Martín López Nores, **Construcción de sistemas y servicios VoIP con software de código abierto**, Andavira editora, 2012
Complementary Bibliography
Jan Lee Ozer, **Video Encoding by the Numbers: Eliminate the Guesswork from your Streaming Video**, Doceo Publishing, 2016
José J. Pazos Arias, Carlos Delgado Kloos, Martín López Nores, **Personalization of Interactive Multimedia Services: a research and development perspective**, Nova Science Publishers, 2008
George Lekakos, Konstantinos Chorianopoulos, Georgios Doukidis, **Interactive Digital Television: technologies and applications**, IGI Publishing, 2007

Liliana Ardissono, Alfred Kobsa, Mark Maybury, **Personalized Digital Television: targeting programs to individual viewers**, Kluwer Academic Publishers, 2004

Digital Video Broadcasting Consortium, **DVB Standards**,

Recommendations

Other comments

It is recommended to have taken or to be taking the following subjects of the Telematics-related module:

+ Operating systems
+ Architecture and Technology of Networks
+ Security
+ Concurrent and Distributed Programming
+ Networks and Switching Theory
+ Multimedia Networks
+ Systems of Information
+ Architectures and Telematic Services

IDENTIFYING DATA				
Wireless and mobile networks				
Subject	Wireless and mobile networks			
Code	V05G301V01402			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	López Bravo, Cristina			
Lecturers	López Bravo, Cristina			
E-mail	clbravo@det.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The subject "Wireless and Mobile Networks" (redes sen fíos e móbiles) examines the area of wireless and mobile networks, one of the technological basis of the present society, studying the existing challenges for the communications protocols, and looks at the opportunities that provides continuous connectivity even in movement. The focus of this subject will be on network protocols above physical layer (nevertheless, it will touch the most important physical layer properties). The documentation will be available in english. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C85	(CE85/OP28) The ability to analyze, plan and deploy wireless communication networks for different coverage ranges: metropolitan, local and short range.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Understand the main concepts of wireless communications.	B3	C85	D2 D3
Understand the main concepts of mobile communications.	B3	C85	D2 D3
Know the main protocols used in wireless communication networks.	B3	C85	D2 D3
Know the architectures used in wireless communication networks.	B3	C85	D2 D3
Ability to design mobile wireless networks.	B4 B9	C85	D2 D3 D4

Contents

Topic	
Introduction to wireless communications	Channel characteristics Multiple access Modulation
Principles of operation of wireless networks	Mobility management Introduction to ubiquitous computing Ad hoc networks, routing Security Network topologies
Wide area networks	Architecture Mobile networks Network topologies Case study
Local networks	Architecture: ad hoc and infrastructure based networks User authentication approaches Security Case study
Low range networks	Architecture Bandwidth/power consumption balance Personal communication Industrial communication

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	19	38	57
Laboratory practical	12	24	36
Mentored work	6	30	36
Problem and/or exercise solving	2	0	2
Report of practices, practicum and external practices	0	3	3
Systematic observation	2	0	2
Project	1	13	14

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Lecturing	Professors present the main theoretical contents related to wireless and mobile networks. Through this methodology the competencies B3 and C85 are developed.
Laboratory practical	Students will complete guided and supervised practices. Through this methodology the competencies B3, B4 and C85 are developed.
Mentored work	Team development of the design, implementation and validation of a protocol, system, application or service. Through this methodology the competencies B3, B4, B9, C85, D2, D3 and D4 are developed.

Personalized assistance

Methodologies	Description
Lecturing	The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. Questions will be answered during the master sessions or during tutorial sessions. Tutorial sessions could be agreed by appointment (https://moovi.uvigo.gal/user/profile.php?id=11583).
Mentored work	The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. Questions will be answered during the supervising sessions or during tutorial sessions. Tutorial sessions could be agreed by appointment (https://moovi.uvigo.gal/user/profile.php?id=11583).
Laboratory practical	The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. Questions will be answered during the lab sessions or during tutorial sessions. Tutorial sessions could also be agreed by appointment (https://moovi.uvigo.gal/user/profile.php?id=11583).

Assessment

	Description	Qualification	Training and Learning Results

Problem and/or exercise solving	Continuous assessment: Two individual tests will be given to evaluate the understanding of the contents presented in the lectures. One in the middle of the term and another one at the end. Global assessment: There will be an individual test to evaluate the comprehension of the contents presented in the lectures, in the School's examination period in ordinary exams.	30	B3 C85
Report of practices, practicum and external practices	Students will individually complete questionnaires and/or reports of practices where they will show the correct completion and understanding of the practices.	20	B3 C85 B4
Systematic observation	During the realization of the mentored work/project, there will be a continuous monitoring of the design and the evolution of the development. The monitoring will be group and individual: each member of the group must document the tasks developed within his team and answer for them.	10	B3 C85 D2 B4 D3 B9 D4
Project	Students will be divided into groups to design, develop and test a protocol, system, application or service using wireless and mobile network technologies. The result will be evaluated after delivery, assessing aspects such as correctness, quality, performance and functionality. The evaluation will take into account both the results of the group and the individual contributions of each of its members.	40	B3 C85 D2 B4 D3 B9 D4

Other comments on the Evaluation

Following the guidelines of the degree, each student will have two assessment opportunities (ordinary and extraordinary) to pass the subject. In turn, in the ordinary opportunity, they will have two evaluation procedures (continuous and global).

Ordinary exam

During the first month, students must declare if they opt for continuous or exam-only assessment. Students who select continuous assessment and submit the first task or lab report may not be listed as "Not Present".

Continuos assessment

The final grade (FG) of the course will be calculated as the weighted geometric mean of the grades obtained in the problem-solving tests (PT), in the practical reports (PR), during the systematic observation (SO) and for the completion of the project (P), according to the following formula:

FG = PR^0.3*PR^0.2*SO^0.1*P^0.4.

In order to pass the course, FG must be greater than or equal to 5. In addition, as a result of the application of the weighted geometric mean, it is not possible to have a zero in any of the parts in order to pass the course.

Global evaluation

Students that opt by the global assessment procedure, must submit an additional dossier with detailed information about the events and issues that arose during the execution of the different tasks, and especially the mentored work, since it will not be possible to assess systematic observation. In addition, during the first month of the course, professors will notify students if they have to do the mentored work individually or in group.

The final grade (FG) of the course will be calculated as the weighted geometric mean of the grades obtained in the problem-solving tests (PT), in the practical reports (PR), in the dossier of task performance (DT) and for the completion of the project (P), according to the following formula:

FG = PR^0.3*PR^0.2*DT^0.1*P^0.4.

In order to pass the course, FG must be greater than or equal to 5. In addition, as a result of the application of the weighted geometric mean, it is not possible to have a zero in any of the parts in order to pass the course.

Extraordinary exam

The assessment system will be the same as the global assessment of the ordinary exam.

Students that have opted by the continuous assessment procedure, can decide to maintain the grades of the parts they have already passed in the first call or discard them.

End-of-program exam

The assessment system will be the same as the global assessment of the ordinary exam.

Other comments

The grades obtained are only valid for the current academic year.

Although the tutored work will be completed (if possible) in groups, the performance of each student in his or her group will be monitored continuously. In the case in which the performance of a member of the group wouldn't be adequate compared with the performance of his or her team mates, he or she could be excluded from the group and/or qualified individually.

The use of any material during the tests will have to be explicitly authorized.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information
Basic Bibliography
Coty Beard, William Stallings, **Wireless communication networks and systems**, 1, Financial Times Prentice Hall, 2015
Ramón Agustí, et al., **LTE: Nuevas tendencias en comunicaciones móviles**, 1, Fundación Vodafone España, 2010
Viajy Garg, **Wireless Communications and Networking**, 1, Morgan Kaufmann-Elsevier, 2007
Pei Zheng, Larry L. Peterson, Bruce S. Davie, Adrian Farre, **Wireless Networking Complete**, 1, Morgan Kaufmann-Elsevier, 2010
Kaveh Pahlavan, Prashant Krishnamurthy, **Networking Fundamentals: Wide, Local and Personal Area Communications**, 1, Wiley and Sons, 2009
Kevin Townsend, Carles Cufí, Akiba, Robert Davidson, **Getting started with Bluetooth Low Energy**, 1, O'Reilly, 2014
Complementary Bibliography
James F. Kurose, Keith W. Ross, **Computer Networking: A Top-Down Approach**, 7, Pearson Education, 2017

Recommendations

IDENTIFYING DATA				
Intelligent systems programming				
Subject	Intelligent systems programming			
Code	V05G301V01403			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	English			
Department				
Coordinator	Burguillo Rial, Juan Carlos			
Lecturers	Burguillo Rial, Juan Carlos Costa Montenegro, Enrique			
E-mail	jrial@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Technologies related to artificial intelligence, machine learning and intelligent distributed systems (e.g. on the Internet of Things) have significantly impacted the labor market in the past decade. In this course we will address these concepts, starting with the notion of agent, to understand what it is, how to build it and how these agents can interact to model and solve complex problems giving rise to multi-agent systems. In the second part of the course, concepts of game theory and self-organized systems will be introduced. Finally, in the last part of the course, classic artificial intelligence techniques will be reviewed, the basic concepts of machine learning, deep learning; as well as the current platforms/libraries that facilitate its design and development. As part of the practices of the subject, students will learn to program intelligent systems, using classic artificial intelligence techniques and machine learning libraries. They will also carry out a common work, in a group, where they will extend what they have learned in class to topics of their personal interest and developed on Android mobile terminals. This course will be taught in English. However, students have the possibility to interact with teachers in Spanish or Galician if necessary. All the documentation needed for the course will be provided in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C86	(CE86/OP29) The ability to program computer applications and services based on artificial intelligence.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
To understand the basic concepts of intelligent systems: search, reasoning and learning.	B3 B4 B9		D2 D3 D4
To know the main concepts related with intelligent agents and multiagent systems.	B3	C86	D2 D3
To achieve a suitable level of expertise in the use of IDEs for programming intelligent systems.	B3	C86	D2
To acquire skills for programming complex adaptive systems.		C86	D2 D3 D4

To acquire skills for applying machine learning technologies.	C86	D2 D3 D4

Contents

Topic	
Introduction to Artificial Intelligence	a) Searching b) Reasoning c) Learning
Intelligent Agents and Multiagent Systems	a) Defining an intelligent agent b) Architectures for intelligent agents c) Distributed artificial intelligence and Multiagent systems d) Communication among agents e) Coordinationa and interaction protocols
Multiagent Systems and Game Theory	a) Cooperation vs. Competition b) Negotiation c) Auctions d) Electronic Commerce
Multiagent Systems and Self-organization	a) Defining a self-organized system b) The concept of emergent properties
Machine Learning in Intelligent Systems	a) Machine Learning techniques b) Reinforcement Learning c) Neural Networks d) Deep Learning e) Generative AI

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	2	0	2
Lecturing	16	32	48
Laboratory practical	14	42	56
Debate	2	0	2
Discussion Forum	0	2	2
Mentored work	7	28	35
Objective questions exam	1	4	5

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	We start doing a generic introduction to the aims, and the global contents of the subject together with the results expected at the end of the course. This activity will be performed individually. Through this methodology the competencies CG3, CG9, CT2, CT3 and CT4 are developed. This activity will be performed individually.
Lecturing	We describe the different topics of the subject providing the necessary educational material. Through this methodology the competencies CG3, CG4, CT2, CT3 and CT4 are developed. This activity will be performed individually.
Laboratory practical	Every student must perform practical tasks in the laboratory to understand better the contents explained along the master lessons. Through this methodology the competencies CG3, CG4, CG9, CE86, CT2 and CT3 are developed. This activity will be performed individually.
Debate	In the classes there will be open discussion, among groups of students, in order to focus on a topic of subject content, the analysis of a case, the outcome of a project, exercise or problem previously developed a keynote address. Through this methodology the competencies CG3, CG4, CG9, CE86, CT2, CT3 and CT4 are developed. This activity will be performed individually.
Discussion Forum	The students must perform some activities within the MOOVI platform in order to discuss topics related to the subject. Through this methodology the competencies CG3, CE86, CT2, CT3 and CT4 are developed. This activity will be performed individually.

Mentored work	The students must perform a project in group, with the support of the professor, to extend and personalize the topics seen along the theoretical and practical classes. At the same time, we will try that the students perform such project demos using Android terminals. Through this methodology the competencies CG3, CG4, CG9, CE86, CT2, CT3 and CT4 are developed.

Personalized assistance

Methodologies	Description
Lecturing	In the practical formative activities and tutoring, the professors of the subject will offer personal guidance to each student in the tasks to be performed, with the aim to orient the approach and the methodology. Also they will offer coordination information with other contents and subjects of the study program. It is recommended to consult the doubts with the teachers along the course in order to improve the understanding of the basic concepts, and for performing the tasks and activities to be evaluated. The students will be able to query and request tutoring through MOOVI platform (https://moovi.uvigo.gal).
Mentored work	In the practical formative activities and tutoring, the professors of the subject will offer personal guidance to each student in the tasks to be performed, with the aim to orient the approach and the methodology. Also they will offer coordination information with other contents and subjects of the study program. It is recommended to consult the doubts with the teachers along the course in order to improve the understanding of the basic concepts, and for performing the tasks and activities to be evaluated. The students will be able to query and request tutoring through MOOVI platform (https://moovi.uvigo.gal).
Laboratory practical	In the practical formative activities and tutoring, the professors of the subject will offer personal guidance to each student in the tasks to be performed, with the aim to orient the approach and the methodology. Also they will offer coordination information with other contents and subjects of the study program. It is recommended to consult the doubts with the teachers along the course in order to improve the understanding of the basic concepts, and for performing the tasks and activities to be evaluated. The students will be able to query and request tutoring through MOOVI platform (https://moovi.uvigo.gal).
Debate	In the practical formative activities and tutoring, the professors of the subject will offer personal guidance to each student in the tasks to be performed, with the aim to orient the approach and the methodology. Also they will offer coordination information with other contents and subjects of the study program. It is recommended to consult the doubts with the teachers along the course in order to improve the understanding of the basic concepts, and for performing the tasks and activities to be evaluated. The students will be able to query and request tutoring through MOOVI platform (https://moovi.uvigo.gal).
Discussion Forum	In the practical formative activities and tutoring, the professors of the subject will offer personal guidance to each student in the tasks to be performed, with the aim to orient the approach and the methodology. Also they will offer coordination information with other contents and subjects of the study program. It is recommended to consult the doubts with the teachers along the course in order to improve the understanding of the basic concepts, and for performing the tasks and activities to be evaluated. The students will be able to query and request tutoring through MOOVI platform (https://moovi.uvigo.gal).

Assessment

	Description	Qualification	Training and Learning Results		
Laboratory practical	The students will perform a practical task in the laboratory, where they will work with the concepts studied in the theoretical classes.	35	B3 B4 B9		D2 D3
Debate	Discussions done along classes related with expositions done or read previously.	5	B3 B4 B9	C86	D2 D3 D4
Discussion Forum	Short answers and interaction done individually by students within the Moovi platform to discuss topics related with the course.	5	B3	C86	D2 D3 D4
Mentored work	Evaluation of the works developed: understanding, maturity, importance and originality of the work and interaction between the group.	25	B3 B4 B9	C86	D2 D3 D4
Objective questions exam	Three successive tests to evaluate the contents given up to that time in the course. The tests will be individual and with time limit.	30	B3 B4	C86	

Other comments on the Evaluation

The elements that are part of the evaluation of the subject are the following:

- **Questionnaires**: along the course the student will fill 3 questionnaires that will contribute 10% to the final mark (each one).

- **Laboratory practice**: each student will have to perform a set of practical tasks in the laboratory that will contribute 35% to the final mark.

- **Group tutored work**: each student will have to do a work in group, about one among several possible topics, that will contribute 25% (20% work done + 5% presentation) to the final mark shared by all group members. Nevertheless, the teachers will follow the work done by every group member, and they will also perform a peer review of the work done. In the case that a student would perform clearly lower than his/her mates, he/she will be rated individually (see note*).

- **Class participation**: students will discuss in class about expositions done by the professor, and this contributes up to a 5% to the final mark.
- **Forum participation**: students should interact individually in the forum of the subject to achieve up to a 5% to the final mark. To achieve such percentage the student should provide at least two relevant contributions.

Therefore, we have: Final Mark = Questionnaires (3*x10% = 30%) + Lab. practices (35%) + Tutored work (25%) + Class participation (5%) + Forum (5%) = 100%.

The students need to pass each of the questionnaires, the practical tasks and the tutored work with at least 4 points over 10 to calculate the average final mark. If any of the marks is below 4, then the final mark will never be higher than 4,9 points over 10 (not passed).

The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester.

Plagiarism is regarded as serious dishonest behaviour. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Following the degree guidelines, the students that will follow this course can choose between two possibilities: continuous assessment and global assessment at the end of the semester.

Continuous assessment: the student follows the continuous assessment since the moment he/she fulfils two questionnaires. From that moment we assume that he/she will participate in the subject, independently of the participation in the global assessment.

Global assessment: if the continuous assessment is not performed, then the student will have to perform a final exam that substitutes the questionnaires done along the course, in addition to provide the practical tasks and the equivalent work to be done as part of the continuous assessment.

Extraordinary Call: the student will have to perform the parts not passed previously.

End-of-program Call: the student will have to perform a final exam that substitutes the questionnaires done along the course, in addition to provide the practical tasks and the equivalent work to be done as part of the continuous assessment.

This subject will be evaluated in English, but students have the possibility to interact in Spanish with the teachers at any time.

The questionnaires and tasks, proposed and performed along the module, are only valid for the current course.

***NOTE: Multidisciplinar Group Tutored Work (optional)**
In this subject, and as a part of an innovation project at UVIGO, some students have the possibility to join a multidisciplinary group (MDG) with other three subjects: (1) Video Games: design and development, 4th year, Degree in Audiovisual Communication. (2) Multimedia Technology and Computer graphics, 4th year, Degree in Telecommunication Engineering Technologies, Sound and Image module. (3) Intelligent systems programming, 4th year, Degree in Telecommunication Engineering Technologies, Telematics module. The activity is coordinated by teachers of the Teaching Innovation Group: ComTecArt (Communication, Technology and Art in Virtual Environments).

The activities and tasks to be performed by the students of this subject in the MDG will be related with using artificial intelligent techniques in videogames. The students that would join this multidisciplinary tutored work will not participate in the ordinary groups C. Besides, each MDG will only join one student from this subject, so he/she will be rated individually in such case.

The participation in the MDG is optional, and if there are more request than available positions; then those students will be ranked and selected according to the global grade mark, provided by the Escola de Enxeñaría de Telecomunicación Secretary.

There will be group work sessions on Wednesday mornings, alternating between the Campus of Vigo and Pontevedra. The University will provide free round trip transportation from the Escola de Enxeñaría de Telecomunicación or the Facultad de Ciencias Sociais e a Comunicación, respectively.

Sources of information

Basic Bibliography

Juan C. Burguillo, **Self-organizing Coalitions for Managing Complexity**, 1a, Springer International Publishing, 2018

Jordi Torres, **Python Deep Learning, Introducción práctica con Keras y TensorFlow 2**, 1a, MARCOMBO, 2020

Complementary Bibliography

Michael Wooldridge,, **An Introduction to Multiagent Systems**, 2a, Addison-Wesley, 2009

Travis Booth, **Deep Learning with Python: A Hands-On Guide for Beginners**, 1a, Independently published, 2019

Stuart Russell, Peter Norvig, **Artificial Intelligence: A Modern Approach,**, 3a, Prentice Hall, 2014

François Chollet, **Deep learning with Python**, 1a, Manning Publications, 2018

Recommendations

Subjects that it is recommended to have taken before

Programming I/V05G301V01105

Programming II/V05G301V01110

Other comments

The only requirement for the students, in order to follow this subject, is to have a basic understanding of Java programming.

IDENTIFYING DATA

Integrated systems design

Subject	Integrated systems design			
Code	V05G301V01404			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Gil Castiñeira, Felipe José			
Lecturers	Gil Castiñeira, Felipe José Rodríguez Hernández, Pedro Salvador			
E-mail	xil@gti.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Embedded systems are part of almost all the diary activities that involve an electronic device (the alarm clock, the mobile phone, the car...). This course introduces the main concepts behind modern embedded systems that include an operating system, and puts them in practice through a series of exercises and projects. The documentation will be provided in English. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results

Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C87	(CE87/OP30) The ability to understand the specific requirements for integrated circuits with strict real time restrictions.
C88	(CE88/OP31) The ability to formulate and solve problems of design and development of integrated systems.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Know the technological base which supports the most recent investigations in the study and design of integrated systems	B3	C87	
Understand the basic aspects of the special requirements inherent to embedded systems with hard real time restrictions	B3 B4 B9	C87	D3
Adopt a global view of the problem of programming environments with real-time restrictions, and know the proper tools for dealing with them, so that embedded systems can be addressed with a system level approach	B3 B4 B9	C88	D2 D4
Understand the basic elements of fault prevention and fault tolerance	B3	C88	D4
Master the concepts related to the organisation of this kind of systems software	B3 B4 B9	C88	D4
Handle the tasks scheduling and resources sharing techniques in embedded systems	B3 B4	C88	
Become familiar with the use of abstraction platforms for developing embedded systems	B4 B9	C88	

Contents	
Topic	
Concept of embedded system	Definition of embedded system Real-time systems Characteristics
Operating systems for embedded systems	Operating systems with real-time restrictions Multitasking: threads and processes Synchronization
Arquitecturas de sistemas integrados	Microprocessor architecture. Peripherals. Buses.
Process scheduling	Cyclic executives Priority-driven scheduling: DMS, EDF Access synchronization
Reliability and fault tolerance	Fault prevention and fault tolerance Static and dynamic redundancy Security, reliability and dependability
Distributed embedded systems	Communication mechanisms Field buses
Abstraction platforms for the development of embedded systems	Android Linux (as a platform)
Communication with sensors and actuators	I/O Hardware Coping with concurrency The Analog/Digital interface

Planning			
	Class hours	Hours outside the classroom	Total hours
Presentation	1	5	6
Laboratory practical	14	0	14
Seminars	6	10	16
Project based learning	0	53	53
Lecturing	20	40	60
Problem and/or exercise solving	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Presentation	Presentation by the students of the developed projects results. Through this methodology the competencies CT2, CT4, CG4, CG9, CE87 and CE88 are developed.
Laboratory practical	Development of guided and supervised assignments. Through this methodology the competencies CT2, CT3, CG3, CG4, CE87 and CE88 are developed. The following software will be used: - Linux system with terminal and a development environment for C. - Web browser. - Virtualización environment with VirtualBox and VMware. - Vrtual machines with a cross compiling environment for ARM and QtCreator will be provided. - Android Studio With NDK. - PSoC Creator
Seminars	Meetings of the professors with the students for tracking the current status and further planning the project activities. Through this methodology the competencies CT2, CT4, CG4, CG9, CE87 and CE88 are developed.
Project based learning	We use learning projects based training: students carry out a project along the semester to resolve a complex problem by means of planning, design and implementation of a series of activities. Through this methodology the competencies CT2, CT3, CT4, CG3, CG4, CG9, CE87 and CE88 are developed.
Lecturing	Professors present the main theoretical contents related to embedded systems with real-time restrictions. Through this methodology the competencies CT3, CG3, CE87 and CE88 are developed.

Personalized assistance	
Methodologies	**Description**

Lecturing	The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. Questions will be answered during the master sessions or during tutorial sessions (https://moovi.uvigo.gal).
Laboratory practical	The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. Te professors will guide and help the students to complete the assigned laboratory practises. Questions will be answered during the lab sessions or during tutorial sessions (https://moovi.uvigo.gal).
Seminars	In addition to the attention to the group, the professors of the subject will provide individual attention adadpted to the students during the group supervision sessions, or during tutorial sessions (https://moovi.uvigo.gal).
Project based learning	The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. The professors will guide and help the students to complete the assigned project. Questions will be answered during the supervising sessions, group supervising sessions, or during tutorial sessions (https://moovi.uvigo.gal).

Assessment

	Description	Qualification	Training and Learning Results		
Presentation	Once their project is implemented, the students will perform a public presentation of its design, development and results. Each member of the group must present the tasks that he or she completed, and provide satisfactory answers to the questions made by the professors.	5	B4 B9	C87	
Laboratory practical	The students will deliver the five practices and complete individual questionnaires where they show the correct completion and understanding of the practices. It is necessary to pass the practicals as a whole in order to pass the subject.	10	B3 B4	C87 C88	
Seminars	A continuous tracking of the design and evolution of the implementation will be held during the realization of the project. Each student must collect and show evidences of her/his individual work. Periodically, the students will present the state and results of their projects, as well as the scheduled tasks. If these results are not satisfactory, a penalization of the 20% of the grade could be applied.	5	B4 B9	C87 C88	
Project based learning	The students will be divided in groups for accomplishing the design, implementation and proof of an embedded system. The result will be evaluated after the his delivery, assessing aspects such as correction, quality, performance and functionalities. In addition, during the implementation of the project, the design and the evolution of the development will be evaluated. If the intermediate results are not satisfactory, a penalization of the 20% of the grade could be applied. The evaluation will be by group and by person: each one of the members of a team must document his/her tasks and answer the questions related to them.	40	B3 B4 B9	C87 C88	D2 D3 D4
Problem and/or exercise solving	Students will be evaluated to asses what they have learned in master sessions.	40	B3	C87 C88	

Other comments on the Evaluation

In order to pass the course it is necessary to complete the different parts of the subject (master sessions, practices in labs, and projects). The final grade will be the **weighted geometric mean** of the grades of the different parts (i.e. it is not possible to pass the subject with a zero in one part). If "x" is the grade obtained for the master sessions, "y" for the practices in labs, and "z" for the project (project, seminars and presentation), the final grade will be:

grade = x^0.4*y^0.1*z^0.5

During the first month, students must provide a written declaration to opt for global assessment. In other case, it will be considered that they opt for continuous assessment. Students who select continuous assessment and submit the first task or questionnaire may not be listed as "Absent".

Students who opt for the global assessment procedure must pass the short answer test (40%), submit a project (50%) and submit the laboratory practises (10%). These parts will be evaluated as indicated in the tests' description section. The final grade will be the **weighted geometric mean** of the grades of the different parts. Besides, they must submit an additional dossier with detailed information about the events and issues that arose during the execution of the different tasks, and especially the project. In addition, during the first month of the course, professors will notify students who opted for final assessment if they have to do the tutored work individually.

Students who opt for continuous assessment must submit each laboratory report before the deadlines that will be notified at the beginning of the course.

Although the project will be developed in groups, the ongoing activities of each student in a group will be monitored individually. In case a student's performance is below his or her group mates, he or she could be expelled from the group or graded on an individual basis.

Intermediate milestones may be required for the project. Those intermediate milestones will be notified at the beginning of the course.

Extraordinary opportunity to pass the course

The extraordinary exam will only be held by students who did not pass the ordinary exams (end of semester).

In order to pass the course, it is necessary to complete the different parts of the subject: pass the short answer test (40%), submit a project (50%) and submit the laboratory practises (10%). These parts will be evaluated as indicated in the tests description section. The final grade will be the **weighted geometric mean** of the grades of the different parts. Besides, it will be necessary to submit an additional dossier with detailed information about the events and issues that arose during the execution of the different tasks, and especially the project.

Students that have opted by the continuous assessment procedure, can decide to maintain the grades of the parts they have already passed in the first opportunity or discard them.

"End of career" opportunity to pass the course

In order to pass the course, it is necessary to complete the different parts of the subject: pass the short answer test (40%), submit a project (50%) and submit the laboratory practises (10%). These parts will be evaluated as indicated in the tests description section. The final grade will be the **weighted geometric mean** of the grades of the different parts. Besides, it will be necessary to submit an additional dossier with detailed information about the events and issues that arose during the execution of the different tasks, and especially the project.

Other comments

The grades obtained are only valid for the current academic year.

Although the tutored work will be completed (if possible) in groups, each student should keep a record of his or her activities. In the case in which the performance of a member of the group wouldn't be adequate compared with the performance of his or her teammates, he or she could be excluded from the group and/or qualified individually.

The use of any material during the tests will have to be explicitly authorized.

The assessment will be performed in any of the official languages in Galicia. If a student wishes to be tested in English, it must give written notice to teachers with 15 days in advance.

In case of detection of plagiarism or unethical behavior in any of the tasks/tests done, the final grade will be "failed (0)" and the professors will communicate the incident to the academic authorities to take the appropriate measures.

In carrying out the academic activities of this course, the use of generative artificial intelligence (GAI) is permitted. Its use must be ethical, critical, and responsible. When using GAI, it is essential to critically evaluate any results it provides and carefully verify any citations or references generated. Additionally, it is recommended to disclose the use of the tools employed.

Sources of information
Basic Bibliography
A. Burns & A. Wellings, **Sistemas de Tiempo Real y Lenguajes de Programación**, 3, ADDISON-WESLEY, 2003
E.A. Lee, S.A. Seshia, **Introduction to Embedded Systems**, 2, MIT PRESS, 2017
Complementary Bibliography
P. Marwedel, **Embedded System Design**, 4, Springer, 2021
P. Barry, P. Crowley, **Modern Embedded Computing**, 1, Morgan Kaufmann, 2012
S. Barrett, J. Kridner, **Bad to the Bone: Crafting Electronics Systems with Beaglebone and BeagleBone Black**, 1627051376, 2, New Publisher, 2021
Lawrence J. Henschen, Julia C. Lee, **Embedded System Design**, 9780443184710, 1, Elsevier, 2023
Elecia White, **Making Embedded Systems: Design Patterns for Great Software**, 1098151542, 2, O’Reilly Media, 2024

Recommendations

Subjects that it is recommended to have taken before

IDENTIFYING DATA

New computerised services

Subject	New computerised services			
Code	V05G301V01405			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	Spanish			
Department				
Coordinator	Álvarez Sabucedo, Luis Modesto			
Lecturers	Álvarez Sabucedo, Luis Modesto Santos Gago, Juan Manuel			
E-mail	lsabucedo@det.uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The global aim of the course is to provide the students with a global outlook of the new technologies in the area of the telematic services. Therefore, the contents of this course will be open and in line with the technological evolution in the most active fields of the new technologies. The subject will be taught in Spanish and the contents will be available in English.			

Training and Learning Results

Code	
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C89	(CE89/OP32) The ability to design and construct new computer services.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Identify new fields of application of the telematic services.	B4	C89	D4
Knowledge of the main tools and environments for the development of new telematic services.	B4 B9		
Obtain skills to develop new telematic services.		C89	

Contents

Topic	
Supporting technologies	PWA Support for recommendations Distributed Web
Horizontal services	IoT Cloud Computing Big data Blockchain
eServices	eLearning, eCommerce, eGovernment
Introduction to quantum science	Information management Transmission models Introduction to computing

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	16	40	56
Laboratory practical	14	28	42
Case studies	5	25	30
Introductory activities	3	6	9
Essay	1	3	4

Essay	1	4	5
Essay questions exam	2	2	4

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Theoretical contents and their practical application will be presented during the lectures. Student are expected to play an active role during lectures.This methodology will impact in all the competences addressed in the subject. The following learning outcomes will be supported: B4, B9, C89 and D4.
Laboratory practical	During practical sessions, it will be developed a semantic project with the support of adhoc software tools. This methodology will impact in all the competences addressed in the subject. The following learning outcomes will be supported: B4, B9, C89 and D4.
Case studies	Use cases will presented to the students. Thus, they will be able to analyze and to study them in depth in order to prepeare their academic projects. This methodology will impact in all the competences addressed in the subject. The following learning outcomes will be supported: B4, B9, C89 and D4.
Introductory activities	Program of the subject will be presented along with the methodologies used, the classroom, practical contents, final project, final and continuous evaluation criteria, and, in general, all aspects of the subject. This methodology will impact in all the competences addressed in the subject. The following learning outcomes will be supported: B4, B9, C89 and D4.

Personalized assistance

Methodologies	**Description**
Lecturing	During these sessions, any questions that may arise will be addresseed. Also during the tutoring sesions, questions that may arise will be resolved. For tutoring support, check: https://moovi.uvigo.gal/user/profile.php?id=11296 and https://moovi.uvigo.gal/user/profile.php?id=11599
Laboratory practical	In the practical sessions, a closer attention will be paid to the tasks assigned to the students. Also, any questions that may arise will be addressed. Also during the tutoring sesions, questions that may arise will be resolved. For tutoring support, check: https://moovi.uvigo.gal/user/profile.php?id=11296 and https://moovi.uvigo.gal/user/profile.php?id=11599
Case studies	In these sessions, any questions that may arise will be addressed. Also during the tutoring sesions, questions that may arise will be resolved. For tutoring support, check: https://moovi.uvigo.gal/user/profile.php?id=11296 and https://moovi.uvigo.gal/user/profile.php?id=11599
Tests	**Description**
Essay	In these sessions, any questions that may arise will be addressed. Also during the tutoring sesions, questions that may arise will be resolved. For tutoring support, check: https://moovi.uvigo.gal/user/profile.php?id=11296 and https://moovi.uvigo.gal/user/profile.php?id=11599
Essay	In these sessions, any questions that may arise will be addressed. Also during the tutoring sesions, questions that may arise will be resolved. For tutoring support, check: https://moovi.uvigo.gal/user/profile.php?id=11296 and https://moovi.uvigo.gal/user/profile.php?id=11599
Essay questions exam	In these sessions, any questions that may arise will be addressed. For tutoring support, check: https://moovi.uvigo.gal/user/profile.php?id=11296 and https://moovi.uvigo.gal/user/profile.php?id=11599

Assessment

	Description	Qualification	Training and Learning Results		
Essay	It will consist of the presentation of two practical-projects using the concepts presented in the subject. It will take place during the development of the course. Marks of each work will be the same for all the members in the group.	35	B4 B9	C89	D4
Essay	It will consist of the presentation of a project that carries out a telematic-based solution. It will take place at the end of the course. Marks of each work will be the same for all the members in the group.	25	B4 B9	C89	D4

Essay questions exam	It will involve all the contents of the course. It will take place at the end of the course	40	B4 B9	C89

Other comments on the Evaluation

The subject can be approved following the continuous assesment or global assesment.

Students who sit for any of the continuous assessment tests cannot be evaluated as "Not presented" and will not be able to opt for the exam-only modality.

Continuous assessment

The weight and content of each of the continuous assessment parts are as follows:

1.- Essay 1 (35%): It will consist of the presentation of 2 practical-projects (specified during the course and in the form of practical-projects) with the same weight. They will be carried out in the laboratory sessions.

2.- Essay 2 (25%): It will consist of a presentation of a complete project, in which models based on telematic services will be used. It will be carried out in the last laboratory session.

3.- Essay questions exam (40%): It will cover all the contents of the course.

Works 1 and 2 will have a single grade for all the members of the group. It is mandatory to obtain a minimum of 50% of the assessment in tasks 1 and 2. In the question exam it will be necessary to get 40% of the maximum score. If the overall score exceeds five points but any of the minimum requirements are not met, the grade on the record will be 4.9.

Global assessment

It will consist of a written test in which all the content of the course can be included. The student will be able to reach a grade of 10 with this option. In addition to the written test, students who appear for this final exam must carry out a project similar to Essay 2. These works must be original.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution

It is a necessary condition to pass the subject to obtain a passing grade in each delivery.

Extraordinary opportunity and Call for end-of-program

The same considerations as the global assessment will follow.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution

Sources of information

Basic Bibliography

Professors, **Lecture Slides**,

Complementary Bibliography

R. Baeza-Yates y B. Ribeiro-Neto., **Modern Information Retrieval**,

Arvind Arasu, Junghoo Cho, Hector Garcia-Molina, Andreas Paepcke, and Sriram Raghavan, **Searching the Web**, 2001

Ethereum Development Documentation,

Juan Benet, **IPFS - Content Addressed, Versioned, P2P File System**,

Aplicaciones Web Progresivas,

Stuart Russell y Peter Norvig, **Artificial Intelligence: A Modern Approach**, 4, 2021

Zebo Yang, **A Survey of Important Issues in Quantum Computing and Communications**, IEEE, 2022

Recommendations

Subjects that it is recommended to have taken before

Internet Services/V05G301V01301

IDENTIFYING DATA

Application Design with micro-controllers

Subject	Application Design with micro-controllers			
Code	V05G301V01406			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	Spanish Galician			
Department				
Coordinator	Costas Pérez, Lucía			
Lecturers	Costas Pérez, Lucía Valdés Peña, María Dolores			
E-mail	lcostas@uvigo.es			
Web	http://moovi.uvigo.gal/course/view.php?id=378			
General description	Design and development of microcontroller-based applications, including design methodologies to develop real time applications, peripheral components configuration and connectivity. The scope of these contents will be adapted to the academic level reached by the students. Teachers will speak in spanish or galician language. Exams will be written in spanish.			

Training and Learning Results

Code	
C58	(CE58/OP1) The ability to design hardware and software systems based on microcontrollers.
C59	(CE59/OP2) The ability to use software tools for microcontrollers simulation.

Expected results from this subject

Expected results from this subject	Training and Learning Results
To know in deep the configuration methodologies of real time microcontrollers.	C58
To know in deep the hardware design of the microcontroller-based electronic systems.	C58
To know in deep the software design of the microcontroller-based electronic systems.	C58 C59
To go deeper into the development of microcontroller-based electronic systems.	C58 C59

Contents

Topic	
Introduction. Previous topics review.	Introduction. Previous topics review. PIC18F45K20. Internal Structure. Arithmetic and Logic Unit. Control Unit. Program memory. Data memory. Peripherals. Watch Dog Timer (WDT).
Instruction set. Addressing modes.	Introduction: Instruction Set. Transfer Instructions. Arithmetic Instructions. Logic Instructions. Jumps. Addressing Modes.
Timers.	Introduction. Timers/Counters: TMR0/TMR1/TMR2/TMR3.
Excepctions and interrupts.	Introduction. Excepctions. Interrupts. Interrupt Response. Registers.
Analog interface.	Introduction. ADC. ADC Operation. Analog Comparator Module.
Compare Mode.	Introduction. Capture Mode. Compare Mode. PWM. ECCP1: Enhanced Mode.
MSSP: Master Synchronous Serial Port SPI. I2C	Introduction. Registers. SPI Mode. I2C Mode.
Power-Managed modes.	Introduction. Different Modes. Switching between modes.
Input/Output.	Introduction. I/O Structure. Ports (A B C D E). Configuration Registers. Parallel Slave Port. Signal Coupling.
C languaje programming.	The XC8 compiler for PIC.
Project:	Practical activities of laboratory of development of applications based in microcontrollers. Configuration of peripherals. Management of interruptions. Connection and management of external peripherals.

Planning

	Class hours	Hours outside the classroom	Total hours

Lecturing	11	23	34
Problem solving	8	25	33
Project based learning	21	60	81
Problem and/or exercise solving	2	0	2

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Lecturing	The lecturer will explain in the classroom the subject contens. The student develops the competency C58 (CE58).
Problem solving	The lecturer will solve exercices related to the subject contens. Software to be used: MPLAB X The student develops the competencies C58 and C59 (CE58 and CE59) .
Project based learning	The students have to develop a project. The lecturers will help and monitor them. Software to be used: MPLAB X The student develops the competencies C58 and C59 (CE58 and CE59).

Personalized assistance

Methodologies	**Description**
Project based learning	The Laboratory teacher will resolve the doubts of students at the schedule established and published on the following websites https://moovi.uvigo.gal/user/profile.php?id=11303
Lecturing	The teacher will resolve the doubts of students at the schedule established and published on the on the following website https://moovi.uvigo.gal/user/profile.php?id=11301.
Problem solving	The teacher will resolve the doubts of students at the schedule established and published on the on the following website https://moovi.uvigo.gal/user/profile.php?id=11301.

Assessment

	Description	Qualification	Training and Learning Results
Problem solving	Students will be asked to program in C languaje. Competencies C58 and C59 (CE58 and CE59) are assessed.	20	C58 C59
Project based learning	Students will be asked to elaborate a report related to the project they have to carry out. The lecturer will also assess individually the student's work developed during the laboratory sessions. Competencies C58 and C59 (CE58 and CE59) are assessed.	50	C58 C59
Problem and/or exercise solving	Exam to evaluate the knowledge acquired by the student. Competency C58 (CE58) is assessed.	30	C58

Other comments on the Evaluation

CONTINUOUS ASSESSMENT:Ordinary exam:

A continuous assessment learning scheme will be offered to the students:

- An exam will be held related to the theory (A sessions).- The student has to solve C languaje programming exercices (A sessions).
- The student has to elaborate a report describing the project (B and C sessions).

Teachers will speak in spanish or galician language. Exams will be written in spanish.
The exam date will be specified in the academic calendar. A minimum score (5 out of 10) is required in order to get a pass.
The project will be comprised in two parts. In the first, the student will work with basic peripherals (25% of the final mark) and in the second the student will work with complex peripherals (25% of the final mark). In order to assess the project, the lecturer will consider the work in the laboratory and the student□s behaviorfor the first part and the quality of the final report (40%) and the work in the laboratory and the student□s behavior (60%) in the second.
To pass the subject, it is necessary that the mark of the exam, the C programming exercices and the project are equal or greater than 5 over 10. The final mark (FM) is calculated as the weighted average of the three individual marks. The formula will apply a weight of 30% to the theory mark (TM), 20% to the C programming exercices mark (CM) and a 50 % to the project mark (PM):

FM = 0,3*TM + 0,2*CM + 0,5*PM (1)

The mínimum passing score required in order to get a pass in the subject is 5. In case the students do not pass any of the tasks of the subject, the final mark (FM2) will be:
FM2= Minimum{4.9, FM}

Being FM the mark applying (1).

One month after the start of the new school year, when a student attend the three first laboratory classes it is considered that he/she choose the continuous assessment scheme.

Extraordinary exam: The assessment policy in this call follows the same scheme, the students have to take the exam and present the monitored project and the C programming exercices.

GLOBAL ASSESSMEN AND END-OF-PROGRAM EXAM:

Students who refuse the continuous assessment scheme will be assessed by means of a final exam to evaluate the theory. The exam will be the same for them as for the students who follow the continuous scheme. The assessment of the laboratory for these students will be carried out by means of a laboratory exam. In this exam, the student has to solve asembly and C languaje programming exercices. The date will be fixed within the examination period. In this case, the final mark (FM) is calculated as the weighted average of the two individual marks. The formula will apply a weight of 20% to the theory mark (TM) and a 70% to the laboratory mark (LM):

FM = 0,3*TM + 0,7*LM (2)

To pass the subject, it is necessary that the mark of each of the exams are equal or greater than 5 over 10. The minimum passing score required in order to get a pass in the subject is 5.

In case the students do not pass any of the tasks of the subject, the final mark (FM2) will be:

FM2= Minimum{4.9, FM}

Being FM the mark applying (2).

IMPORTANT REMARK: Students who refuse the continuous assessment scheme have to contact the lecturer at least two weeks before the exam date.

Sources of information
Basic Bibliography
http://ww1.microchip.com/downloads/en/DeviceDoc/41303F.pdf, **PIC18FXXK20 Data Sheet**,
Complementary Bibliography
F. E. Valdés Pérez, R. Pallás Areni, **Microcontroladores. Fundamentos y Aplicaciones con PIC.**, Marcombo,
http://ww1.microchip.com/downloads/en/DeviceDoc/52116A.pdf, **PICkit 3 In-Circuit Debugger/Programmer Users Guide**,
http://ww1.microchip.com/downloads/en/DeviceDoc/41370C.pdf, **PICkit 3 Debug Express PIC18F45K20 MPLAB® C Lessons**,
http://ww1.microchip.com/downloads/en/devicedoc/50002053g.pdf, **MPLAB® XC8 C CompilerUsers Guide**,
https://ww1.microchip.com/downloads/en/DeviceDoc/50002737C%20XC8%20C%20Compiler%20UG%20for%20PIC.pdf, **MPLAB® XC8 C Compiler Users Guide for PIC® MCU**,

Recommendations

Subjects that it is recommended to have taken before
Programmable Electronic Circuits/V05G301V01302
Electronic Instrumentation and Sensors/V05G301V01316

IDENTIFYING DATA				
Optoelectronic devices				
Subject	Optoelectronic devices			
Code	V05G301V01407			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Moure Rodríguez, María José			
Lecturers	Moure Rodríguez, María José			
E-mail	mjmoure@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This subject deals with the optoelectronic properties of semiconductors and their application in electronic devices for detection, emission, amplification and conversion of optical/electrical signals. Devices include light-emitting diodes, lasers diodes, photodiodes, phototransistors and solar cells. The contents of the course and the laboratory activities coverage the basic operating principles, design considerations, driving circuits and applications of optoelectronic devices. The subject will enable students to apply the physics of optoelectronic devices in optical sensors design and fiber optic communications. Emphasis will also be place on understanding the data sheets of optoelectronic components and their applications to different technologies. Finally integrated optoelectronics, display and image sensor technologies are introduced. Subject of the English Friendly Program. International students can ask teaching staff for: a) teaching materials and bibliographic references in order to follow the subject in English, b) attending office hours in English, c) tests and assessments in English. In addition, all the documentation for this subject has be written in English.			

Training and Learning Results	
Code	
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B12	CG12 The development of discussion ability about technical subjects
B14	CG14 The ability to use software tools to search for information or bibliographical resources.
C60	(CE60/OP3) The ability to design circuits based on optoelectronics devices used in telecommunication systems.
C61	(CE61/OP4) The ability to acquire, condition and process the information obtained from optoelectronic sensors.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
To know the fundamentals and applications of different optoelectronic devices.		C61	
The capability to analyze the data sheets and to compare different optoelectronic devices.	B12 B14	C61	
To know the applications of electronic devices, especially the ones related to telecommunication technologies	B9	C60	D4
The capability to design basic circuits for driving photoemitter devices.		C60	
The capability to design basic circuits for photodetection.		C60 C61	
To know different optoelectronic sensors.		C61	
To know the architecture and the operating modes of displays.		C60	
To know of the architecture and characteristics of image sensors.		C60 C61	
The ability to select the more suitable devices according to each application.	B12 B14	C60 C61	

Contents	
Topic	
Unit 1: Introduction	Fundamentals and classification of optoelectronic devices. Radiometric and photometric units and their relationships.

Unit 2: Light Emitting Diodes	Principles of LED operation. Types of LEDs and properties. Parameters and characteristics. Driving circuits. Basic applications.
Unit 3: Optoelectronic Detectors	Light Dependent Resistors: principles of LDR operation, properties, parameters, driving circuits and applications. Photodiodes: principles of photoconductive detectors, types, parameters, driving circuits and applications. Phototransistor: principles of phototransistor operation, types, parameters, driving circuits and applications. Photodetector comparison.
Unit 4: Solar Cells	Photovoltaic detectors: principles and properties. Manufacture and performance of solar cells, parameters and characteristics. Applications.
Unit 5: Laser Diodes	Principles of Laser operation. Types of lasers. Laser diode operation. Driving circuits and applications.
Unit 6: Image Sensors	Principles of CCD and CMOS operation. Parameters and characteristics. Color detection. Applications.
Unit 7: Optical Sensors	Principles of optical sensing. Internal design, types, parameters and applications of: optocouplers, optical encoders, object sensors, code-bar readers, humidity sensors, color detection, distance sensors, anemometers, temperature sensors and biomedical sensors.
Unit 8: Display Technologies	Principles of Liquid Crytal Display operation. Principles of LED and Organic LED displays. Introduction to plasma, electroluminescence and digital light processor technologies.
Unit 9: Introduction to Fiber Optics	Fiber Optic fundamentals. Classification of fibers. Fiber optic emitters and detectors. Principles of fiber optic communications. Principles of fiber optic sensors.
Laboratory Practices	1. Basic optoelectronic circuits. LEDs and LDRs. Laboratory measurements. 2. Analog optical modulation. Optical detectors based on photodiodes and phototransistors. 3. Optoelectronic sensors for object sensing. 4. Digital communications based on fiber optic. 5. Optical circuits for color measurement. 6. LASER sensor for distance measurement. Measurements using a spectrometer. 7. Other optoelectronic sensors.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	15	30	45
Case studies	4	8	12
Project based learning	6	30	36
Presentation	1	3	4
Laboratory practical	14	9	23
Problem and/or exercise solving	2	24	26
Report of practices, practicum and external practices	0	4	4

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The professor explains the theoretical contents of the course, encouraging critical discussion and the student involvement. Reading assignments for each session will be previously available on Moovi, and students are expected to come to the theoretical class having completed the assigned reading. In the master sessions the competencies C60 and C61 are developed.
Case studies	The study and analysis of actual technological solutions completes the theoretical presentations. This activity includes the study of different alternatives, commercial devices or systems, cost and power estimation, environmental impact and performance analysis. Through the case studies the competencies C60, C61 and B12 are developed.
Project based learning	This activity focuses on applying the techniques described in the lecture classes and the skills developed at laboratory to a project implementation. These sessions are developed in a laboratory with skilled equipment. Students should obtain well founded solutions, choosing appropriate methods and devices. These projects are planned and tutored in small size groups. In the projects the competencies B9, B12, B14 and D4 are mainly developed.

Presentation	The project developed by the students must be oral presented by the authors. Through the oral presentations the competencies B9 and B12 are developed.
Laboratory practical	During laboratory sessions the student learns the design, hardware implementation, verification and measurement of basic optoelectronics circuits. All the sessions are guided and supervised by the professor. In the laboratory practices, the competencies C60, C61 and B14 are developed.

Personalized assistance

Methodologies	Description
Lecturing	Students have the opportunity to solve doubts in personalized attention sessions. The appointment with the corresponding professor should be required and agreed by e-mail, preferably during the hours which are published on the faculty website. The links to the profile data of the teachers are: María José Moure Rodríguez - https://moovi.uvigo.gal/user/profile.php?id=11642
Laboratory practical	Students have the opportunity to solve doubts in personalized attention sessions. The appointment with the corresponding professor should be required and agreed by e-mail, preferably in the hours which are published in the faculty website.
Project based learning	Each group of students developing a project will attend periodic follow-up meetings.

Assessment

	Description	Qualification	Training and Learning Results		
Project based learning	The students should present a tutored project which deserves the 40% of the final qualification. The progress of this job will be supervised from continuous assessment but the final work should be oral presented by the authors.	40	B9 B12 B14	C60 C61	D4
Problem and/or exercise solving	The student must pass a short answer test which covers all of the contents taught in the theoretical classes or laboratory practices. This test will deserve the 30% of the final qualification.	30		C60 C61	
Report of practices, practicum and external practices	The assistance to the laboratory practices is mandatory: at least the student should complete 6 of the 7 sessions. The implementation of the circuits described in the practice guidelines and the reports submitted at the end on each session will deserve the 30% of the final qualification.	30	B9 B12 B14	C60 C61	D4

Other comments on the Evaluation

The subject can be pased with the maximum grade through continuous assessment (CA) or global assessment (GA). Both methods are mutually exclusive. If the student attends more than 2 laboratory sessions, it is considered that he/she chooses the continuous evaluation. However, if the student wishes to waive the continuous evaluation, he/she may do so within a maximum period of one month before the end of the term. The request should be sent by e-mail addressed to the coordinator of the subject.

A. Continuous assessment (CA)

Students who choose the CA modality will have two evaluation opportunities: the ordinary opportunity at the end of the term and the extraordinary one at the end of the academic year.

A1. Ordinary call of CA

The ordinary opportunity consists of a set of tasks to be taken throughout the term on the dates established at the beginning of the course. The weight and content of each part of continuous assessment are as follows:

A1.1 Test (NTest):

- It consists on a short answer questionnaire carried out preferably using the Moovi platform.
- It covers all of the contents taught in the theoretical classes or laboratory practices.
- The date will be approved by the Academic Commission of the Grade and it will be published at the beginning of the course.
- The student pass this part if he/she gets a mark greater than or equal to 5.

A1.2 Laboratory practices (NPrac):

- The student should complete 6 of the 7 sessions in order to pass this part.
- The student should correctly implement the circuits described in the guidelines of the practice and submit a report corresponding to each laboratory session. The qualification of each practice depends on these achievements.
- It can be developed individually or by groups of 2 students. In this last case and if both attend the practice, the qualification is the same for the 2 students.
- The student will pass this part if he/she gets an average greater than or equal to 5. The weighting of each practice is the same to obtain the NPrac mark.

A1.3 Project (NPro):

- It should be oral presented by the authors.
- It can be developed individually or by groups of 2 students. In this last case, the 85% of the qualification is common for both members of the group meanwhile the 15% represents the individual qualification obtained from the oral presentation of each student.
- The student will pass this part if he/she gets a mark greater than or equal to 5.

A1.4 Final qualification of continuous assessment (Final_ca):

The final qualification of continuous assessment is obtained as follows:

Final_ca: = (NTest*0.3 + NPrac*0.3 + NPro*0.4) if NTest is greater than or equal to 5 and NPrac is greater than or equal to 5 and NPro is greater than or equal to 5;

Final_ca = min [(NTest*0.3 + NPrac*0.3 + NPro*0.4), 4.9] in other case.

A.2 Extraordinary call of CA

The student who fails one or more of the parts of continuous assessment has another opportunity to pass any part before the end of the academic year:

- He/she can make a written long answer exam and this mark replaces NTest.
- He/she student can improve his/her laboratory mark (NPrac) by means of an exam. This exam consists of several problems related to the contents of laboratory practices.
- He/she can complete and present his/her project (NPro) before the date of the final exam.

B. Global assessment (GA) and end-of-program call

In those cases in which the student decides not to carry out the continuous evaluation tasks, the final qualification is based on:

- A final exam comprising all the topics of the subject. It usually consists of several questions and problems and lasts about 2.5 hours. The pass mark for this exam is 5 out of 10 and deserves 60% of the final qualification (NEx).
- The students should also present a project with the same objectives and complexity of the project developed in continuous assessment. This project deserves 40% of the final qualification (NPro) and should be presented before the date of the final exam.

The final qualification (Final_ex) is obtained as follows:

Final_ex = (NEx*0.6 + NPro*0.4) if NEx is greater than or equal to 5 and NPro is greater than or equal to 5;

Final_ex = min [(NEx*0.6 + NPro*0.4) , 4.9] in other case.

This assessment system applies as well to the ordinary call, extraordinary call and the end-of-program call.

C. Other comments

- The exams will be written in Spanish. The student can use the Spanish, English or Galician for the reports, works or presentations.
- The grades obtained from the continuous assessment and final exams are only valid for the current academic year.
- The use of books, notes or electronic devices such as phones or computers is not permitted in any test or exam. Mobile phones must be turned off and out of reach of the student.
- In the case that plagiarism is detected in any of the tasks/exams done/taken, the final score for the subject will be

'fail' (0) and the teachers will inform the School authorities so that they take the actions that they consider appropiate.

Sources of information

Basic Bibliography

Kasap S.O., **Optoelectronics and Photonics**, 2, Pearson, 2013

Complementary Bibliography

Martin V. D., **Optoelectronics**, PROMPT Publications, 1997

Wilson J., Hawkes J., **Optoelectronics. An introduction**, 3, Prentice-Hall, 1998

Udd E., **Fiber Optic Sensors. An Introduction for Engineers and Scientists**, 2, John Wiley&Sons, 2011

Kasap, Ruda, Boucher, **Cambridge Illustrated Handbook of Optoelectronics and Photonics**, Cambridge University Press, 2009

Yu F.T.S., Yang X., **Introduction to Optical Engineering**, Cambribge University Press, 1997

Uiga E., **Optoelectronics**, Prentice-Hall, 1995

Midwinter J.E., Guo Y.L., **Optoelectronics and Lightwave Technology**, Wiley, 1992

Holst G.C., **CCD Arrays, Cameras and Displays**, Optical Engineering Press, 1998

Carr J. J., **Electro-Optics. Electronic Circuit Guidebook**, Prompt Publications, 1997

Göpel Ed. W., Hesse J., Zemel J.N., **Sensors. A comprehensive Survey**, 1992

Goetzberger A., Knobloch J., Voss B., **Crystalline Silicon Solar Cells**, Wiley, 1998

Watson J., **Optoelectrónica**, Limusa, 1993

Smith S.D., **Optoelectronic Devices**, Prentice Hall, 1995

Theuwissen A.J.P., **Solid-state Imaging with Charge-Coupled Devices**, Kluwer, 1995

Lasky R.C., Österberg U.L., Stigliani D.P., **Optoelectronics for Data Communication**, 1995

Wood D., **Optoelectronic Semiconductors Devices**, Prentice Hall, 1995

Goff D.R., **Fiber Optic Reference Guide. A Practical Guide to Communications Technology**, Focal Press, 2002

Marston R.M., **Circuitos de optoelectrónica**, CEAC, 2000

Bob Tucker, **Handbook of Optical Sensors**, CLANRYE International, 2019

Moure M.J., **Apuntes de DOE**, 2017

Cao A.M., **Prácticas de DOE**, 2017

Recommendations

Subjects that it is recommended to have taken before

Physics: Fundamentals of electronics/V05G301V01201

Electronic technology/V05G301V01206

IDENTIFYING DATA

Design and synthesis of digital systems

Subject	Design and synthesis of digital systems			
Code	V05G301V01408			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	English			
Department				
Coordinator	Álvarez Ruiz de Ojeda, Luís Jacobo			
Lecturers	Álvarez Ruiz de Ojeda, Luís Jacobo			
E-mail	jalvarez@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	This course will be taught and assessed in English. The course documentation is in English. The main learning goals of this course are: Introduction to VHDL for synthesis. Design and synthesis of synchronous digital systems. Development, synthesis and verification of programmable digital circuits, using VHDL for its application in the field of the Telecommunications.			

Training and Learning Results

Code	
B1	CG1: The ability to write, develop and sign projects in the field of Telecommunication Engineering, according to the knowledge acquired as considered in section 5 of this Law, the conception and development or operation of networks, services and applications of Telecommunication and Electronics.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B13	CG13 The ability to use software tools that support problem solving in engineering.
C62	(CE62/OP5) The ability to design and synthesize complex digital systems by hardware description language.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
To be able to distinguish the differences between the use of Hardware Description Languages for simulation and for synthesis.	B13	C62	
To deepen the understanding of synchronous digital design techniques using VHDL for synthesis.	B13	C62	
To acquire skills at designing complex synchronous digital systems using VHDL.	B1 B9 B13	C62	D4

Contents

Topic	
LESSON 1 THEORY. INTRODUCTION TO COMPLEX DIGITAL SYSTEM DESIGN AND SYNTHESIS.	1.1.- Introduction. 1.2.- Complex application specific digital system design by means of FPGAs. 1.2.1.- Sequential processing systems. 1.2.2.- Continuous processing systems.
LESSON 2 THEORY. DIGITAL SYSTEM DESIGN RULES.	2.1.- Introduction. 2.2.- General rules for the design of digital systems. 2.2.1.- Hierarchical design. 2.2.2.- Technology independent design. 2.2.3.- Design timing. 2.2.4.- Design for reuse. 2.2.5.- Design for verificability. 2.2.6.- Design documentation. 2.3.- Intellectual Property (IP) cores.

LESSON 3 THEORY. INTRODUCTION TO SYNTHESIS OF DIGITAL SYSTEMS DESCRIBED IN VHDL.	3.1.- Introduction. 3.2.- Definition of synthesis. Basic concepts on synthesis. 3.3.- Conversion of a VHDL description to real hardware. Differences between the original VHDL model and the result of the synthesis / implementation. Timing simulation model. 3.4.- Recommendations for the description in VHDL synthesisable of distinct types of circuits. 3.5.- Examples of synthesisable models of commonly used circuits.
LESSON 4 THEORY. VHDL ADVANCED SENTENCES.	4.1.- Introduction. 4.2.- Access to files. 4.2.1.- Memory initialisation. 4.2.2.- Testbench stimuli. 4.3.- Generic data type. Parameterisable circuits. 4.4.- Libraries and packages. 4.5.- Subprograms. 4.5.1.- Functions. 4.5.2.- Procedures. 4.6.- Conditional compilation.
LESSON 5 THEORY. VHDL FOR SYNTHESIS. RESTRICTIONS.	5.1.- Introduction. 5.2.- IEEE standard for synthesis. 5.3.- Time sentences (After, Wait). 5.4.- Loops (Loop). Loops generate. 5.5.- Real data type. Type conversion. 5.6.- Complex arithmetical operations. Division (/). 5.7.- Complex mathematical functions. (Without, Cos, Log). 5.8.- Two-dimensional matrices. (Array). 5.9.- Exercises of non- synthesisable models and equivalent synthesisable circuits.
LESSON 6 THEORY. ARITHMETICAL CIRCUITS DESIGN IN VHDL.	6.1.- Introduction. 6.2.- Representation of binary numbers with decimal part. Fixed point. Floating point. 6.3.- Design of fixed point applications. 6.4.- Design of floating point applications. 6.5.- Implementation of arithmetical circuits in FPGAs.
LESSON 7 THEORY. VERIFICATION OF COMPLEX DIGITAL SYSTEMS.	7.1.- Introduction. 7.2.- Verification through simulation. 7.2.1.- Signals. Delay models. Definition of driver. 7.2.2.- Design analysis and simulation. Simulation cycle. Delta delay. 7.2.3.- Recommendations for VHDL simulation. Examples. Testbench design. 7.2.4.- Differences between functional and timing simulation. 7.3.- Verification through timing analysis. 7.4.- Verification through test in a development board. 7.5.- Exercises.
LESSON 1 LABORATORY. PRACTICAL TUTORIAL OF DIGITAL SYSTEM DESIGN AND SYNTHESIS.	1.1.- Introduction. 1.2.- Basic digital system design in synthesisable VHDL. 1.3.- Testbench design in VHDL. 1.4.- Implementation of digital systems in FPGAs. 1.5.- Testing digital systems.
LESSON 2 LABORATORY. DESIGN OF A MEDIUM-COMPLEXITY DIGITAL SYSTEM IN SYNTHESISABLE VHDL.	2.1.- Introduction. Task explanation. (2 h. TYPE B) 2.2.- Project based learning. Discussions on the most suitable approach. (6 h. TYPE C) 2.2.- Design of a medium-complexity digital system in synthesisable VHDL. (6 h. TYPE B) 2.3.- Oral presentation. (1 h. TYPE C)

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	4	8	12
Project based learning	15	31.5	46.5
Laboratory practical	6	7.5	13.5
Project based learning	14	51	65
Presentation	1	8	9
Introductory activities	2	2	4

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Lecturing	Conventional lectures. Through this methodology the outcome C62 is developed.
Project based learning	Problem based learning (PBL): Problem solving. It will consist mainly of the design of non-synthesisable models and synthesisable circuits in VHDL. To solve them, the student has to previously develop certain outcomes. Through this methodology the outcomes B9, B13 and C62 are developed.
Laboratory practical	VHDL design of digital circuits and circuit implementation in FPGAs. Software to be used: Vivado Design Suite de Xilinx Through this methodology the outcomes B9, B13 and C62 are developed.
Project based learning	Project based learning. The students must design a digital system in VHDL to solve a problem. In order to do that, the students must plan, design and implement the necessary steps. The project development will be implemented in laboratory hours (type B). Besides, in type C hours there will be discussions and one-to-one interaction with the teacher. Activities to develop in the groups C: Analysis and debate about the project approach and different alternatives. Analysis and follow-up of the proposed solution. Design implementation. Analysis and debate of results. Oral presentations of the project results. Through this methodology the outcomes B1, B9, B13, D4 and C62 are developed.
Presentation	Presentations/exhibitions: Exhibition of the results of the project developed. Through this methodology the outcomes B1 and B9 are developed.
Introductory activities	Introduction to the subject key topics both theoretical and practical. Through this methodology the outcomes B13 and C62 are developed.

Personalized assistance	
Methodologies	**Description**
Project based learning	In class the teacher will assist the students. Besides, the students will have the opportunity to consult with the teacher in office hours which will be published in the following website: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/luis-jacobo-alvarez-ruiz-ojeda
Laboratory practical	In class the teacher will assist the students. Besides, the students will have the opportunity to consult with the teacher in office hours which will be published in the following website: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/luis-jacobo-alvarez-ruiz-ojeda
Project based learning	In class the teacher will assist the students. Besides, the students will have the opportunity to consult with the teacher in office hours which will be published in the following website: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/luis-jacobo-alvarez-ruiz-ojeda

Assessment			
	Description	Qualification	Training and Learning Results
Project based learning	Problem-based learning. The total mark will be the sum of the marks of each one of the weekly exercise reports divided by the number of reports: TE = (Report 1 + ... + Report N) / N The estimated number of reports is 10. Resolution of theoretical problems and exercises. The majority of them will be focused on the design of non-synthesisable models and synthesisable circuits in VHDL. The problems will be based on the theoretical topics. It will be necessary to teach to the professor the operation of each one of the models and circuits. The correct application of the theoretical concepts to the problems will be assessed, based on the published criteria. It will be necessary to deliver the documentation requested by the professor for each one of the exercises.	40	B13 C62
Laboratory practical	These practical exercises will consist of the development of circuits in a guided manner. The assessment will be based on the operation of the digital system, according to the published criteria.	10	B13 C62

Project based learning	Laboratory Project. Design of a medium-complexity synthesisable digital system in VHDL. It will be necessary to deliver the design source files. The assessment will be based on the operation of the digital system and the correct application of the theoretical concepts, according to the published criteria.	40	B1 B9 B13	C62	D4
Presentation	It will be necessary to do an oral presentation of 15 minutes as a maximum about the work, according to the index supplied by the teacher.	10	B1 B9		D4

Other comments on the Evaluation

The total mark will be the sum of the marks obtained in the different tasks of the subject.

The global mark of the theoretical problems has to be equal or greater than 5 over 10 in order to pass the subject.

The mark of the Laboratory Project has to be equal or greater than 5 over 10 in order to pass the subject.

The students will be offered two assessment systems: continuous assessment and global assessment.

All the students, whether they follow the subject continuously or want to be assessed in the global assessment (ordinary or extraordinary call or end-of-program call), will have to do the tasks described in the previous section.

The students that do not attend classes regularly will also have to do the same tasks as the students who attend classes.

The final mark will be expressed in numerical form ranging from 0 to 10.

CONTINUOUS ASSESSMENT IN ORDINARY CALL

The students are considered to have chosen the continuous assessment when they have done 2 laboratory practices and/or 2 reports of theoretical exercises. However, it is possible to waive continuous assessment and opt for global assessment, upon a written request to the subject coordinator, within one month from the beginning of the semester.

The students that have chosen continuous assessment, but do not pass the course, will have to do the global assessment at the extraordinary opportunity.

The students that pass the course by means of continuous assessment will not be allowed to repeat any task in the global assessment in order to improve the mark.

The different tasks should be delivered in the date specified by the teacher, otherwise they will not be assessed for the continuous assessment.

The students will develop the theoretical exercises and the laboratory practices individually.

The laboratory projects will be developed in groups of two students during the continuous assessment but the students will be assessed individually. To achieve this, the students will be required to explain during the oral presentation which parts of the project each of them has developed.

The students who want to be assessed in the continuous assessment can only miss two sessions as a maximum. If they miss more than 2 sessions, it will be compulsory to do an additional individual task or an examination.

GLOBAL ASSESSMENT (ordinary or extraordinary call) and END-OF-PROGRAM CALL

The students that opt for the global assessment (whether it is at the ordinary or extraordinary call) or for the end-of-program call will have to do all the theoretical and practical tasks and the project individually.

The tasks for the single assessment must be delivered before the official date of the examination set by the faculty.

FINAL MARK OF THE COURSE

In case the students pass the theoretical exercises (TE) and the Laboratory Project (LP), that is, the mark of each part >= 5,

the final mark (FM) will be the weighted sum of the marks of each part of the subject:

FM = 0,40 * TE + 0,10 * Lp + 0,40 * LP + 0,10 * OP

Where:

TE = Global mark of the theoretical exercises and problems.

Lp = Laboratory Practices.

LP = Laboratory Project.

OP = Oral presentation.

In case the students have a final mark greater or equal than 5 but have not passed any of the two main parts of the subject, the theoretical exercises (TE) or the Laboratory Project (LP), that is, the mark of any part < 5, the final mark (FM) will be 4.9.

Theoretical exercises and problems

Each one of the theoretical exercises and problems proposed in the theoretical sessions will be marked from 0 to 10. Its influence in the total mark of the subject will be weighted in function of the number of exercises assigned.

The majority of the exercises will consist in the design of non-synthesisable models and synthesisable circuits in VHDL.

It will be necessary to deliver the required source files.

The total mark will be the sum of the marks of each one of the exercise reports divided by the number of reports:

TE = (Report 1 + ... + Report N) / N

The estimated number of reports is 10.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the exercises, the final mark will be FAIL (0), and the incident will be reported to the corresponding academic authorities for appropriate action

Sources of information

Basic Bibliography

CHU, PONG P., **RTL Hardware Design Using VHDL: Coding for Efficiency,Portability, and Scalability**, John Wiley & Sons Inc, 2006

ÁLVAREZ RUIZ DE OJEDA, L.J., **Diseño Digital con FPGAs**, Visión libros, 2013

Complementary Bibliography

ASHENDEN, PETER J., **The Designer's Guide to VHDL**, 3, MorganKaufmann Publishers, 2008

Standard IEEE VHDL Language Reference Manual (IEEE Srd 1076-2001), IEEE, 2001

CHU, PONG P., **FPGA Prototyping by VHDLExamples**, John Wiley & Sons Inc, 2008

Recommendations

Subjects that it is recommended to have taken before

Digital electronics/V05G301V01203
Programmable Electronic Circuits/V05G301V01302
Electronic Systems for Signal Processing/V05G301V01312

Other comments

The students will have previously followed the subjects Digital Electronics and Programmable Electronic Circuits. They give the necessary knowledge to understand the topics of this course.
It is not necessary to have passed them.
The students of the specialisation Electronic Systems, should have previously followed the subject Electronic Systems for Signal Processing, but it is not indispensable.

IDENTIFYING DATA				
Advanced electronic sensors				
Subject	Advanced electronic sensors			
Code	V05G301V01409			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	Spanish Galician			
Department				
Coordinator	Costas Pérez, Lucía			
Lecturers				
E-mail				
Web	http://moovi.uvigo.gal			
General description	The main purpose of this subject is to train students in order that they become well-qualified to understand the physical principles and current techniques employed in the most recent electronic sensors technology. Course outline: + Optical fiber sensors. + Microelectromechanical sensors (MEMS). + Image sensors. + Acoustic wave sensors. + Ionizing radiation detection. The documentation of the course will be in English. It will be taught in Galician and Spanish. It will be assessed in Spanish.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C63	(CE63/OP6) The ability to design and use optoelectronic sensors, micromechanical sensors (MEMS) and acoustic wave sensors.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Knowledge of the modes of operation and applications of fiber optic sensors.	B3	C63	
Knowledge of the modes of operation and applications of microelectromechanical sensors.	B3	C63	
Knowledge of the modes of operation and applications of acoustic wave sensors.	B3	C63	
Ability to select and work with next generation electronic sensors.	B4	C63	
Ability to evaluate the measurement systems uncertainty.	B3	C63	
Ability to work in groups and to develop communications skills in order to elaborate and present technical reports related to the subject.	B9	C63	D4

Contents	
Topic	
Unit 1: Physical principles of measurements	- Pyroelectricity y piezoelectricity - Hall effect - Acoustic waves
Unit 2: Optical components of sensors	- Mirrors - Lenses - Waveguides
Unit 3: Interface electronic systems for sensors	- Precision circuits - Low noise techniques

Unit 4: Advanced electronics sensors	- Optic sensors - Microelectromechanical sensors - Acoustic wave sensors . Image sensors (CCD and CMOS sensors) - Ionizing radiation detection
Unit 5: Sensor fusion	- Inertial measurement unit - Mahony, Madgwick and Kalman filter
Groups B: 7 Practices of laboratory with sensors preferably not previously used by the students.	
Groups C: Practice or practical realized with sensors preferably not preferably no previously used by the students. Always that it was possible, will facilitate the material so that the students work of autonomous form out of the laboratory.	

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	1	2
Lecturing	17	8	25
Mentored work	1	12	13
Mentored work	2	18	20
Laboratory practical	12	40	52
Studies excursion	2	0	2
Project based learning	7	29	36

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Subject presentation. Presentation of laboratory sessions, instrumentation and software resources to be used. Individual task. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.
Lecturing	The lecturer will explain in the classroom the main contents of the subject. The students individually have to manage the proposed bibliography to carry out a self-study process in a way that leads to acquire the knowledge and the skills related to the subject. The lecturer will answer the students questions in the classroom or at the office. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.
Mentored work	The students have to manage basic concepts to search and select information in order to get a deeper understanding in some specific fields related to the subject. The lecturer will propose in the classroom the topic of this individual task and monitor the students work in personalized attention sessions. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.
Mentored work	The students have to manage basic concepts to search and select information in order to get a deeper understanding in some specific fields related to the subject. The lecturer will propose in the classroom the topic of this individual task and monitor the students work in personalized attention sessions. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.
Laboratory practical	Small-group activities designed to apply the main concepts and definitions of the subject. The student will be asked to acquire the basic skills to manage the laboratory instrumentation, software tools and components in order to construct and test electronic circuits. The student has to develop and demonstrate autonomous learning and collaborative skills. He/she is supposed to be able to manage bibliography and recently acquired knowledge. Possible questions can be answered in the laboratory sessions or at the lecturers office. Software to be used: National Instruments (NI) LabVIEW and NI Multisim, and Ardunio IDE. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.
Studies excursion	Large-group activities designed to apply, contrast and observe the knowledge within a particular context in an outdoor space. The student will acquire more knowledge about a specific type of sensors through a guided visit to a site where these sensors are being used. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.
Project based learning	Project-based learning: students have to develop a group activity that goes on over a period of time and address a specific problem. They have to design, schedule and carry out a set of tasks to achieve a solution. The assessment will be based on the quality of the proposed solution, the depth of content understanding demonstrated and the final presentation. In these sessions, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be developed.

Personalized assistance

Methodologies	Description
Lecturing	The students can attend tutoring sessions (individually or in a group). The information can find published in the web page: https://moovi.uvigo.gal/. In these sessions the lecturer will answer the students questions and also give instructions to guide the studying and learning process.
Laboratory practical	The students can attend tutoring sessions (individually or in a group). The information can find published in the web page: https://moovi.uvigo.gal/. In these sessions the lecturer will help students understand the work to be developed in the laboratory (components, circuits, instrumentation and tools).
Mentored work	The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject website at the beginning of the term (https://moovi.uvigo.gal/). In these sessions the lecturer will help students to deal with the monitored work.
Project based learning	The students can attend tutoring sessions (individually or in a group). The information can find published in the web page: https://moovi.uvigo.gal/.The lecturers will be available to help students in order to deal with the contents of the subject, the practices as well as the monitored work.

Assessment

	Description	Qualification	Training and Learning Results
Mentored work	It will evaluate the number and the suitability of the bibliographic sources and the contents selected to tackle to thematic assigned. The final mark of this first part of the work (NTT1: Note of the Mentored Work 1) will be comprised between 0 and 10 points. They will evaluate the skils B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4).	15	B3 B4 B9 C63 D4
Mentored work	It will evaluate the work taking into account the quality of the results obtained, of the presentation and analysis of the same, as well as of the final memory delivered. The final mark of this second part of the work (*NTT2: Note of the Mentored Work 2) will be comprised between 0 and 10 points. They will evaluate the skils B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4).	35	B3 B4 B9 C63 D4
Laboratory practical	The lecturers will check the level of compliance of the students with the goals related to the laboratory skills. They will consider the work of the students carried out before the practical session to prepare the proposed tasks, the attendance, and the quality of the work done. The mark for this part (FML: Final Mark of Laboratory) will be graded in a 10 points scale. In these practices, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be assessed.	30	B3 B4 B9 C63 D4
Project based learning	The lecturers will consider the quality of the results obtained, their analysis, and the classroom presentation. Marks will be (GPM: Group Project Mark) assigned in a 10 points scale. In these tasks, the skills B3, B4, B9, C63 and D4 (CG3, CG4, CG9, CE63 and CT4) will be evaluated.	20	B3 B4 B9 C63 D4

Other comments on the Evaluation

1. Continuous assessment

According to the guidelines of the degree and the agreements of the academic commission, a *continuous assessment learning scheme* will be offered to the students.

When the students go to the lectures regularly (less than 10% unjustified absence), or miss at most one B laboratory session, or miss at most one C group project session, ***they will be assessed by continuous assessment.*** An attendance register will be made at each session.

The subject comprises three different parts: theory (15% and 35 %), laboratory practical (30%) and group project (20%). Once a task has been assessed, the students cannot do/repeat the task at a later date. The marks are valid only for the current academic course. The final grade for the students which have selected this option, may not be "no standing".

1.a Theory

In the first weeks of the course each student will be asked to carry out a task individually with the help of the lecturer about a topic related to the subject. The work will be divided in two parts (15% and 35 %). In order to assess the first part, the lecturer will consider the quality of the sources of information ant the contents selected . In order to assess the second part, the lecturer will consider the quality of the results obtained, their analysis, the final report, and the classroom presentation. The students will be informed of the deadline by the lecturer. Marks will be (TWM: Tutored Work Mark) assigned in a 10 points scale. If the students present their works after the deadline the WM will be 0.

The final mark of this part will be:

FMT (Final Mark of Theory) = TWM (Tutored Work Mark)

It is compulsory to get a score of FMT >= 5 and to have attended a lectures regularly (less than 10% unjustified absence) to pass this part by continuous assessment.

1.b Laboratory

Six laboratory sessions and one outdoor study (if it possible to schedule this activity) are scheduled. Each practical session lasts approximately 120 minutes and the students will work in pairs.

The lecturers will assess the individual student work. They will consider the individual work carried out before the laboratory session to prepare the proposed tasks, the laboratory attendance, as well as the student work in the laboratory.

In the first session, the practice 1 will be performed. The mark of this session (P1M: Practice 1 Mark) will be assigned in a 10 points scale.

In the remaining sessions, a practical work related to process control modules available in laboratory will be carried out. In order to assess this work, the lecturer will consider the quality of the results obtained, their analysis, and the classroom presentation. The final mark of this part, (LWM: Laboratory Work Mark) , will be graded in a 10 points scale.

The outdoor study will be also assessed in a 10 points scale (OSM: Outdoor Study Mark).

The final mark of this part is calculated as the weighted sum of the three individual marks:

FML (Final Mark of Laboratory) = 0.15·P1M + 0.75·LWM + 0.10·OSM

Attendance at these classes is compulsory to pass this part by continuous assessment. If the student miss more than one session without a valid documented reason (medical, bereavement or other) he/she will be assigned a grade of 0 for this part (FML=0).

1.c Group project

The classroom workload will be carried out in the C group project sessions. In the first session lecturers will present the objectives and the schedule of the project. They also assign a specific project to each group. In this sessions the lecturer will monitor the group work and the individual student work.

In order to assess the project, the lecturer will consider the quality of the results obtained, their classroom presentation and analysis, and the quality of the final report. The students will be duly informed of the report deadline by the lecturer. The final mark of this part, (GPM: Group Project Mark) , will be assessed in a 10 points scale.

In order to pass this part by continuous assessment, the student can not miss more than one project sessions and only if this absence is duly justified.

1.d Final mark of the subject

In order to past the subject by continuous assessment, students will be required:

+ to obtain FMT >= 5, and

+ no more than one missed practical session, and

+ no more than one missed group project session.

The weighted *points* from all assessed parts are added together to calculate the final *mark(FM)*. The following weightings will be applied: 50% theory, 30% laboratory and 20% group project.

FM = 0.50·FMT + 0.30·FML + 0.20·GPM

A final mark higher than five points (FM >= 5) should be achieved in order to *pass the subject*.

However, when:

+ FMT < 5, or

+ more than one missed practical session, or

+ more than one missed group project session,

the final mark (FM) will be:

NF = min{ 4.9, 0.50·FMT + 0.30·FML + 0.20·GPM }

2. Global assessment

If a student prefers a different educational policy he/she can take an exam on a scheduled *date*. The date will be specified in the academic calendar. This exam will comprise three parts (similar to the activities completed by the continuously assessed students):

+ an **exam** or a task monitored by a tutor (**tutored work**),

+ a **practical exam**,

+ a previously assigned **project**.

The tutored work and the project will be assigned following the procedure described in advance by the lecturer.

2.a Theory

2.a.1 Theory Exam or Tutored Work

In order to pass the theory, the student will have to attend to an exam or a tutored work:

+ the exam with short or long answer questions. Marks will be (EM: Exam Mark) assigned in a 10 points scale.

+ to evaluate the tutored work the lecturer will consider the results, the presentation, the analysis and the quality of the final report. Marks will be (TWM: Tutored Work Mark) assigned in a 10 points scale.

2.a.2 Theory Final Mark

The final mark of theory (FMT) will be:

FMT = EM (Exam Mark) if the exam has been carried out.

FMT = TWM (Tutored Work Mark) if the tutored work has been carried out.

2.b Laboratory

In order to pass the laboratory part, the student will have to attend to a practical exam. In this exam the student will be asked to deal with some of the electronic circuits developed in the practical sessions as well as some short answer questions related to these sessions. Marks will be (LEM: Laboratory Exam Mark) assigned in a 10 points scale.

The final mark of laboratory (FML) will be FML = LEM (Laboratory Exam Mark).

2.c Project

In order to assess the project, the lecturer will consider the quality of the results obtained, their analysis, and the classroom presentation. Marks will be (GPM: Group Project Mark) assigned in a 10 points scale.

2.d Final mark

In order to pass the subject, it is mandatory:

+ FMT >= 5, and

+ FML >= 5, and

+ GPM >= 5.

The final mark will be the weighted average of the marks obtained by the student in the different parts. The final mark (FM) will apply a weight of 50% to the final theory mark (FMT), a 30% to the laboratory final mark (FML) and a 20 % to the group project mark (GPM).

FM = 0,50·FMT + 0,30·FML + 0,20·GPM

A final mark higher than five points (FM >= 5) should be achieved in order to *pass the subject*.

However, when:

+ FMT < 5, or

+ FML < 5, or

+ GPM < 5,

the final mark (FM) will be:

NF = min{ 4.9, 0.50·FMT + 0.30·FML + 0.20·GPM }

3.Extraordinary opportunity and End-of-program exam

The assessment policy in these calls will follow the scheme described in the single assessment. Dates will be specified in the academic calendar. The lecturer will assign the tutored work and the project to the student. The student has to contact to the lecturer according to an established procedure. The procedure will be published in advance.

Marks obtained in the previous continuous or global assessment are kept if the student have got a pass in some parts. Moreover, students cannot take an exam, develop a project or a tutored work task if they have got a pass previously.

The final mark will be the weighted average of the marks obtained by the student as it has described in section 2.

Sources of information

Basic Bibliography

Pérez García, M.A., **Instrumentación Electrónica**, 1ª ed., Ediciones Paraninfo, S.A., 2014

Pallás Areny, R., **Sensores y Acondicionadores de Señal**, 4ª ed., Marcombo D.L., 2003

Norton, H.N., **Sensores y analizadores**, Gustavo Gili D.L., 1984

Fraile Mora, J., García Gutiérrez, P., y Fraile Ardanuy, J., **Instrumentación aplicada a la ingeniería**, 3ª ed., Editorial Garceta, 2013

Martín Fernández, A., **Instrumentación electrónica. Transductores y acondicionadores de señal y sistemas de adquisición de datos**, 2ª ed., Dpto. de publicaciones de la E.U.I.T.T. de Madrid,, 1990

Complementary Bibliography

Jacob Fraden, **Handbook of Modern Sensors, Physics, Design, and Applications**, 5ª, Springer,

del Río Fernández, J., Shariat-Panahi, S., Sarriá Gandul, S., y Lázaro, A.M., **LabVIEW: Programación para Sistemas de Instrumentación**, 1ª ed., Editorial Garceta, 2011

Paul Horowitz y Winfield Hill, **The Art of Electronics**, 3ª, Cambridge Press,, 2015

Recommendations

Other comments

It recommends to have passed the following subjects:
+ Electronic Technology/V05G301V01206
+ Digital Electronics/V05G301V01203
+ Analogue Electronics/V05G301V01311
+ Data Acquisition Systems/V05G301V01314
+ Electronic Instrumentation and Sensors/V05G301V01316

IDENTIFYING DATA				
Remote sensing				
Subject	Remote sensing			
Code	V05G301V01411			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	English			
Department				
Coordinator	Cuiñas Gómez, Íñigo			
Lecturers	Cuiñas Gómez, Íñigo Expósito Pérez, Isabel			
E-mail	inhigo@uvigo.gal			
Web	http://moovi.uvigo.gal			
General description	Remote Sensing is the subject devoted to all systems that allow the collection of data related to objects or surface characteristics without physical contact. We begin presenting the principles of Remote Sensing, in visible, infrared and in microwaves spectrum. Special care will be put on active and passive sensors, with a deep explanation of RADAR and optic-electronic systems. Then, the subject involves technological elements and signal processing, with a focus on the applications on Earth surface and other space bodies. The academic language is English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B7	CG7: The ability to analyze and assess the social and environmental impact of technical solutions.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C65	(CE65/OP8)Applying conceptual, theoretical and practical tools of telecommunications in the development and applications of radar and remote sensing systems.
C66	(CE66/OP9) The ability for selection of circuits, subsystems and systems of remote sensing.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Identify and analyse problems that can be solved with Remote Sensing techniques	B3 B4 B9	C65	D4
Propose solutions based on RADAR, microwaves, infrared, LIDAR or visible spectrum observation	B3 B4 B9	C66	D3 D4
Specify sensors and Remote Sensing systems that are more adequate for each application	B3 B7	C65 C66	D2
Interpret and analyse images taken from satellites	B3 B4 B9	C65	D2

Contents
Topic

Introduction to Remote Sensing	The aim of this topic is to provide a panoramic of the meaning and application of remote sensing of earth, sea and air. Special attention is given to different points of view: from our usual perception of the Earth to its appearance when it is observed from a satellite or another airlifted platform. Besides, the subject shows the historical evolution of Remote Sensing and its implication in the human life, standing out the hits of the space exploration and the different programs that have been designed along the space race. The contents given in group A have an autonomous activity associated, called "The Earth from the air/space", proposed when the subject begins.
Fundamental concepts	The three fundamental concepts of Remote Sensing are the core of this topic: the spectral signature, the classification and the compositions of color. All these are explained after an introduction to the multispectral sensors.
Sensors	Explanation of the concept of sensor, introduction to the different types of sensors, the concept of resolution and calibration. Then, there is at least a session of two hours devoted to the passive sensors (optical-electronic, thermal and radiometers of microwaves) and another session to the active sensors (RADAR and LIDAR). This explanation includes the foundations and operation, its characteristics, advantages and inconvenients, and typical applications. The contents given in group A have several associated practices of laboratory (group B), those called "Sensors calibration", "Passive Sensors: infrared", and "RADAR Fundamentals".
Processing, interpretation and formation of images	This section is a summary of the different techniques of signal processing applied to interpreting and classifying images taken from satellites. It uses an example image to which all different processing techniques are applied and explained. The subject also takes care of the formation of images of big regions of the surface of the Earth from pictures of areas more reduced, by means of the use of mosaics. It shows the process of constructing the mosaic from both satellite and airborne images. All the contents are given in laboratory (group B), for four sessions of 2 hour each. Besides, the works developed in group C will support the contents of this chapter.
Geographic Information Systems (GIS)	Its aim is to introduce the foundations and applications of the GIS, orienting all the explanation to the support in the decisions process related with geographic locations. The second part of the session devotes to deepen in the knowledge of applications of GIS by means of the study of practical cases.
Terrestrial exploration	This section devotes to some examples of applications of Remote Sensing in diverse fields: studies of the ground, agriculture, mining, geology. The own actuality at teaching time can determine the applications in which more upsetting is done. The contents given in group A could have associated some of the works developed by students in groups C, depending on the focus of each group challenge.
Meteorology and Oceanography	In this section, the applications that more satellites have used along the history of Remote Sensing are introduced: the meteorology and the oceanography. In Meteorology, we introduce which types of sensors are employed, and we analyse the different parameters of interest, the characteristics regarding resolution and the results of climatic studies along the planet. Regarding Oceanography, the subject focuses on the observed parameters, the sensors, and it also presents images that show the results of the observations both directly and after the application of distinct processed. The contents given in group A could have associated some of the works developed by students in groups C, depending on the focus of each group challenge.

Space exploration	The aim of the lesson is to show a panoramic of the space exploration. Beginning with the sensors employed along the years of history of the humanity in the space, the subject shows the main knowledges that we have obtained from the distinct bodies of the solar system and it explains how they arrived to this knowledge (missions, peculiarities of the ships and sensors employed, etc.).

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	17.2	25.8	43
Laboratory practical	4	8	12
Practices through ICT	10	17	27
Mentored work	5	43	48
Presentation	2	4	6
Introductory activities	1	1.2	2.2
Autonomous problem solving	0	2	2
Systematic observation	0	2	2
Essay	0	5	5
Essay questions exam	2.8	0	2.8

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The course topics are presented and developed by the lecturer: foundations, theoretical bases, applications, etc. Group A sessions. 1 session/week. 2 hours/session Through this methodology the competencies C65, C66, D2, and B3 are developed.
Laboratory practical	Experimental work on sensor calibration and infrared termography. Group B sessions. 2 sessions/semester. 2 hours/session. Through this methodology the competencies C65, C66, D4, and B4 are developed.
Practices through ICT	Computer-based work on radar fundamentals and satellite imagery processing and interpretation. Group B sessions. 5 sessions/semester. 2 hours/session Through this methodology the competencies B4, B7, B9, D4, and D3 are developed.
Mentored work	The students will be assigned a challenge to be developed in groups of 5-7 students (group C). The challenge will include both electronics and storytelling. Face to face sessions will be devoted to discussion and follow-up of the project, and each content will be defined in advance. Group C sessions. 6 sessions/semester. 1 hour/session. Additional tutorial sessions will be scheduled if required. Through this methodology the competencies B4, B7, B9, D4, and D3 are developed.
Presentation	The students will present, in an open session, the results of their project. Previously, the students must send, by e-mail to the lecturer, a report summarizing the results. Group C sessions. 1 session/semester. 1 hour/session. Through this methodology the competency B9 is developed.
Introductory activities	Activities focused on taking contact and gathering information on the students, as well as to present the topic. For this activity, one face-to-face hour is reserved in group A, during which the professor presents the topic, explain the practices of laboratory and computer, and what expects of the works in group C. This methodology works on competences C65, C66, and B4
Autonomous problem solving	Homework to check the ability of observing the Earth from space images. B4 and D3 are the used competences.

Personalized assistance

Methodologies	Description
Introductory activities	Time that each professor has reserved to attend and resolve doubts of the students https://www.uvigo.gal/es/universidad/administracion-personal/pdi/inigo-cuinas-gomez
Lecturing	Time that the lecturer of group A has reserved to attend and resolve doubts of the students https://www.uvigo.gal/es/universidad/administracion-personal/pdi/inigo-cuinas-gomez
Laboratory practical	Time that the lecturer of groups B can use to help the students understand the lab practices and to resolve doubts. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/inigo-cuinas-gomez
Practices through ICT	Time that the lecturer of groups B can use to help the students understand the lab practices and to resolve doubts. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/inigo-cuinas-gomez
Mentored work	Time that the lecturer of groups C can use to provide support to the tutored groups, additional to the scheduled meetings. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/inigo-cuinas-gomez
Presentation	Time that the lecturer of groups C can use to help the students in preparing their results presentations. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/inigo-cuinas-gomez
Tests	**Description**
Essay questions exam	The lecture of group A will support the students to solve any doubt related to the tests. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/inigo-cuinas-gomez

Assessment

	Description	Qualification	Training and Learning Results		
Lecturing	Essay questions exams: there will be four proofs (10% each), at dates informed to the students at the beginning of the academic year, of 10 minutes length, that allows the student to pass part of the matters.	40	B3 B7	C65 C66	
Laboratory practical	Systematic observation: During laboratory practices, the results and the demonstration of having understood the procedure to arrive to them will be evaluated: 1. "Sensors calibration": 5% 2. "Infrared thermography": 10%	15	B4 B9	C66	D3
Practices through ICT	Systematic observation: During the computer practices , the results and the demonstration of having understood the procedure to arrive to them will be evaluated: 1. "Foundations of RADAR": 7% 2. "Image Processing": 13%	20	B4	C65	D2
Mentored work	The works developed in C groups will be evaluated in two parts: the own dynamics of the works and the presentations. The work itself will receive 15% of the final mark of the subject. Each of the members of the work would receive the same mark, as each of them is co-responsible of the development.	15	B7 B9	C66	
Presentation	Presentations of the works developed by the groups C. After the presentation, the lecturers will ask questions, individually, to the members of the group. The mark of this part will be given individually, depending on the demonstrated knowledge of each member of the group, and will represent 7% of the total subject mark.	7	B9		D4
Autonomous problem solving	Short solution of a homework	3	B4		D3
Essay questions exam	These exams are used to assess the lecture contents, and they are included in that issue	0	B3 B7	C65 C66	

Other comments on the Evaluation

The subject language is English. **Tests, reports and exams should be written in English.**

Evaluation and grading.

The students can chose any of the following assessment systems:

1.-**Continuous evaluation.** This consist of the following activities

1.1. Four quizzes. They account for 40%of the final grade (10% each).

1.2. Performance at lab classes. It accounts for a 35% of the final grade.

1.3. Simulation project results andreport. 15% of the grade.

1.4. Project presentation. 7% of the grade. In carrying out academic activities in this subject, the use of generative artificial intelligence (GAI) is permitted. Its use must be carried out in an ethical, critical and responsible manner. In the case of using GAI, any results it provides must be critically evaluated, and any generated citations or references must be carefully verified. It is also recommended that the use of the tools used be declared.

1.5. Homework. 3% of the final grade.

Missed quizzes and/or lab classes will not be rescheduled.

Students attending to two of the four quizzes will be considered in the continuous assessment system. A student in continuos assessment is considered to be presented to the exam, independently of having taken all assessment events.

Students that want to improve their grade may also attend the exam-only assessment test. Their final grade will be the average between the final exam and the continuous assessment grade.

2.- **Global assessment.** It consists of a 10 questions exam. Time and place are published in the School web page. All material given in the lectures, lab classes and project presentations is subject to questioning.

The extraordinay exam will follow the scheme of global assessment.

The end-of-program exam will also follow the scheme of global assessment.

Ethical code

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information

Basic Bibliography

Iñigo Cuiñas, **Notes of Remote Sensing**, Moovi - UVIGO, 2022

Complementary Bibliography

Emilio Chuvieco Salinero, **Teledetección ambiental: La Observación de la Tierra desde el espacio**, 3, Digital Reasons, 2019

Nicholas M. Short, Sr., **The Remote Sensing Tutorial**, Code 935, Goddard Space Flight Center, 1999

Varios autores, **Exploring the Moon**, NASA, 1997

Águeda Arquero Hidalgo, Consuelo Gonzalo Martín, Estíbaliz Martínez Izquierdo, **Teledetección: Una aproximación desde la superficie al satélite**, Fundación General de la UPM, 2003

Varios autores, **Fundamentals of Remote Sensing**, Canadian Centre for Remote Sensing, 1998

Gerald C. Holst, **Common Sense Approach to Thermal Imaging**, SPIE Optical Engineering Press, 2000

Gary Jedlovec, **Advances in Geoscience and Remote Sensing**, In-Teh, 2009

Iñigo Cuiñas, Verónica Santalla, Ana V. Alejos, María Vera-Isasa, Edita de Lorenzo, Manuel G. Sánche, **Playing LEGO Mindstorms® while Learning Remote Sensing**, International Journal of Engineering Education, vo, 2011

Iñigo Cuiñas, Verónica Santalla, Pablo Torío, **Aprender jugando: fundamentos de Termografía en asignaturas de Teledetección**, Jornada de Innovación Educativa 2012, 2012

Recommendations

Subjects that are recommended to be taken simultaneously

Navigation systems and satellite communications/V05G301V01412

Subjects that it is recommended to have taken before

Microwave Circuits/V05G301V01322
Radio Frequency Circuits/V05G301V01319
Optical Telecommunication Infrastructures/V05G301V01325
Principles of Digital Communications/V05G301V01324

Wireless Systems and Networks/V05G301V01326
Radio Communication Systems/V05G301V01320
Multimedia Signal Processing/V05G301V01321

Other comments

The subject is going to be taught in English.
All the documents will be in English.

IDENTIFYING DATA				
Navigation systems and satellite communications				
Subject	Navigation systems and satellite communications			
Code	V05G301V01412			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	English			
Department				
Coordinator	Aguado Agelet, Fernando Antonio			
Lecturers	Aguado Agelet, Fernando Antonio Mosquera Nartallo, Carlos			
E-mail	faguado@uvigo.gal			
Web	http://moovi.uvigo.gal			
General description	The contents of this course cover the basics of satellite navigation and satellite communication systems: GPS and Galileo, the different segments of satellite communication systems, and an introduction to the planning and development standards. The course will be entirely conducted in English; the use of Spanish or Galego will be optionally allowed in the last exam.			

Training and Learning Results	
Code	
B2	CG2: The knowledge, comprehension and ability to apply the needed legislation during the development of the Technical Telecommunication Engineer profession and aptitude to manage compulsory specifications, procedures and laws.
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C67	(CE67/OP10) Applying conceptual, theoretical and practical tools of telecommunications in the development and applications of navigation and satellite communications systems.
C68	(CE68/OP11) The ability for selection of navigation and satellite communications systems and subsystems.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
To know the planning and development standards of satellite systems.	B2 B3	C67 C68	D3
To know the different alternatives of communication and navigation satellite systems, their different segments (space, ground and user) and the type of orbits.	B3 B4	C67 C68	D2 D3
To know the more usual systems and services for satellite communications, including their technological capabilities and limitations.	B3	C67 C68	D3
To know and apply satellite navigation systems: GPS, Galileo, and other systems.	B2 B3 B4	C67 C68	D2 D3

Contents	
Topic	
Introduction (Theoretical).	- System definition - Standards - Regulations - Allocated frequency bands
Elements of a System (Theoretical).	- Ground Segment - Space Segment - Launch Segment - User Segment

Astrodynamics (Theoretical and Practical).	- Orbital mechanics. - Orbit calculation. - Orbit perturbations.
Architecture of the Communication Subsystems (Theoretical)	Subsystems: - Antennas - Payload: transponders
Introduction to Satellite Communications (Theoretical and Practical).	- Main elements in a communications payload - Signal propagation impairments - Link budget - Multibeam satellites - Satellite Communication Services - Satellite Constellations
Introduction to Navigation Systems (GNSS) (Theoretical and Practical)	- GPS, Galileo, Glonass, and other systems.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	21	42	63
Practices through ICT	13	39	52
Laboratory practical	4	8	12
Mentored work	3	9	12
Problem and/or exercise solving	1	10	11

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	We describe the different aspects of the subject providing all the necessary educational material, including the possibility of using the flipped learning methodology. Through this methodology the competencies B2, B3, C67, C68, D2 and D3 are developed.
Practices through ICT	Every student will apply the theoretical knowledge to different practical tasks covering the main part of the contents of the subject with the help of the software suites. Software to be used: Matlab, Python, Excel. Through this methodology the competencies B3, B4, C67, C68 and D3 are developed.
Laboratory practical	Every student will apply in a practical way the different theoretical knowledge in a specific context. Through this methodology the competencies B3, B4, C67, C68 and D3 are developed.
Mentored work	The student will work in groups, with the support of the university lecturers, to apply, extend and personalize the contents covered in the theoretical and laboratory hours. Through this methodology the competencies B4, C67, C68, D2 and D3 are developed.

Personalized assistance

Methodologies	Description
Mentored work	The students will have the opportunity to attend tutorial hours (face-to-face or virtually) with the university lecturers in the schedule that will be established and published in the subject web-page (https://moovi.uvigo.gal/user/profile.php?id=11661). They may also send their queries by email.

Assessment

	Description	Qualification	Training and Learning Results		
Practices through ICT	The students will perform laboratory practice where they will work with concepts studied in the theoretical classes. The practices will be carried out in groups of 2 people. The final grade will be individual, including the assessment of the student's participation during the sessions as well as the individual final report and, in some practices an individual test.	40	B3 B4	C67 C68	D3

Laboratory practical	Each student will perform field practices. The evaluation will be performed by means of a report for a total weight of 15% of the final mark. The practices will be carried out in groups of 2 people. The final grade will be individual, including the assessment of the student's participation during the sessions as well as the individual final report and, in some practices an individual test.	15	B3 C67 D3 B4 C68
Mentored work	The evaluation of the group work will be taken into account as well as the understanding, maturity, importance and originality of the work and interaction between the group. The tutored works will be carried out in groups of 2 people. The final grade will be individual, including the assessment of the student's participation during the sessions as well as the individual final report.	5	B3 C67 D2 B4 C68 D3
Problem and/or exercise solving	A final test to evaluate the contents presented in the master sessions. The test will be individual with time limit.	40	B2 C67 D2 B3 C68 D3 B4

Other comments on the Evaluation

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Within a maximum period of one month from the start of the course, the student must choose the assessment method for the ordinary opportunity: global assessment or continuous assessment. In the case of having chosen continuous assessment, the qualification cannot be 'not presented'. However, the students may switch to global assessment one week before the final test.

The extraordinary opportunity will always be assessed by global assessment, although, optionally, part of the grades from the continuous assessment can be taken into account.

Language of instruction: English.

All course documentation will be conducted in English, as well as the presentations.

The assessment of the reports and practices will also be carried out in English.

The final exam can be answered in English, Galician or Spanish.

1.- Ordinary opportunity

Global assessment: There will be a final exam that will include questions and problems related to the contents explained both in the master classes, in the computer classroom practices and in the laboratory practices. It will be necessary to score a 5 out of 10 to pass the exam.

Continuous assessment. The subject will be assessed throughout the course:

 Computer classroom practices: different practices will be carried out. Their assessment will weigh 40% of the final grade.

 Tutored works: different tutored works will be carried out throughout the course. Their assessment will be carried out through the correction of the corresponding reports and this part will weigh 5% of the final grade.

 Laboratory practices: different laboratory practices will be carried out. Their assessment will be carried out through the correction of the corresponding reports and this part will weigh 15% of the final grade.

 Final test: this exam will be the last test of the continuous assessment, and will weigh 40% of the final grade.

A grade will be mandatorily assigned in the continuous assessment mode.

.- Extraordinary opportunity: The students will carry out a single evaluation that will include topics and/or problems related to the contents taught both in master classes, seminars and in the supervised works (100% of the final grade). Students who chose continuous assessment for the first opportunity can, optionally, take this single evaluation over 40% of the final grade.

3.- End of career call:

It will consist of an exam with questions and problems related to the contents explained both in the master classes, in the computer classroom practices and in the laboratory practices. It will be necessary to score a 5 out of 10 to pass the exam. The proposed and performed practical works and tasks of this course are not recoverable and are only valid for the current course.

4.- Use of Generative Artificial Intelligence

In conducting the academic activities of this subject, the use of generative artificial intelligence (GAI) is permitted. Its use must be ethical, critical, and responsible. If GAI is used, any results it provides should be critically evaluated, and any generated citations or references should be carefully verified. Additionally, it is recommended to declare the use of the tools utilized.

Sources of information
Basic Bibliography
Maral and Bousquet, **Satellite Communications Systems: Systems, Techniques and Technology.**, 5th. December 2009,
Elliott D. Kaplan, Christopher J. Hegarty, editors, **Understanding GPS : principles and applications**, 2nd. 2006,
Carlos Mosquera, **Satellite Communication Systems: Class notes**, 2024
Maral and Bousquet, **Satellite Communications Systems: Systems, Techniques and Technology.**,
Complementary Bibliography
James R. Wertz, David F. Everett and Jeffery J. Puschell, **Space Mission Engineering: The New SMAD**, 4th.,
http://www.ecss.nl,
Teresa M. Braun, **Satellite Communications, Payload and System**, 1st. 2012,
E. Lutz, M. Werner, A. Jahn, **Satellite Systems for Personal and Broadband Communications**, 1st. 2000,
Organización de Aviación Civil Internacional, **Telecomunicaciones aeronáuticas : Anexo 10 al Convenio sobre aviación civil internacional. Volumen III, Sistemas de telecomunicaciones / Organizacion de Aviación Civil Internacional**, 2009,
Bernhard Hofmann-Wellenhof, Herbert Lichtenegger, Elmar Wasle, **GNSS - global navigation satellite systems : GPS, GLONASS, Galileo, and more**, 1st. 2007,
http://www.trimble.com/gps_tutorial/,
http://www.insidegnss.com/magazine,
http://igs.bkg.bund.de/,
http://waas.stanford.edu/index.html,

Recommendations

Subjects that are recommended to be taken simultaneously
Remote sensing/V05G301V01411

IDENTIFYING DATA				
Digital processing in real time				
Subject	Digital processing in real time			
Code	V05G301V01413			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Cardenal López, Antonio José			
Lecturers	Cardenal López, Antonio José			
E-mail	cardenal@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This course is designed to provide the student with basic knowledge about the design and implementation of real-time digital signal processing (DSP) algorithms. The main objective for the student is to obtain knowledge about the different platforms available for this purpose in scenarios with real-time restrictions, and to learn the practical issues related with the implementation of DSP algorithms in such platforms. Knowledge acquired on lectures will be reinforced by laboratory practices. For this purpose a Digital Signal Processor development board, will be employed. The course will be taught in Spanish, but all teaching materials will be in English. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C69	(CE69/OP12) The ability to implement digital signals processing schemes in programming devices.
C70	(CE70/OP13) The ability to interact digitally with radio signals.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Know the architectures for applications in real time	B3	C69	D2
Develop applications in real time on selected architectures.	B3 B4	C69	D2
Adapt the knowledges of digital signal processing to real time tasks.	B3 B4	C69 C70	D3
Propose digital solutions for its integration in radio transceptors.	B4	C70	D3

Contents	
Topic	
Topic 1 Elementary concepts	Definition of real-time processing. Real-time restrictions for digital signal processing. Overview of hardware platforms for real time digital signal processing.
Topic 2 Time-domain algorithms.	Signal generation. Advanced structures for IIR filters. Finite-precision effects.
Topic 3 Frequency-domain Algorithms	Fast Fourier Transform (FFT). Discrete Cosine Transform. Goertzel algorithm
Topic 4 Introduction to Digital Signal Processors.	DSP architecture. Arithmetic-logic unit. Address-Generation Unit. Program flow control. Performance measures.
Topic 5 High level programming for DSP	Development systems structure. Fixed point programming techniques. Optimising high level code.

Practice 1: Introduction to the development system	Compiling, runing and debugging programs on the DSP development system. Signal generation using lool¡k-up tables
Practice 2: Signal generation	Signal generation using polynomials.
Practice 3: FIR filters	Fixed point FIR filter programming.
Practice 4: IIR filters (I)	IIR filters: coefficient quantization and scaling.
Practice 5: IIR filters (II)	IIR filters: overflow.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	21	42	63
Mentored work	7	35	42
Laboratory practical	3	6	9
Laboratory practical	3	6	9
Laboratory practical	2	4	6
Laboratory practical	2	4	6
Laboratory practical	2	4	6
Essay questions exam	2	7	9

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Presentation of main topics in class. Multimedia material will be made available in faitic before classes take place. Personal study. Support from the instructors through tutorial help. Individual activity. Through this methodology the competencies B3, C69, D2 and D3 are developed.
Mentored work	Group work on a project centered in a practical application using the DSP development board employed in the laboratory.Group activity. Through this methodology the competencies B3, B4, C69, C70, D2 and D3 are developed.
Laboratory practical	Practical exercises on a DSP development board. Matlab will be used for designing filters, and for simulation purpose if necessary. Individual activity. Through this methodology the competencies B4, C69, C70, D2 and D3 are developed.
Laboratory practical	Practical exercises on a DSP development board. Matlab will be used for designing filters, and for simulation purpose if necessary. Individual activity. Through this methodology the competencies B4, C69, C70, D2 and D3 are developed.
Laboratory practical	Practical exercises on a DSP development board. Matlab will be used for designing filters, and for simulation purpose if necessary. Individual activity. Through this methodology the competencies B4, C69, C70, D2 and D3 are developed.
Laboratory practical	Practical exercises on a DSP development board. Matlab will be used for designing filters, and for simulation purpose if necessary. Individual activity. Through this methodology the competencies B4, C69, C70, D2 and D3 are developed.
Laboratory practical	Practical exercises on a DSP development board. Matlab will be used for designing filters, and for simulation purpose if necessary. Individual activity. Through this methodology the competencies B4, C69, C70, D2 and D3 are developed.

Personalized assistance

Methodologies	Description
Laboratory practical	In practical sessions, each student must solve his/her own tasks. The teacher will be available during the session to solve any problem/question or doubt the student may have.
Lecturing	Lectures are develop within a continuous interaction framework, where students can answer questions delivered by the teacher. They could also solve their particular doubts during the sessions. Tutoring hours will be available at https://www.uvigo.gal/universidade/administracion-persoal/pdi/antonio-jose-cardenal-lopez.
Mentored work	Tutored works are developed in small working groups. The works are followed during meetings between the groups and the teacher. In those meetings the students can interact and ask their questions to the teacher.
Laboratory practical	In practical sessions, each student must solve his/her own tasks. The teacher will be available during the session to solve any problem/question or doubt the student may have.
Laboratory practical	In practical sessions, each student must solve his/her own tasks. The teacher will be available during the session to solve any problem/question or doubt the student may have.
Laboratory practical	In practical sessions, each student must solve his/her own tasks. The teacher will be available during the session to solve any problem/question or doubt the student may have.
Laboratory practical	In practical sessions, each student must solve his/her own tasks. The teacher will be available during the session to solve any problem/question or doubt the student may have.

Assessment

	Description	Qualification	Training and Learning Results		
Mentored work	Group work centred in a practical application of real-time signal processing, using the DSP development board.	20	B3 B4	C69	D3
Laboratory practical	Evaluation of practical exercices using the DSP development board. Introduction: signal generation using look-up tables.	10	B3 B4	C69 C70	D2
Laboratory practical	Evaluation of practical exercices using the DSP development board. Signal generation using polynomials .	15	B3 B4	C69 C70	D2
Laboratory practical	Evaluation of practical exercices using the DSP development board. FIR filter programming.	15	B3 B4	C69 C70	D2
Laboratory practical	Evaluation of practical exercices using the DSP development board. IIR filter programming (I).	15	B3 B4	C69 C70	D2
Laboratory practical	Evaluation of practical exercices using the DSP development board. IIR filter programming (II).	15	B3 B4	C69 C70	D2
Essay questions exam	Written exam encompassing all the material exposed in the classroom and laboratory. The teacher will provide the students support to solve any questions related to the exam.	10	B3 B4	C69	D3

Other comments on the Evaluation

The course will be taught in Spanish, but all teaching materials will be in English.

Evaluation

Students shall be offered two evaluation systems: continuous assessment or evaluation at the end of the semester.

Continuous assessment

The continuous assessment of the course will consist in:

- 5 individual practices developed on the DSP development board. These practices will account for 70% of the final grade.
- 1 project to be carried out in group that will account for 20% of the final grade.
- A written exam encompassing all the material exposed in the classroom and in the laboratory. It will take place in the dates scheduled by the school. It will account for 10% of the final grade.

The final qualification of the student will be computed as a weighted sum (70%, 20% and 10%,respectively) of the qualifications of laboratory, group project and final exam.

The contents and the weight of each continuous assessment exercise are the following:

- Introduction: signal generation using look-up tables (10%)
- Signal generation using polynomials (15%)
- FIR filter programming (15%)
- IIR filter programming (I) (15%)
- IIR filter programming (II) (15%)
- Project: (20%)

The laboratory and group project will be considered mandatory for all students who chose continuos assessment.

It will be considered that the student has chosen continuous assessment upon submision of the first three practices. The choice of continuous assessment means that the student can not have a final grade of "Not presented".

Global assessment

1. **Ordinary exam**. Should a student decide not to be graded through continuous assessment,he will have a written examination opportunity that will take place thesame day of the final exam for all the students. The exam will cover all the material mastered in the classroom and the laboratory. Students should communicate their intention to renounce to be graded through continuous assessment at least a week before the date of the final exam.
2. **Extraordinary exam**. Students who do not pass the course at the end of the semester have an opportunity to retest on the end of the academic year. Previously to the exam, students will be asked to choose to be evaluated by continuous assessment system or only by the final exam. In the former case, they will have the opportunity to

improve the continuous assessment grade by means of redoing and improving selected practices.

3. **End-of-program exam.** The student will have a written examination covering all the material mastered in the classroom and the laboratory.

Ethical code

Plagiarism is regardedas serious dishonest behavior. If any form of plagiarism is detected in any of the tests, the final grade will be FAIL (0), and the incident willbe reported to the corresponding academic authorities for prosecution.

Sources of information
Basic Bibliography
Sanjit K. Mitra, **Digital Signal Processing: A Computer Based Approach**, McGraw-Hill,
Complementary Bibliography
Sen M. Kuo, Bob H. Lee, **Real-Time Digital Signal Processing,: Implementations, Application and Experiments with the TMS320C55X**, John Wiley & Sons,
Alan V. Oppenheim, Ronald W. Schafer, **Discrete-Time Signal Processing**, Prentice Hall,

Recommendations

Subjects that it is recommended to have taken before
Multimedia Signal Processing/V05G301V01321

IDENTIFYING DATA				
Digital Communications				
Subject	Digital Communications			
Code	V05G301V01414			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	English			
Department				
Coordinator	Pérez González, Fernando			
Lecturers	Mosquera Nartallo, Carlos Pérez González, Fernando			
E-mail	fperez@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This course covers the fundamentals of modulations that are used in practically all modern communication standards, including digital terrestrial television, WiFi, 4G and 5G mobile communications, digital radio, visible light communications (LiFi). Contents, teaching and exams are in English. Students may participate in classes and answer to exams preferably in English, but Spanish and Galician are also accepted.			

Training and Learning Results	
Code	
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B12	CG12 The development of discussion ability about technical subjects
C71	(CE71/OP14) The ability to analyze the physical layer in modern digital communications systems.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Acquire the intuition and needed math skills to understand the role played by diversity in improving the provision of communication systems.	B4 B9 B12	C71	D2
Handle the necessary tools to understand the different aspects of the physical layer of communications system a system and put them to practice when it comes to simulating, designing or dimensioning.	B4 B9 B12	C71	D2
Develop the capability of analyzing the physical layer of current telecommunication systems.	B4 B9 B12	C71	D2
Strengthen the capacity to follow a technical class in English.	B4 B9 B12		D4

Contents	
Topic	
Subject 1: Multicarrier modulations (theoretical-practical contents).	1.Introduction. 2 Analog and digital OFDM modulations 3 Diagram of an OFDM transmitter. 4 Effect of the channel on the received signal. 5 Diagram of an OFDM receiver. 6 OFDM seen as a block process.

Subject 2: Equalization, coding and synchronization in multicarrier modulations (theoretical-practical contents).	1. Pilot carriers. 2 ZF and MMSE equalization. 3 Zero-padding methods. 4 Coded OFDM (COFDM). 5 Carrier synchronization algorithms. 6 Timing recovery algorithms. 7 Channel state information estimation.
Subject 3: Advanced digital communications (theoretical-practical contents).	1 Convolucional coding. 2 Trellis coding. 3 Advanced channel coding: turbo and LDPC codes.
Subject 4: Applications (practical contents).	1 Digital Radio/TV standards. 2 OFDM wireless communications standards. 3 OFDM cable communications standards. 4 OFDM in visible light communications.

Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	14	57.6	71.6
Mentored work	7	0	7
Lecturing	19	21.6	40.6
Problem and/or exercise solving	2	0	2
Report of practices, practicum and external practices	0	11.5	11.5
Report of practices, practicum and external practices	0	2.9	2.9
Essay	0	14.4	14.4

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Laboratory practical	Lab practices will consist in the demodulation of Digital Radio Mondiale (DRM) signals. This will allow students to practically implement some of the concepts seen in the lectures: OFDM, demodulations, synch recovery,...
Mentored work	Guided work with design considerations for a practical system based on OFDM.
Lecturing	The course is structured in four main subjects that revolve around the concept of multicarrier modulations. Each subject will be taught through lectures in the classroom.

Personalized assistance

Methodologies	Description
Lecturing	The teachers will provide individualized and personalized attention to students during the course, soving their doubts and questions. Doubts will be answered during the master session, or during the office hours. Office hours will be given at the beginning of the course and published in the subject's webpage. Contact: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-perez-gonzalez https://www.uvigo.gal/es/universidad/administracion-personal/pdi/carlos-mosquera-nartallo
Laboratory practical	The teachers will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered during the office hours. Office hours will be given at the beginning of the course and published in the subject's webpage. Contact: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-perez-gonzalez https://www.uvigo.gal/es/universidad/administracion-personal/pdi/carlos-mosquera-nartallo
Mentored work	The teachers will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered during the office hours. Office hours will be given at the beginning of the course and published in the subject's webpage. Contact: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-perez-gonzalez https://www.uvigo.gal/es/universidad/administracion-personal/pdi/carlos-mosquera-nartallo
Tests	**Description**
Report of practices, practicum and external practices	The teachers will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered during the office hours. Office hours will be given at the beginning of the course and published in the subject's webpage. Contact: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-perez-gonzalez https://www.uvigo.gal/es/universidad/administracion-personal/pdi/carlos-mosquera-nartallo
Essay	The teachers will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered during the office hours. Office hours will be given at the beginning of the course and published in the subject's webpage. Contact: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-perez-gonzalez https://www.uvigo.gal/es/universidad/administracion-personal/pdi/carlos-mosquera-nartallo

Report of practices, practicum and external practices	

Assessment

	Description	Qualification	Training and Learning Results		
Problem and/or exercise solving	Final exam with short questions on the contents of the subject, that will include also some questions on the projects. Evaluated competences: CG4, CG9, CG12, CE71, CT2.	20	B4 B9 B12	C71	D2
Report of practices, practicum and external practices	Deliverables for the lab project. Tasks corresponding to a lab project. Deliverables correspond to each of the stages for the Matlab implementation of a simplified OFDM receiver. The weight given to each of these tasks is the following: Task 1 (Demodulation to baseband): 5% Task 2 (Mode detection and temporal allignment): 5% Task 3 (Frequency error correction): 10% Task 4 (Frame synchronization): 10% Task 5 (Channel estimation and equalization - I): 10%	40	B4 B9 B12	C71	D2 D4
Report of practices, practicum and external practices	Deliverables for the lab project. Implementation in Matlab of a task corresponding to a simplified OFDM receiver. Task 6 (Channel estimation and equalization - II): 10%	10	B4 B9 B12	C71	D2 D4
Essay	Short report related to one of the digital communications standards/systems that employ the techniques seen in the lectures. The report will consist of the answers to a list of questions that will be handed at the beginning of the course, related to practical design aspects of a digital communications system using OFDM. Evaluated competences: CG4, CG9, CE71, CT2.	30	B4 B9	C71	D2

Other comments on the Evaluation

In those cases where the student decides not to take part in the continuous assessment tests, the grade for the short-answer exam covering the course content will account for 100% of the final grade.

The student follows the continuous assessment from the moment they submit their first assignment for the course. In any case, they may opt out of continuous assessment within one month. A student who chooses continuous assessment is considered to have taken the course, regardless of whether they sit for the final exam.

For group reports, each student's contribution must be explicitly stated, and assessment will be individualized based on that contribution. The professor may conduct interviews to determine individual contributions.

Continuous assessment tasks cannot be retaken and are only valid for the current academic year.

The grades from continuous assessment tests are retained for the extraordinary exam. For the end of program evaluation, assessment will consist solely of a written exam.

In cases of plagiarism or widespread use of AI tools in any of the assignments/tests, the final grade for the course will be a fail (0), and the professors will report the matter to the school's administration to take appropriate actions. Furthermore, professors will inform the school's administration of any unethical conduct by students, with the possibility of the administration taking necessary measures.

Sources of information

Basic Bibliography

M. Engels, Ed, **Wireless OFDM Systems. How to make them work?**, Springer-Verlag,

Antonio Artés, Fernando Pérez González, Carlos Mosquera et al., **Comunicaciones Digitales**, Pearson,

Complementary Bibliography

Ye Li, G.L. Stuber, **Orthogonal Frequency Division Multiplexing for Wireless Communications**, Springer-Verlag,

J.R. Barry, E.A. Lee, D.G. Messerschmitt, **Digital Communication**, Kluwer,

Recommendations

IDENTIFYING DATA				
Basics of bioengineering				
Subject	Basics of bioengineering			
Code	V05G301V01415			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	English			
Department				
Coordinator	Hermida Domínguez, Ramón Carmelo			
Lecturers	Hermida Domínguez, Ramón Carmelo			
E-mail	rhermida@uvigo.es			
Web	http://faitic.uvigo.es			
General description	This course provides an introduction to several aspects of biomedical engineering, including basic concepts of human physiology, description of most common systems and biomedical signals, and a brief introduction to several electromedical systems. This course will be tough and evaluated in English. All the documentation for this course will be in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B10	CG10 The ability for critical reading of scientific papers and docs.
C72	(CE72/OP15) The knowledge of biomedical engineering elements and techniques and their application in solving therapy, monitoring and diagnostic problems.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Know the systemic structure of the human physiology	B3 B10	C72	D3
Identify biomedical signals and learn their utility in the clinical environment	B3 B4 B9 B10	C72	D2 D3 D4
Adapt the adquired knowledge to propose solutions for the design of systems of diagnostic, monitoring and therapy	B3 B4 B9 B10	C72	D2 D3 D4
Consolidate the capacity to follow a technical class in English	B9 B10		D4

Contents	
Topic	
1. Introduction to biomedical engineering.	Physiology and anatomy of the circulatory system. Measurements in the cardiovascular system. Nervous and endocrine systems. Introduction to chronobiology.

2. Biomedical signals and systems.	Linear least-square estimation. Model comparison and analysis of variance. Techniques for model construction. Introduction to rhythmometry.
3. Diagnosis, monitorization, and therapy.	Criteria for the diagnosis of vascular risk. Ambulatory blood pressure monitoring. Treatment of hypertension: Current approaches. Chronotherapy for cardiovascular risk reduction. Early identification and prevention of complications in pregnancy.
4. Electromedical systems.	Diagnosis by X rays. Nuclear medicine. Ultrasounds. Nuclear magnetic resonance. Biotelemetry. Telemedicine.

Planning

	Class hours	Hours outside the classroom	Total hours
Mentored work	2	35	37
Presentation	7	9	16
Problem solving	10	15	25
Lecturing	21	42	63
Problem and/or exercise solving	2	7	9

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Mentored work	The student, in groups, prepares a document on an application of Biomedical Engineering. Through this methodology the students will develop the competencies B3, B4, B9, and C72.
Presentation	Exhibition by the students in front of the professor and the rest of students of the work realized in small groups. Through this methodology the students will develop the competencies B9 and C72.
Problem solving	Some topics will be complemented with problem resolution. Through this methodology the students will develop the competencies B3, B4, B9, and C72.
Lecturing	Exposition by the professor of the main concepts of each topic. This will be complemented by the student´s own work with recommended readings to extend the concepts explained in the classroom. Through this methodology the students will develop the competencies B3, B4, B9, B10, C72, D2, D3, and D4.

Personalized assistance

Methodologies	Description
Lecturing	Students will have the opportunity to attend personalized tutorials in the modality that each teacher will establish for this purpose at the beginning of the course. Tutorials may be carried out in person or by telematic means. On the page of the course in MooVi, within the section "Teachers and tutorials" (https://moovi.uvigo.gal) the contact details of the teaching staff will be specified.
Mentored work	Students will have the opportunity to attend personalized tutorials in the modality that each teacher will establish for this purpose at the beginning of the course. Tutorials may be carried out in person or by telematic means. On the page of the course in MooVi, within the section "Teachers and tutorials" (https://moovi.uvigo.gal) the contact details of the teaching staff will be specified.
Problem solving	Students will have the opportunity to attend personalized tutorials in the modality that each teacher will establish for this purpose at the beginning of the course. Tutorials may be carried out in person or by telematic means. On the page of the course in MooVi, within the section "Teachers and tutorials" (https://moovi.uvigo.gal) the contact details of the teaching staff will be specified.

Assessment

	Description	Qualification	Training and Learning Results		
Mentored work	Composition, in small groups, of a monographic document related to one of the electromedical systems in bioengineering (nuclear medicine, ultrasounds, magnetic resonance, biotelemetry, telemedicine).	20	B9 B10	C72	D4
Presentation	Exhibition by the students of the tutored work, and discussion of the findings with the professor and other students.	10	B9 B10	C72	D4
Problem solving	Short questions on the problems solved in the practices in relation to the contents of the master sessions.	40	B3 B4	C72	D2 D3

Problem and/or exercise solving	The final exam will consist on small questions and problems in relation to the master sessions, laboratory practices, and presentation of the tutored works.	30	B3 B4	C72	D2 D3

Other comments on the Evaluation

Following the own guidelines of the degree, two systems of assessment will be offered to the students registered in this course: continuous assessment and global assessment. All the students that wish to renounce to the continuous assessment (election by default), will have to communicate it to the professor during the first month after the beginning of classes.

The continuous assessment will be based on the grades obtained in the tutored work and its exposition, as well as in up to three intermediate tests. The tutored work will be evaluated in terms of composition, accuracy and style and the grade will be the same for all members of the group. The use of artificial intelligence will not be allowed for the composition of the tutored work. Individualized evaluation will be based on the exposition of the work (timing, clarity, accuracy) and the answers to specific questions by the professor and other students. The grades obtained throughout the continuous evaluation will only be valid for the first opportunity of the current academic year. The tests of the continuous assessment are not recoverable, that is to say, if somebody cannot make them the professors are not obligated to repeat them. For a student under continuous assessment his/her final grade cannot be "not presented".

The students who do not opt for the continuous assessment will have to make a final examination, with theory and problems on all the contents of the course. This final exam will be graded between 0 and 10, and this will be the final grade obtained by the student. The extraordinary exam, as well as the end-of-program exam, will have a similar structure to the final examination of those students who do not choose the continuous assessment.

All tests will be performed in English.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information

Basic Bibliography

Guyton & Hall, **Textbook of Medical Physiology**, 13th edition, W.B. Saunders Company, 2015

Weisberg S, **Applied Linear Regression**, 4ª Ed., J Wiley & Sons,, 2013

Hermida RC, Smolensky MH, Ayala DE, et al., **2013 ambulatory blood pressure monitoring recommendations for the diagnosis of adult hypertension, assessment of cardiovascular and other hypertension-associated risk, and attainment of therapeutic go**, 30, Chronobiol Int, 2013

Complementary Bibliography

Webster JG, **Medical Instrumentation. Application and Design**, 4th edition, Wiley, 2009

Cook RD, Weisberg S, **Residuals and Influence in Regression**, Chapman Hall, 1982

Enderle J, Blanchard S, Bronzino J., **Introduction to Biomedical Engineering.**, 3rd edition., Academic Press, 2012

Recommendations

IDENTIFYING DATA				
Image and video analysis				
Subject	Image and video analysis			
Code	V05G301V01416			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	English			
Department				
Coordinator	Alba Castro, José Luis			
Lecturers	Alba Castro, José Luis			
E-mail	jalba@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This subject is the continuation of the one of 3º Image Processing Fundamentals. The student will acquire knowledges and competence on high level techniques to analyse images and extract information of interest for different applications. The subject is taught and evaluated in English. The documentation is in English.			

Training and Learning Results	
Code	
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B10	CG10 The ability for critical reading of scientific papers and docs.
B12	CG12 The development of discussion ability about technical subjects
C73	(CE73/OP16) Ability to design and construct solutions based on image and video analysis and processing for different practical applications.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Understand the foundations of standard techniques to analyze images	B10 B12		D2
Apply image analysis techniques in computers	B9 B12	C73	D4
Understand the foundations of image description techniques in advanced systems	B10 B12		D2
Identify different analysis necessities for different imaging systems	B9 B12	C73	D4
Design an image and video analysis and description system	B4 B9	C73	D4

Contents	
Topic	
Image analysis	Overview of color spaces. Spatial filters.Filters and the convolutional networks. Segmentation based in colour, textures, outlines and models. Segmentation by means of trained models. Extraction of descriptive characteristics and invariants. There will be a hands-on practice for this part, programming a small project.
Description and classification of objects.	Clustering. Image descriptors. Classical and probabilistic decisors. Classification. convolutional neural networks (CNN). Deep learning based object detection. There will be a hands-on practice for this part, programming a small project.

Applications	Description of end-to-end pipeline processing. Classical approximation, with models of deep and hybrid learning. Real-time video processing There will be a hands-on practice for this part, programming a small project.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	10	10	20
Mentored work	24	82	106
Presentation	3	6	9
Introductory activities	3	0	3
Objective questions exam	2	0	2
Report of practices, practicum and external practices	0	10	10

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Each 3-hour class will include one hour of explanation of subject contents, encouraging critical discussion and assimilation through computer programming and visualization.
Mentored work	Each 3-hour session will include 2 hours of "hands-on" working to assimilate the explained concepts through problem-based learning (PBL). Every Problem/Task will take several weeks of the subject during which the student will have to discover, alone or with the professor guidance, what he needs to solve the problem effectively.
Presentation	The third and last task will be presented in front of the class mates. The students from the same group will have to split the presentation, so both of them explain one part of the work.
Introductory activities	In the first class of the course, concepts learned in FPI and the programming tools for the course will be reviewed.

Personalized assistance

Methodologies	**Description**
Introductory activities	The introductory activities are related to motivation for learning how to to develop projects in real-life.
Lecturing	During the master sessions, the teacher asks questions to the class and/or specific student to grab their attention about the current topic.
Mentored work	This methodology gives a lot of room for personalized attention. The teacher sits with each of the groups and guides every student through the step-by-step process of building a solution.
Presentation	Every time a student has to deliver a presentation (in the last guided task and also when challenged to beat another group in a specific subtask), the teacher explains him/them how to improve the impact of their presentation.

Assessment

	Description	Qualification	Training and Learning Results		
Objective questions exam	Each part of the subject has theoretical concepts that are explained in class. The concepts are assessed through these tests, that are also formally linked to the delivery of each guided task. They are meant to grade each student individually. They help to assess general competence A82. The concepts are discussed in class and also individually through the e-learning platform and/or counseling hours.	30	B10 B12	C73	
Report of practices, practicum and external practices	Each part of the subject is learnt through a hands-on guided task. Most of the teacher's time is devoted to discuss, both in group and individually, how to go step by step through the process of building a solution. The score of the guided task includes: the follow-up of each student, the techniques used, the results achieved, the quality of the report and the oral presentation of the last one. The guided tasks help to assess general competences A4, A82, B1 and B3.	70	B4 B9	C73	D2 D4

Other comments on the Evaluation

The language of instruction and assessment is English.

Attendance in Continuous Assessment (CA) is mandatory, except under exceptional circumstances. CA is used to evaluate the course, based on the student's work in the laboratory and assignments related to the course content.

There is a Global Assessment (GA) exam on the official date set by the School Board, for students who have not passed CA and wish to pass the course. This GA exam will be graded from 0 to 10 points and includes all course topics along with concepts and techniques explained in the assignments. To pass, the student must score at least five points. Students who wish to improve their CA grade may also take this exam, in which case the final course grade will be the higher of the CA grade or the GA grade.

Throughout the semester, students will receive feedback on their progress in CA, along with the grades of each assignment and associated tests. Submitting any assignment or test constitutes official participation in CA, implying that the student has registered for the course even if they do not take the final exam.

The extraordinary opportunity at the end of the academic year will consist of an exam for students who have not passed either CA or GA. The course grade will be the grade of this extraordinary exam. This exam will be graded from 0 to 10 points and includes all course topics. To pass, the student must score at least five points.

In conducting academic activities for this course, the use of generative artificial intelligence (GAI) is permitted and encouraged. Its use should be ethical, critical, and responsible. If GAI is used, any results it provides should be critically evaluated, and any citations or references generated should be carefully verified. Additionally, the use of such tools must be declared. Failure to declare their use will be considered another form of plagiarism.

If plagiarism is detected in any tests or assignments, the final grade will be FAIL (0) and the incident will be reported to the school administration for appropriate action.

Sources of information

Basic Bibliography

Rafael C. Gonzalez, Richard E. Woods, **Digital Image Processing**, 3ª (2008),

Robert Laganière, **OpenCV 2 Computer Vision Application Programming Cookbook**, 2011,

Complementary Bibliography

Richard O. Duda, Peter E. Hart, David G. Stork, **Pattern Classification**, 2ª (2001),

Recommendations

Subjects that it is recommended to have taken before

Fundamentals of Sound and Image/V05G301V01209
Fundamentals of Image Processing/V05G301V01333
Multimedia Signal Processing/V05G301V01321
Video and Television/V05G301V01329

IDENTIFYING DATA				
Video games and virtual reality				
Subject	Video games and virtual reality			
Code	V05G301V01417			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Pena Giménez, Antonio			
Lecturers	Pena Giménez, Antonio			
E-mail	apena@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Topics related to Virtual Environments (video games, augmented reality, virtual reality). A videogame is developed in a multidisciplinary group, with students from other degrees. The development engine is Unity and programming language is C #. English Friendly subject, International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B12	CG12 The development of discussion ability about technical subjects
C74	(CE74/OP17) The ability to construct, exploit and manage image and synthetic video generation systems and interactive multimedia applications.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Understand and apply the production pipeline of a video game code, as an example of a complex virtual environment.	B3 B12	C74	D3
Know how to optimize the performance of graphics engines in virtual environments. Understand and apply the necessary mathematical tools in three-dimensional virtual environments.	B3 B12	C74	D3
Understand the key aspects when designing Augmented Reality applications. Understand the key aspects when designing Virtual Reality applications.	B3 B9	C74	D3 D4

Contents	
Topic	
Computer image synthesis	Approach to the associated electronics with the graphic processing boards on computers.
Audio 3D	Programming the soundscapes in a three-dimensional virtual environment. Mixing of different sound sources (environment, dialogues, effects, ...).
Virtual Reality, Enhanced Reality	Description of the mathematics underlying the creation of a Virtual Environment. Description and issues of virtual reality and augmented reality applications.

Video games	Multidisciplinarity in the construction of a video game. Notions of video game design. Pipeline in the development of a video game. Management and programming of a virtual environment engine (Unity).

Planning			
	Class hours	Hours outside the classroom	Total hours
Project based learning	7	59.5	66.5
Practices through ICT	16	8.5	24.5
Lecturing	17	26	43
Flipped Learning	0	14	14
Problem and/or exercise solving	2	0	2

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Project based learning	Collaborative work in a small multidisciplinary group, with students from other Degrees of the University of Vigo, for the elaboration of a video game, following the professional production process of the related industry, from an initial concept to a final product. Group work, role assignments, working in common, planning, technical reports and oral presentation are considered. Through this methodology, competencies CG3, CG9, CE74, CT3, CT4 are developed.
Practices through ICT	Management and adjustment of the engine of a Virtual Environment. Programming of components in virtual objects. Through this methodology, competencies CG3, CG12, CE74, CT3 are developed.
Lecturing	Exposition by the teacher of the contents of the subject, encouraging the critical discussion of the concepts. The theoretical bases of algorithms and procedures used to solve problems are laid down. Through this methodology, competencies CG3, CG12, CE74, CT3 are developed.
Flipped Learning	Written and / or audiovisual material is provided to study and prepare an online test. This activity is prior to the master class or computer room sessions where doubts will be solved and challenges will arise. Through this methodology, competencies CG3, CE74 are developed.

Personalized assistance

Methodologies	Description
Lecturing	Tutoring to solve issues related to master sessions or lab practice is implemented either individually or in reduced groups (no more than 2-3 students). E-mail confirmation to match the date of the appointment is needed. Contact: https://moovi.uvigo.gal/user/profile.php?id=11310
Practices through ICT	Tutoring to solve issues related to master sessions or lab practice is implemented either individually or in reduced groups (no more than 2-3 students). E-mail confirmation to match the date of the appointment is needed. Contact: https://moovi.uvigo.gal/user/profile.php?id=11310
Project based learning	During group projects an individualized tracking of the student is developed. Cross-evaluation within the group and autoevaluation may be used.

Assessment					
	Description	Qualification	Training and Learning Results		
Project based learning	Assessment of different tasks in a collaborative work, developed along the semester, including a written report and oral presentation.	50	B3 B9	C74	D3 D4
Practices through ICT	Work assessment in the computer room.	15	B3 B12	C74	D3
Flipped Learning	Automatic corrected online test.	10	B3	C74	
Problem and/or exercise solving	Written test with short questions and problems to solve.	25	B3 B12	C74	D3

Other comments on the Evaluation

*** "Students who choose continuous assessment" conditions:**

A student follows the continuous assessment system if she/he assigns a document that will be delivered and collected after week 4.

If a student has participated in continuous assessment and does not pass the course he/she will receive a grade of fail, regardless of he/she takes the written exam or not.

CONDITIONS TO PASS THE SUBJECT

In order to ensure that students acquire a balanced minimum on the subject competences, they will pass the course if they meet these two conditions:

1) get a final mark equal to or greater than 5 (on a ten-points scale)

2) and a score equal to or greater than 4 (on the same scale) in each of the partial marks (written exam and collaborative group, respectively).

If some of these conditions are not fulfilled, then the final grade (on a ten-points scale) will be the minimum between the final mark and the value 4.9.

*** "Students who choose for global assessment" conditions:**

The possibility of a final examination will be provided to students who do not opt for the continuous assessment.

In order to ensure that students acquire a balanced minimum on the subject competences, they will pass the course if they meet both these two conditions:

1) get a final mark equal to or greater than 5 (on a ten-points scale)

2) and a score equal to or greater than 4 (on the same scale) in each of the sections of the exam. These sections, respectively, correspond with:

* contents included in all activities

* project developed in group, including group internals, management, writing of technical reports and oral presentations.

If some of these conditions are not fulfilled, then the final grade (on a ten-points scale) will be the minimum between the final mark and the value 4,9.

--- EXTRAORDINARY EXAM

Two different situations:

=> Students that are evaluated using continuous assessment:

Two options to choose (just before the exam begins):

* repeat the written exam included in the continuous assessment planning an be evaluated under the "Students who choose continuous assessment" conditions, described above.

* be evaluated with the same final exam of students who choose for global assessment, under the "Students who choose for global assessment" evaluation conditions, described above. No other activities are considered.

=> Students who choose for global assessment:

A final examination will be provided to students who do not opt for the continuous assessment, and are evaluated under the "Students who choose for exam-only assessment" conditions, described above. No other activities are considered.

In case of detection of plagiarism in any of the exams or assignments, the final grade will be SUSPENSE (0) and the fact will be communicated to the management of the Center for the corresponding effects.

Sources of information
Basic Bibliography
Jeremy Gibson, **Introduction to Game Design, Prototyping, and Development (Game Design and Development)**, Ed. 1, Addison Wesley, 2014
Fletcher Dunn, Ian Parberry, **3D Math Primer for Graphics and Game Development**, Ed. 2, A K Peters/CRC Press, 2011
Unity, **Unity web: API description, tutorials and more. (https://unity3d.com)**,
Complementary Bibliography
Jason Gregory (Editor), **Game Engine Architecture**, Ed. 2, A K Peters/CRC Press, 2014
Durant R. Begault, **3-D sound for virtual reality and multimedia (https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20010044352.pdf)**, Ed. 1, 1994

Eric Lengyel, **Mathematics for 3D Game Programming and Computer Graphics**, Ed. 2, Course Technology, 2011
Guy Somberg, **Game Audio Programming: Principles and Practices**, Ed. 1, CRC Press, 2016
Steven M. LaValle, **Virtual Reality (http://vr.cs.uiuc.edu/vrbooka4.pdf)**, Ed. 1, University of Illinois, 2017
Robert Nystrom, **Game Programming Patterns (http://gameprogrammingpatterns.com/contents.html)**, Ed. 1, 2014
Dieter Schmalstieg, Tobias Hollerer, **Augmented Reality: Principles and Practice (Usability)**, Ed. 1, Addison-Wesley Professional, 2016

Recommendations

Subjects that continue the syllabus

Final Year Dissertation/V05G301V01991

Subjects that are recommended to be taken simultaneously

Audiovisual production CGI/V05G301V01420

Subjects that it is recommended to have taken before

Interactive Audio Systems/V05G301V01331

Other comments

There will be group work virtual sessions on Wednesday mornings and two face-to-face meetings, one at the Campus of Vigo and other at the Campus of Pontevedra. The University will provide free round trip transportation from the Escola de Enxeñaría de Telecomunicación or the Facultad de Ciencias Sociais e a Comunicación, respectively.

Multidisciplinary groups will be formed by students of the following three subjects: (1) Video Games: design and development, 4th year, Degree in Audiovisual Communication. (2) Video games and virtual reality, 4th year, Degree in Telecommunication Engineering Technologies, Sound and Image module. (3) Intelligent systems programming, 4th year, Degree in Telecommunication Engineering Technologies, Telematics module. The activity is coordinated by teachers of the Teaching Innovation Group: ComTecArt (Communication, Technology and Art in Virtual Environments).

The use of generative artificial intelligence (GAI) is allowed while carrying out the academic activities of this subject. Its use must be ethical, critical and responsible. When using GAI, any result should be critically evaluated, and any citations or references generated should be carefully verified. Likewise, it is recommended to declare the use of the tools used.

IDENTIFYING DATA				
Advanced acoustics				
Subject	Advanced acoustics			
Code	V05G301V01418			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	English			
Department				
Coordinator	Sobreira Seoane, Manuel Ángel			
Lecturers	García Lomba, Guillermo			
E-mail	msobre@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	In this subject, the use of advanced calculation methods in Acoustics are introduced. The Finite Element Method (FEM) and the Boundary Element Method (BEM) are applied to study problems of acoustic radiation, diffraction and modal analysis (calculation of mode shapes and resonance frequencies). Statistical Analysis Methods (SEA) are also introduced and applied to the calculation of flanking transmission in buildings.			

Training and Learning Results	
Code	
B2	CG2: The knowledge, comprehension and ability to apply the needed legislation during the development of the Technical Telecommunication Engineer profession and aptitude to manage compulsory specifications, procedures and laws.
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
B7	CG7: The ability to analyze and assess the social and environmental impact of technical solutions.
C76	(CE76/OP19) The ability to apply numerical methods in acoustical problem solving.
C77	(CE77/OP20) The ability to indentify industrial noise problems and to design appropriate control solutions.

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Knowledge on the application of numerical methods in acoustics.	B2
Knowledge on the application of calculation models of sound transmission in structures.	B5
Knowledge on design techniques of acoustic noise barriers.	B7
Capacity for understanding the results of complex acoustic measures and relate them with the calculations obtained by means of simulations	C76
The ability to indentify industrial noise problems and to design appropriate control solutions	C77

Contents	
Topic	
Introduction.	Review of acoustic concepts: impedance, boundary conditions, Helmholtz and Euler equations.
The Finite Elements Method in Acoustics (FEM)	Theoretical introduction to the Finite Element Method. Radiation Problems with FEM. Diffraction Problems. Modal analysis with FEM: resonance frequencies and modes
The Boundary Element Method in Acoustics (BEM)	Introduction to the Boundary Element Method in Acoustics. Integral equation of Kirchhoff Helmholtz. Application to radiation and diffraction problems. The calculation of resonances in BEM.
Calculation methods based in S.E.A. Calculation of sound transmission in buildings.	Building Acoustics: acoustic insulation in buildings and determination of the flanking transmission. Calculation method of the international standard ISO 12354.
Other calculation methods.	Ray tracing and application to evaluation of sound propagation outdoors. Prediction of noise levels in industrial plants. Noise control.

Planning			
	Class hours	Hours outside the classroom	Total hours
Mentored work	12	30	42
Practices through ICT	12	24	36

Previous studies	0	15	15
Lecturing	19	38	57

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Mentored work	The student have develop two projects and deliver the corresponding reports for evaluation. Through this methodology the general competencies CG2, CG5, CG7 and the specific competency CE77 are developed. Transversal competencies as CT3 and CT4 are also developed.
Practices through ICT	The student will work with different software packages to apply the different calculation methods presented un the subject. 1. CAD and mesh generation: FreeCAD and Gmsh. 2. Finite Element calculations : COMSOL. 3. Boundary Element calculations: OpenBEM. 4. Calculations in building acoustics. Through this methodology the specific competencies CE 75, CE67 and CE77 are developed
Previous studies	The students must study and prepare with the sources of information given before the lectures and the practical sessions. Through this methodology the general competencies CG2, CG5, CG7 and the specific competencies CE75, CE76 and CE77 are developed.
Lecturing	Lectures will be given, developing the main theoretical concepts of the subject. Through this methodology the general competencies CG2, CG5, CG7 and the specific competencies CE75, CE76 and CE77 are developed.

Personalized assistance

Methodologies	Description
Lecturing	Lectures are developed within a continuous interaction framework, where students can answer questions delivered by the teacher. They could also solve their particular doubts during the sessions. In any case the students will be able to contact the teacher to request tutoring through the platform of the subject (moovi.uvigo.gal).
Mentored work	Tutored works are developed in small working groups. The works are followed during meetings between the groups and the teacher. In those meetings the students can interact and ask their questions to the teacher.
Practices through ICT	In practical sessions, each student must solve his/her own tasks. The teacher will be available during the session to solve any problem/question or doubt the student may have.

Assessment

	Description	Qualification	Training and Learning Results	
Mentored work	Two practical project, with the delivery of a final report. The learning aims related to the ability to elaborate projects and application of calculation methods (numerical methods) are assessed. Learning aims related to the identification of problems are also assessed (through the application of numerical calculations).	50	B2 B5 B7	C77
Practices through ICT	Realisation of 4 practices on simulation in acoustics using numerical methods: In three practices the Finite Element Method will be applied. The software COMSOL Multiphysics for the simulation of some specific cases in Acoustics will be used. The set of three practices will have a weight of 40% on the global grade. The remaining practice will solved using the with the package OpenBEM, that allows to apply the boundary elements method (BEM) to the analysis of the acoustic field in cavities (10% of the global note).	50	B2 B5 B7	C76 C77

Other comments on the Evaluation

Following the guidelines of the degree, students who take this subject will be offered two evaluation systems: continuous and global assessment (at the end of the semester). By default it is assumed all students follow the continuous evaluation system unless they present a written resignation after the first month of class. The global evaluation system is only recommended in situations where it is impossible to follow the continuous evaluation process.

LANGUAGE: Any student can choose which language will use during the assessment process (English, Spanish).

CONTINUOUS ASSESSMENT:

The continuous assessment will be carried out according to the methodologies and tests indicated below:

- Two supervised works (50% of the final grade). Each work weights a 25% on the final grade. The supervised works will be developed in groups.

    - The individual grade of each component of the group will be obtained through the results of cross-evaluation surveys among the members of the group and the individual presentation of the contribution to the work of the group. The minimum grade necessary to consider that the contribution of a student to the work of the group is satisfactory will be 2 out of 5 points.
    - The student's competences will be evaluated during the presentation of the work. Their capacities of synthesis, analysis, mastery of the specific vocabulary of the specialty and their skills for oral exchange will be taken into account. 25% of the final grade of the work will be assigned from the individual presentation.

- Delivery of three reports and results of practices with the support of ICT carried out with the finite element method (FEM) (40% of the final grade).
- Delivery of a practice report carried out with the boundary element method (BEM), on the acoustic field analysis in cavities. (10% of the final grade).

The final grade will be obtained through the weighted average of the grades obtained. A minimum of 4 out of 10 points in each work / practical report is required. In case a student does not meet the requirement in any of the competences evaluated but the weighted average is greater than 5, he will be assigned a failed as final grade (4.9 points). In this case, the student in continuous evaluation will have to do the tasks required to pass the final examination in the official data.
ORDINARY EXAM, GLOBAL ASSESSMENT:In case a student does not follow the continuous evaluation process, a final exam must be take on on the date published by the center. The student will have to:

- Deliver of two works requested by the teaching staff (1 work on the application of boundary elements, 1 work on the application of the finite element method). The student must obtain at least 4 out of 10 points in each of the works.
- Answer in a written exam questions about the theoretical contents of the subject. The student must obtain at least 4 out of 10 points.

The final grade will be obtained by averaging all the grades. In case the average grade exceeds 5 points but in either any of the works or in the written test the minimum requirement has not been met, the final grade will be fail (4.9 points).
EXTRAORDINARY AND END OF PROGRAM EXAMS: 1, GLOBAL ASSESSMENT:
Students who have to take a final extraordinary exam or an end or program exam must contact the teaching staff previously to request the assignment of two works, to proceed as described previously in case of the final exam in ordinary call.
2. CONTINUOUS ASSESSMENT:
In the case that a student following the continuous assessment proceess has passed he minimum requirements in some proof of evaluation (works/tests written) the grade will be kept during 1 academic year. Either a written test or some works agreed with the teacher mus be done. The grades will not be kept if they have been obtained in past academic years.
Plagiarism is regarded as serious misconduct. If any form of plagiarism is detected in any test or work, according to the circumstances, the final grade of the course might be FAIL (0) and the corresponding academic authorities informed about the fact in order to take further measures.

Sources of information
Basic Bibliography
Ciskowski R.D. and Brebbia C.A., **Boundary Element Methods in Acoustics**,
CEN European Standards, **EN 12354-1:2000. Building Acoustics - Estimation of acoustic performance of buildings from the performance of elements - Part 1: Airborne sound insulation between rooms**,
Reddy, J.N., **An introduction to the Finite Element Method,**, 2ª y 3ª ed,
Complementary Bibliography
Johnson C., **Numerical solution of PDE by the finite element method.**,
Quarteroni A, Valli A., **Numerical approximation of partial differential equations**,
Juhl, P.M., **The Boundary Element Method for Sound Field Calculations**,

Recommendations

IDENTIFYING DATA				
Legislation and noise measurement techniques				
Subject	Legislation and noise measurement techniques			
Code	V05G301V01419			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	English			
Department				
Coordinator	Torres Guijarro, María Soledad			
Lecturers	Torres Guijarro, María Soledad			
E-mail	soledadtorres@uvigo.es			
Web	http://faitic.uvigo.es			
General description	In this subject, the main methods of measurement of environmental noise are discussed. The European an national regulations on noise and acoustic insulation are also presented. As part of the measurement process, a guide for the evaluation of the measurement uncertainty in acoustics is also presented. The teaching will be in English.			

Training and Learning Results	
Code	
B2	CG2: The knowledge, comprehension and ability to apply the needed legislation during the development of the Technical Telecommunication Engineer profession and aptitude to manage compulsory specifications, procedures and laws.
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
B7	CG7: The ability to analyze and assess the social and environmental impact of technical solutions.
B8	CG8: To know and apply basic elements of economics and human resources management, project organization and planning, as well as the legislation, regulation and standarization in Telecommunications.
C75	(CE75/OP18) The ability to elaborate noise maps and their geographical information display.
C78	(CE78/OP21) The ability to write essays on environmental, construction and automation acoustics.
C79	(CE79/OP22) The ability to elaborate specific acoustic essay procedures.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
Knowledge of the European, national and regional legislation in the field of acoustic engineering.	B2	
Knowledge of the most common measurement standards in acoustics testing laboratories.	B2	
Ability to prepare technical reports, test reports and expert reports in the field of acoustic engineering.	B5 B7 B8	C75
Ability to develop measurement procedures adapted to legislative requirements.		C78 C79

Contents	
Topic	
Introduction: noise, its description and annoyance.	Classification of noise and descriptors. The assessment of noise. General overview of measurements in acoustics. Nose levels, vehicle noise. Practices for measurement car pass by nosie.
Description and measurement of environmental noise	Characterization of the noise sources. Influence of the propagation conditions. Practices for indoor and outdoor noise measurements
Environmental noise regulations in Europe.	The EU Environmental Noise Directive. Directive 2002/49/EC of the European Parliament and of the Council of 25th June 2002 relating to the assessment and management of environmental noise. National noise regulations. Practices for measurement procedures application.
Acoustic Insulation, description and regulations in Europe.	Acoustic insulation, descriptors. National Code Buildings in Europe, and the regulations on acoustic insulation. Practices for measurement.

Measurement uncertainty.	The need to assess the measurement uncertainty: quality management in laboratories. The guide for expression of uncertainty in measurement- GUM. Measurement Uncertainty in Acoustics. Exercices for uncertainty computation.

Planning

	Class hours	Hours outside the classroom	Total hours
Mentored work	6	24	30
Laboratory practical	12	9	21
Previous studies	0	15	15
Lecturing	19	38	57
Problem and/or exercise solving	2	8	10
Report of practices, practicum and external practices	2	10	12
Essay	1	4	5

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Mentored work	The student has to develop in group and write a report on two projects: 1. Procedure to describe and assess environmental noise un a real scenario. 2. Project of acoustic insulation according to the simplified method described in the CTE-DB HR (Spanish Building Code, document for protection against noise). Through this methodology the competencies B2, B5, B7, B8, C75, C78, C79 are developed.
Laboratory practical	Laboratory practises in group on: 1. Characterization and assessment of noise annoyance. Spatial and temporal sampling. 2. Measurement of vehicle pas-by noise. 3. Measurement of acoustic insulation in buildings. 4. Uncertainty budget of the measurements made in the practical session 3. 5. Estimation of uncertainties by the Monte Carlo method. Software to be used: Excel, Matlab/Python Through this methodology the competencies B2, B5, B7, B8, C78, C79 are developed.
Previous studies	The students must individually study and prepare with the sources of information given before the lectures and the practical sessions. Through this methodology the competencies B2, B5, B8, B75, C78, C79 are developed.
Lecturing	Lectures will be given, developing the main concepts of the subject. Through this methodology the competencies B2, B5, B7, B8, C75, C78, C79 are developed.

Personalized assistance

Methodologies	Description
Lecturing	Doubts can be solved in the rests of the classes and in the teacher tutorial sesions. These tutorial sessions will be done individually or in short groups (with a maximum of 2-3 students). The tutorial sessions are typically agreed with the professor. The meetng requests can be done personally or by email. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/maria-soledad-torres-guijarro
Mentored work	The projects have its own classes of C group in which the students of each team consult their doubts about the project and the professor is with them helping to define the project and giving them support for the development of their particular project. They are classes with a very pleasant interaction.
Laboratory practical	In the classes of practices is a good moment to consult doubts with the professor. The professor moves between the tables and some students take advantage of the proximity of the professor to consult doubts of the own class or punctual doubts of other classes.

Assessment

	Description	Qualification	Training and Learning Results	
Mentored work	Tutored practical project, with the delivery of a final report and oral presentation of results. The individual grade of group work is obtained as the weighted sum of: 1) the common grade of the group (60%); 2) The individual grade (40%), obtained from one or more of the following assessment methods: peer assessment by the other members of the group, oral questions during presentations of the work, written questions about the content of the work.	30	B2 B5 B7 B8	C75 C78 C79

Problem and/or exercise solving	Written test, with short questions on the theory of the subject.	40	B2 B5 B7	C75 C78 C79
Report of practices, practicum and external practices	Questions and report of the practical tasks.	30	B2 B5 B7	C78 C79

Other comments on the Evaluation

TEACHING LANGUAGE: English

ASSESSMENT LANGUAGE: The student can choose to do the written test in English or Spanish.

Following the guidelines of the degree, two systems of evaluation are offered: CONTINUOUS ASSESSMENT (recommended) and GLOBAL ASSESSMENT. Global assessment will be only allowed in situations in which it is imposible to follow the recommended system.

In case of detection of plagiarism in any of the tests (short tests, reports of the laboratory practices, reports of the directed works or final exam), the final grade will be of FAIL (0) and the fact will be communicated to the Centre Management for the opportune effects.

ORDINARY EXAM

A) CONTINUOUS ASSESSMENT:

The continuous assessment will be based in the evaluation of practical task, projects and two tests. Once a student has signed a document of agreement with the process of continuous assessment, and if not communicated otherwise within one month, it will be understood that the student has submitted to the call, and the final degree will be obtained by the application of the criteria described bellow, regardless of whether or not the final exam is taken.

The subject is assessed in a 0 to 10 points scale and is considered "passed" if each activity is graded equal or greater than 4, and the final grade obtained is equal or greater than 5. The final grade with be obtained from the weighted sum of the grade obtained in the following tasks with the given weights. If in anyof the activities the grade does not reach 4 but the average exceeds 5, the final grade will be 4.9.

Types and weights of the activities:

1. Tutored works: 30 % of the final grade. Two reports will be delivered: the first halfway through the term and the second at the end. The individualized part of the assessment will be done through cross-evaluation, oral questions during presentations, and written exam questions.
2. Reports of practical tasks (Weight: 40 %).
3. Short answer tests: A short answer test is included in the process of continuous assessment, at the end of the term, with a weight of 40% on the final grade.

B) GLOBAL ASSESSMENT

A final examination is available for those students that for some reason could not follow the continuous evaluation assessment process. In this case the final examination will consist in a short answer test, and some additional questions related with the practical tasks and projects.The subject is assessed in a 0 to 10 points scale and it is considered "passed" if the final grade obtained is equal or greater than 5.

EXTRAORDINAY EXAM

There is scheduled date for a final examination retake, for those students that either dropped out during the semester or failed. Prior the examination, a student can choose to follow the continuous assessment or the global assessment. In the former selection, the grades obtained in the projects and practical tasks will be taken into account and the student will only answer to the short answer test. If the later, the student will have also to answer a full examination as described before.

END-OF-PROGRAM EXAM

The exam will consist of a short answer test. This final exam will be rated between 0 and 10 points. It includes all the topics of the course. To pass, at least five points are needed. No other activity is valued.

USE OF GENERATIVE ARTIFICIAL INTELLIGENCE

The use of generative artificial intelligence (GAI) is permitted in the academic activities of this subject. Its use must be carried out in an ethical, critical and responsible manner. In the case of using GAI, any output it provides must be critically evaluated, and any citations or references generated must be carefully checked. It is also necessary to declare the use of the used tools.

Sources of information
Basic Bibliography
DIRECTIVE 2002/49/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 June 2002 relating to the assessment and management of environmental noise,
ISO Standard, **ISO 1996-1. Acoustics -- Description, measurement and assessment of environmental noise -- Part 1: Basic quantities and assessment procedures**,
ISO Standard, **ISO 1996-2. Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels**,
UNE EN ISO 11819-1:2002 Measurement of the influence of road surfaces on traffic noise Part 1 Statistical pass-by method,
ISO 16283-1 (2014). Acoustics Field measurement of sound insulation in buildings and of building elements,
Ley 37/2003 del Ruido,
Real Decreto 1367/2007,
Decreto 106_2015 sobre contaminación acústica de Galicia,
Documento Básico de protección frente al ruido del Código Técnico de la Edificación,
ISO 717- 1 (2013) Acoustics Rating of sound insulation in buildings and of building elements, Part 1 Airborne sound insulation,
ISO IEC Guide 98-3 Guide to the expression of uncertainty in measurement, GUM (1995),
ISO 12999-1-(2014) Uncertainties in building acoustics,
A Beginners Guide to Uncertainty of Measurement (1999), National Physical Laboratory (NPL),
Estimating Uncertainties in Testing (2001), National Physical Laboratory (NPL),
Sonometer uncertainty (2004), National Physical Laboratory (NPL),
Complementary Bibliography
RODRIGO AVILÉS LÓPEZ, ROCÍO PERERA MARTÍN, **Manual de acústica ambiental y arquitectónica**, Paraninfo, 2017

Recommendations

Subjects that are recommended to be taken simultaneously

Room Acoustics/V05G301V01330

Subjects that it is recommended to have taken before

Fundamentals of Sound and Image/V05G301V01209
Design of audiovisual installations/V05G301V01334
Fundamentals of Acoustics Engineering/V05G301V01327

IDENTIFYING DATA				
Audiovisual production CGI				
Subject	Audiovisual production CGI			
Code	V05G301V01420			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	Spanish			
Department				
Coordinator	Fernández Santiago, Luis Emilio			
Lecturers	Fernández Santiago, Luis Emilio			
E-mail	faraon@uvigo.es			
Web	http://https://moovi.uvigo.gal/			
General description	General knowledge of the processes of production and realization of Audio and video, aim to achieve the skills needed to work in a team of production/realization, mainly in the technical positions. using cameras, edition systems and creation of CG content. The documentation will be in English			

Training and Learning Results	
Code	
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B8	CG8: To know and apply basic elements of economics and human resources management, project organization and planning, as well as the legislation, regulation and standarization in Telecommunications.
B12	CG12 The development of discussion ability about technical subjects
C74	(CE74/OP17) The ability to construct, exploit and manage image and synthetic video generation systems and interactive multimedia applications.
C80	(CE80/OP23) The ability to conceptually and technically manage the phases in an audiovisual production.
C81	(CE81/OP24) The ability to creatively and skillfully use the technical equipment for production development.
C82	(CE82/OP25) The ability to use specific software applications in audiovisual production.
C83	(CE83/OP26) The ability to organize an audiovisual production.
D2	CT2 Understanding Engineering within a framework of sustainable development.

Expected results from this subject			
Expected results from this subject	Training and Learning Results		
Know the phases and the technical positions of an Audiovisual production.	B4 B8 B12	C80 C83	
Identify the distinct audiovisual structures.		C80 C83	
Know how to use the necessary technologies for the development an audiovisual production.	B4 B12	C74 C80 C81 C82	D2
Know how to use the software tools of postproduction.	B12	C74 C81 C82	
Know how to manage an audiovisual project.	B4 B8 B12	C80 C81 C83	D2

Contents	
Topic	
Production and realization techniques.	Audiovisual language basics.
The audiovisual production: characteristic and production and realization workflow.	Workflow for Vfx, 3DCGI and interactive. Pipelines. Production charts.
Audiovisual structures, linear and interactive.	The script as a technical document. Technical breakdown.

Computer Generated Image.	Producción assets (geometry, shaders, animation) Graphic and render Engines.
Virtual enviroments: elements and creation of the levels.	Layouts, terrains, lighting.
Creation of contents and catchment of sound and image.	Basics of video cameras handling. Basics os Audio for film.
Audiovisual projects Management.	Gestion of media, data and control of a production. Pipelines And Workflows.
Postproduction systems.	NLE. Basics of Video composicion: Layers and channels. Color, grading and Conform.
Diigital creation	Creation of simple elements 3D in graphic engine
Recording and Edition	Audiovisual production from script to master.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	21	21	42
Laboratory practical	7	7	14
Workshops	14	7	21
Objective questions exam	2	0	2
Laboratory practice	5	15	20
Project	5	18	23
Project	7	18	25
Report of practices, practicum and external practices	0	3	3

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Theoretical sessions on concepts of visual language, formats, equipment and their use. Elements of linear and interactive visual production, workflows and integration of technical personnel in production teams. CG8 CG12 CE80 CE82 CT2
Laboratory practical	Creation of synthetic elements and use of graphic engines for Audiovisual Production.
Workshops	Practical classes on obtaining images and sounds, Creation of synthetic elements and postproduction for the creation of audiovisual products. The work is done in work groups, with rotation in the positions to ensure individual contact with the different resources. CG12 CE74 CE81 CE82

Personalized assistance

Methodologies	Description
Workshops	Use of audiovisual production equipment and software, question time during workshop, access to office and questions via email or message. Individual report about the contents.
Tests	**Description**
Laboratory practice	Use of audiovisual production equipment and software, question time during workshop, access to office and questions via email or message. Individual report about the contents.
Project	Access to office and solution of doubts via email or message. Schedule of office time in https://moovi.uvigo.es/

Assessment

	Description	Qualification	Training and Learning Results		
Objective questions exam	Test, theoretical contents and practical concepts of the subject.	20	B4	C80 C81 C82	
Laboratory practice	Insertion of elements in graphic engine. (Individual)	20	B4	C74 C81 C82	D2
Project	Screenplay and recording of a scene. (Group)	20	B4 B8 B12	C81 C83	D2

Project	Technical screenplay and edition of a scene. (Individual)	25	B4 B8 B12	C74 C80 C81 C82 C83	D2
Report of practices, practicum and external practices	Report on the assessment of the production process in the different cases and conclusions of the practices.	15	B8 B12	C80 C83	D2

Other comments on the Evaluation

Breakdown:

Insertion of elements in graphic engine. (Individual) 20% (~4 weeks)
Script and recording of a scene. (Group) 20% (~8 weeks)
Technical script and editing of a scene. (Individual) 25% (~13 weeks)
Report (Individual) 15% (~13 weeks)
Students must explicitly determine in the first delivery of material if they opt for continuous evaluation, in this case the final grade cannot be "not presented". In group practices, the work of each member will be supervised by the teacher.

The global evaluation requires the delivery of the practices, taking the group as individual (the student will need to set up a human team of collaborators to carry out this), coinciding with the date of the exam In extraordinary and end-of-degree calls, it will be necessary to pass a Test-type test (30%-theoretical content and practical concepts of the subject) and questions to be developed (30%-knowledge of the production process and formats) and ONE practical solvency exercise in autonomous camera management and NLE editing O (xor) insertion of elements in graphic engine O (Xor) development of production flow from a technical script. (40%). The note will be the sum of the percentages.
The marks of the parts passed from the ordinary call are kept for the extraordinary during the same course if the student wishes. In the event of detection of plagiarism in any of the tests or papers, the final grade will be FAIL (0) and the fact will be communicated to the Center's management for appropriate purposes.

Sources of information

Basic Bibliography

Dunlop, Renee, **Production Pipeline Fundamentals for Film and Games**, 1st Edition, Focal Press, 2014
Zwerman, Susan & Okun, Jeffrey A., **The VES Handbook of Visual Effects: Industry Standard VFX Practices and Procedures**, 2nd ed, 2014
MMILLERSON, GERALD. OWENS, JIM, **Television production**,

Complementary Bibliography

ALTEN, STANLEY, **Audio in media**,
TRIBALDOS, CLEMENTE, **Sonido profesional**,
RUMSEY, FRANCIS. MCCORMICK, TIM, **Sonido y grabación; Introducción a las técnicas sonoras**, 2ª edición,
ONDAATJE, MICHEL, **The Conversations: Walter Murch and the Art of Editing Film**,
BRINKMANN, R., **The art and science of digital compositing**, 2nd ed,
HERRERO, JULIO CESAR, **Manual de teoria de la información y telecomunicación**, 2009,
Glor, Flax & Sardella, Andrea, **Filmmaking Simplified: Practical Techniques for Getting More out of Any Production**, Edition: 1, kindle,

Recommendations

Subjects that are recommended to be taken simultaneously

Video games and virtual reality/V05G301V01417

Subjects that it is recommended to have taken before

Design of audiovisual installations/V05G301V01334
Interactive Audio Systems/V05G301V01331

IDENTIFYING DATA				
Technology Management				
Subject	Technology Management			
Code	V05G301V01426			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	4th	2nd
Teaching language	#EnglishFriendly Spanish English			
Department				
Coordinator	González Castaño, Francisco Javier			
Lecturers	Díaz Otero, Francisco Javier Docio Fernández, Laura			
E-mail	javier@det.uvigo.es			
Web	http://https://moovi.uvigo.gal/			
General description	This course provides skills in design, management and leadership of technological projects. This includes detection of needs, technological surveys, team creativity techniques, project management, property definition and protection, and business models. The course is taught in Spanish and English. English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B7	CG7: The ability to analyze and assess the social and environmental impact of technical solutions.
B8	CG8: To know and apply basic elements of economics and human resources management, project organization and planning, as well as the legislation, regulation and standarization in Telecommunications.
C54	(CE54/PY1) The ability to elaborate the proposal of technical projects according to the specified requirements in a public competitive bidding.
C55	(CE55/PY2) The ability for technical direction of telecommunication project.
C56	(CE56/PY3) The ability to manage telecommunication project human resources and economic.
C57	(CE57/PY4) The ability to elaborate technical reports and for the follow up of a telecommunication project.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
- To analyze the technical and economic feasibility of a project. Project budgets.	B7 B8	C55 C56 C57
- To learn how to find statistical information and indicators - To learn how to perform technological surveys and consulting		C57
- Project reporting		C54 C55 C56 C57
- Project planning and management	B8	C54 C55 C56
- Sociological and human aspects of projects		C55 C56
- Learn the regulations in telecommunications, privacy and environment	B7	C54
- To develop models for the creation of entreprises, products and services - To propose business models in telecommunications	B8	C55 C56
- Learn how to apply the main certification directives	B7	

Contents
Topic

Project design and management	- Definition of technical goals - Translating goals into tasks - Planning the project - Project resources - Human team. R&D profiles - Budget - Tracking project evolution
Identifying and interpreting needs	- Gathering requisites - Translating needs into technical objectives - Technological perspective. Hype cycles - Sources and methods for technical surveys
Creativity techniques	- Research, development and innovation - Team methods to boost creativity - Is my idea original? Formulating and evaluating it
Collaborative Tools	- Purpose - Tools - Tool-assisted collaborative techniques
Legal aspects	- Types of property: Intellectual and industrial - Technological actives vs. legal property. Models, patents. Licenses - Spanish case/international case. Europe and the US. Internationalization hints - CIN/352/2009 regulation
Business models. Entrepeneurship.	- Product proposal - Risk analysis - Customer survey - From the idea to the business plan - First steps towards the creation of an enterprise
(*)-	(*)-

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	24	38	62
Project based learning	4	20	24
Practices through ICT	28	36	64

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Lecturing	Oral presentation of the main concepts of the course by the professors, supported by multimedia. Lectures by experts. Through this methodology the competencies B7, B8, C54, C55, C56 and C57 are developed.
Project based learning	Group project to be presented during class hours A of the last week. Through this methodology the competencies C54, C55, C56 and C57 are developed.
Practices through ICT	Practice on aspects of specification of requisites, creativity and business plans (in groups) and project planning using computer tools (individual). Through this methodology competencies C54, C55, C56 and C57 are developed.

Personalized assistance

Methodologies	Description
Lecturing	The professors will be available during tutoring hours to clarify any doubts on master session contents. Tutoring hours will be published at the beginning of the course at https://atlanttic.uvigo.es/es/equipo/staff/francisco-javier-gonzalez-castano/.
Project based learning	All techniques in the course will be applied to the creation and planning of a project. The project will be performed in groups. At the beginning of the course, the professors will notify a working field for the course (ex. medical applications, intelligent furniture). Projects will focus on product proposals in that specific working field. Nevertheless, the professors will track individual performance, and at the final defence there may be individual questions. Personalized individual attention on these aspects will take place during official tutoring times or via e-mail at any time.

Assessment

	Description	Qualification	Training and Learning Results
Lecturing	Exam	35	B7 B8 C54 C55 C56 C57
Project based learning	Individual defense (commitee), evidences, peer evaluation	40	C55 C56 C57
Practices through ICT	Evaluation of partial results+exam	25	C55 C56 C57

Other comments on the Evaluation

ORDINARY OPPORTUNITY with CONTINUOUS EVALUATION:

· Individual exam (Maximum 3.5 points). Official calendar.

· Intermediate practical test (Maximum 1.5 points).

· Final project (Maximum 4 points).

· Participation in class (Maximum 1 points).

To pass the course, the final student score (as the sum of the previous activities) must be 5 points or more. Maximum score is 10 points. To pass the course it is necessary to get at least 1/4 in the individual exam.

The project will be performed in groups of 5-6 people. Individual scores will be assigned according to student interaction in B hours, peer review and the part corresponding to each student in the public project defence.

ORDINARY OR EXTRAORDINARY OPPORTUNITIES with GLOBAL EVALUATION:

It will consist in an exam with theoretical and practical parts in the official date. The practical part will cover the same content as the continuous evaluation along the course.

Sources of information

Basic Bibliography

Carl Chatfield,Timothy Johnson, **Microsoft Project 2013 Step by Step**, 1, Microsoft Press, 2013

Complementary Bibliography

Michael Michalko, **Thinkertoys: A Handbook of Creative Thinking Techniques**, 2, Ten Speed Press, 2006

Alexander Osterwalder, Yves Pigneur, **Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers**, 1, John Wiley and Sons, 2010

Edward de Bono, **Six Thinking Hats**, 2, Back Bay Books, 1999

Recommendations

IDENTIFYING DATA				
Projects Lab				
Subject	Projects Lab			
Code	V05G301V01427			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	12	Mandatory	4th	2nd
Teaching language	#EnglishFriendly Spanish Galician English			
Department				
Coordinator	Caeiro Rodríguez, Manuel			
Lecturers	Machado Domínguez, Fernando Marcos Acevedo, Jorge Nogueiras Meléndez, Andres Augusto			
E-mail	mcaeiro@det.uvigo.es			
Web	http://moovi.uvigo.es			
General description	Interdisiciplinary projects must be addressed by a team of students who must represent at least two of the four technologies of the Telecommunication Technologies Engineering Degree. The teams are supervised by two faculty members from different Departments to enrich and facilitate the cross-fertilization between different areas of work. The work developed by the different teams will be defended at the end of the course as part of the evaluation process. The teaching language is Spanish, Galician or English. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B1	CG1: The ability to write, develop and sign projects in the field of Telecommunication Engineering, according to the knowledge acquired as considered in section 5 of this Law, the conception and development or operation of networks, services and applications of Telecommunication and Electronics.
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B7	CG7: The ability to analyze and assess the social and environmental impact of technical solutions.
B8	CG8: To know and apply basic elements of economics and human resources management, project organization and planning, as well as the legislation, regulation and standarization in Telecommunications.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B11	CG11 To approach a new problem considering first the essential and then the secondary aspects
B12	CG12 The development of discussion ability about technical subjects
C54	(CE54/PY1) The ability to elaborate the proposal of technical projects according to the specified requirements in a public competitive bidding.
C55	(CE55/PY2) The ability for technical direction of telecommunication project.
C56	(CE56/PY3) The ability to manage telecommunication project human resources and economic.
C57	(CE57/PY4) The ability to elaborate technical reports and for the follow up of a telecommunication project.
D1	CT1 Development of sufficient autonomy to carry out works within the area of Telecommunications in interdisciplinary contexts.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.
D5	CT5 Ability to communicate orally and in writing in the Galician language.

Expected results from this subject	
Expected results from this subject	Training and Learning Results

Learn to work in group in a medium term project	B1 B4 B6 B8 B9 B11 B12	C54 C56 C57	D4 D5
Plan the development of a team project	B9 B11	C55 C56 C57	D4
Integrate the required skills in a multidisciplinary team	B4 B9 B12	C56	D1 D4
Keep a dynamic attitude and foster an on-going improvement effort	B1 B4 B7 B9		D1 D2

Contents

Topic	
Team work	The contents for each team will be specific of the project developed. In any case, they will be multidisciplinary contents.
Technical edition	Executive report Stages in report development
Project development	Introduction to project development methodologies such as, Design Thinking, Lean and Agile, where key principles are introduced: focus on the final user, rapid prototyping, to provide value to the client from the beginning, communication, etc.
Public presentations	Key elements in a presentation. Hints to perform an effective presentation. How to prepare a good presentation: - Strategy - Structure - Examples - Issues to take into account

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	2	0	2
Mentored work	4	4	8
Project based learning	14	244	258
Presentation	8	24	32

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Some practical hints on skills such as oral and written presentation, and team working. This activity is individual. Competences D1, D2, D4 and D5 are developed here.
Mentored work	Partial review of the different projects evolution, with short presentations and discussions. This is a group activity. Competences B9, B11, B12 and D4 are developed here.
Project based learning	This is the core of the course: the team of students must address a project, either proposed by them or by two faculty members. During the duration of the course the team members must work in close cooperation to achieve the objectives of the project; the supervision is such that a weekly one hour meeting willl take place with one or both advisors. It is recommended the creation of a web site, such as a wiki, blog or similar, for each team to document and show the works developed during the term. All members of the team must be able to defend its project at the end of the course in both oral and two public poster sessions. This is a group activity. Competences B1, B4, B6, B7, B8, C54, C55, C56 and C57 are developed here.
Presentation	Every team must defend its project in a final oral presentation and in two poster sessions, known as LPRO DAYS. The oral presentation can be made by one or more members of the team, and must include evidences to show proof of the work developed and achieved results. At the end of the presentation all members must be available for Q&A. The poster sessions require the presence of all members of the team. A summary of the work must be submitted to the evaluation committee three days in advance. This is a group activity. Competences B9, B12 and C5 are developed here.

Personalized assistance

Methodologies	Description
Introductory activities	Subject teachers will be available during tutoring hours to solve any doubts and issues about theses activities. Teachers will establish timetables for this purpose at the beginning of the term and will be available at the e-learning platform https://moovi.uvigo.gal/.
Project based learning	Each team will have the support of their tutors for the development of the project and to solve any doubts and issues about it in tutoring hours. Teachers will establish timetables for this purpose at the beginning of the term and will be available at the e-learning platform https://moovi.uvigo.gal/.
Mentored work	Subject teachers will be available to solve any doubts and issues about the development of these tasks during tutoring hours. Teachers will establish timetables for this purpose at the beginning of the term and will be available at the e-learning platform https://moovi.uvigo.gal/.

Assessment

	Description	Qualification	Training and Learning Results		
Mentored work	A portion of the final grade will be based on: 1. Advisors recommendations (15%). For an adequate tracking of the project development, advisors will request different pieces of evidence, both oral and/or written, including partial and/or final reports. Each pair of advisors must submit a justified recommendation to the committee as to the team work methodology and the performance of the team members in the accomplishment of the project goals. Although the grade is expected to be similar for the entire group as a general principle, exceptions might apply. Competences B9, B11 and B12 will be evaluated here. 2. Group mates (10%). Although the grade is expected to be similar for the entire group as a general principle, exceptions might apply. A peer review among the team members will be also requested as additional evidence for competences B9 y D4.	25	B9 B11 B12		D4
Project based learning	Advisors recommendations. For an adequate tracking of the project development, advisors will request different pieces of evidence, both oral and/or written, including partial and/or final reports. Each pair of advisors must submit a justified recommendation to the committee as to the team work methodology and the performance of the team members in the accomplishment of the project goals. Although the grade is expected to be similar for the entire group as a general principle, exceptions might apply. Competences B1, B4, B6, B7, B8, C54, C55, C56, C57 will be evaluated here.	40	B1 B4 B6 B7 B8	C54 C55 C56 C57	D5
Presentation	A portion of the final grade will be based on the committee evaluation during the LPRO DAYS. The attendance to these days will be mandatory for all students. They must submit an executive summary of the project at least three days in advance to help assess their work. This part of the assessment will be made taking into account the summary of the project, the presentation, the poster and the work performed during the LPRO DAYS. The members of the evaluation committee will be the instructors of the Type-A ECTS, as long as they are not involved in the supervision of any project. Otherwise, additional assistance for the evaluation of those conflicting projects will be requested from other instructors from the course. Although the grade is expected to be similar for the entire group as a general principle, exceptions might apply. Thus, especially underperforming students not contributing to the team effort can get a different grade. Similarly, students contributing well above the average of the group can get a higher grade.	35	B1 B7 B9 B12		D2 D5

Other comments on the Evaluation

The continuous assessment is carried out in accordance to the previously mentioned Presentation and Project based learning methodologies. It is mandatory the attendance to the 80% of the face to face sessions during the term, both in type-A and Type-C academic activities. Midterm presentations will be in Galician. Final presentations are allowed in Galician, Spanish or English. In any case, those students that decide to take the course in English should participate always in the English activities.

Those students/teams not getting the minimum grade to pass the course in the ordinary exam will have some additional weeks till the allocated date in the extraordinary exam and end-of-program exam to present the project again. In this case, the individual learner will need to show a comprehensive domain of the project developed by his/her team, together with sufficient additional contributions of his/her own.

Generative AI

In the performance of the academic activities of this subject, the use of generative artificial intelligence (GAI) is allowed. Its use must be done ethically, critically and responsibly. In the case of using GAI, any results provided by GAI should be critically evaluated, and any citations or references generated should be carefully checked. It is also mandatory to declare the use of the tools.

Sources of information

Basic Bibliography

Eric Ries, **El método Lean Startup: Cómo crear empresas de éxito utilizando la Innovación Continua**, 1, Deusto, 2011

Ken Beck y colegas, **Manifiesto por el Desarrollo Ágil de Software**, 1, 2001

Complementary Bibliography

Jim Highsmith e Ken schwaber, **Lean Software Development. An Agile Toolkit**, 1, Addison Wesley, 2003

Recommendations

Other comments

This subject involves a high workload for the students outside of the classrooms related to the development of the projects: 300 hours. This effort is not just required individually, but also for the team as a joint group. In addition, it is important to have time availability to maintain meetings and perform group activities. Therefore, it is highly recommended to take this subject just with the subjects included in the second semester of the fourth year (DTEC and TFG) or equivalent. It is recommended to inform about subjects of other courses taken simultaneously with LPRO.

The work teams of this subject are multidisciplinary taking into account the 4 specializations of the degree. As a generic rule, if possible, teams cannot involve more than 3 students of the same specialization and students of 3 different specializations will be involved.

IDENTIFYING DATA				
Externships: Internships I				
Subject	Externships: Internships I			
Code	V05G301V01981			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	Spanish			
Department				
Coordinator	Marcos Acevedo, Jorge			
Lecturers				
E-mail				
Web	http://faitic.uvigo.es			
General description	(*)Estancia nunha empresa desenvolvendo funcións propias dun/a Enxeñeiro/a Técnico/a de Telecomunicación relacionadas co perfil profesional cursado polo alumno (Sistemas de Telecomunicación, Telemática, Sistemas Electrónicos ou Son e Imaxe) e supervisado por profesorado do Centro e persoal da empresa.			

Training and Learning Results	
Code	
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
B12	CG12 The development of discussion ability about technical subjects
B13	CG13 The ability to use software tools that support problem solving in engineering.
C21	CE21/ST1 The ability to construct, exploit and manage telecommunication networks, services, process and applications, considered as systems of receiving, transporting, representation, processing, storage, management and presentation of multimedia information from the point of view of transmission systems.
C22	CE22/ST2 The ability of applying the basic techniques of telecommunication networks, services and applications for mobile and fixed environments, personal, local or long distance, with different bandwidth, including telephony, radio broadcasting, TV and data, from the point of view of transmission systems.
C23	CE23/ST3 The ability to analyze the components and their specifications for guided and non-guided communications systems
C24	CE24/ST4 The ability to select circuits, subsystems and systems of radiofrequency, microwaves, broadcasting, radio link and radio determination.
C25	CE25/ST5 The ability to select transmission antennas, equipment and systems, propagation of guided and non-guided waves, with electromagnetic, radiofrequency and optical media, and their corresponding radio electric spectrum management and frequency designation.
C26	CE26/ST6 The ability to analyze, codify, process and transmit multimedia information using analogical and digital signal processing techniques.
C27	CE27/TEL1The ability to construct, operate and manage telecommunication networks, services, processes and applications considered as systems to receive, transport, represent, process, store, manage and present multimedia information from the computer services point of view.
C28	CE28/TEL2 The ability to apply the techniques that are basis of computer networks, services and applications, such as management, signaling and switching, routing and securing systems (cryptographic protocols, tunneling, firewalls, charging mechanisms, authentication and content protection) traffic engineering (graph theory, queuing theory and teletraffic) rating, reliability and quality of service in both fixed, mobile, personal, local or long distance environments with different bandwidths, including telephony and data.
C29	CE29/TEL3 The ability to build, operate and manage computer services using planning, sizing and analytical tools
C30	CE30/TEL4 The ability to describe, program, assess and optimize communication protocols and interfaces at different network architecture layers .
C31	CE31/TEL5 The ability to follow the technological progress of transmission, switching and processing to improve computer networks and services.
C32	CE32/TEL6 The ability to design networks and service architectures.
C33	CE33/TEL7 The ability to program network and distributed applications and services.
C34	CE34/SI1The ability to construct, exploit and manage telecommunication services and applications, such as receiving, digital and analogical treatment, codification, transporting and representation, processing, storage, reproduction, management and presentation of audiovisual and multimedia information services.
C35	CE35/SI2 The ability to analyze, specify, carry out and maintain systems, equipments, heads and installations of TV, audio and video for mobile and fixed environments.

C36	CE36/SI3 The capacity to implement projects at places and installations for the production and recording of audio and video signals.
C37	CE37/SI4 The ability to carry out acoustic engineering projects related to: acoustical isolation and conditioning of rooms, loudspeaker installations, specification, analysis and selection of electro acoustical transducers, measurement, analysis and control of radio vibration systems, environmental acoustics, submarine and acoustical systems.
C38	CE38/SI5 The ability to create, modify, manage, broadcast and distribute multimedia contents taking into account the use and accessibility criteria to audiovisual, broadcasting and interactive services.
C39	(CE39/SE1): The ability to construct, exploit and manage the receiving, transporting, representation, processing, storage, manage and presentation multimedia information from the electronic systems point of view.
C40	(CE40/SE2): The ability to select electronic circuits and devices specialized in transmission, forwarding or routing, and terminals for fixed and mobile environments.
C41	(CE41/SE3):The ability to make the specification, implementation, documenting and tuning of electronic systems and equipment (both instrumentation and control oriented), considering the corresponding technical aspects and the regulations.
C42	(CE42/SE4): The ability to apply electronics as support technology in other fields and activities and not only in information and communication technologies.
C43	(CE43/SE5): The ability to design analogical and digital electronics circuits of analogical to digital conversion and vice versa, of radiofrequency, of feeding and electrical energy conversion for computing and telecommunication engineering.
C44	(CE44/SE6): The ability to understand and use feedback theory and electronic control systems.
C45	(CE45/SE7): The ability to design interface, data capturing and storage devices, and terminals for services and telecommunication systems.
C46	(CE46/SE8): The ability to specify and use electronic instrumentation and measurement systems.
C47	(CE47/SE9): The ability to analyze and solve interference and electromagnetic compatibility problems .
D2	CT2 Understanding Engineering within a framework of sustainable development.
D5	CT5 Ability to communicate orally and in writing in the Galician language.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Experience in the exert of the profession of Technical Engineer of Telecommunication and of his more usual functions (according to the programme of the student) in some real surroundings of company.	B4 B5 B12 B13	C21 C22 C23 C24 C25 C26 C27 C28 C29 C30 C31 C32 C33 C34 C35 C36 C37 C38 C39 C40 C41 C42 C43 C44 C45 C46 C47	D2 D5

Contents

Topic	
General content	To define by the tutor in the company and the academic tutor
Integration in the company and in his surroundings of work	During his stay the student will be integrated into the organization of the company and must coordinate with the rest of members of the work team to he was assigned.
Development of his professional activity	The student will make the tasks entrusted, in accordance with his knowledges and competences.

Planning

	Class hours	Hours outside the classroom	Total hours
Practicum, External practices and clinical practices	145	5	150

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Practicum, External practices and clinical practices	Stay in a company developing functions of a Telecommunications Technical Engineer so that they can put into practice the knowledge and skills acquired, to complete their academic training.

Personalized assistance

Methodologies	**Description**
Practicum, External practices and clinical practices	The student will have a tutor inside the company that will guide him and will supervise in the specific tasks that it will have to develop inside the same; and an academic tutor - professor of the E.E.T. of the University of Vigo- that will define together with the tutor of the company, the general frame of the activity of the student, checking that it adjusts to the profile studied by the student.

Assessment

	Description	Qualification	Training and Learning Results		
Practicum, External practices and clinical practices	The evaluation will realise in function of: 1) The memory of activities 2) The evaluation of the tutor in the company	100	B4 B5 B12 B13	C21 C22 C23 C24 C25 C26 C27 C28 C29 C30 C31 C32 C33 C34 C35 C36 C37 C38 C39 C40 C41 C42 C43 C45 C46 C47	D2

Other comments on the Evaluation

REPORT OF ACTIVITIES: The student must submit a report explaining the activities undertaken during practices, specifying its duration, departments of the company that were conducted, training received (courses, software, etc.), the level of integration within the company and personal relationships.

The report must also include a section of conclusions, containing a reflection on the adequacy of the lessons learned during the university studies to performance practice (negative and positive aspects significant related to the development of practices). It also assessed the inclusion of information on the professional and personal experience with the practices (personal assessment of learning achieved over practices or own contributions and suggestions on the structure and operation of the company visited).

The assessment of memory will be 60% of the final qualification.

COMPANY TUTOR EVALUATION: The company tutor will submit a report assessing aspects with the practices carried out by students: punctuality, attendance, responsibility, teamwork ability and integration in the enterprise, quality of work done, etc.

The assessment of the tutor in the company will be 40% of the final qualification.

Sources of information

Basic Bibliography

Complementary Bibliography

Recommendations

Other comments

It recommends have studied the three first courses of the degree.

IDENTIFYING DATA

Externships: Internships II

Subject	Externships: Internships II			
Code	V05G301V01982			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	4th	1st
Teaching language	Spanish			
Department				
Coordinator	Marcos Acevedo, Jorge			
Lecturers				
E-mail				
Web	http://faitic.uvigo.es			
General description	(*)Estancia nunha empresa desenvolvendo funcións propias dun/a Enxeñeiro/a Técnico/a de Telecomunicación relacionadas co perfil profesional cursado polo alumno (Sistemas de Telecomunicación, Telemática, Sistemas Electrónicos ou Son e Imaxe) e supervisado por profesorado do Centro e persoal da empresa.			

Training and Learning Results

Code	
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
B12	CG12 The development of discussion ability about technical subjects
B13	CG13 The ability to use software tools that support problem solving in engineering.
C21	CE21/ST1 The ability to construct, exploit and manage telecommunication networks, services, process and applications, considered as systems of receiving, transporting, representation, processing, storage, management and presentation of multimedia information from the point of view of transmission systems.
C22	CE22/ST2 The ability of applying the basic techniques of telecommunication networks, services and applications for mobile and fixed environments, personal, local or long distance, with different bandwidth, including telephony, radio broadcasting, TV and data, from the point of view of transmission systems.
C23	CE23/ST3 The ability to analyze the components and their specifications for guided and non-guided communications systems
C24	CE24/ST4 The ability to select circuits, subsystems and systems of radiofrequency, microwaves, broadcasting, radio link and radio determination.
C25	CE25/ST5 The ability to select transmission antennas, equipment and systems, propagation of guided and non-guided waves, with electromagnetic, radiofrequency and optical media, and their corresponding radio electric spectrum management and frequency designation.
C26	CE26/ST6 The ability to analyze, codify, process and transmit multimedia information using analogical and digital signal processing techniques.
C27	CE27/TEL1The ability to construct, operate and manage telecommunication networks, services, processes and applications considered as systems to receive, transport, represent, process, store, manage and present multimedia information from the computer services point of view.
C28	CE28/TEL2 The ability to apply the techniques that are basis of computer networks, services and applications, such as management, signaling and switching, routing and securing systems (cryptographic protocols, tunneling, firewalls, charging mechanisms, authentication and content protection) traffic engineering (graph theory, queuing theory and teletraffic) rating, reliability and quality of service in both fixed, mobile, personal, local or long distance environments with different bandwidths, including telephony and data.
C29	CE29/TEL3 The ability to build, operate and manage computer services using planning, sizing and analytical tools
C30	CE30/TEL4 The ability to describe, program, assess and optimize communication protocols and interfaces at different network architecture layers .
C31	CE31/TEL5 The ability to follow the technological progress of transmission, switching and processing to improve computer networks and services.
C32	CE32/TEL6 The ability to design networks and service architectures.
C33	CE33/TEL7 The ability to program network and distributed applications and services.
C34	CE34/SI1The ability to construct, exploit and manage telecommunication services and applications, such as receiving, digital and analogical treatment, codification, transporting and representation, processing, storage, reproduction, management and presentation of audiovisual and multimedia information services.
C35	CE35/SI2 The ability to analyze, specify, carry out and maintain systems, equipments, heads and installations of TV, audio and video for mobile and fixed environments.

C36	CE36/SI3 The capacity to implement projects at places and installations for the production and recording of audio and video signals.
C37	CE37/SI4 The ability to carry out acoustic engineering projects related to: acoustical isolation and conditioning of rooms, loudspeaker installations, specification, analysis and selection of electro acoustical transducers, measurement, analysis and control of radio vibration systems, environmental acoustics, submarine and acoustical systems.
C38	CE38/SI5 The ability to create, modify, manage, broadcast and distribute multimedia contents taking into account the use and accessibility criteria to audiovisual, broadcasting and interactive services.
C39	(CE39/SE1): The ability to construct, exploit and manage the receiving, transporting, representation, processing, storage, manage and presentation multimedia information from the electronic systems point of view.
C40	(CE40/SE2): The ability to select electronic circuits and devices specialized in transmission, forwarding or routing, and terminals for fixed and mobile environments.
C41	(CE41/SE3):The ability to make the specification, implementation, documenting and tuning of electronic systems and equipment (both instrumentation and control oriented), considering the corresponding technical aspects and the regulations.
C42	(CE42/SE4): The ability to apply electronics as support technology in other fields and activities and not only in information and communication technologies.
C43	(CE43/SE5): The ability to design analogical and digital electronics circuits of analogical to digital conversion and vice versa, of radiofrequency, of feeding and electrical energy conversion for computing and telecommunication engineering.
C44	(CE44/SE6): The ability to understand and use feedback theory and electronic control systems.
C45	(CE45/SE7): The ability to design interface, data capturing and storage devices, and terminals for services and telecommunication systems.
C46	(CE46/SE8): The ability to specify and use electronic instrumentation and measurement systems.
C47	(CE47/SE9): The ability to analyze and solve interference and electromagnetic compatibility problems .
D2	CT2 Understanding Engineering within a framework of sustainable development.
D5	CT5 Ability to communicate orally and in writing in the Galician language.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Experience in the exert of the profession of Technical Engineer of Telecommunication and of his more usual functions (according to the programme of the student) in some real surroundings of company.	B4 B5 B12 B13	C21 C22 C23 C24 C25 C26 C27 C28 C29 C30 C31 C32 C33 C34 C35 C36 C37 C38 C39 C40 C41 C42 C43 C44 C45 C46 C47	D2 D5

Contents

Topic	
General content	To define by the tutor in the company and the academic tutor.
Integration in the company and in his surroundings of work	During his stay the student will be integrated into the organization of the company and must coordinate with the rest of members of the work team to he was assigned.
Development of his professional activity	The student will make the tasks entrusted, in accordance with his knowledges and competences.

Planning

	Class hours	Hours outside the classroom	Total hours
Practicum, External practices and clinical practices	145	5	150

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Practicum, External practices and clinical practices	Stay in a company developing functions of a Telecommunications Technical Engineer so that they can put into practice the knowledge and skills acquired, to complete their academic training.

Personalized assistance

Methodologies	Description
Practicum, External practices and clinical practices	The student will have a tutor inside the company that will guide him and will supervise in the specific tasks that it will have to develop inside the same; and an academic tutor - professor of the E.E.T. of the University of Vigo- that will define together with the tutor of the company, the general frame of the activity of the student, checking that it adjusts to the profile studied by the student.

Assessment

	Description	Qualification	Training and Learning Results		
Practicum, External practices and clinical practices	The evaluation will realise in function of: 1) The memory of activities 2) The evaluation of the tutor in the company	100	B4 B5 B12 B13	C21 C22 C23 C24 C25 C26 C27 C28 C29 C30 C31 C32 C33 C34 C35 C36 C37 C38 C39 C40 C41 C42 C43 C45 C46 C47	D2

Other comments on the Evaluation

REPORT OF ACTIVITIES: The student must submit a report explaining the activities undertaken during practices, specifying its duration, departments of the company that were conducted, training received (courses, software, etc.), the level of integration within the company and personal relationships.

The report must also include a section of conclusions, containing a reflection on the adequacy of the lessons learned during the university studies to performance practice (negative and positive aspects significant related to the development of practices). It also assessed the inclusion of information on the professional and personal experience with the practices (personal assessment of learning achieved over practices or own contributions and suggestions on the structure and operation of the company visited).

The assessment of memory will be 60% of the final qualification.

COMPANY TUTOR EVALUATION: The company tutor will submit a report assessing aspects with the practices carried out by students: punctuality, attendance, responsibility, teamwork ability and integration in the enterprise, quality of work done, etc.

The assessment of the tutor in the company will be 40% of the final qualification.

Sources of information

Basic Bibliography

Complementary Bibliography

Recommendations

Other comments

It recommends have studied the three first courses of the degree.

IDENTIFYING DATA

Final Year Dissertation

Subject	Final Year Dissertation			
Code	V05G301V01991			
Study programme	Grado en Ingeniería de Tecnologías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	12	Mandatory	4th	2nd
Teaching language	Spanish Galician English			
Department				
Coordinator	Herrería Alonso, Sergio			
Lecturers	Herrería Alonso, Sergio			
E-mail	sha@det.uvigo.es			
Web	http://moovi.uvigo.es			
General description	The Bachelor Thesis (TFG) is a constituent part, as a unit module, of the curriculum of Degree in Engineering of Technologies of Telecommunication. It is an original and personal work that each student will realise autonomously under educational supervision, and has to allow him to show in a comprehensive form the acquisition of the formative contents and the competences associated to the title. Its definition and contents are explained in detail in the regulation for the realisation of the Bachelor's thesis approved by the Academic Commission of Degree, whose content appears in the web of the School of Engineering of Telecommunication. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results

Code	
A1	Students have the ability to gather and interpret relevant data (usually within their field of study) to inform judgments that include reflection on relevant social, scientific or ethical topics.
A2	Students can communicate information, ideas, problems and solutions to both general and specialized public.
A4	Students can communicate information, ideas, problems and solutions to both general and specialized public.
B1	CG1: The ability to write, develop and sign projects in the field of Telecommunication Engineering, according to the knowledge acquired as considered in section 5 of this Law, the conception and development or operation of networks, services and applications of Telecommunication and Electronics.
B2	CG2: The knowledge, comprehension and ability to apply the needed legislation during the development of the Technical Telecommunication Engineer profession and aptitude to manage compulsory specifications, procedures and laws.
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
B10	CG10 The ability for critical reading of scientific papers and docs.
B14	CG14 The ability to use software tools to search for information or bibliographical resources.
C90	(CE90/TFG)Original and individual exercise to be defended before an examining board consisting of a project in a specific technology of Telecommunication Engineering and of a professional nature, where the abilities acquired from the teachings are integrated and synthesized.
D1	CT1 Development of sufficient autonomy to carry out works within the area of Telecommunications in interdisciplinary contexts.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject

Expected results from this subject	Training and Learning Results			
Search, management and structuring of information on any topic	A2	B2 B10 B14		D1
Development and writing of a project document which are collected: history, state of the art or problematic, objectives, project phases, project development, conclusions and future lines.	A2	B1 B10		D1 D2 D4

Prototyping, programming simulation software, etc., according to specifications.	A4	B1 B2 B4 B9	C90	
Write and develop projects in the field of Telecommunication Engineering, according to the knowledge acquired towards the conception and development or operation of networks, services and applications of Telecommunication and Electronics.	A1	B1	C90	D1 D2 D4

Contents	
Topic	
The contents of each TFG will be defined in individual proposals offered by tutors and approved by the Academic Degree Commission under the rules for carrying out the Bachelor Thesis, the content of which is available on the website of the School of Telecommunication Engineering.	Each TFG will have different contents

Planning			
	Class hours	Hours outside the classroom	Total hours
Previous studies	0	20	20
Project based learning	0	20	20
Presentation	0	8	8
Mentored work	30	210	240
Essay	2	10	12

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Previous studies	Search, read and work documentation, troubleshooting suggestions and / or exercises to be performed in the classroom and / or laboratory ... independently by students.
Project based learning	The student presents the results obtained in the preparation of a document on the subject matter. It will be carried out individually, and both in writing (memory) and orally.
Presentation	Students must prepare and defend the work in front of a jury.
Mentored work	The student, individually, produces a paper on the subject matter, or he/she prepares seminars, research, memoirs, essays, summaries, etc.

Personalized assistance

Methodologies	Description
Mentored work	Each student receives academic advice by his/her supervisor concerning the specific topic of the Bachelor's thesis. Students will meet regularly with their supervisors for tracking of their progress. The TFG coordinator will establish tutoring hours at the beginning of the term. These hours could be checked at the subject web page https://moovi.uvigo.gal/.
Previous studies	Each student receives academic advice by his/her supervisor concerning the specific topic of the Bachelor's thesis. Students will meet regularly with their supervisors for tracking of their progress. The TFG coordinator will establish tutoring hours at the beginning of the term. These hours could be checked at the subject web page https://moovi.uvigo.gal/.
Project based learning	Each student receives academic advice by his/her supervisor concerning the specific topic of the Bachelor's thesis. Students will meet regularly with their supervisors for tracking of their progress. The TFG coordinator will establish tutoring hours at the beginning of the term. These hours could be checked at the subject web page https://moovi.uvigo.gal/.
Presentation	Each student receives academic advice by his/her supervisor concerning the specific topic of the Bachelor's thesis. Students will meet regularly with their supervisors for tracking of their progress. The TFG coordinator will establish tutoring hours at the beginning of the term. These hours could be checked at the subject web page https://moovi.uvigo.gal/.

Assessment			
	Description	Qualification	Training and Learning Results

Essay	A panel of three teachers for each of the mentions of the Degree shall be appointed. The evaluation was carried out according to the rules for carrying out the Final Year Work and assessment rubric approved by the Academic Degree Committee, whose contents are available on the website of the school of Telecommunication Engineering.	100

Other comments on the Evaluation

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

The use of Generative Artificial Intelligence (GAI) is allowed in the realization of the TFG. Its use must be done in an ethical, critical, and responsible manner. When using GAI, any result provided by GAI should be critically evaluated, and any citation or reference generated should be carefully verified. It is also mandatory to declare the use of GAI tools.

All information related to the TFG is available on the website of the School of Telecommunication Engineering at the following link:

https://teleco.uvigo.es/estudos/organizacion-academica/tfg-tfm/

Sources of information

Basic Bibliography

Complementary Bibliography

Recommendations

Other comments

Having passed all necessary subjects to obtain the Bachelor degree except the TFG, or enroll simultaneously in all subjects.