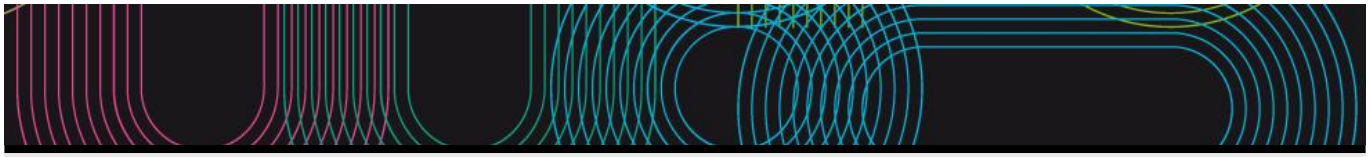

(*)Escola de Enxeñaría de Telecomunicación

(*)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.

Bachelor's Degree in Telecommunication Technologies Engineering (EUR-ACE®).

The mail goal of the Bachelor's 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-ACE's. **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 master's 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

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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

(*)Máster Universitario en Enxeñaría de Telecomunicación

Subjects			
Year 1st			
Code	Name	Quadmester	Total Cr.
10414-53350-S		1st	6
10414-53355-S		2nd	6
10414-76017		1st	5
10414-76018		1st	5
10414-76019		1st	5
10414-76020		1st	5

10414-76021		2nd	5
10414-76022		2nd	5
10414-76023		2nd	5
10414-76024		2nd	5
10414-76025		2nd	5
10414-76026		2nd	5
10414-76027		2nd	5
10414-76028		2nd	5
10414-76029		2nd	5
10414-76030		2nd	5
10414-76031		2nd	5
10414-76032		2nd	5
10414-76033		2nd	5
10414-76034		2nd	5
10414-76035		2nd	5

Year -

Code	Name	Quadmester	Total Cr.
10414-76037-S		1st	5
10414-76038		1st	5
10414-76040		1st	5
10414-76043-S		1st	5
10414-76048-S		1st	5

Year 2nd

Code	Name	Quadmester	Total Cr.
10414-76054-S		1st	5
10414-76055-S		1st	5
10414-76056-S		1st	5
10414-76057-S		1st	10

IDENTIFYING DATA				
(*)Procesado de señales II				
Subject	(*)Procesado de señales II			
Code	10414-53350-S			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Arias Acuña, Alberto Marcos			
Lecturers	Arias Acuña, Alberto Marcos Obelleiro Basteiro, Fernando Rodríguez Banga, Eduardo Rodríguez Vaqueiro, Yolanda Rubiños López, José Óscar			
E-mail	marcos@com.uvigo.es			
Web	http://http://moovi.uvigo.gal			
General description	In this matter will give the foundations of the processed of continuous signals			

Training and Learning Results	
Code	
B7	Know the procedures to innovate and manage ideas and creativity
B12	Know the main standards in the field of audio and video coding.
C31	Model, operate, manage, and address the complete lifecycle and packaging of networks, services, and applications, considering quality of service, direct and operational costs, the implementation plan, monitoring, security, scaling, and maintenance, managing and ensuring quality throughout the development process.

Expected results from this subject	Training and Learning Results	
New	B7 B12	C31

Contents	
Topic	
1. Introduction to the signals and systems in continuous time (theoretical-practical)	1.1 Properties of the signals in continuous time 1.2 Exponential, unitary stair and unitary impulse 1.3 Systems in continuous time
2. Linear systems and invariants in the continuous time (theoretical-practical)	2.1 Convolution 2.2 Systems as convolution 2.3 Properties of LTI systems
3. Fourier Analysis in continuous time (theoretical-practical)	3.1 LTI systems outpu to complex exponential signals 3.2 Continuous Time Fourier Transform (CTFT) 3.3 CTFT of periodic signals 3.4 Properties of the CTFT 3.5 Convolution and filtering
4. Fourier Analysis in discreet time (theoretical-practical)	4.1 Discrete Time Fourier Transform (DTFT) 4.2 Discrete Fourier Transform (DFT) 4.3 Circular convolution 4.4 FFT
5. Particular cases of the analysis of Fourier (theoretical-practical)	5.1 Modulation and windowing 5.2 Sampling 5.3 Reconstruction 5.4 Processed discreet of signals in continuous time 5.5 Sampling of signals in discrete time

Planning			
	Class hours	Hours outside the classroom	Total hours

Introductory activities	1.5	2	3.5
Lecturing	31.5	44	75.5
Practices through ICT	24	33	57
Problem and/or exercise solving	1.5	2	3.5
Problem and/or exercise solving	1.5	2	3.5
Problem and/or exercise solving	1.5	2	3.5
Problem and/or exercise solving	1.5	2	3.5

*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	Introduction the first day of class in which it details the organisation of the course and the evaluation. I review to contents given in previous subjects. With this methodology work the learning results B12, D25, D26 and D30. Group activity.
Lecturing	Exhibition by part of the teachers of the contents on the matter object of study, theoretical bases and/or guidelines of a work, exercise or project to develop by the students. With this methodology work the learning results B7, B12, C31, D25, D26. Group activity.
Practices through ICT	Activities of application of the knowledges to concrete situations and of acquisition of basic skills and procedures related with the matter object of study. They develop in classrooms or computer rooms. With this methodology work the learning results B7, B12, C31, D25, D26, D30. Group activity.

Personalized assistance

Methodologies	Description
Lecturing	In this methodology, attends and answers to all the questions that can do each person enrolled that it assist to the class.
Practices through ICT	In this methodology, attends and answers to all the questions that can do each person enrolled that it assist to the class.
Tests	**Description**
Problem and/or exercise solving	In this methodology, attends and answers to all the questions that can do each person enrolled previous to the realisation of the examination.
Problem and/or exercise solving	In this methodology, attends and answers to all the questions that can do each person enrolled previous to the realisation of the examination.
Problem and/or exercise solving	In this methodology, attends and answers to all the questions that can do each person enrolled previous to the realisation of the examination.
Problem and/or exercise solving	In this methodology, attends and answers to all the questions that can do each person enrolled previous to the realisation of the examination.

Assessment

	Description	Qualification	Training and Learning Results	
Problem and/or exercise solving	First partial examination	15	B7 B12	C31
Problem and/or exercise solving	Second partial examination	20	B7 B12	C31
Problem and/or exercise solving	Third partial examination	25	B7 B12	C31
Problem and/or exercise solving	Global examination: it consists in an individual and autonomous proof for the evaluation of the competitions purchased by the students. They will have to develop, relate, organise and present the knowledges purchased during the course.	40	B7 B12	C31

Other comments on the Evaluation

The people that are enrolled in this subject will be able to opt by one of the following systems of qualification: continuous evaluation or qualification by means of global examination (at the end of semester). Those students that renounce by writing to the global evaluation will have the qualification of the final examination. The date and procedure of review of the qualifications obtained will publish together with these.

1. Qualification by means of CONTINUOUS EVALUATION. The continuous evaluation consists of the tasks that detail in this guide. The qualification obtained in these tasks will be valid so alone for the academic course in which they are passed. The

system of continuous evaluation consists in: a) Three sessions of resolution of exercises and questions (that they will designate proofs of continuous evaluation) in which they will evaluate the contents given in the matter from his start until the previous week to his realisation, included; b) final Examination. The planning of the different proofs of intermediate evaluation will approve in an academic commission of degree (CAG) and will be available at the beginning of the semestre.
2. GLOBAL EXAMINATION AT THE END OF THE SEMESTRE. Based only in the final examination.
3. FORMULA OF QUALIFICATION
PEC = grades obtained by the proofs of continuous evaluation until 10 points.EF = grades of the final examination until 10 points.
To surpass the subject will be necessary to obtain a minimum qualification of 3.5 points in the final examination. If it fulfils this condition, the final note will calculate as: Grades = max(EF, 0.6*PEC + 0.4*EF)
In case of not reaching the minimum of 3.5 points in the final examination, the final qualification will be: Grades= min(4, max(EF, 0.6*PEC + 0.4*EF))
4. RECOVERY IN THE EXTRAORDINARY OPPORTUNITY. The system of evaluation and formula of qualification will be the same that for the ordinary announcement.
5. EXAM OF END OF CAREER. His evaluation will be only the one of the final examination.
6. STUDENTS PRESENTED TO THE SUBJECT. It will consider presented to all person enrolled in this matter that receive the text of the final examination.
7. In case of detection of plagiarism/copies or use of devices or unauthorised tools in any one of the proofs (partial examinations or global examination), the final qualification will be of FAIL (0) and the fact will be communicated to the direction of the Centre.
8. After any assessment, teaching staff may call students for oral verification interviews, either at random or where there are indications of cheating, unauthorized use of artificial intelligence, or other fraudulent means in completing the exam. Grades for the assessments shall remain provisional until any such interviews have been completed. During these interviews, students must demonstrate that they possess the knowledge and skills needed to adequately justify the solutions they submitted.

Sources of information

Basic Bibliography

Oppenheim, A. V., Willsky, A. S., & Nawab, S. H., **Signals and systems**, 9781292025902, 2, Pearson new international edition, 2013

Oppenheim, A. V., Willsky, A. S., & Nawab, S. H., **Signals and systems**, 9780138147570, 2, Prentice Hall, 1997

Oppenheim, A. V., Willsky, A. S., & Nawab, S. H., **Señales y sistemas**, 9789701701164, 2, Pearson Educación, 1998

Oppenheim, A. V., Schafer, R. W., & Buck, J. R., **Discrete-time signal processing**, 9780137549207, 2, Prentice Hall, 1999

Complementary Bibliography

Oppenheim, A. V., & Schafer, R. W., **Tratamiento de señales en tiempo discreto**, 9788483227183, 3, Pearson Educación, 2011

Alkin, O., **Signals and systems: A MATLAB® integrated approach.**, 9781466598539, 1, CRC Press, 2014

Lathi, B. P., & Green, R., **Linear systems and signals**, 9780190200176, 3, Oxford University Press, 2017

M. D. Adams, **Signals and Systems.**
https://www.ece.uvic.ca/~frodo/sigsysbook/downloads/signals_and_systems-6.0.pdf, 9781990707070, 6, CC, 2024

Recommendations

Subjects that it is recommended to have taken before

(*)Álgebra lineal/11585-53337
(*)Análisis de circuitos lineales/11585-53343
(*)Cálculo II/11585-53341
(*)Cálculo I/11585-53336
(*)Procesado de señales I/11585-53344

IDENTIFYING DATA				
(*)Redes de ordenadores				
Subject	(*)Redes de ordenadores			
Code	10414-53355-S			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	López Ardao, José Carlos			
Lecturers	Fondo Ferreiro, Pablo López Ardao, José Carlos Rodríguez Pérez, Miguel Rúa Estévez, José Manuel 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	
B4	Conceiving Engineering within a framework of sustainable development.
B5	Acquire advanced knowledge and demonstrate, in a highly specialized or scientific and technological research context, a detailed and well-founded understanding of the theoretical and practical aspects and working methodology in one or more fields of study.
C7	Apply the principles of economics and human resources and project management, as well as telecommunications legislation, regulation, and standardization.
C11	Become aware of the need for continuous quality training and improvement, developing values inherent to the dynamics of scientific thought, demonstrating a flexible, open, and ethical attitude toward diverse opinions or situations, particularly regarding non-discrimination based on sex, race, or religion, respect for fundamental rights, accessibility, etc.
D3	Integrate knowledge and face the complexity of formulating judgments based on information that, although incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of knowledge and judgments

Expected results from this subject	Training and Learning Results		
New	B4 B5	C7 C11	D3
New	B4 B5	C7 C11	D3
New	B4 B5	C7 C11	D3
New	B5	C7 C11	D3
New	B4 B5	C7 C11	D3
New	B4 B5	C7 C11	D3

Contents	
Topic	
Computer Networks and the Internet	Global Structure. Architectural Models. The TCP/IP Model.
Packet switching	Switch architecture. Data and control planes. Key performance metrics.
Link/subnet layer	Link types. IEEE 802 LANs: Ethernet and WiFi
The network layer	IPv4 and IPv6 addressing. IP forwarding. NAT. Interaction with the link layer. Routing in Internet
The transport layer	Protocols. Secure transport. Reliability. Flow control. Congestion control

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	36	60	96
Laboratory practical	23	23	46
Gamification	0	4	4
Essay questions exam	2	0	2
Objective questions exam	1.5	0	1.5
Problem and/or exercise solving	0.5	0	0.5
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies	
	Description
Lecturing	Exposition of the ideas, concepts, technics and algorithms related to the thematic units of the course. This methodology addresses competencies B4, B5, C7, C11, C49, D3 and D28.
Laboratory practical	The practical laboratory sessions will serve to reinforce the content covered in the lectures. There will be various types of practical sessions: 1) development of small network programmes; 2) use of network tools and utilities (WireShark, ping, traceroute, dig, etc.); 3) network configuration of host devices, switches and routers using the GNS3 emulator; and 4) solving problems related to the course content. This methodology addresses competencies B4, B5, C7, C11, C49, D3 and D28.
Gamification	A gamification system will be used in the virtual classroom, employing points, mechanics and gamification elements to encourage class attendance, the completion and performance of tasks carried out in practical classes, and participation in the course forum on MooVi. This will allow students to earn rewards to be used in exams or in continuous assessment. The course forum on MooVi will be the preferred channel for remote support regarding queries about the course content. Gamification will encourage peer support and the collaborative resolution of queries in the forums. This methodology addresses competencies B4, B5, C7, C11, C49, D3, D28.

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/
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		
Laboratory practical	Network programmes created during the lab sessions, as well as any short assignments or problems to be completed in some of these lab sessions must eb submitted to the MooVi platform for assessment	10	B4 B5	C7 C11	D3
Essay questions exam	Final exam covering the whole subject. It has a weight of 40% but a minimum mark of 4 out of 10 is required to pass the subject.	40	B4 B5	C7 C11	D3
Objective questions exam	Two multiple-choice control tests to check the progress on the subject (duration one hour). The part of objective questions has a weight of 20% in each test	40	B4 B5	C7 C11	D3
Problem and/or exercise solving	Two multiple-choice control tests to check the progress on the subject (duration one hour). The part of problem solving has a weight of 5% in each test	10	B4 B5	C7 C11	D3

Other comments on the Evaluation

The evaluation method, continuous or global, is left to the choice of students.

Continuous assessment (CA)

The student must make the choice of the option in the virtual classroom before the first evaluation test. After this deadline, the chosen evaluation option cannot be changed. Students who do not make any choice will automatically opt for overall evaluation.

Continuous evaluation consists of 3 types of activities or tests:

- Autonomous Problem solving delivered in MooVi. During the course, 3 small network programs must be carried out and delivered during the practical classes. Each program allows students to obtain up to 25 "merit points" (PM). In addition in some practical classes tasks or problems will also be performed that must be delivered and allow students to obtain another 75 additional "merit points" (PM). Therefore, a maximum of 150 "merit points" (PM) can be obtained. However the highest score in this section is 100 PM.

- Two test-type intermediate control tests, one hour long, for subject monitoring control (C1 and C2). Each control test has a weight of 25% on the final grade (FG). The planning of the different tests will be approved in an Academic Committee of Degree (CAG) and will be available at the beginning of the semester.

- A final written exam (FE) including all the contents of the subject, which has a weight of 40% on the Final Grade (FG) and in which it is necessary to reach 4 points out of 10 to be able to pass the subject.

The Final Note obtained by Continuous Assessment (CA) will be:

$FG\text{-}CA = 0.25 \times (C1 + C2) + \min(PM, 100)/100 + 0.4 \times FE$ if $FE \geq 4.0$

If $FE < 4 \Rightarrow FG\text{-}CA = \min\{FE; FG\text{-}CA\}$ where FG-CA would be the continuous evaluation note calculated above.

Continuous evaluation has the added advantage of being able to participate in the Gamification mechanism, based essentially on the tasks and programs carried out and delivered in the practical classes. Gamification allows the students to get rewards for use in the Final Exams, such as a sheet of notes/formulas or extra time in the final exam. It also allows students to get additional PM.

Failure to complete any of the intermediate tests, C1 or C2, implies a rating of "0" in that test. These tests, like the scoring activities and the network practices carried out and delivered during the practical classes, are not recoverable.

Gobal Assessment (GA)

Students who have not made any evaluation choice within the stipulated period follow Global Assessment.

The Global Assessment (GA) will consist of the realization of the same EF at the end of the semester, and must obtain a score equal to or greater than 5 to pass the subject.

Extraordinary Opportunity

On the officially established dates there will be a new FE, which can only be carried out by students who have not passed the subject at the ordinary opportunity.

This Extraordinary Opportunity FE is a possibility for improving the grade of this test with respect to the first. The calculation of the Final Grade will take into account the best grade of those obtained in these two tests between the two opportunities. That is to say

$FE = \max(FE1; FE2)$

Those students who have opted for AC and wish to change to the AG modality in this Extraordinary Opportunity, must communicate it in writing to the coordinator of the subject before 20h. of the day of the review of the examination of the ordinary opportunity.

In this case, the conditions for passing the subject are exactly the same as those of the rest of the students presented by AG.

Additionally, no reward obtained in the AC can be used.

Obtaining the Final Notes is identical to that of the ordinary opportunity.

Call End of Career

Students who appear in this extraordinary call concur exactly in the same conditions as those of the Global Assessment.

Other considerations

All students who attend any FE are considered to be presented to the subject. The qualifications of all tests, partial or final, programs and activities delivered will only take effect in the academic year in which they are proposed.

In the case of detection of plagiarism in any of the works/tests/examinations/programs carried out, the final qualification of the subject will be of Fail (0) and the fact will be communicated to the Management Team of the School to take the appropriate measures.

All official communications of the Course will be published in the Virtual Classroom Notices and News Forum, to which all students are forcibly subscribed by e-mail. It is assumed that every student reads these messages and is adequately informed of their content.

Given any contradiction that may occur between the different versions of the guide, due to some translation error, the version that will prevail is the Galician language version, with the exception of the English teaching group, for which it will be this guide in English.

Sources of information

Basic Bibliography

J.F. Kurose, K.W. Ross, **Computer networking: a top-down approach**, 9780135429334, 9, Pearson, 2025

José Carlos López Ardao e Miguel Rodríguez Pérez, **Redes de Ordenadores: Fundamentos y Tecnologías de Internet**, 1, 2026

Complementary Bibliography

L. Peterson, B. Davie, **Computer networks: a systems approach**, 9780128182000, 6, Morgan Kaufmann, 2021

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**, 6.1, 2019

Recommendations

Subjects that it is recommended to have taken before

Data Communication/V05G301V01204

Other comments

In order to develop network programmes, it is important to have some programming skills in a language such as Java, C/C++, Rust or Python. The learning outcomes from Programming II are sufficient

IDENTIFYING DATA				
(*)Sistemas distribuidos				
Subject	(*)Sistemas distribuidos			
Code	10414-76017			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	Spanish			
Department				
Coordinator	Fernández Vilas, Ana			
Lecturers	Cajaraville Aboy, Diego Fernández Vilas, Ana García Méndez, Silvia			
E-mail	avilas@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This course provides an overview of the key principles and technologies behind modern distributed systems. Students will learn to design and deploy efficient and scalable solutions, addressing challenges such as coordination, virtualization, cloud computing, and resource management in distributed environments.			

Training and Learning Results	
Code	
B9	Understand and apply the functioning and organization of the Internet, next-generation Internet technologies and protocols, component models, middleware, and services.
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C8	Communicate (orally and in writing) the conclusions - and the knowledge and ultimate reasons that support them - to specialized and non-specialized audiences in a clear and unambiguous manner.
C9	Learn continuously, self-directedly, and autonomously.
C17	Carry out planning, decision-making and packaging of networks, services and applications considering the quality of service, direct and operating costs, the implementation plan, supervision, security procedures, scaling and maintenance, as well as managing and ensuring quality in the development process
C18	Solve the convergence, interoperability and design of heterogeneous networks with local, access and backbone networks, as well as the integration of telephone, data, television and interactive services.
D1	Project, calculate, and design products, processes, and facilities in all areas of telecommunications engineering
D4	Design and dimension transport, broadcast and distribution networks for multimedia signals
D6	Model, design, implement, manage, operate, administer, and maintain networks, services, and content.

Expected results from this subject	Training and Learning Results
Understand the fundamental principles of distributed systems, including synchronization, mutual exclusion, and concurrency, as well as group communication mechanisms.	B9 C3 C8 C9 C17 C18 D1 D4 D6
Apply and analyze classical distributed algorithms, such as consensus and distributed quorum, evaluating their efficiency and robustness.	B9 C3 C8 C9 C17 C18 D1 D4 D6

Identify and use virtualization techniques, understanding the functioning of virtual machines, containers, and network function virtualization, assessing their advantages and limitations.	B9 C3 C8 C9 C17 C18 D1 D4 D6
Design architectures following the principles of the Cloud□Edge□Mist continuum, evaluating the advantages it offers in terms of elasticity, availability, and efficiency.	B9 C3 C8 C9 C17 C18 D1 D4 D6
Design efficient resource management strategies, including allocation and scheduling, persistent storage, replication, consistency, and load balancing in distributed environments.	B9 C3 C8 C9 C17 C18 D1 D4 D6
Develop and deploy complex distributed systems using orchestration and choreography techniques, continuous delivery methodologies, and applying usability and user-centered design principles.	B9 C3 C8 C9 C17 C18 D1 D4 D6

Contents	
Topic	
Distributed environments.	Synchronization, mutual exclusion, and concurrency. Group communication. Classical distributed algorithms (Consensus, distributed quorum, Paxos, etc.). Multicast and gossip solutions.
Virtualization.	Platforms and Techniques. Virtual Machines and Containers. Network function virtualization.
Cloud Computing.	Cloud Layers and Architectures. Platforms. Elasticity and availability. Administration and Operation. Fluid computing: Cloud vs Edge vs Mist.
Resource management.	Resource allocation and scheduling. Persistent storage. Replication and consistency. Load balancing.
Systems Development.	Components and services. Orchestration and choreography. Development based on continuous delivery. Usability and user-centered design.

Planning			
	Class hours	Hours outside the classroom	Total hours
Laboratory practical	19	34	53
Previous studies	0	25	25
Flipped Learning	9	9	18
Problem solving	8	9	17
Laboratory practice	2	0	2
Essay questions exam	2	0	2
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

Laboratory practical	Students will carry out a set of laboratory practices related to the design and deployment of a distributed system, following the architectural principles of the cloud□edge□mist continuum, as well as continuous delivery standards.
Previous studies	Students will be provided with the necessary material for the prior study before the flipped class, allowing them to arrive in class with the basic knowledge already acquired and facilitating a more active, participatory learning focused on resolving doubts and practical activities.
Flipped Learning	A flipped classroom methodology will be primarily used, encouraging student autonomy through prior study, so that class time is devoted to practical application, discussion, and doubt resolution.
Problem solving	A problem-solving methodology will be employed to address the more conceptual and analytical aspects of the subject.

Personalized assistance

Methodologies	Description
Laboratory practical	Doubts will be addressed in person, online, or via Moovi. In the case of synchronous tutorials, they will be scheduled in advance.
Previous studies	Doubts will be addressed in person, online, or via Moovi. In the case of synchronous tutorials, they will be scheduled in advance.

Assessment

	Description	Qualification	Training and Learning Results		
Laboratory practice	The laboratory practice will be continuous assessment with at least three separate submissions. The total of these submissions will account for 50% of the course grade.	50	B9	C3 C8 C9 C17 C18	D1 D4 D6
Essay questions exam	In the official exam session, a written exam will be held covering all the course content, including open-ended questions that demonstrate the students□ maturity and understanding of the subject matter.	30	B9	C3 C8 C9 C17 C18	D1 D4 D6
Problem and/or exercise solving	Between weeks 7 and 9, students will be required to solve a set of proposed exercises and case studies related to the more conceptual and analytical aspects.	20	B9	C3 C8 C9 C17 C18	D1 D4 D6

Other comments on the Evaluation

Continuous assessment will be based on the progressive submission of practical assignments, the completion of proposed exercises, and the final exam. In the final assessment, the evaluated components will be the laboratory practices and a written development exam scheduled in the official exam period, each with a 50 % weight. The end-of-degree assessment will be equivalent to the final assessment.

Sources of information

Basic Bibliography

Complementary Bibliography

George Colouris, Jean Dollimore, Tim Kindberg, Gordon Blair, **Distributed systems: Concepts and design.**, Ed. Pearson, 2012

Nayan B. Ruparelia, **Cloud Computing, revised and updated edition (The MIT Press Essential Knowledge series)**, The MIT Press, 2023

Wan Fokkink, **Request exam copy View preview Distributed Algorithms An Intuitive Approach**, The MIT Press, 2013

Dan C. Marinescu, **Cloud Computing: Theory & Practice**, Elsevier, 2013

Rajkumar Buyya, James Broberg, Andrzej Goscinski, **Cloud computing: principles and paradigms**, wiley, 2014

Kai Hwang, Geoffrey C. Fox andJack J. Dongarra, **Distributed and Cloud Computing**, elsevier, 2012

Recommendations

IDENTIFYING DATA				
(*)Radio				
Subject	(*)Radio			
Code	10414-76018			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	Spanish			
Department				
Coordinator	González Valdés, Borja			
Lecturers	González Valdés, Borja			
E-mail	bgvaldes@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	In this compulsory matter of first semester, the student familiarises with the radiocommunication systems, beginning with the antenna properties, continuing with the study of the noise and interferences and finalising with the calculation of the link budget in different propagation scenarios. These concepts apply to the study of the services of radar and radiolocalization.			

Training and Learning Results	
Code	
C2	Manage the tools necessary to direct, plan and supervise multidisciplinary teams
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C5	Use tools specific to general management, technical management, and research, development, and innovation project management in companies and technology centers.

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Capacity to realise basic antenna designs	C2
Capacity to calculate link budgets taking into account both signal and perturbations in distinct stages	C2 C3
Capacity to design radionavegation and positioning systems	C3 C5
Capacity to design radar systems	C5

Contents	
Topic	
1. Basic design of antennas	1.1 Electromagnetic Foundations 1.2 Antennas 1.3 Friis formula Competitions related: C6, C15
2. Models of noise and interferences	2.1 Thermal Noise 2.2 Noise of antenna and receptor 2.3 Interferences 2.4 Availability, fading and diversity 2.5 Radio systems limited by noise and by interference Competitions related: C6, C15, C16
3. Calculation of links in distinct stages of propagation	3.1 Propagation in low frequencies 3.2 Propagation in high frequencies 3.3 Propagation models Competitions related: C6,C15
4. Design of systems of radionavegation	4.1 Radionavegation systems foundations and types 4.2 Satellite radionavegation systems Competitions related: C8, C16, D5
5. Design of systems radar	5.1 Foundations and types of radar system. Radar cross section. 5.2 Design of a radar systems Competitions related: C8, D5

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	21	33	54
Seminars	5	20	25
Laboratory practical	14	14	28
Problem and/or exercise solving	1	8	9
Essay questions exam	1	8	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	Exhibition of the contained of the subject; it includes exhibition of concepts; introduction of practices and exercises; and resolution of problems and/or exercises in common classroom. With this methodology will work the competencies CB2, CE2, CE3 and CE5
Seminars	Teaching in small rooms, in the that the student takes part very actively in the evolution of the kinds deepening in one specific item, enlarging and relating with contents guided to the professional practice; including the participation in scientific events and/or conferences, organized or not in the own School; the organisation of enabling debates compare ideas and proposals, guided by the teacher, both physically and online; and the study of cases/analysis of situations (analysis of a problem or real case, with the aim to know it, interpreted, resolved, generate hypothesis, diagnosed and deepening in alternative procedures of solution, to see the application of the theoretical concepts in the reality). These activities can had related a lot of autonomous work of the student. With this methodology will work the competencies CB4, CE2, CE3 and CE5
Laboratory practical	Application, to practical level, of the knowledges and skills purchased in the theoretical kinds, by means of practices realized with equipment of test and measure, both in the laboratory or of field. Also including practices of laboratory realized on computers (simulation, analysis, processing, etc.), exercises of programming, works realized online, etc. With this methodology will work the competencies CB2, CE2 and CE5

Personalized assistance

Methodologies	Description
Lecturing	In this methodology, all the questions that each student may ask are attended and answered. Tutoring schedules and how to request them are shown in the Moovi of the subject.
Seminars	Each student will be attended in an individual way.
Laboratory practical	Each student will be attended in an individual way.

Assessment

	Description	Qualification	Training and Learning Results
Seminars	Presentation of an individual project on the link budget of a concrete system.	10	C2 C3 C5
Laboratory practical	Students during the course participate in individual or group practices and perform individual jobs. The individual note for each student of this item is that corresponding to the continuous evaluation and I can be worth up to 30% of the final score.	20	C2 C3 C5
Problem and/or exercise solving	Final examination: it consists in a proof for the evaluation of the competencies adquired by the students by means of the resolution of simple problems and short questions of theory.	40	C2 C5
Essay questions exam	Final exam: it consists in a proof for the evaluation of the competencies adquired by the students. They will have to develop, organise and present the knowledges adquired during the course.	30	C2 C5

Other comments on the Evaluation

Students during the course participate in individual or group practices and do individual work within the continuous assessment. The individual grade can account for up to 30% of the final grade. In the continuous assessment, attendance at practices is mandatory, although there is no minimum number of papers submitted to obtain a grade.

The continuous evaluation will additionally consist of a written exam on the first two topics that will mean up to 30% of the mark.

All students must take the final exam on the date set by the center, which will consist of a single test for students in continuous assessment. Students who take the global evaluation will also have to take a test equivalent to the partial exam.

To pass the subject it is necessary to get a minimum of 4 out of 10 in the two written exams. If this minimum is not exceeded, the maximum rating that could be obtained would be 4.9.

The final mark, both in the ordinary and in the extraordinary, will be the highest between the mark of the written exams and the sum of the continuous evaluation mark including that of the final exam.

Any person enrolled in this subject who receives either of the two written exams will be considered submitted.

The evaluation in the end of career call will be similar to that of the global evaluation.

In the event of detection of plagiarism in any of the work/tests carried out, the final grade for the subject will be "Fail (0)" and the teachers will notify the school management of the matter so that they can take the appropriate measures.

Sources of information
Basic Bibliography
Marcos Arias Acuña, Oscar Rubiños López, **Radiocomunicación**, 1a, Andavira Editora, 2011
José María Hernando Rábanos, **Transmisión por Radio**, 6a, Editorial Universitaria Ramón Areces, 2008
John Griffits, **Radio Wave Propagation and Antennas. An Introduction**, 1st, Prentice Hall, 1985
Complementary Bibliography
Robert R. Collin, **Antennas and Radiowave Propagation**, 1st, Mc Graw Hill, 1985
Thomas A.Milligan, **Modern Antenna Design**, 2nd, Wiley, 2005
ngel Cardama, L. Jofre, J.M. Rius, S. Balnch, M. Ferrando, **Antenas**, 2a, Ediciones UPC, 2002
Constantine A. Balanis, **Antenna Theory. Analysis and Design**, 3rd, Wiley, 2005
ITU-R, Recommendations,

Recommendations
Subjects that continue the syllabus
Satellites/V05M145V01311
Radio Laboratory/V05M145V01209
Wideband Radio Systems/V05M145V01312
Antennas/V05M145V01208

IDENTIFYING DATA				
(*)Tratamiento de señal en comunicaciones				
Subject	(*)Tratamiento de señal en comunicaciones			
Code	10414-76019			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	English			
Department				
Coordinator	López Valcarce, Roberto			
Lecturers	López Valcarce, Roberto			
E-mail	valcarce@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This course presents several of the signal processing techniques most commonly found in the design and implementation of communication systems, with focus on digital processing schemes. Covered aspects include sampling and quantization, block and adaptive estimation, block transform based modulation, efficient resampling and filtering methods.			

Training and Learning Results	
Code	
B4	Conceiving Engineering within a framework of sustainable development.
B8	Understand the limitations, risks, and implications of using Generative AI.
C1	Manage the tools necessary to manage telecommunication system construction and installations, complying with current regulations and ensuring service quality.
C2	Manage the tools necessary to direct, plan and supervise multidisciplinary teams
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.

Expected results from this subject	Training and Learning Results
Ability to implement advanced signal processing techniques in diverse fields of application: bioengineering, bioinformatics, etc.	A1 A1 B4 B8 B18 C38 C38 C38 C38
Ability to apply signal processing techniques to the modeling and simulation of communication systems	B4 C1 C2
Ability to simulate the physical layer of cable, wireline, satellite systems in fixed/mobile communication environments.	A1 B18 B18 B4 B8 C2 C3 C38 C38 D10 D10

Contents
Topic

Sampling and quantization	- Aliasing - Baseband and bandpass sampling - Sampling rate conversion: decimation, interpolation - Quantization noise - Converter overload - Spurious-free dynamic range - Sampling jitter
Block-based Transforms in Communications and Multimedia	- DFT: formulation and properties. - Frequency Analysis based on DFT. Windowing. - Power Spectrum Estimation: Welch's periodogram - DFT-based digital modulation schemes: SC-FDE, OFDM.
Linear estimation	- Least Squares criterion - Minimum Mean Squared Error criterion - LMMSE properties - State-space description - The Kalman filter

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	26	20	46
Practices through ICT	14	24	38
Autonomous problem solving	0	24	24
Essay questions exam	2	0	2
Report of practices, practicum and external practices	0	5	5
Report of practices, practicum and external practices	0	5	5
Report of practices, practicum and external practices	0	5	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	Presentation of main topics, possibly with audiovisual aids. Applied/theoretical problem sessions. Skills involved: CG4, CG8.
Practices through ICT	Under the guidance of the instructor, students will develop the design and/or simulation of a number of signal processing systems involving several of the techniques studied during the course, under the MATLAB programming environment. Skills involved: CE1, CE2, CE3.
Autonomous problem solving	Computer-based simulation of signal processing applications to communications and multimedia. Skills involved: CE1, CE2, CE3.

Personalized assistance

Methodologies	Description
Practices through ICT	Student aid will be provided during office hours by appointment, as well as on-line (email) (see https://moovi.uvigo.gal/user/profile.php?id=11637). An on-line discussion forum will be set up for the course, through the usual e-learning platform
Lecturing	Student aid will be provided during office hours by appointment, as well as on-line (email) (see https://moovi.uvigo.gal/user/profile.php?id=11637). An on-line discussion forum will be set up for the course, through the usual e-learning platform

Assessment

	Description	Qualification	Training and Learning Results	
Essay questions exam	Final test in which the student must solve a series of exercises.	40	B4	C1 C2
Report of practices, practicum and external practices	Written report corresponding to the first lab assignment. In general, it will be carried out in groups of two. The instructor may monitor students' progress and require further clarifications in order to check the contribution to the report of all members of the group.	20	B4 B8	C1 C2 C3
Report of practices, practicum and external practices	Written report corresponding to the second lab assignment. In general, it will be carried out in groups of two. The instructor may monitor students' progress and require further clarifications in order to check the contribution to the report of all members of the group.	20	B4 B8	C1 C2 C3

Report of practices, practicum and external practices	Written report corresponding to the third lab assignment. In general, it will be carried out in groups of two. The instructor may monitor students' progress and require further clarifications in order to check the contribution to the report of all members of the group.	20	B4 B8	C1 C2 C3

Other comments on the Evaluation

Students may choose one of the following two assessment options:

1) Continuous assessment: Final grade will consist of a comprehensive test (up to 4 points) and lab assignments (up to 6 points)

A minimum grade of 35% in the comprehensive test is required in order to pass the course. If this minimum is not reached, the final grade will directly be the one obtained in the comprehensive test.

Lab assignment grades from the ordinary call will be kept for the extraordinary call, in which students will be allowed to take a new comprehensive test.

2) Global assessment: The final grade is the one achieved in the comprehensive test, for both ordinary and extraordinary calls.

It is assumed that students choose the continuous assessment mode as soon as a lab report is turned in.

Students are allowed to turn in their reports and exam indistinctly in English, Spanish or Galician.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the deliverables 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

Richard G. Lyons, **Understanding Digital Signal Processing**, 9780132119375, 3rd, Pearson Education International, 2011

Behrouz Farhang-Boroujeny, **Signal Processing Techniques for Software Radios**, 5800046161148, 2nd, Lulu, 2010

M. S. Grewal and A. P. Andrews, **Kalman filtering: theory and practice using Matlab**, 978-0-470-17366-4, 2nd, Wiley, 2008

Complementary Bibliography

J.G. Proakis and D.G. Manolakis, **Digital Signal Processing**, 0-13-228731-5, 4th, Pearson Education International, 2007

Recommendations

Subjects that continue the syllabus

(*)Comunicaciones digitales avanzadas/10414-76033
(*)Codificación de fuente y canal/10414-76034

Other comments

It is assumed that students are knowledgeable in the following areas:
- Signal Processing: analog and discrete-time signals, time and frequency domains, Fourier Transform, linear systems (continuous- and discrete-time), convolution, transfer function, FIR and IIR filters, group delay, poles and zeros.
- Probability and statistics: random variables, probability density function, probability distribution function, mean, variance. Gaussian and uniform distributions. Stochastic processes: autocorrelation, crosscorrelation, stationarity, power spectral density.
- Communications: bit rate, baud rate, carrier frequency, PAM and QAM modulation.

IDENTIFYING DATA				
(*)Sistemas electrónicos digitales avanzados				
Subject	(*)Sistemas electrónicos digitales avanzados			
Code	10414-76020			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Valdés Peña, María Dolores			
Lecturers	Moure Rodríguez, María José Valdés Peña, María Dolores			
E-mail	mvaldes@uvigo.es			
Web	http://moovi.uvigo.gal/course			
General description	The objective of this course is to provide students with the ability to design complex or high frequency digital systems. Firstly, the electrical characteristics, power consumption, speed and fan-out of digital integrated circuits and the technologies of semiconductor memories are studied. Subsequently, the interface with external peripherals and the methodology for designing synchronous sequential systems are analyzed. Finally, the course focuses on the design of digital communications systems implemented using high density integrated programmable circuits. Meanwhile, throughout all contents, emphasis is placed in the VHDL description of high complexity digital 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	
B10	Know the hardware description languages for highly complex circuits.
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C6	Apply acquired knowledge and solve problems in new or unfamiliar environments within broader, multidisciplinary contexts, being able to integrate knowledge.
C8	Communicate (orally and in writing) the conclusions - and the knowledge and ultimate reasons that support them - to specialized and non-specialized audiences in a clear and unambiguous manner.
C9	Learn continuously, self-directedly, and autonomously.
C19	Use programmable logic devices and design advanced electronic systems, both analog and digital. Design communications components such as routers, switches, hubs, transmitters, and receivers in different bands.
D7	Design and manufacture integrated circuits.

Expected results from this subject	Training and Learning Results
The knowledge of the integrated circuit manufacturing technologies.	D7
The ability to analyze and design advanced digital circuits.	C3 C38 C19
The ability to design input/output interface circuits.	C38 C19 D7
The knowledge of the design methodologies of complex digital circuits.	C38 C6 C9 C38 C19 D10 D10 D10

The ability to design communication components using programmable logic devices.	B18 B10 C6 C38 C8 C19 D10 D10
The ability to design complex digital electronic systems using hardware description languages.	A1 A1 B18 B18 B10 C38 D10 D10 D10 D10 D10

Contents	
Topic	
Introdution to digital integrated circuits	CMOS technology: NMOS and PMOS technologies, CMOS gates, CMOS fabrication. HW design methodologies: custom, semicustom, cell-based, array-based, programmable logic devices (FPGAs). SW design methodologies: abstraction levels, design methods, design flow, IPs.
Advanced VHDL	VHDL description of complex digital systems: variables, arrays, records, generics, generate, funcion, procedure. VHDL coding of Finite State Machines. Advances synthesis: inference, primitives, IPs.
CMOS integrated circuits	Design Metrics: voltages, noise, fan-in, fan-out, delay, power. Power issues in FPGAs Input/Output: standard levels, package. Timing issues: set-up, hold, metastability, skew, jitter, clock distribution.
Sequential design	Synchronizers: asynchronous inputs, PLLs, DLLs Clocking resources in FPGAs. Sequential Design methods: Moore and Mealy Finite State Machines.
Semiconductor memories	Architecture of semiconductor memories: RAM, CAM, ROM, EEPROM, FLASH. Memory Interfacing: RAM, DRAM, EEPROM, FLASH interfacing. Memory in FPGAs: distributed, blocks, external memory, memory IPs.
Arithmetic in FPGAs	Numeric representations. Overflow. Techniques to mitigate overflow. Precision vs. hardware cost. Arithmetic operations. Low cost hardware implementations. Design arithmetic considerations for HDL coding.
Frequency synthesis for communication applications	Frequency synthesis using numerically controlled oscillators (NCOs). NCO architecture. Design parameters. Spurious Free Dynamic Range (SFDR) characterization. Design techniques. NCO implementation using FPGAs.

Retiming and pipeline techniques	Signal flow graphs (SFGs). Analysis of the critical path of digital systems. Analysis of the input to output latency. Retiming techniques to reduce propagation delay in digital systems: pipelining and time scaling. Applying retiming techniques to the design of digital filters. Hardware cost. Applying the concepts to the implementation of digital filters using FPGAs.
Series vs. parallel implementation issues	Design techniques: fully serial, fully parallel, serial-parallel. Hardware cost and timing issues. Applying the concepts to the implementation of digital filters using FPGAs.
Hardware-in-the-loop	Description, simulation and test of FPGAs based circuits. Applying the concepts to the design of data acquisition and signal processing circuits. Using tools for hardware-in-the-loop.
Laboratory Practices	Advanced tools for the design and test of complex digital circuits. Design and implementation of ADC/DAC interfaces, sensor interfaces, digital signal processing modules, communications blocks and memory interfaces.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	20	10	30
Laboratory practical	14	14	28
Project based learning	7	10	17
Previous studies	0	3	3
Mentored work	0	6	6
Autonomous problem solving	0	2	2
Objective questions exam	1	8	9
Laboratory practice	0	15	15
Project	0	15	15
*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 via Moovi, and students are expected to come to the theoretical class having completed the assigned reading. Through lecturing sessions the outcomes C9, D7, B10 and C19 are developed.
Laboratory practical	During laboratory sessions students apply the design methods described in the lecturing sessions. All practices are guided and supervised by the professor. Through laboratory practises the outcomes C3, D7, B10 and C19 are developed.
Project based learning	This activity focuses on applying the design techniques studied in the theoretical classes and the skills acquired at the laboratory to a project implementation. Students should obtain well founded solutions, choosing appropriate methods and devices. These projects are planned and tutored in small size groups. Through this activity the outcomes B10, C3, C6, C8, C9, C19 and D7 are developed.
Previous studies	This task includes the preparation of theory sessions and laboratory practices. Through this activity the outcomes B10, C3, C6, C9, C19 and D7 are developed.
Mentored work	It consists of the guided activities performed in the laboratory practices. Through this activity the outcomes B10, C3, C6, C9, C19 and D7 are developed.
Autonomous problem solving	The teacher presents a set of problems to be solved independently during individual work hours. Through this activity the outcomes B10, C3, C6, C9, C19 and D7 are developed.

Personalized assistance

Methodologies	Description
Lecturing	Students have the opportunity to resolve doubts in personalized attention sessions. The appointment with the corresponding professor must be requested and agreed by email, preferably within the hours published on the faculty website. The links to the contact details of the teachers are: María José Moure Rodríguez - https://moovi.uvigo.gal/user/profile.php?id=11642 María Dolores Valdés Peña - https://moovi.uvigo.gal/user/profile.php?id=11303
Laboratory practical	Students have the opportunity to resolve doubts in personalized attention sessions. The appointment with the corresponding professor must be requested and agreed by email, preferably within the hours published on the faculty website. The links to the contact details of the teachers are: María José Moure Rodríguez - https://moovi.uvigo.gal/user/profile.php?id=11642 María Dolores Valdés Peña - https://moovi.uvigo.gal/user/profile.php?id=11303
Project based learning	Meetings will be planned with each student team to supervise the progress of the projects.
Mentored work	Students have the opportunity to resolve doubts in personalized attention sessions. The appointment with the corresponding professor must be requested and agreed by email, preferably within the hours published on the faculty website. The links to the contact details of the teachers are: María José Moure Rodríguez - https://moovi.uvigo.gal/user/profile.php?id=11642 María Dolores Valdés Peña - https://moovi.uvigo.gal/user/profile.php?id=11303
Autonomous problem solving	Students have the opportunity to resolve doubts in personalized attention sessions. The appointment with the corresponding professor must be requested and agreed by email, preferably within the hours published on the faculty website. The links to the contact details of the teachers are: María José Moure Rodríguez - https://moovi.uvigo.gal/user/profile.php?id=11642 María Dolores Valdés Peña - https://moovi.uvigo.gal/user/profile.php?id=11303

Assessment

	Description	Qualification	Training and Learning Results		
Objective questions exam	At the end of the semester there will be an exam of short problems and/or development questions. This exam asses all of the contents taught in the theoretical classes.	40	B10	C19	D7
Laboratory practice	The assessment of the laboratory practices takes place during the practical sessions. The student should complete at least the 80% of the sessions. The implementation of the circuits described in the practice guidelines and the reports submitted at the end on each session will deserve the 25% of the final grade.	30	B10	C3 C6 C19	D7
Project	Students will develop a design project in groups of 2 persons, preferably, demonstrating the skills acquired in the theoretical lessons and laboraory practices. The project represents the 25% of the final grade.	30	B10	C3 C6 C8 C9 C19	D7

Other comments on the Evaluation

The subject can be passed with the maximum grade through continuous assessment (CA) or global assessment (GA). Both evaluation methods are mutually exclusive. The student who attends more than 2 laboratory sessions is considered to have opted for continuous assessment. However, those who wish to waive continuous assessment may do so within a maximum period of one month before the end of the semester.

1. Continuous assessment:

Students who opt for the CA modality will have two evaluation opportunities, the ordinary call at the end of the semester and the extraordinary one at the end of the course (June-July).

1.1 Ordinary call

The ordinary call consists of a set of assessments that will be carried out throughout the semester. The dates of all the tests will be published in a shared calendar and will be available at the beginning of the semester.

The weight and content of the assesssments is as follows:

- Objective questions exam and/or questions of development (NExam):

- It covers all of the contents taught in the theoretical classes and/or practices. Includes short problems or questions, or multiple answer questions.

- Laboratory practices (NPrac):

- The student must correctly implement the circuits described in the practice scripts and deliver a results report corresponding to each practice. The mark of each practice depends on these results.
- It can be done individually or by groups of 2 students. In the latter case, if both attend the practice, the mark is the same for both.
- The practices are compulsory. Students must attend at least 80% of the practice sessions.
- The laboratory practices grade is calculated as the average of the grades obtained in each evaluable practice.

- Project (NPro):

- This project will be developed by students through autonomous work and supervised by teachers in type C hours.

Continuous assessment final grade (Final_CA):

The final grade of the ordinary CA is obtained as follows:

Final_CA = (NExam*0.4 + NPrac*0.3 + NPro*0.3) if **NExam, NPrac and NPro are greater than or equal to 4**;

Final_CA = min [(NExam*0.4 + NPrac*0.3 + NPro*0.3), 4.9] in any other case;

1.2 Extraordinary call:

The student that does not pass one or more assessments of the ordinary call can recover the following parts in the extraordinary call:

- He/she can complete the project and this mark replaces the previous one (NPro).
- He/she can take the theoretical exam and this mark replaces the previous one (NExam).

The final grade of the extraordinary call is obtained in the same way as the ordinary one.

2. Global assessment:

As with the continuous assessment, students who opt for global assessment will have two opportunities, ordinary and extraordinary calls. In both cases it will consist of the following parts:

- An exam in which all the theoretical contents of the subject are evaluated. It consists of several short problems and/or development questions and lasts 2 hours. This exam represents 40% of the final grade (NExam).
- A practical exam covering the same aims of the labortory practices developed during the course. This exam lasts 2 hours. The weight of this evaluation represents 30% of the

final grade (Nprac).

- An individual project with the same objectives and complexity as the project carried out in the continuous assessment. This project represents 30% of the final grade (NPro).

Global assessment final grade (Final_GA):

The final grade (Final_GA) is obtained as follows:

Final_GA = (NExam*0.4 + NPrac*0.3 + NPro*0.3) if NExam, NPrac and NPro are greater than or equal to 4;

Final_GA = min [(NExam*0.4 + NPrac*0.3 + NPro*0.3), 4.9] in any other case.

3. Other comments:

- Students may write their reports, papers, exams or presentations in Spanish, Galician or English.

- The grades obtained in the continuous or 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 exam. Mobile phones must be turned off and out of reach of the student.

- Plagiarism is regarded as serious dishonest behavior. In the case that plagiarism is detected in any of the reports/tasks/exams done/taken, 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
Complementary Bibliography
Weste N., Harris D., **CMOS VLSI Design. A circuits and systems perspective**, 4, 2011
Roth C.H., John L.K., **Digital systems design using VHDL**, 3, 2008
Sharma A.K., **Semiconductor memories : technology, testing, and reliability**, 1997
Kurinec S.K., Iniewski K., **Nanoscale Semiconductor Memories: Technology and Applications (Devices, Circuits, and Systems)**, 2013
Kleitz W., **Digital Electronics: A Practical Approach with VHDL**, 9, 2011
Comer D.J., **Digital logic and state machine design**, 3, 1995
Wakerly J.F., **Digital Design. Principles and Practices**, 4, 2007
Moure M.J., Valdés M.D:, **Apuntes y prácticas de SEDA**, 2017

Recommendations
Subjects that continue the syllabus
(*)Circuitos mixtos analógicos y digitales/10414-76030
(*)Codiseño hardware/software de sistemas empotrados/10414-76031

IDENTIFYING DATA				
(*)Redes integradas				
Subject	(*)Redes integradas			
Code	10414-76021			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	2nd
Teaching language	#EnglishFriendly			
Department				
Coordinator	Fernández Veiga, Manuel			
Lecturers	Díaz Redondo, Rebeca Pilar Fernández Veiga, Manuel			
E-mail	mveiga@det.uvigo.es			
Web				
General description	(*)Conceptos, arquitecturas e tecnoloxías de Concepts, architecture and technology for contemporary communications networks, wired and wireless. Multiple access, non-orthogonal systems, 5G/6G networks, satellite networks.			

Training and Learning Results	
Code	
B9	Understand and apply the functioning and organization of the Internet, next-generation Internet technologies and protocols, component models, middleware, and services.
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C4	Apply methodologies for the development, strategic planning, direction, coordination, and technical and economic management of projects in all areas of telecommunications engineering, following quality and environmental criteria.
C5	Use tools specific to general management, technical management, and research, development, and innovation project management in companies and technology centers.
C6	Apply acquired knowledge and solve problems in new or unfamiliar environments within broader, multidisciplinary contexts, being able to integrate knowledge.
C9	Learn continuously, self-directedly, and autonomously.
C16	Implement cable, landline, and satellite systems in fixed and mobile communications environments.
C17	Carry out planning, decision-making and packaging of networks, services and applications considering the quality of service, direct and operating costs, the implementation plan, supervision, security procedures, scaling and maintenance, as well as managing and ensuring quality in the development process
C18	Solve the convergence, interoperability and design of heterogeneous networks with local, access and backbone networks, as well as the integration of telephone, data, television and interactive services.
D1	Project, calculate, and design products, processes, and facilities in all areas of telecommunications engineering
D4	Design and dimension transport, broadcast and distribution networks for multimedia signals
D6	Model, design, implement, manage, operate, administer, and maintain networks, services, and content.

Expected results from this subject	
Expected results from this subject	Training and Learning Results

Know and know how to apply contemporary unified methods of information coding.	A1 A1 A1 A1 A1 B18 B18 B18 B18 B9 B18 B18 B18 C3 C4 C5 C6 C38 C16 C17 C18 C38 C38 C38 D1 D10 D10 D10 D4 D10 D10 D6 D10 D10 D10 D10 D10 D10

Know and know how to apply in real systems the principles of communication theory and interference management: non-orthogonal transmission and rate splitting.	A1 A1 A1 A1 A1 B18 B18 B18 B18 B18 B9 B18 B18 B18 C3 C4 C5 C6 C9 C38 C16 C17 C18 D1 D10 D10 D10 D4 D10 D6 D10 D10 D10
Know and know how to apply mass access techniques for multiple access in the design of advanced communications solutions.	A1 A1 A1 A1 A1 B18 B18 B18 B18 B18 B9 B18 B18 B18 C3 C4 C5 C6 C9 C38 C16 C17 C18 D1 D10 D10 D10 D4 D10 D6 D10 D10 D10

Understand and know how to design with the principles of advanced communication networks: softwarization, virtualization, cell-free networks, RAN disaggregation	A1 A1 A1 A1 A1 B18 B18 B18 B18 B18 B9 C3 C4 C5 C38 C6 C9 C38 C16 C17 C18 D1 D10 D10 D4 D10 D10 D6 D10
To know and know how to build solutions with the technologies and architectures of integrated space-air-ground networks	A1 A1 A1 A1 A1 B18 B18 B18 B18 B18 B9 C3 C4 C5 C38 C6 C9 C38 C16 C17 C18 D1 D10 D10 D4 D10 D10 D6 D10

Contents	
Topic	
1. Coding of information: a unified vision unified	Codes for massive storage of data. Advanced channel coding. Network coding. Coded caching
2. Multiple access and management of interferences	Non orthogonal transmission. Rate splitting. MIMO communications
3. Massive multiple access	Principles of access URA. Coding schemes
4. Advanced network architectures	Software controlled networks. Cell-free networks. Virtualization. RAN disaggregation

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	19	38	57
Problem solving	7	10	17
Autonomous problem solving	0	15	15
Laboratory practical	14	20	34
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	Presentation and debate of the technical contents of the course
Problem solving	Resolution of exercises and representative problems of the concepts covered in the course
Autonomous problem solving	Resolution by writing of exercises proposed by the instructors
Laboratory practical	Development and construction of software prototypes of systems and integrated networks

Personalized assistance	
Methodologies	**Description**
Lecturing	Personalized advising and tutoring will be offered on any topic covered during the course, theoretical or applied.
Problem solving	Personalized advising and tutoring will be offered on any topic covered during the course, theoretical or applied.

Assessment					
	Description	Qualification	Training and Learning Results		
Autonomous problem solving	Homework problems, individual work.	30	B9	C3 C4 C5 C6 C9 C16 C17	D1 D4 D6
Laboratory practical	Systems programming project	30	B9	C3 C4 C5 C6 C9 C16 C17 C18	D1 D4 D6
Essay questions exam	Written exam	40	B9	C3 C4 C5 C6 C9 C16 C17 C18	D1 D4 D6

Other comments on the Evaluation

The use of generative AI tools for solving the tasks and assignments in the course is not forbidden, yet the degree of originality and authorship of the answers will be closely monitored and assessed.

Assessment in the second opportunity will follow the same requirements and obligations as in the first opportunity

Sources of information

Basic Bibliography

Complementary Bibliography

Y. Polyanski, Y. Wu, **Information Theory**, 1, Cambridge University Press, 2025

Matteo Berioli, Giuseppe Cocco, Gianluigi Liva and Andrea Munari, **Modern Random Access Protocols**, 1, Foundation and Trends in Networking, 2016

Özlem Tugfe Demir, Emil Björnson and Luca Sanguinetti, **Foundations of User-Centric Cell-Free Massive MIMO**, 1, Foundations and Trends in Signal Processing, 2021

Emil Björnson, Jakob Hoydis and Luca Sanguinetti, **Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency**, 1, Foundations and Trees in Networking, 2017

Recommendations

IDENTIFYING DATA				
(*)Electrónica y fotónica avanzadas para comunicaciones				
Subject	(*)Electrónica y fotónica avanzadas para comunicaciones			
Code	10414-76022			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Fernández Barciela, Mónica			
Lecturers	Fernández Barciela, Mónica Fraile Peláez, Francisco Javier Marante Boado, María Morales Fernández, Ainhoa			
E-mail	monica.barciela@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The aim of the subject is that students acquire knowledge on the actual implementation of transceivers for the modern communication systems that transmit in the radiofrequency and optical bands bands. In the case of RF and MW transceivers, students will learn to evaluate performance, select and design components and analog circuits (active and passive) for them. As an learning aid, the student will use commercial circuit simulators. In the field of the optical communications, students will learn the operation of the basic transmission and reception components and active optoelectronical subsystems , and will be able to characterise them and select them as function of the optical system to be designed. In this course the student will handle technical and scientific bibliography in English language.			

Training and Learning Results	
Code	
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C15	Develop radiocommunication systems: antenna, equipment and subsystem design, channel modeling, link calculation and planning
C16	Implement cable, landline, and satellite systems in fixed and mobile communications environments.
C19	Use programmable logic devices and design advanced electronic systems, both analog and digital. Design communications components such as routers, switches, hubs, transmitters, and receivers in different bands.
C20	Apply advanced knowledge of photonics and optoelectronics, as well as high-frequency electronics.
D1	Project, calculate, and design products, processes, and facilities in all areas of telecommunications engineering

Expected results from this subject	Training and Learning Results
Learn the operation of the components and basic transmission and reception active optoelectronical subsystems in optical communications and photonic processing, and being able to characterise them and select them as function of the optical system to design.	C3 C20 D1
Handle technical documentation and scientific bibliography in English	D1
Learn to evaluate performance, select and design components and analog subsystems (active and passive) for communications transmitters and receivers in different frequency bands (radiofrequency, microwaves, millimeter waves). As a support tool in this work, students will use a commercial circuit simulator.	C3 C15 C16 C19 C20 D1

Contents	
Topic	
1. Introduction to advanced circuit design for RF and high frequency transceivers for communications.	a. Communication systems transmitting at RF and microwave frequency bands. b. Technologies and design techniques at the different frequency bands. c. Basic tools: S parameters and Impedance matching networks.

2. CAD design of passive components for transceivers.	Couplers, filters and resonators.
3. CAD design of active linear circuits for transceivers.	a. Bias and stabilisation networks. b. Circles of stability, power gain and noise. c. Amplifier design for maximum transducer gain. d. Design of low noise amplifiers. e. Design of broadband amplifiers.
4. CAD design of active nonlinear circuits for transceivers.	a. Power Amplifiers: classes of operation, linearity, dynamic loadline, power and efficiency contours. Architectures for maximum energy efficiency. b. Frequency converters. c. Frequency synthesizers.
5. Introduction to advanced Photonics and Optoelectronics.	a. Semiconductors optical properties. b. Fabry-Perot lasers and DFB. c. Photodetectors. Static and dynamic regime. d. Electro-optic and electro-absorbing modulators.
6. Optic transmitters and receivers.	(*)
7. Photonic processing devices.	(*)

Planning

	Class hours	Hours outside the classroom	Total hours
Practices through ICT	19	11.5	30.5
Lecturing	20	52	72
Problem and/or exercise solving	1.5	2	3.5
Problem and/or exercise solving	0	15	15
Problem and/or exercise solving	1.5	2.5	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	This practices apply concepts related to the microwaves technologies part of the subject. They will be performed individually or in small teams of 2 students. With the aid of a commercial microwave and RF circuit simulator, students will analyze various passive (matching networks, filters, couplers, etc.) and active (amplifiers,..) circuits. It will be defined and evaluated different figures of merit and other parameters that will be used for circuits performance evaluation. In Moovi, students will have available support files and documentation. Through an agreement between UVIGO and the simulator provider, the student may apply for a temporary license of the simulator for his/her PC. The student work in these practice classes will be individually evaluated: 1. In continuous Evaluation: by test/s which include short questions/exercises or the design of some circuits, with the aid of the simulator. 2. In Exam-only Evaluation: by means of short questions/exercises and circuit designs (with or without the aid of the simulator) related with the work performed during the practices in computer rooms. In these practices, students with work towards achieving competencies: D1, C3, C15, C16, C19 and C20
Lecturing	It will take place in a classroom with video projection facilities, blackboard and occasionally CAD tools. During these sessions it will be described in detail the relevant contents in the Subject program. The applications of some of theses concepts will be done thought exercises resolution, with or without CAD tools. In fact, some classes will be fully theoretical while others will include both theory and applications. Students will have available in Moovi support documentation and files. Competencies under work: C3, C15, C16, C19 and C20.

Personalized assistance

Methodologies	Description

Lecturing	During the master sessions the lecturer will answer the questions addressed by the students. Students will be also guided by the lecturer team during the time assigned for personalized attention in the office, in which their questions, related to the subject theoretical and practical work as well as the assessment tests and deliverables, will be solved. To apply for office hours: https://moovi.uvigo.gal/user/profile.php?id=11321
Practices through ICT	During the practices through ICT the lecturer will answer the questions addressed by the students and guide their assigned work. To apply for office hours: https://moovi.uvigo.gal/user/profile.php?id=11321

Assessment

	Description	Qualification	Training and Learning Results	
Practices through ICT	The student work in these practices, related to microwave technologies, will be individually evaluated: 1. In Continuous Assessment: through one/several short examinations with questions/exercises and/or performing simple designs, with the aid of the simulator, during or out of the practices schedule. One of these tests may imply a deliverable involving the design of a circuit. 2. In Exam-only Assessment: by means of short questions/exercises and circuit designs (with or without the aid of the simulator) related with the work performed during the practices.	25	C3 C15 C16 C19 C20	D1
Problem and/or exercise solving	In Continuous Assessment: - There will be 1 Short Examination with exercise solving (no use of simulator, may include short questions), related to the microwave technologies part. In Exam-only Assessment: -The Final Exam will also include exercises resolution, with or without the aid of the simulator, and may include short questions.	25	C3 C15 C16 C19 C20	D1
Problem and/or exercise solving	With respect to the part of the subject related to RF technologies: In Continuous Assessment, students will solve, in individual form or in reduced groups, the proposed exercises/designs, with the help of CAD tools. They will deliver a written report that will be evaluated. The evaluation could be complemented by means of an interview about the performed work. In Exam-only Assessment, the examination will include similar exercise solving, to solve individually.	15	C3 C15 C16 C19	D1
Problem and/or exercise solving	In Continuous Assessment: - There will be 1 Short Examination with exercise solving (may also include short questions), related to Photonics. In Exam-only Assessment: -The Final Exam will also include exercises resolution and may include short questions, related to this part.	35	C3 C16 C20	D1

Other comments on the Evaluation

It is convenient that students attend all CAD practices, since through them the lecturer will guide the student home work related to these practices. It is also convenient for the student to perform all the proposed practices and exercises, in order to achieve the skills required to pass the Subject assessment tools.

First Call:

A) In the case that the student opts for *Continuous Assessment*:

1. It is mandatory to attend at least 80% of the CAD practices, related to microwave technologies. In this case, the evaluation of these practices will be done through one/several individual Examinations with the support of CAD tools. One of these tests may be replaced by a deliverable report about a proposed circuit design. The total grade achieved in these assessment test corresponds up to 25% of the Subject Qualification (SQ).
2. The evaluation of the subject part related to RF circuit design, will be done through one or several deliverable reports (performed individually or in group) about some proposed designs or exercises, with the aid of CAD tools. This evaluation may include an interview about the work. The total grade achieved will be up to 15% of the SQ.
3. The rest of the assessment with be individually performed through 2 Short Examinations, that may contain exercise resolution and/or short questions:- Exam 1 related to the microwave technologies content, 25 % SQ.
- Exam 2 related to Photonics, 35% SQ.
 Up to 3 days before Exam 2 takes place, students must sent to the subject coordinator a written communication about their chosen option for the Subject Assessment in this Call: Continuous Assessment or *Ex*am-only Assessment; otherwise, it will be assumed Exam-only Assessment.

The schedule of the midterm/intermediate exams will be approved by the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester. These intermediate exams do not have "second-chance" examinations.
B) If the student opts for *Exam-only Assessment (100% SQ)*, this exam will involve all the subject content (theory and practices) and include: exercises resolutions and/or designs (with or without the aid of the circuit simulator) and/or short questions.
Second Call and *End-of-program call*:
Students who failed the First Call will perform a similar exam as the one in option B. In particular, students that in the First Call chose continuous assessment and want to preserve his/her qualifications obtained in the microwave CAD practices (25 % SQ) and the RF technology deliverables (15% SQ), must perform a shorted version of the exam in option B (with a total weight of up to 60% SQ), involving most of the subject content, but excluding the RF part and the simulator aid.
Up to 3 days before the Exam takes place, students must sent to the subject coordinator a written communication about their chosen option for the Subject Assessment in this Call: Continuous Assessment or Exam-only Assessment; otherwise, it will be assumed Exam-only Assessment.
After any assessment, teaching staff may call students for oral verification interviews, either at random or where there are indications of cheating, unauthorized use of artificial intelligence, or other fraudulent means in completing the exam. Grades for the assessments shall remain provisional until any such interviews have been completed. During these interviews, students must demonstrate that they possess the knowledge and skills needed to adequately justify the solutions they submitted.
In case of plagiarism detection in any of the proposed works/assessment tools performed by the student, his final Subject qualification will be a failure rate of (0), and the coordinator will communicate the school Board this issue so appropriate measures may be taken.

Sources of information

Basic Bibliography

D.M. Pozar, **Microwave Engineering**, 4, Wiley, 2011

Guillermo González, **Microwave Transistor Amplifiers: Analysis and Design**, 2, Prentice Hall, 1996

Steve C. Cripps, **RF Power Amplifiers for Wireless Communications**, 2, Artech House, 2006

Bahaa E. A. Saleh, Malvin Carl Teich, **Fundamentals of Photonics**, 2, Wiley, 2007

Rhea, Randall W., **HF filter desing and computer simulation**, 1, Scitech Publishing, 1994

Complementary Bibliography

Enrique Sánchez, **Introducción a los dispositivos y circuitos semiconductores de microondas**, 1, PEARSON, 2012

Steve C. Cripps, **Advanced Techniques in RF Power Amplifier Design**, 1, Artech House, 2002

Amnon Yariv, Pochi Yeh, **Photonics Optical Electronics in Modern Communications**, 6, Oxford Univ. Press, 2006

S. O. Kasap, **Optoelectronics and Photonics: Principles and Practice**, 2, PEARSON, 2013

Guillermo González, **Foundations of Oscillator Circuit Design**, 1, Artech House, 2008

Rhea, Randall W., **Discrete oscillator design : linear, nonlinear, transient, and noise domains**, 1, Artech House, 2010

John L. B. Walker, **Handbook of RF and Microwave Power Amplifiers**, 1, Cambridge University Press, 2011

Stephen A. Maas, **Nonlinear Microwave and RF Circuits**, 2, Artech House, 2003

Recommendations

IDENTIFYING DATA				
(*)Acondicionadores de señal y sensores				
Subject	(*)Acondicionadores de señal y sensores			
Code	10414-76023			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Quintáns Graña, Camilo Pastoriza Santos, Vicente			
Lecturers	Costas Pérez, Lucía Pastoriza Santos, Vicente Quintáns Graña, Camilo			
E-mail	quintans@uvigo.gal vpastoriza@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	In ACSS, measurement sensors and their electronic conditioning circuits are studied so that the generated signals can be appropriately coupled to data acquisition systems and digital processors. The overall objective is for students to create a complete measurement system, from the sensor to the user interface. This course has an eminently practical focus, maintaining a balance between the acquisition of new knowledge and its application in solving real-world problems. It expands the knowledge, skills, and abilities students have acquired in their undergraduate studies on analog circuits and sensors. It introduces students to the field of metrology and presents sensors and their conditioning circuits from the perspective of a telecommunications engineer. 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	
C19	Use programmable logic devices and design advanced electronic systems, both analog and digital. Design communications components such as routers, switches, hubs, transmitters, and receivers in different bands.
C21	Develop electronic instrumentation, as well as transducers, actuators and sensors
C28	Build a measurement system for a physical variable from the transducer to the user interface, including knowledge of metrology, basic signal conditioning topologies, and instrumentation software.

Expected results from this subject	Training and Learning Results
Use programmable logic devices and design advanced electronic systems, both analog and digital. Design communications components such as routers, switches, hubs, transmitters, and receivers in different bands.	C19
Develop electronic instrumentation, as well as transducers, actuators and sensors	C21
Build a measurement system for a physical variable from the transducer to the user interface, including knowledge of metrology, basic signal conditioning topologies, and instrumentation software.	C28

Contents	
Topic	
Unit 1. Introduction to measurement systems.	Stages of measurement systems. Sensor characteristics.
Unit 2. Measurement errors and uncertainties.	Introduction to the calculation of uncertainties. Errors and uncertainty associated with the calibration curve.
Unit 3. Resistive sensors and their conditioning.	PT100, NTC, and gauges. Passive measuring bridges. Instrumentation amplifier.
Unit 4. DC Sensors and Conditioners.	DC Active Bridges. Conditioner for a Hall Effect Sensor. Isolation Amplifier.
Unit 5. Filtering in measurement systems.	Functionalities. Active filters.
Unit 6. AC/DC converters and demodulationing filters.	Unsigned precision rectifier. Signed precision rectifier: synchronous rectifier. Phase demodulator. Frequency/voltage converter. Demodulationing filter.

Unit 7. Sensors and basic AC conditioning circuits.	Voltage divider: conditioner for an inductive position sensor. AC amplifier: conditioner for a liquid level sensor, conditioner for a capacitive position sensor, conditioner for an inductive sensor.
Unit 8. Advanced AC Conditioners.	AC Active Bridge. Blocking Amplifier.
Unit 9. Conditioners for Generator Sensors.	Conditioning for Electromagnetic Sensors. Conditioner for a Photodiode. Conditioner for a Thermocouple.
Laboratory activities	Project 1. DC Measurement System Practice 1. Characterization of a strain gauge bridge. Practice 2. Conditioning a strain gauge bridge. Amplification and filtering. Practice 3. Data acquisition and programming of a virtual instrument. Practice 4. Adjustments and testing of the DC measurement system. Project 2. AC Measurement System Practice 5. PV converter. Practice 6. Active AC bridge. Practice 7. Study of an AC measurement sensor. Practice 8. AC conditioning. Practice 9. Programming a data acquisition system in C language. Practice 10. Adjustments and testing of the DC measurement system.

Planning			
	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	2	3
Lecturing	13	26	39
Problem solving	4	8	12
Laboratory practical	18	10	28
Project based learning	3	1	4
Essay questions exam	2	10	12
Objective questions exam	1	6	7
Problem and/or exercise solving	0	10	10
Laboratory practice	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
Introductory activities	Activities directed to take contact and gather information on the students, as well as to present the subject.
Lecturing	Exhibition by part of the professor of the contents on the matter object of study, theoretical bases and/or guidelines of a work, exercise that the/the student has to develop. The learning outcomes that are developed are: C19, C21 and C28.
Problem solving	Activity in which they formulate problems and/or exercises related with the subject. The student has to develop the suitable or correct solutions by means of the practice of routines, the application of formulas or algorithms, the application of procedures of transformation of the available information and the interpretation of the results. It is used to use as I complement of the lecturing. The learning outcomes that are developed are: C19, C21 and C28.
Laboratory practical	Activities of application of the knowledges to concrete situations and of acquisition of basic skills and procedures related with the matter object of study. They develop in special spaces with skilled equipment (laboratories, computer classrooms, etc). The learning outcomes that are developed are: C19, C21 and C28.
Project based learning	Realisation of activities that allow the cooperation of several subjects and confront to the students/ace, working in team, to open problems. They allow to train, between others, the capacities of learning in cooperation, of leadership, of organisation, of communication and of strengthening of the personal relations. The learning outcomes that are developed are: C19, C21 and C28.

Personalized assistance	
Methodologies	**Description**
Lecturing	The professor will attend personally doubts and queries of the students on the study of the theoretical concepts and exercises. Office hours will take place in the teacher's office at the time established at the beginning of the course and published on the personal profile accessible on Moovi.
Problem solving	The professor will attend personally doubts and queries of the students on the resolution of the problems. Office hours will take place in the teacher's office at the time established at the beginning of the course and published on the personal profile accessible on Moovi.

Laboratory practical	The professor will attend personally doubts and queries of the students to prepare the practices of laboratory and to the realisation of the reports of results. Office hours will take place in the teacher's office at the time established at the beginning of the course and published on the personal profile accessible on Moovi.
Project based learning	The professor will attend personally doubts and queries of the students on the preparation of the projects that are developed in the laboratory. Office hours will take place in the teacher´s office or in the laboratory in the schedule that publish at the beginning of the course in the accessible personal profile in Moovi.

Assessment

	Description	Qualification	Training and Learning Results
Essay questions exam	Tests that include open questions about a topic. Students must develop, relate, organize and present the knowledge they have about the subject in a comprehensive response.	25	C19 C21 C28
Objective questions exam	Tests that assess the knowledge that includes enclosed questions with different alternatives of answer (true/false, multiple election, pairing of elements, etc.). The students select an answer between a number limited of possibilities.	15	C19 C21 C28
Problem and/or exercise solving	Test in which the student must solve a series of problems and/or exercises in a time/conditions established by the teacher. In this way, students must apply the knowledge acquired.	10	C19 C21 C28
Laboratory practice	Completion of real or simulated practical tasks. These are tests in which the performance of the students will be evaluated on the basis of their ability to demonstrate their knowledge of the material, their ability to organize and plan during the practice sessions, as well as their reflection on the results obtained, and the preparation of a report by the student in which the characteristics of the work carried out are reflected.	50	C19 C21 C28

Other comments on the Evaluation

1. Ordinary exam

1.1. Continuous Assessment: This consists of the following three parts, each with its respective weights:
Part 1: Laboratory (50%), which is divided into:

- Laboratory practice (25%).
- Laboratory practice report (25%).

Part 2: Theory exams (40%), which is divided into:

- Essay question exam (25%).
- Objective question exam (15%).

Part 3: Problem-solving and/or exercises (10%).
The final grade, which is scored out of a maximum of 10 points, is the sum of the grades for each part if the following conditions are met:

Condition 1: Complete a minimum of 80% of the laboratory practices.

Condition 2: Obtain a minimum score of 40% in the laboratory assessment (Part 1), the exams (Part 2), and the problem-solving and/or exercises (Part 3).

If any of the previous requirements are not met, the final grade will be the sum of all grades or 4 points, if that sum is equal to or greater than 5 points.
Students who opt for continuous assessment and who have not reached the minimum mark in any part can recover it in the final exam of the ordinary or extraordinary calls. In the case of laboratory reports, if the minimum grade was not reached, the deadline to present the improvements proposed by the teaching team is the date of the final exam of the ordinary or extraordinary calls.
To pass, students have to obtain a mark equal to or greater than 50% of the maximum grade (5 points).
If after the first month of academic activity and after taking the first partial exam the students do not expressly waive continuous assessment, it will be considered to be the assessment method they have chosen.

1.2. Global assessment

Students who do not opt for continuous assessment or who do not carry out at least 80% of the laboratory work can make a global final exam.
The format of the final exam will consist of a laboratory part with practical tasks and a writing part that may include essay and problem solving questions. Each part accounts for 50% of the final grade. To pass, students have to obtain at least the 40% in each part and get a sum of both parts equal or greater than 5 points. If the minimum grade of any part is not achieved, the final grade will be the sum of both grades or 4 points, if that sum is equal to or greater than 5 points.
Students who do not opt for continuous assessment and do not attend the final exam will receive a grade of "No show".

2. Extraordinary exam

In the extraordinary exam the assessment will be like the final exam of the global assessment.

3.- Academic Integrity

Plagiarism is regarded as seriously dishonest behavior. If any form of plagiarism is detected on 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

Miguel Ángel Pérez García, **Instrumentación electrónica**, 2014

Camilo Quintáns Graña, **Simulación de circuitos electrónicos con OrCAD® PSpice®**, 2, Marcombo, 2022

European Accreditation Laboratory Committee, **Evaluation of the Uncertainty of Measurement in calibration**, European Accretitation (EA), 2022

Complementary Bibliography

Miguel Ángel Pérez García, **Instrumentación electrónica: 230 problemas resueltos**, 2012

Ramón Pallás-Areny y John G. Webster, **Sensors and Signal Conditioning**, Wiley, 2012

Centro Español de Metrología, **Evaluación de datos de medición. Guía para la Expresión de la Incertidumbre de Medida**, NIPO EDICIÓN DIGITAL 1: 706-10- 001- 0, 2008

Recommendations

IDENTIFYING DATA				
(*)Ciberseguridad				
Subject	(*)Ciberseguridad			
Code	10414-76024			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	López Ardao, José Carlos			
Lecturers	López Ardao, José Carlos Rivas Costa, Carlos Rodríguez Rubio, Raúl Fernando			
E-mail	jardao@det.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This is a basic subject that covers the fundamentals of cybersecurity in organisations and companies and the fundamental concepts of cybersecurity, information security and network security. More specifically, the content covers cyberattack modelling, vulnerability management, cyber incident management and response, and cyber intelligence applied in this field.			

Training and Learning Results	
Code	
C1	Manage the tools necessary to manage telecommunication system construction and installations, complying with current regulations and ensuring service quality.
C2	Manage the tools necessary to direct, plan and supervise multidisciplinary teams
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C4	Apply methodologies for the development, strategic planning, direction, coordination, and technical and economic management of projects in all areas of telecommunications engineering, following quality and environmental criteria.
C17	Carry out planning, decision-making and packaging of networks, services and applications considering the quality of service, direct and operating costs, the implementation plan, supervision, security procedures, scaling and maintenance, as well as managing and ensuring quality in the development process
C32	Understand, design, configure, manage, maintain, diagnose, troubleshoot, and implement security policies on a corporate network (equipment, protocols, and services).
D6	Model, design, implement, manage, operate, administer, and maintain networks, services, and content.

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Know and understand all the fundamental concepts related to cybersecurity: vulnerabilities, malware, cyberattack models and techniques.	C32 D6
Understand concepts related to vulnerabilities and manage the tools necessary for their management.	C1 C3 C4 C17 C32 D6
Understand and manage the procedures and tools related to cyber defence operations in a SOC (Security Operations Centre) and cybersecurity incident management.	C1 C2 C4 C17 C32 D6
Know, understand, and manage the fundamentals, techniques, and methodologies essential for obtaining, analysing, and producing cyber threat intelligence, with a focus tailored to the operational and strategic requirements of cyber defence.	C1 C2 C4 C17 C32 D6

Contents

Topic	
1. Fundamental concepts of cybersecurity	a) Confidentiality, integrity and availability b) Vulnerabilities, actors, APTs, cyber threats and attack vectors. c) Malware. Exploits. d) Introduction to cyberattack models: Cyber Kill Chain and MITRE e) Cyberattack techniques
2. Vulnerability management	a) Vulnerability Publication Sources. NVD (NIST) b) CVSS and EPSS Indicators c) Vulnerability Identification and Analysis
3. Cyberdefense operations	a) The Security Operations Centre (SOC) and the response team (CERT). Workflow in the event of a threat alert. b) Cybersecurity incident management. Lifecycle c) Monitoring: IDS/IPS. Antivirus / EDR. SIEM d) Response to cybersecurity incidents
4. Cyberintelligence applied to cybersecurity incident management	a) Cyberintelligence: tactical, operational and strategic b) Cyberintelligence generation lifecycle c) Cyberintelligence sources d) Generation and consumption of cyberthreat intelligence: IoCS. IDS rules e) Cyberintelligence analysis f) Application of cyberintelligence techniques to APTs

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	24	42	66
Practices through ICT	8	16	24
Problem solving	6	12	18
Autonomous problem solving	0	13	13
Essay questions exam	2	0	2
Objective 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	Presentation of the ideas, concepts, techniques, and algorithms of each of the course's thematic units. This methodology will be used to work on all of the subject's learning outcomes.
Practices through ICT	Practical use of some of the most commonly used tools in the field of cybersecurity, based on the knowledge acquired in the lectures. This methodology will be used to work on all the learning outcomes of the subject.
Problem solving	Resolution of subject-related problems in the classroom by the teacher. This methodology will be used to work on all the subject's learning outcomes.
Autonomous problem solving	Problem solving, practical exercises and self-assessment tests in the virtual classroom that must be completed by students individually, independently and remotely, always with a deadline. These activities have a combined overall weighting of 20% in the case of continuous assessment. This methodology will be used to work on all the learning outcomes of the subject.

Personalized assistance

Methodologies	Description
Lecturing	Personalised attention will be provided on an individual basis, either in person or via videoconference. Students can request tutoring sessions with the subject's teaching staff via messaging or email. This methodology covers all competencies.
Practices through ICT	Personalised attention will be provided on an individual basis, either in person or via videoconference. Students can request tutoring sessions with the subject's teaching staff via messaging or email. This methodology covers all competencies.
Problem solving	Personalised attention will be provided on an individual basis, either in person or via videoconference. Students can request tutoring sessions with the subject's teaching staff via messaging or email. This methodology covers all competencies.
Autonomous problem solving	In the case of online assignments, detailed solutions to all assignments will be provided in the virtual classroom. In the case of self-assessment tests, the tests will be designed to provide students with appropriate feedback on the questions they got wrong. In any case, personalised assistance is also available on an individual basis, either in person or via videoconference. Students can request tutoring sessions with the subject teachers via messaging or email. This methodology covers all competencies.

Assessment				
	Description	Qualification	Training and Learning Results	
Autonomous problem solving	Throughout the course, self-assessment tasks and tests are set in the virtual classroom, which must be completed by students individually, independently and remotely, always with a deadline. These tasks have a combined overall weighting of 20%.	20	C1 C2 C3 C4 C17 C32	D6
Essay questions exam	Final exam covering all the material. It accounts for 40% of the final grade, but a minimum grade of 4 out of 10 is required to pass the course.	40	C1 C2 C3 C4 C17 C32	D6
Objective questions exam	During the course, there will be two one-hour multiple-choice tests to assess students' understanding of the subject matter. Each test accounts for 20% of the final mark.	40	C1 C2 C3 C4 C17 C32	D6

Other comments on the Evaluation

The final grade for the subject is calculated as the weighted average of the grades for each section if the final exam grade is greater than or equal to 4. If it is lower, the final grade will be the minimum between 4.0 and the previous weighted average.

Students who take the first intermediate monitoring test are considered to have opted for **Continuous Assessment (CA)**. Otherwise, they are considered to have opted for **Global Assessment (GA)**.

Global Assessment (GA) consists of taking the same Final Exam, and the grade will be the one obtained in that exam.

Extraordinary Opportunity

In June/July, there will be a new Final Exam on the officially established dates, which may only be taken by students who have not passed the subject in the ordinary opportunity.

Those students who have failed the ordinary opportunity through Continuous Assessment and wish to renounce it in order to choose Global Assessment must request this in writing to the subject coordinator before the date of review of the final exam of the ordinary opportunity.

Other considerations

All students who take either of the two final exams are considered to have taken the subject. The grades for all exams, assignments, practical work and non-classroom activities will only be valid for the academic year in which they are taken.

If plagiarism is detected in any of the assignments/tests/exams/quizzes taken, including non-classroom activities submitted or completed in the virtual classroom, the final grade for the subject will be Fail (0) and the teachers will report the matter to the Head of the School so that appropriate measures can be taken.

In the event of any contradiction between the different versions of the guide due to a translation error, the Galician language version shall prevail.

Sources of information

Basic Bibliography

Rebekah Brown & Scott J Roberts, **Intelligence-Driven Incident Response: Outwitting the Adversary**, O'Reilly Media, 2023

Joseph Steinberg y otros, **Cybersecurity All-in-One For Dummies**, 2023

Linda K. Lavender, **Principles of Cybersecurity**, Goodheart-Willcox, 2018

José Lominchar Jiménez y Pablo Luis Gómez Sierra, **Principios de ciberinteligencia**, Udima, 2022

Arturo Enrique Mata García, **Ciberseguridad. Curso Práctico**, RA-MA S.A. Editorial y Publicaciones, 2024

Complementary Bibliography

Recommendations

IDENTIFYING DATA				
(*)Distribución de contenidos multimedia				
Subject	(*)Distribución de contenidos multimedia			
Code	10414-76025			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Herrería Alonso, Sergio			
Lecturers	Herrería Alonso, Sergio Rivas Costa, Carlos			
E-mail	sha@det.uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	This subject presents the main specific technologies for the distribution of multimedia contents by communication networks.			

Training and Learning Results	
Code	
B6	Possess and understand knowledge that provides a basis or opportunity for originality in the development and/or application of ideas, often in a research context.
B9	Understand and apply the functioning and organization of the Internet, next-generation Internet technologies and protocols, component models, middleware, and services.
B12	Know the main standards in the field of audio and video coding.
B13	Understand the main problems that arise in the transmission of multimedia content
B14	Know the transport and signaling protocols used by multimedia applications.
B15	Learn the main techniques for the efficient distribution of multimedia content.
B16	Know the main network technologies for multimedia distribution in access networks.
C6	Apply acquired knowledge and solve problems in new or unfamiliar environments within broader, multidisciplinary contexts, being able to integrate knowledge.
C8	Communicate (orally and in writing) the conclusions - and the knowledge and ultimate reasons that support them - to specialized and non-specialized audiences in a clear and unambiguous manner.
C9	Learn continuously, self-directedly, and autonomously.
C17	Carry out planning, decision-making and packaging of networks, services and applications considering the quality of service, direct and operating costs, the implementation plan, supervision, security procedures, scaling and maintenance, as well as managing and ensuring quality in the development process
C18	Solve the convergence, interoperability and design of heterogeneous networks with local, access and backbone networks, as well as the integration of telephone, data, television and interactive services.
C33	Configure and deploy streaming and VoIP services.
D3	Integrate knowledge and face the complexity of formulating judgments based on information that, although incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of knowledge and judgments
D4	Design and dimension transport, broadcast and distribution networks for multimedia signals
D6	Model, design, implement, manage, operate, administer, and maintain networks, services, and content.

Expected results from this subject	Training and Learning Results
Understand the main problems that arise in the transmission of multimedia content.	B6 B13 C6 D3
Know the main standards in the field of audio and video coding.	B12
Know the transport and signaling protocols used by multimedia applications.	B9 B14
Learn the main techniques for the efficient distribution of multimedia content.	B9 B15 C17 D4

Know the main network technologies for multimedia distribution in access networks.	B16 C18 D6
Configure and deploy streaming and VoIP services.	C8 C9 C33

Contents	
Topic	
Multimedia applications	Audio/video coding. Types of multimedia applications. Requirements of QoS. QoE.
Interactive multimedia services	VoIP. Videoconferencing. Transport and signaling protocols. Control architectures: IMS, VoLTE, VoNR. WebRTC.
Streaming services	VoD. IPTV. Transport protocols. Scalable distribution. Adaptive streaming.
Multimedia distribution in access networks	Metropolitan networks, EPON/GPON, Carrier Ethernet, mobile networks.

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	17	27	44
Practices through ICT	14	28	42
Mentored work	6	28	34
Objective questions exam	1	0	1
Objective questions exam	1	0	1
Objective questions exam	1	0	1
Objective questions exam	1	0	1
Project	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	Exhibition of the ideas, concepts and techniques of each topic of the course. During these sessions, students must acquire competences B6, B12, B13, B14, B15, B16, C17, C18, D3 and D4.
Practices through ICT	Practical learning of basic tools for the distribution of multimedia contents on computer networks. During these sessions, students must acquire competences B9, C6, C9 and C33.
Mentored work	Configuration, with the teacher's guidance, of a multimedia service. This work should help students to acquire competences B9, C8, C9, C33 and D6.

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://netlab.det.uvigo.es/sha/ Carlos Rivas Costa: https://moovi.uvigo.gal/user/profile.php?id=11473
Practices through ICT	Personalized assistance will be provided in person and/or remotely by email, Moovi forums or Campus Remoto. Sergio Herrería Alonso: https://netlab.det.uvigo.es/sha/ Carlos Rivas Costa: https://moovi.uvigo.gal/user/profile.php?id=11473
Mentored work	Personalized assistance will be provided in person and/or remotely by email, Moovi forums or Campus Remoto. Carlos Rivas Costa: https://moovi.uvigo.gal/user/profile.php?id=11473

Assessment					
	Description	Qualification	Training and Learning Results		
Objective questions exam	A one-hour written exam covering the contents presented in topic "Multimedia applications". Questions and problems of conceptual, logical, analytical or applied nature.	20	B6 B12 B13	C17 C18	D3 D4
Objective questions exam	A one-hour written exam covering the contents presented in topic "Interactive multimedia services". Questions and problems of conceptual, logical, analytical or applied nature.	20	B6 B13 B14 B15	C17 C18	D3 D4
Objective questions exam	A one-hour written exam covering the contents presented in topic "Streaming services". Questions and problems of conceptual, logical, analytical or applied nature.	20	B6 B13 B14 B15	C17 C18	D3 D4

Objective questions exam	A one-hour written exam covering the contents presented in topic "Multimedia distribution in access networks". Questions and problems of conceptual, logical, analytical or applied nature.	20	B6 B13 B15 B16	C17 C18	D3 D4
Project	Evaluation of the features and performance of the multimedia service configured during the course.	20	B9	C6 C8 C9 C33	D6

Other comments on the Evaluation

Two different methods of assessment are offered: continuous assessment and global assessment.

Students opting for continuous assessment will be required to complete five assignments: four midterm exams (each worth 20% of the final score) and a project involving the configuration of a basic multimedia service (20% of the final score). None of the five 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 written 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 any of the midterm exams or the project. Only students who take at least three midterm exams (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 assignments, 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 exam 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 Mestrado (CAM) 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**, 1, Artech House Publishers, 2019

Z. Li, M. Drew, J. Liu, **Fundamentals of Multimedia**, 3, Springer, 2021

Complementary Bibliography

J. F. Kurose, K. W. Ross, **Computer networking: a top-down approach**, 9, Pearson, 2025

H. W. Barz, G. A. Bassett, **Multimedia networks: protocols, design, and applications**, 1, Wiley, 2016

Gary Hallberg, **Quality of Service in Modern Packet Networks**, 1, Independiente, 2019

Recommendations

IDENTIFYING DATA				
(*)Laboratorio de Redes Móviles				
Subject	(*)Laboratorio de Redes Móviles			
Code	10414-76026			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Gil Castiñeira, Felipe José			
Lecturers	Fondo Ferreiro, Pablo Gil Castiñeira, Felipe José Rúa Estévez, José Manuel			
E-mail	xil@gti.uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The course "Mobile Networks Laboratory" examines mobile communications, the services they enable, and the technologies that support them. It takes a hands-on approach, working with experimental equipment that allows students to have direct contact with the different components of a modern mobile network, designing and implementing protocols and services. It is taught in Galician and Spanish, but the documentation will be in English. This is an English Friendly course. International students may request from the teaching staff: a) materials and bibliographic references in English to follow the course, b) tutorials in English, and c) exams and assessments in English.			

Training and Learning Results	
Code	
B5	Acquire advanced knowledge and demonstrate, in a highly specialized or scientific and technological research context, a detailed and well-founded understanding of the theoretical and practical aspects and working methodology in one or more fields of study.
B6	Possess and understand knowledge that provides a basis or opportunity for originality in the development and/or application of ideas, often in a research context.
C6	Apply acquired knowledge and solve problems in new or unfamiliar environments within broader, multidisciplinary contexts, being able to integrate knowledge.
C9	Learn continuously, self-directedly, and autonomously.
C17	Carry out planning, decision-making and packaging of networks, services and applications considering the quality of service, direct and operating costs, the implementation plan, supervision, security procedures, scaling and maintenance, as well as managing and ensuring quality in the development process
C18	Solve the convergence, interoperability and design of heterogeneous networks with local, access and backbone networks, as well as the integration of telephone, data, television and interactive services.
D2	Develop sufficient autonomy to participate in research projects and scientific or technological collaborations within their thematic scope, in interdisciplinary contexts and, where appropriate, with a high level of knowledge transfer.
D4	Design and dimension transport, broadcast and distribution networks for multimedia signals
D6	Model, design, implement, manage, operate, administer, and maintain networks, services, and content.

Expected results from this subject	Training and Learning Results
Understand the basic aspects of mobile communications.	B5 C9
Be able to design, modify, configure, and validate mobile networks, as well as deploy new protocols and services and conduct experiments.	B5 B6 C6 C9 C17 C18 D2 D4 D6

Contents	
Topic	
Introduction to Mobile Network Architectures	Access network, core, edge, applications, etc.
Familiarization with the experimental network and the measurement and generation equipment	Description of the existing equipment and first experiments.
Execution of a development, deployment, and performance evaluation project in one of the areas related to mobile networks	Projects may cover topics such as: mobile network architectures; fronthaul and backhaul networks; network function virtualization; core network architectures; mobility management; authentication and encryption; handover; roaming; multipath; QoS; network slicing; edge computing; APIs; etc.

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	12	28	40
Mentored work	21	49	70
Laboratory practical	6	3	9
Essay questions exam	2	0	2
Report of practices, practicum and external practices	0	2	2
Essay	0	1	1
Presentation	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	Students must study the main theoretical contents related to mobile networks. This methodology will contribute to the acquisition of competencies B5, B6, and C9.
Mentored work	Design, implementation, and testing of a protocol, system, application, or service. This methodology will address the development of competencies B5, B6, C6, C9, C17, C18, D2, D4, and D6.
Laboratory practical	Computer based practical work

Personalized assistance	
Methodologies	**Description**
Lecturing	The teaching staff will provide individual and personalized support to students throughout the course, addressing their doubts and questions. Questions will be answered during in-person sessions or during the scheduled office hours. The office hours can be consulted or requested on the course website (https://moovi.uvigo.gal).
Mentored work	The teaching staff of the course will provide individual and personalized support to students throughout the academic term, addressing their doubts and questions. Additionally, the staff will guide students in the development of their project. Questions will be addressed during in-person sessions or during the scheduled office hours. The office hours can be consulted or requested on the course website (https://moovi.uvigo.gal).
Laboratory practical	

Assessment					
	Description	Qualification	Training and Learning Results		
Lecturing	An exam will be conducted to assess the understanding of the content presented during the lecture sessions.	40	B5 B6		D4 D6
Mentored work	Students will individually complete quizzes and/or lab reports demonstrating the correct execution and understanding of the practical exercises. The concepts studied in these practical sessions may also be included in the course exams.	20	B5 B6	C6 C9 C17 C18	D2 D4 D6
Laboratory practical	Students will design, implement, and test a protocol, system, application, or service. The result will be evaluated after submission, considering aspects such as correctness, quality, performance, and functionality.	40	B5 B6	C6 C9	

Other comments on the Evaluation

To pass the course, students must complete the different parts into which the subject is divided (lecture sessions, laboratory practices, and projects). The final grade will be the result of applying the weighted geometric mean of the grade for each

part. Let "x" be the grade for the lecture sessions, "y" for the lab practices, and "z" for the projects. The final grade will be:

grade = x^0.4 × y^0.2 × z^0.4

During the first month, students must explicitly and in writing indicate their wish to follow the global assessment method. Otherwise, it will be assumed they are following continuous assessment. Those who follow continuous assessment may no longer be considered "not presented" once they submit the first quiz or task.

Students opting for global assessment must pass written exams (40%), submit a project (40%), and present the lab practices (20%). These components will be evaluated as described in the section outlining the various tests. The final grade will be the result of applying the weighted geometric mean of the grade for each part. Additionally, they must submit a dossier, to be defended before the teaching staff, including all details regarding the completion of the various tasks, especially the supervised work. During the first month of the course, the teaching staff will inform students who choose global assessment whether they must complete the work individually.

Intermediate milestones may be established for the project. Failure to meet them may result in a penalty of up to 20% of the final project grade.

Extraordinary and end-of-program calls to pass the course

Only students who have not passed the regular (ordinary) opportunity (at the end of the semester) may opt for the extraordinary or final-year examination opportunities.

To pass the course, students must complete the different parts into which the subject is divided: short-answer tests (40%), submit a project (40%), and present the lab practices (20%). These components will be evaluated as described in the section outlining the various tests. The final grade will be the result of applying the weighted geometric mean of the grade for each part. Additionally, students must submit a dossier, to be defended before the teaching staff, including all details regarding the completion of the various tasks, especially the supervised work. During the first month of the course, the teaching staff will inform students who choose global assessment whether they must complete the work individually.

Students who followed continuous assessment may choose to keep the grades obtained in the regular opportunity for the different parts of the course or discard them.

Other comments

Grades obtained are only valid for the current academic year.

Although supervised work will (as far as possible) be carried out in groups, each student must provide evidence of their individual contribution within the group. If a student's performance is not in line with that of their peers, they may be removed from the group and/or evaluated individually for this component.

The use of any materials during exams must be explicitly authorized by the teaching staff.

If any instance of plagiarism or unethical behavior is detected in any task or test, the final grade for the course will be "fail (0)", and the teaching staff will report the case to the academic authorities so that appropriate measures can be taken.

In the academic activities of this course, the use of generative artificial intelligence (GAI) is permitted. Its use must be ethical, critical, and responsible. If GAI is used, it is essential to critically assess any results provided and carefully verify any generated citations or references. In addition, it is recommended to declare the use of the tools employed.

After any assessment, teaching staff may call students for oral verification interviews, either at random or where there are indications of cheating, unauthorized use of artificial intelligence, or other fraudulent means in completing the exam. Grades for the assessments shall remain provisional until any such interviews have been completed. During these interviews, students must demonstrate that they possess the knowledge and skills needed to adequately justify the solutions they submitted.

Sources of information

Basic Bibliography

Andreas F. Molisch, **Wireless Communications: From Fundamentals to Beyond 5G, 3rd Edition**, 3, 2022

Complementary Bibliography

p4language consortium, **P4 Tutorial**, https://github.com/p4lang/tutorials/tree/master,

Dr. Ian C. Wong, Dr. Aditya Chopra, Dr. Sridhar Rajagopal, Dr. Rittwik Jana, **Open RAN: The Definitive Guide**, 1, Wiley, 2023

Recommendations

IDENTIFYING DATA				
(*)Antenas				
Subject	(*)Antenas			
Code	10414-76027			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Rodríguez Rodríguez, José Luis			
Lecturers	Rodríguez Rodríguez, José Luis Vazquez Alejos, Ana María			
E-mail	banner@com.uvigo.es			
Web				
General description	The subject devotes to the study of *antenas and encompasses from the electromagnetic bases tie the practical design of the same, spending poles models of analysis and behavioural @simulación of the *antenas.			

Training and Learning Results	
Code	
B4	Conceiving Engineering within a framework of sustainable development.
C2	Manage the tools necessary to direct, plan and supervise multidisciplinary teams
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C5	Use tools specific to general management, technical management, and research, development, and innovation project management in companies and technology centers.

Expected results from this subject	Training and Learning Results
Know the main parameters that characterise the behaviour of the transmitting and receiving antennas	B4 C2 C3 C5
Know the distinct types of antennas according to their applications and operating frequencies	B4 C2 C3 C5
To be able to understand and develop models to simulate the behavior of the antennas and predict their characteristic parameters	B4 C2 C3 C5
To be able to cope antenna design exercises for certain specifications	B4 C2 C3 C5

Contents	
Topic	
1. Electromagnetic antennas Basics Competencies related: CE2, CE3, CE5	1.1 Generalities 1.2 Phenomenon of electromagnetic radiation 1.3 Properties of the field of radiation 1.4 The antenna in transmission 1.5 The antenna in reception 1.6 The antenna in systems of communications and in radar
2. Modeling antennas Competencies related: CB4, CG4	2.1 Linear Antennas 2.2 Aperture Antennas 2.3 Arrays
3. Types of antennas CB4, CG4, CE2, CE3, CE5	3.1 Wire Antennas 3.2 Printed and Slot Antennas 3.3 Horns, lens and reflectors

4. Practices	4.1 Design of a single band planar GPS antenna 4.2 Design of a dual band GPS antenna 4.3 Measurement of the final antenna prototype

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	20	17	37
Problem solving	5	15	20
Case studies	5	15	20
Practices through ICT	5	15	20
Problem and/or exercise solving	3	9	12
Laboratory practice	2	6	8
Essay questions exam	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 contents on the subject under study, instructions and exercises or projects to be developed by the student. Competencies A2, C2, C3, C5
Problem solving	Problems and / or exercises related to the subject. The student should develop appropriate or correct solutions through the exercise routines, applying formulas or algorithms, applying transformation methods available and interpretate the results. Complement of the Master session Competencies A2, B4, C2.
Case studies	Analysis of a fact, problem or real event in order to learn, interpret it, solve it, generate hypotheses, compare data, complete knowledges, diagnose it and train in alternative procedures of solution. Competencies A2, B4, C2, C3, C5.
Practices through ICT	Activities of applying knowledge in a given context and acquiring basic and procedural skills in relation to the subject, through ICT. Competencies A2, A4, B4, C2.

Personalized assistance	
Methodologies	**Description**
Lecturing	Personalized attention. Questions and doubts during teaching timetable. Contact: https://www.uvigo.gal/universidade/administracion-persoal/pdi/jose-luis-rodriguez-rodriguez
Problem solving	Questions and doubts during teaching timetable and in office hours.
Practices through ICT	Questions and doubts during teaching timetable, in office hours, Faitic and e-mail.

Assessment			
	Description	Qualification	Training and Learning Results
Problem and/or exercise solving	Conceptual questions on the course syllabus.	10	
Laboratory practice	It will value the quality of the homeworks assigned, the participation and attitude showed in the lectures, as well as the oral presentation of the work.	60	
Essay questions exam	Final examination: Evaluation of the competencie that includes open questions on a subject. The students have to develop, relate, organise and present the knowledges that have on the matter in an extensive answer to a practical situation posed.	30	

Other comments on the Evaluation

It will be offered to the students enrolled in this class two systems of evaluation: continuous assesment and exam-only assesment.

1. CONTINUOUS ASSESMENT
The system of continuous assesment will consist on:

- A short test to be held in class around the mid-teaching period. 10% rating. Rating EC1, with a maximum of 1 point.

- An antenna design for a particular application. It will be held autonomously through the use of software simulation tools. The student will prepare and deliver a report to be presented in class at the end of the semester. Rating EC2, with a maximum of 6 points. The 6 points of this exercise will be distributed as follows: 2 points for active participation in the sessions (in C groups) dedicated to the design, presentation and discussion; 2 points for the quality of the proposed solution; 1 point for the quality of the report submitted; and 1 point for the quality of the oral presentation.

- An extended-response exercise in which problems of analysis and design of antennas for specific applications will be solved. It will be held in the same day fixed for the regular final exam for the course. 30% rating. Rating EC3, with a maximum of 3 points.

- The continuous assessment tests are not recoverable, ie, if a student can not fulfill them within the stipulated period the teacher is not required to repeat them.

- The final score for continuous assessment (EC) was calculated as the sum of the scores on the three planned tests: EC =EC1 + EC2 + EC3, and covers the following competences: CB2, CG4, CE2, CE3, CE5

- The score on the assessable tasks (EC) will be valid only for the academic year in which they are made.
- There is a 1 month period to leave continuous evaluation.
- The participation in practices is voluntary.

2.GLOBAL ASSESMENT - ORDINARY CALL

It involves:

- A final exam that will assess competencies CB2, CG4, CE2, CE3, CE5. 40% rating. EF1 score, with a maximum of 4 points.
- The day of the exam the student will deliver a report on an antenna design previously assigned. The student will give an oral presentation at a public meeting in the shortest possible time respecting the compatibility with other tests of the same course and certification. Rated EF2 with a maximum of 3 points for the report and 3 points for the presentation.
- The EF1 and EF2 partial qualifications may be held only until the single evaluation - second call and within the ongoing course.

3. GLOBAL ASSESMENT - EXTRAORDINARY CALL

It will follow the same procedure as in global assesment - ordinary call. Students, communicating it previously to the start of the exam, may retain their previous note EF1 part (or alternatively EC1 EC3 +) or the EF2 (or EC2) part.

4. GLOBAL ASSESMENT - END OF DEGREE CALL

It will follow the same procedure as in global assesment - ordinary call. Students, communicating it previously to the start of the exam, may retain their previous note EF1 part (or alternatively EC1 EC3 +) or the EF2 (or EC2) part.

COMMENTS:

- Before the completion or delivery date of each test, the procedure and review of scores will be published within a reasonable period of time.
- Every student that comes to the final test is considered as presented. It will also be considered as presented to the test every student who qualifies for the continuous evaluation system in the terms described above.
- It is considered that the subject is approved if the final grade is equal to or greater than 5.

Sources of information
Basic Bibliography
C. A. Balanis, **Advanced Engineering Electromagnetcis**, 2, Wiley, 2005
C. A. Balanis, **Antenna Theory and Design**, 4, Wiley, 2016
W.L.Stutzman,G.A.Thiele, **Antenna Theory and Design**, 3, Wiley, 2013
Complementary Bibliography
R.S.Elliot, **Antenna Theory and Design**, 1, Prentice Hall, 1981
R.E.Collin, **Antennas and Radiowave Propagation**, 1, Mc Graw Hill, 1985

P.S.Kildal, **Foundations of Antenas. A Unified Approach**, 1, Studentlitteratur,
T.A. Milligan, **Modern Antenna Design**, 2, Wiley, 2005

Recommendations

Subjects that continue the syllabus

Satellites/V05M145V01311
Wireless and Mobile Communications/V05M145V01313
Wideband Radio Systems/V05M145V01312

Subjects that are recommended to be taken simultaneously

Radio Laboratory/V05M145V01209

Subjects that it is recommended to have taken before

Radiocommunication/V05M145V01103

IDENTIFYING DATA				
(*)Comunicaciones ópticas				
Subject	(*)Comunicaciones ópticas			
Code	10414-76028			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Curty Alonso, Marcos			
Lecturers	Curty Alonso, Marcos			
E-mail	mcurty@com.uvigo.es			
Web	http://https://moovi.uvigo.gal			
General description	First, the main optical devices for optical communications are reviewed. Next, various advanced fiber transmission and optical network systems are described. Finally, quantum communications systems using photonic technology are presented.			

Training and Learning Results	
Code	
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C6	Apply acquired knowledge and solve problems in new or unfamiliar environments within broader, multidisciplinary contexts, being able to integrate knowledge.
C20	Apply advanced knowledge of photonics and optoelectronics, as well as high-frequency electronics.

Expected results from this subject	
Expected results from this subject	Training and Learning Results
2. Knowledge of advanced systems for fibre transmission: new formats of modulation, coherent systems, nonlinear systems and dispersion management.	A1 B18 C3 C20
3. Knowledges of specific technologies for WDM and DWDM optical networks, together with their design.	A1 B18 C3 C20
4. Knowledge of photonic tecnologies for quantum communications, particularly for quantum key distribution.	A1 C38 C3 C6 C20 D10 D10 D10

Contents	
Topic	
1. Photonic Devices for Optical Communications	1.1. Introduction to guided optical communications systems. 1.2. Active devices: laser, LED, photodetector, EOM modulator, and doped fiber optical amplifier. 1.3. Passive devices: couplers, splitters, filters, gratings, and circulators.
2. Advanced Optical Systems	2.1. Coherent Links and New Formats.
3. WDM Optical Networks	3.1. WDM and DWDM Systems 3.2. Crosstalk in WDM Systems Due to Linear Effects 3.3. Crosstalk in WDM Systems Due to Nonlinear Effects

4. Photonic Technologies for Optical Communications	4.1. Introduction to Quantum Mechanics 4.2. Quantum Communication Systems, QKD 4.3. Photonic Technologies for QKD
Laboratory exercise 1. Dispersion in multi-mode fibres	Characterisation of both the intermodal and intramodal dispersion on a graded index fibre
Laboratory exercise 2. Spectral characteristics of optical sources and observation of the chirp.	Characterization of various optical sources and chirp observation in an external cavity tunable laser
Laboratory exercise 3. Systems DWDM	Characterisation of DWDM systems working in third telecom window
Laboratory exercise 4. Quantum Eraser	Demonstrates the principles of quantum complementarity and the erasure of which-path information.
Laboratory exercise 5. Interaction-free quantum measurements	Illustrates interaction-free quantum measurements, allowing one to determine whether a bomb is functional without triggering it.
Laboratory exercise 6. Quantum Key Distribution	A classical implementation of the BB84 protocol to simulate the distribution of a secret key between two parties in the presence of an eavesdropper.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	1	2
Lecturing	23	28	51
Laboratory practical	14	14	28
Essay questions exam	2	12	14
Problem and/or exercise solving	1	12	13
Essay	1	16	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	Teachers' explanation of the course's progress and assessment. Any questions are answered.
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 B1, C3, C6 and C20 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. Through this methodology the competencies B1, C3, C6 and C20 are developed.

Personalized assistance

Methodologies	**Description**
Lecturing	The students can use the office hours of the professor to solve doubts related to the subject. The schedule and/or request for office hours can be checked at: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/marcos-curty-alonso
Laboratory practical	The students can use the office hours of the professor to solve doubts related to the subject. The schedule and/or request for office hours can be checked at: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/marcos-curty-alonso
Introductory activities	The students can use the office hours of the professor to solve doubts related to the subject. The schedule and/or request for office hours can be checked at: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/marcos-curty-alonso
Tests	**Description**
Essay	The students can use the office hours of the professor to solve doubts related to the subject. The schedule and/or request for office hours can be checked at: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/marcos-curty-alonso

Assessment			
	Description	Qualification	Training and Learning Results
Essay questions exam	At the end of the semester, the students will perform a final test that covers all the contents of the course.	30	C3 C6 C20
Problem and/or exercise solving	After the last lab session, the student will perform a test (20%) about the exercises done in the lab. Moreover, the students will perform a test (20%) about the contents of half of the course.	40	C3 C6 C20
Essay	Evaluation of the work performed. The use of artificial intelligence tools will not be permitted for the performance of this work.	30	C3 C6 C20

Other comments on the Evaluation

Ordinary opportunity:

We will offer to the students two possible assessment systems: continuous assessment or global assessment.

Each student has to decide on one of these two options by the fifth week of the course. In principle, the professor considers that the student decides continuous assessment unless the student explicitly indicates by written statement to the professor that he decides global assessment at the end of the course.

Continuous assessment:

The continuous assessment comprises a series of tasks that the student has to realise along the course (70%), together with a long answer test (30%) that he/she performs at the end of the course. These tasks include (a) the completion of one short answer test about the lab (20%), which will take place after the last lab exercise, and one short answer test about the contents of half of the subject (20%) that will take place when these are completed, and (b) the assessment of the activities realised by the student related with the 'Essay' (30%) that has to be completed by the end of the course. The activities related to the 'Essay' could be performed in groups of students. In this case, the mark of the students in this task will be the mark of the group. 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 do 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 the following conditions in order to pass the course: (a) perform at least 4 out of the 6 lab exercises; (b) obtain, at least, 12 points out of 30 in the 'Essay'; (c) obtain, at least, 12 points out of 30 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 49 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.

Global assessment:

In addition to the system of continuous assessment described above, the student can opt for a global assessment. This global 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 fifth week of the course. These tasks have to be delivered on the day of the final 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.

Extraordinary opportunity:

Those students who opted for a continuous assessment in the ordinary opportunity and fulfill the requirements (a) and (b) above, will be able, if they so wish, to keep the mark obtained in the tasks performed during the continuous assessment (70%). In such a case, they will only take a long answer test (30%). To pass the course, these students will have to obtain, at least, 12 points out of 30 in the long answer test, and obtain a minimum of 50 points in total.

Alternatively, these students can also opt for a global 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 a long answer test and to keep the mark obtained in the tasks performed during the continuous assessment.

The rest of students (i.e., those that opted for a system of continuous assessment in the ordinary opportunity and do not fulfil the requirements (a) and (b) above, and those students that opted for a global assessment in the ordinary opportunity) will be evaluated by a global assessment, which covers all the contents of the course.

In the case of choosing a global assessment, the professor may demand the student to deliver some additional tasks, which will be notified to the student one month prior to the final exam. These tasks have to be delivered at the day of the final 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-Degree Call

The students will be evaluated by a global assessment, which covers all the contents of the course.

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
J. Capmany y B. Ortega-Tamarit, **Redes Ópticas**, 1a Edición, Universidad Politécnica de Valencia, 2006
R. Wolf, **Quantum Key Distribution: An Introduction with Exercises**, 1a Edición, Springer, 2021
Michael A. Nielsen, Isaac L. Chuang, **Quantum Computation and Quantum Information**, 10th Anniversary Edition, Cambridge University Press, 2011

Recommendations

Subjects that it is recommended to have taken before
(*)Electrónica y fotónica avanzadas para comunicaciones/10414-76022

IDENTIFYING DATA				
(*)Laboratorio de radio				
Subject	(*)Laboratorio de radio			
Code	10414-76029			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Torío Gómez, Pablo			
Lecturers	Torío Gómez, Pablo			
E-mail	ptorio@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Deepening in the knowledge of the diverse systems of radius applying a practical methodology of analysis and synthesis			

Training and Learning Results	
Code	
B8	Understand the limitations, risks, and implications of using Generative AI.
C2	Manage the tools necessary to direct, plan and supervise multidisciplinary teams
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C5	Use tools specific to general management, technical management, and research, development, and innovation project management in companies and technology centers.
C13	Be able to use Generative AI in an ethical, critical and responsible manner

Expected results from this subject	Training and Learning Results
* Knowledge of the basic instrumentation for measuring radiofrequency, microwaves, millimeter and sub-millimeter waves	B8 C2 C3 C5 C13
* Knowledge of the main configurations for measuring characteristic parameters of different subsystems: Measure of impedance, transmission and reflection coefficients, noise factor, dynamic margin, and field strength level.	B8 C2 C3 C5 C13
* Knowdlege of experimental characterization techniques regarding the mechanisms of signal propagation.	B8 C2 C3 C5 C13

Contents
Topic

Theoretical and practical content. Several of these topics will be covered as laboratory exercises, using the equipment available at the School.	1. Basic instrumentation. 2. Measures of active elements. · Measure of parameters of transmission and reflection in quadripoles · Measure of the noise factor · Measure of reception parameters (noise, selectivity, sensitivity, dynamic margin....) · Effect of the LNA in the sensitivity of the receptor and with this measured of propagation. · Measure of amplifiers of power of RF: efficiency, gain,... · Measure of parameters of oscillators. 3. Measure of passive elements · Measured of passive filters of RF: losses, selectivity,.... · Measure of the frequency of cut of a wave guide · Measured of antennas: diagrams, gain and join up electromagnetic. · Measure of common elements of microwaves: circulators, directional couplers,... 4. Measures of propagation. · Measure of mitigation with distance · Measured of mitigation with obstacles. Analysis of the phenomena of transmission and reflection. · Statistical study of the variability of the signal 5. Use of a radar. 6. Measures of electromagnetic compatibility. 7. Measures in millimeter and sub-millimeter bands 8. Design, setting and measure of a LNA 9. Design, setting and measure of an oscillator of RF. 10. Analog modulations 11. Digital modulations 11. Network analyzers 12. Software Defined Radio (SDR) 13. Vector signal generators 14. Digital Video Broadcasting Terrestrial (DVB-T) 15. Digital Radio Mondiale (DRM) 16. Pseudorandom codes 17. Enhanced Spectrum 18. Multiple Input Multiple Output (MIMO)

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	9	9	18
Laboratory practical	29	14	43
Problem and/or exercise solving	1	20	21
Problem and/or exercise solving	3	40	43

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

Methodologies

	Description
Lecturing	Explanation of the theoretical-practical basis of the work to be developed by the students in the laboratory. A1, A2, B8, C2, C3, C5, C13.
Laboratory practical	Setting and measure of circuits and telecommunication systems. Employing specific instrumental. In groups. A1, A2, B8, C2, C3, C5, C13.

Personalized assistance

Methodologies	Description
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 else at moovi.uvigo.gal. Place and time will preferrably be as officially scheduled.
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 else at moovi.uvigo.gal. Place and time will preferrably be as officially scheduled.

Tests	Description
Problem and/or exercise 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 else at moovi.uvigo.gal. Place and time will preferrably be as officially scheduled.
Problem and/or exercise 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 else at moovi.uvigo.gal. Place and time will preferrably be as officially scheduled.

Assessment

	Description	Qualification	Training and Learning Results
Laboratory practical	Laboratory practises 1	40	C2 C3 C5 C13
Problem and/or exercise solving	Midterm 1	30	B8
Problem and/or exercise solving	Midterm 2	30	B8

Other comments on the Evaluation

ORDINARY CALL:

Following the guidelines for the degree program, students taking this course will be offered two assessment systems for the ordinary call:

Continuous Assessment, which is the recommended method and around which teaching activities are organized, and a Global Assessment option, which is only recommended in situations where it is impossible to follow the recommended system.

CONTINUOUS ASSESSMENT
Continuous assessment consists of the following tests:* Laboratory practices. Group assessment (Weight: 40%)* Problem-solving and exercises. Midterm 1. Individual assessment (Weight: 30%)* Problem-solving and exercises. Midterm 2. Individual assessment (Weight: 30%)
Attendance at laboratory practices is mandatory.At the end of each practice session, students must submit a report with the results obtained, which constitutes the purpose of the practice assessment.The continuous assessment system is chosen by attending any of the laboratory practical sessions and submitting the report, starting in the first month of the course.With group assessment, all group members will receive the same grade, as long as their contribution in the mandatory attendance sessions is reasonably similar.Continuous assessment assignments and exams are non-recoverable.Continuous assessment assignments and exams have no impact beyond the continuous assessment process.Anyone who has not completed at least 50% of the practical sessions will not be eligible to participate in the continuous assessment process.If continuous assessment is chosen, the final grade cannot be missed.Those who have opted for continuous assessment are not entitled to take a comprehensive assessment in the same session.
EXAM-ONLY ASSESSMENT
Those who do not opt for continuous assessment must take a single final exam on the official date assigned by the center, covering the content of all activities, demonstrating that they have acquired the same skills as those who have opted for continuous assessment.
SECOND CALL:
Those who have been assessed by Continuous Assessment can choose between two options on the exam day:* Take the corresponding exams in a single session, retaining only the grade for attendance at the practical sessions and being assessed with the weighting stipulated for the continuous assessment system.* Be assessed with a single final exam on the official date assigned by the center, as stipulated for the comprehensive assessment system.Those who have NOT been assessed by Continuous Assessment:* Will be assessed with a single final exam on the official date assigned by the center, as stipulated for the comprehensive assessment system.

END OF PROGRAM CALL:

Those who take the End of Program call will be assessed with a single final exam on the official date assigned by the Center, as stipulated in the Global Assessment system.

If plagiarism is detected in any of the tests or assignments, the final grade will be FAIL (0), and the Center's management

will be notified for the appropriate action.

After any assessment, teaching staff may call students for oral verification interviews, either at random or where there are indications of cheating, unauthorized use of artificial intelligence, or other fraudulent means in completing the exam. Grades for the assessments shall remain provisional until any such interviews have been completed. During these interviews, students must demonstrate that they possess the knowledge and skills needed to adequately justify the solutions they submitted.

Sources of information

Basic Bibliography

Walter Tuttlebee, **Software defined radio : Enabling technologies**,

Fuqin Xiong, **Digital modulation techniques**,

Complementary Bibliography

Ulrich Reimers, **DVB : The family of international standards for digital video broadcasting**,

M. E. Van Valkenburg, **Network analysis**,

Wes Hayward, **Introduction to radio frequency design**,

George Brown, **Radio and electronics cookbook**,

John Davies, **Newnes radio and RF engineer's pocket book**,

Y.T. Lo, S.W. Lee, **Antenna handbook**,

Rajeswari Chatterjee, **Antenna theory and practice**,

Yi Huang, Kevin Boyle, **Antennas : from theory to practice**,

Walter C. Johnson, **Transmission lines and networks**,

Brian C. Wadell, **Transmission line design handbook**,

Recommendations

Subjects that continue the syllabus

Satellites/V05M145V01311
Wireless and Mobile Communications/V05M145V01313
Wideband Radio Systems/V05M145V01312

Subjects that are recommended to be taken simultaneously

Electronics and Photonics for Communications/V05M145V01202
Optical Communications/V05M145V01207
Antennas/V05M145V01208

Subjects that it is recommended to have taken before

Signal Processing in Communications/V05M145V01102
Radiocommunication/V05M145V01103

IDENTIFYING DATA				
(*)Circuitos mixtos analógicos y digitales				
Subject	(*)Circuitos mixtos analógicos y digitales			
Code	10414-76030			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Quintáns Graña, Camilo			
Lecturers	Quintáns Graña, Camilo			
E-mail	quintans@uvigo.gal			
Web	http://moovi.uvigo.gal			
General description	Most electronic systems combine analog and digital circuits. Therefore, in addition to studying them separately, it is necessary to consider them as a whole and understand their specific characteristics. This course introduces analog and digital mixed circuits from different perspectives, covering both theoretical and practical aspects. The content taught combines the theory of continuous and discrete systems, and analog and digital circuits, within the framework of applications related to the telecommunications electronics curriculum (format converters, modulators, filters, signal synthesis, etc.). 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	Possess and understand knowledge that provides a basis or opportunity for originality in the development and/or application of ideas, often in a research context.
B10	Know the hardware description languages for highly complex circuits.
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C6	Apply acquired knowledge and solve problems in new or unfamiliar environments within broader, multidisciplinary contexts, being able to integrate knowledge.
C19	Use programmable logic devices and design advanced electronic systems, both analog and digital. Design communications components such as routers, switches, hubs, transmitters, and receivers in different bands.
C21	Develop electronic instrumentation, as well as transducers, actuators and sensors

Expected results from this subject	
Expected results from this subject	Training and Learning Results
To know and to understand the basics of mixed circuits in order to obtain new applications that combine different methods and resources for the design of complex systems	B6
To know the modeling of mixed electronic systems by using the mathematical basis of the continuous analog systems and discrete systems.	C3
The ability to combine different methods and resources for the design of complex systems that include analog and digital circuits.	C6
The knowledge of the characteristics of the description languages modeling the analog and digital mixed electronic circuits. To be able of modeling mixed electronic systems using hardware description languages.	B10
Knowing how to combine different methods and resources for the design of complex systems that include analog and digital circuits. To design matching circuits from analog to digital signal processors efficiently. Besides of the output signals from analog systems to digital processors.	C19
To know how to design specific digital filters and modulators for sampling and reconstruction of signals. To know how to use the modulation techniques for conditioning of sensors and for generating electrical signals to actuators.	C21

Contents
Topic

Unit 1: Introduction to mixed analog and digital electronic circuits.	Characteristics of mixed circuits. Modeling, simulation, and applications of mixed circuits.
Unit 2: Introduction to the modeling and simulation of mixed analog and digital electronic circuits.	Introduction to hardware description languages for mixed analog/digital circuits. Examples based on PSPICE and VHDL-AMS.
Unit 3: Oversampling techniques for signal processing.	Oversampling techniques. Resolution gain. Quantization noise spectrum modification. First-order modulator. Modeling, simulation, and testing techniques for sigma-delta modulators.
Unit 4: Sigma-delta ADC modulators.	Design of sigma-delta modulators with different topologies. Operating parameters. Low-pass, band-pass, and multi-stage modulators.
Unit 5: Sigma-delta DAC modulators.	System-level modeling and VHDL description of first- and second-order DAC modulators.
Unit 6: Hardware implementation of decimating filters.	VHDL synthesis of digital filters. Averaging and decimation filters. Equalizing filter.
Unit 7: Introduction to multistage A/D converter circuits.	Segmented analog A/D converter circuits. Basic stages, synchronization, and alignment. Test methods.
Unit 8: Hardware implementation of circuits for direct digital signal synthesis.	Methods for digital synthesis of analog signals. Direct synthesis. Modeling of digital analog signal synthesizers using hardware description languages.
Unit 9: Hardware implementation of IIR filters.	Hardware implementation of z-transfer functions for low-pass filters and signal synthesis.
Laboratory activities.	1. Modeling and simulation of a mixed-chip circuit using VHDL-AMS. 2. Modeling and simulation of a mixed-chip circuit using PSPICE. 3. Assembly of a Sigma-Delta ADC modulator. 4. Testing and analysis of a Sigma-Delta ADC modulator. 5. Implementation and testing of Sigma-Delta DAC modulators. 6. Configuration of decimation filters on an FPGA. 7. Configuration of DDS circuits on an FPGA. 8. Configuration of an IIR filter-based synthesizer circuit on an FPGA.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	0.5	1	1.5
Lecturing	13.5	20	33.5
Problem solving	4	8	12
Laboratory practical	19	12	31
Laboratory practice	2	10	12
Essay questions exam	1.5	8	9.5
Problem and/or exercise solving	1.5	8	9.5
Report of practices, practicum and external practices	0	16	16
*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 aimed at making contact and gathering information about the students, as well as presenting the subject.
Lecturing	Exhibition by the teacher of the reports on the subject matter of study, theoretical bases and / or guidelines of a work, exercise that the student has to develop. The learning outcomes that are developed are: B6, B10, C3, C6, C19 and C21.
Problem solving	Activity in which problems and / or exercises related to the subject are formulated. The student must develop the correct solutions through the exercise of routines, and application of formulas or algorithms, the application of procedures of transformation of the available information and the interpretation of the results. The learning outcomes that are developed are: B6, B10, C3, C6, C19 and C21.
Laboratory practical	Activities of application of knowledge and concrete situations, and acquisition of basic and procedural skills, related to the object of study. They are developed in special spaces with specialized equipment (laboratories, computer rooms, etc.). The learning outcomes that are developed are: B6, B10, C3, C6, C19 and C21. Software to be used: OrCAD PSpice, Excel, Matlab, Vivado, PARTQUEST.

Personalized assistance

Methodologies	Description

Lecturing	The professor will attend personally doubts and queries of the students on the study of the theoretical concepts and exercises. Office hours will take place in the teacher's office at the time established at the beginning of the course and published on the personal profile accessible on Moovi (https://moovi.uvigo.gal/user/profile.php?id=11317).
Laboratory practical	The professor will attend personally doubts and queries of the students to prepare the practices of laboratory. Office hours will take place in the teacher's office at the time established at the beginning of the course and published on the personal profile accessible on Moovi (https://moovi.uvigo.gal/user/profile.php?id=11317).
Problem solving	The professor will attend personally doubts and queries of the students on the resolution of the problems. Office hours will take place in the teacher's office at the time established at the beginning of the course and published on the personal profile accessible on Moovi (https://moovi.uvigo.gal/user/profile.php?id=11317).
Tests	**Description**
Report of practices, practicum and external practices	The professor will attend personally doubts and queries of the students on the preparation of the report of practices. Office hours will take place in the teacher's office at the time established at the beginning of the course and published on the personal profile accessible on Moovi (https://moovi.uvigo.gal/user/profile.php?id=11317).

Assessment

	Description	Qualification	Training and Learning Results	
Laboratory practice	Completion of real or simulated practical tasks. These are tests in which the performance of the students will be evaluated on the basis of their ability to demonstrate their knowledge of the material, their ability to organize and plan during the practice sessions, as well as their reflection on the results obtained, etc.	30	B10	C6 C19 C21
Essay questions exam	Tests that include open questions about a topic. Students must develop, relate, organize and present the knowledge they have about the subject in a comprehensive response.	25	B10	C3 C6 C19 C21
Problem and/or exercise solving	Test in which the student must solve a series of problems and / or exercises in a time / conditions established by the teacher. In this way, students must apply the knowledge acquired.	25	B6 B10	C3 C6 C19 C21
Report of practices, practicum and external practices	Preparation of a report by the student in which the characteristics of the work carried out are reflected.	20	B10	C6 C19

Other comments on the Evaluation

1. Ordinary exam

1.1. Continuous assessment

The continuous assessment consists of the following two parts (with their respective grading policy):

Part 1.- The laboratory work (50%) will be evaluated based on the quality of experimental techniques and results analysis (15%), the writing of laboratory reports (20%) and the Laboratory exam (15%).

Part 2.- The exams will cover material from lectures and additional provided resources (50%). The format of the exams may include essay questions (25%) and problem solving questions (25%).

The final grade, which ranges from 0 to 10 points, will be the sum of those from all parts, if the following requirements are met:

Requirement 1.- Attend and participate actively in a minimum of 80% of the laboratory sessions.

Requirement 2.- Obtain a minimum of 40% of the grade in the laboratory work (part 1), and in the exams (part 2).

If any of the previous requirements are not met, the final grade will be the sum of all grades or 4 points, if that sum is equal to or greater than 5 points.

Students who opt for continuous assessment and who have not reached the minimum mark in any part can recover it in the final exam of the ordinary or extraordinary calls. In the case of laboratory reports, if the minimum grade was not reached, the deadline to present the improvements proposed by the teaching team is the date of the final exam of the ordinary or

extraordinary calls.

To pass, students have to obtain a mark equal to or greater than 50% of the maximum grade (5 points).

The laboratory exam will be held during one of the final sessions. The part with essay and problem solving questions will be divided in two exams throughout the semester.

If after the first month of academic activity and after taking the first partial exam the students do not expressly waive continuous assessment, it will be considered to be the assessment method they have chosen.

1.2. Global assessment

Students who do not opt for continuous assessment or who do not carry out at least 80% of the laboratory work can make a global final exam.

The format of the final exam will consist of a laboratory part with practical tasks and a writing part that may include essay and problem solving questions. Each part accounts for 50% of the final grade. To pass, students have to obtain at least the 40% in each part and get a sum of both parts equal or greater than 5 points. If the minimum grade of any part is not achieved, the final grade will be the sum of both grades or 4 points, if that sum is equal to or greater than 5 points.

Students who do not opt for continuous assessment and do not attend the final exam will receive a grade of "No show".

2. Extraordinary exam

In the extraordinary exam the assessment will be like the final exam of the global assessment.

3.- Academic Integrity

Plagiarism is regarded as seriously dishonest behavior. If any form of plagiarism is detected on 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. Quintáns et al, **Methodology and Resources for the Practical Teaching of Mixed Analog-Digital Circuits**, 1, IEEE, 2024

Shanthi Pavan; Richard Schreier; Gabor C. Temes, **Understanding Delta-Sigma Data Converters**, 2, Wiley-IEEE Press, 2017

U. Meyer-Base, **Digital Signal Processing with Fiel Programmable Gate Arrays**, 4, Springer, 2014

C. Quintáns, **Simulación de Circuitos Electrónicos con OrCAD PSpice**, 2, Marcombo, 2021

Complementary Bibliography

Charles H. Roth, Lizy Kurian John, **Digital Systems Design using VHDL**, 3, Cengage Learning, 2017

F. Maloberti, **Data Converters**, Springer, 2008

Steven W. Smith, **The Scientist and Engineer's Guide to Digital Signal Processing**, California Technical Publishing, 1997

G.I. Bourdopoulos, et al, **Delta-Sigma modulators : modeling, design and applications**, Imperial College Press, 2003

S. J. Orfanidis, **Introduction to signal Processing**, Prentice Hall International, Inc., 1997

Alfi Moscovici, **High Speed A/D Converters: Understanding Data Converters Through SPICE**, Kluwer Academic Publishers, 2006

Libin Yao, Michel Steyaert and Willy Sansen, **Low-Power Low-Voltage Sigma-Delta Modulators in nanometer CMOS**, Springer, 2006

Recommendations

Subjects that are recommended to be taken simultaneously

(*)Acondicionadores de señal y sensores/10414-76023

Subjects that it is recommended to have taken before

(*)Sistemas electrónicos digitales avanzados/10414-76020

IDENTIFYING DATA				
(*)Codiseño hardware/software de sistemas empotrados				
Subject	(*)Codiseño hardware/software de sistemas empotrados			
Code	10414-76031			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish Galician English			
Department				
Coordinator	Álvarez Ruiz de Ojeda, Luís Jacobo			
Lecturers	Álvarez Ruiz de Ojeda, Luís Jacobo Poza González, Francisco			
E-mail	jalvarez@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Part of this course may be taught and assessed in English. The documentation of the subject will be in English. The main learning goals of this course are: - To learn the codesign methods to design applications based on embedded microprocessors in FPGAs. - To get to know the microprocessors that can be implemented in commercial FPGAs. - To handle the necessary software tools for the development of embedded applications by means of FPGAs. - To design application specific peripherals and their connection to the buses of the embedded microprocessors. - To design real digital applications with embedded microprocessors in FPGAs.			

Training and Learning Results	
Code	
B10	Know the hardware description languages for highly complex circuits.
C6	Apply acquired knowledge and solve problems in new or unfamiliar environments within broader, multidisciplinary contexts, being able to integrate knowledge.
C9	Learn continuously, self-directedly, and autonomously.
C19	Use programmable logic devices and design advanced electronic systems, both analog and digital. Design communications components such as routers, switches, hubs, transmitters, and receivers in different bands.
D1	Project, calculate, and design products, processes, and facilities in all areas of telecommunications engineering

Expected results from this subject	Training and Learning Results
To learn the codesign methods to design applications based on embedded microprocessors in FPGAs.	B18 B18 B10 B18 C38 C38 C19 D10
To get to know the microprocessors that can be implemented in commercial FPGAs.	B18 B18 B10 B18 C38 C38 C19 D10

To handle the necessary software tools for the development of embedded applications by means of FPGAs.	B18 B18 B10 B18 C38 C38 C19 D10
To design application specific peripherals and their connection to the buses of the embedded microprocessors.	B18 B18 B10 B18 C38 C38 C6 C19 D1 D10
To design real applications with embedded microprocessors in FPGAs.	B18 B18 B10 B18 C38 C38 C6 C9 C19 D1 D10

Contents	
Topic	
LESSON 1 THEORY. INTRODUCTION TO THE DESIGN OF EMBEDDED SYSTEMS.	1.1. Introduction. 1.2. Programmable Systems On Chip (PSOC). 1.3. Hardware/Software Codesign. Codesign phases. 1.4. Xilinx SOC Zynq family introduction. 1.5. Xilinx Vivado and SDK tools for codesign of embedded systems.
LESSON 2 THEORY. MICROPROCESSOR OF THE XILINX ZYNQ FAMILY SOCs.	2.1. ARM processor from Zynq SOC family (Zynq Processing Systems (PS)). 2.2. Processor peripherals from Zynq SOC family. 2.3. Clock, reset and processor debugging. 2.4. AXI interface.
LESSON 3 THEORY. FPGA OF THE XILINX ZYNQ FAMILY SOCs.	3.1. Introduction to 7 series Xilinx FPGAs. 3.1.1. Logic resources. 3.1.2. Input/output resources. 3.1.3. Memory and signal processing resources. 3.1.4. Analog to digital converter. 3.1.5. Clock resources.
LESSON 4 THEORY. CONNECTION OF PERIPHERAL CIRCUITS TO THE XILINX ARM MICROPROCESSOR.	4.1.- Introduction. 4.2.- Interface for basic peripherals. GPIO. 4.3.- Interface for advanced peripherals. IPIF. 4.4.- Interface for user coprocessors
LESSON 5 THEORY. SOFTWARE DEVELOPMENT FOR THE XILINX ARM MICROPROCESSOR.	5.1.- Introduction. 5.2.- Structure of the routines for handling of peripherals. 5.3.- Interrupt handle. 5.4.- Program debugging.
LESSON 6 THEORY. HARDWARE / SOFTWARE PARTITIONING.	6.1.- Introduction. 6.2.- Examples of hardware / software codesign. 6.3.- Distribution of tasks between hardware and software. 6.4.- Software profiling.
LESSON 7 THEORY. EMBEDDED SYSTEMS ANALISYS PROJECT.	7.1. Design of a software routine for the assigned function. 7.2. Design of a hardware peripheral (coprocessor) for the assigned function. 7.3. Profiling analysis from software routine and hardware peripheral. Comparison of results.

LESSON 8 THEORY. INTERRUPTS IN THE XILINX ARM MICROPROCESSOR.	8.1. Introduction. 8.2. Interrupt Handling. 8.3. Generic Interrupt Controller. 8.4. Interrupt Service Routine.
LESSON 1 LABORATORY. XILINX VIVADO ENVIRONMENT FOR THE DESIGN OF EMBEDDED SYSTEMS.	1.1. Introduction. 1.2. Xilinx Vivado environment. 1.3. Design of basic examples of embedded systems. 1.3.1. Addition of predefined peripherals (IP cores). 1.4. Implementation of the developed systems in Digilent evaluation boards.
LESSON 2 LABORATORY. DESIGN OF BASIC PERIPHERAL CIRCUITS.	2.1. Introduction. 2.2. Development of basic user peripherals. GPIO.
LESSON 3 LABORATORY. DESIGN OF ADVANCED PERIPHERAL CIRCUITS.	3.1. Introduction. 3.2. Development of advanced user peripherals (Custom IP).
LESSON 4 LABORATORY. XILINX VITIS ENVIRONMENT FOR THE DESIGN OF EMBEDDED SYSTEMS SOFTWARE.	4.1. Introduction. 4.2. Xilinx Vitis environment for software development. 4.3. Basic Design Examples.
LESSON 5 LABORATORY. SOFTWARE DEBUGGING OF EMBEDDED APPLICATIONS.	5.1. Introduction. 5.2. Software debugging of embedded systems by means of the GNU debugger from SDK.
LESSON 6 LABORATORY. HARDWARE VERIFICATION OF EMBEDDED APPLICATIONS.	6.1. Introduction. 6.2. Embedded systems hardware verification using Vivado hardware analyzer.
LESSON 7 LABORATORY. INTERRUPTS IN THE XILINX ARM MICROPROCESSOR.	7.1. Introduction. 7.2. Basic examples with interrupts.
LESSON 8 LABORATORY. DESIGN PROJECT. DESIGN OF AN APPLICATION BASED IN THE XILINX ARM MICROPROCESSOR.	8.1. Design and test of the assigned application. 8.1.1. Design of the required hardware peripherals. 8.1.2. Design of the software program for the application. 8.1.3. Design and test of the complete embedded system.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	10	5	15
Problem solving	5	5	10
Problem solving	6	12	18
Laboratory practical	6	16	22
Mentored work	14	40	54
Presentation	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	Conventional lectures. Through this methodology the outcomes B10 and C19 are developed.
Problem solving	Problem based learning (PBL): Problem solving. Design of synthesizable circuits in VHDL and software programs in C language. To solve them, the student has to previously develop certain outcomes. Through this methodology the outcomes B10, C6, C9, C19 and D1 are developed.
Problem solving	Problem based learning (PBL): The students must design a software routine and a hardware peripheral of an embedded system to solve a problem. In order to do that, the students must plan, design and implement the necessary steps. Through this methodology the outcomes B10, C6, C9, C19 and D1 are developed.
Laboratory practical	VHDL design of digital circuits and circuit implementation in FPGAs and development of software programs in C language. Integration of both to build an embedded system in a FPGA. Software to be used: Vivado Design Suite from Xilinx. Through this methodology the outcomes B10, C6, C9 and C19 are developed.
Mentored work	Project based learning. The students must design an embedded system to solve a problem. In order to do that, the students must plan, design and implement the necessary steps. Through this methodology the outcomes B10, C6, C9, C19 and D1 are developed.

Presentation	Exhibition of the results of the project developed. Through this methodology the outcomes B10, C9 and C19 are developed.

Personalized assistance

Methodologies	Description
Lecturing	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://moovi.uvigo.gal/user/profile.php?id=11300
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://moovi.uvigo.gal/user/profile.php?id=11300
Problem solving	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://moovi.uvigo.gal/user/profile.php?id=11300
Mentored work	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://moovi.uvigo.gal/user/profile.php?id=11300
Problem solving	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://moovi.uvigo.gal/user/profile.php?id=11300

Assessment

	Description	Qualification	Training and Learning Results		
Problem solving	Problem Based Learning. Resolution of exercises and theoretical problems. The correct application of the theoretical concepts to the problems will be assessed, based on the published criteria.	10	B10	C6 C9 C19	D1
Problem solving	Problem Based Learning. Design of a software routine and a hardware peripheral to perform the function assigned. Comparison of the performance of both, in terms of execution time and logical resources used. The assessment will be based on the operation of the system and the correct application of the theoretical concepts, according to the published criteria. It will be necessary to deliver a brief report explaining the work done.	15	B10	C6 C9 C19	D1
Laboratory practical	Design circuits and programs in the laboratory sessions corresponding to the laboratory lessons 1 to 7. It will be necessary to show to the professor the operation of each one of the circuits and programs. 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.	25	B10	C6 C9 C19	D1
Mentored work	Project Based Learning. Laboratory Project. Design of a complete embedded system with several peripherals. It will be necessary to deliver the source files of the work realized. The assessment will be based on the operation of the embedded system and the correct application of the theoretical concepts, according to the published criteria.	40	B10	C6 C9 C19	D1
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	B10	C9 C19	

Other comments on the Evaluation

The final mark will be expressed in numerical form ranging from 0 to 10, according to the valid regulation (Royal decree 1125/2003 of 5 September; BOE 18 September).

Following the guidelines of the degree the students will be offered two evaluation systems: continuous assessment and global assessment. Students must choose at the start of the subject if they wish to follow the continuous evaluation or prefer to follow the global assessment at the end of the semester. Students who choose global assessment must notify the subject coordinator in writing within one month from the beginning of the semester.

CONTINUOUS ASSESSMENT IN ORDINARY CALL

The students that have chosen continuous assessment, but do not pass the course, will have to do the global assessment in extraordinary call.

The different tasks should be delivered in the date specified by the teacher, otherwise they will not be assessed for the continuous evaluation.

If the number of students allows it, the students will develop the theoretical exercises, the laboratory practices and the laboratory projects individually. In case of doing them in groups of two students the mark will be the same for both.

The students who want to be assessed in the continuous evaluation can only miss two sessions of any type 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

1) Laboratory practices (LP).

Each laboratory practice 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 hours assigned to each lesson. That is, the mark of the practices will be obtained through the following formula:

LAB = Lesson 1L + ... + Lesson N L

2) Theoretical exercises (TE).

Each one of the theoretical exercises and problems proposed in the theoretical sessions will be evaluated. Each exercise will be marked from 0 to 10. Its influence in the total mark of the subject will be weighted according to the difficulty and length of the exercise.

The total mark will be the sum of the marks of each one of the exercises:

TE = Exercise 1 + ... + Exercise N

3) Theoretical Problem (TP).

It will consist of the design of a software routine and a hardware peripheral to perform the function assigned to each student and the comparison of the performance of both, in terms of execution time and logical resources used. The content corresponds to topic 7 of theory. It will be necessary to show the teacher the operation of each one of the circuits and programs. It will be necessary to deliver a brief report explaining the work done.

4) Laboratory Tutored Work (LTW).

This work consists in the design of an embedded system. The correct operation of the developed circuits and programs will be evaluated. This work will be marked from 0 to 10.

5) Presentation (OP).

The work developed during the laboratory project will be presented. The presentation will be marked from 0 to 10.

In case the students pass the theoretical part (TE+TP), the laboratory practices (LP) and the Laboratory Tutored Work (LTW), 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 = 0,10 * TE + 0,15 * TP + 0,25 * LP + 0,40 * LTW + 0,10 * OP

In case the students do not pass any of the three main parts of the subject, that is, the mark of any task < 5, the final mark (FM) will be:

FM = Minimum [4'9; (0,10 * TE + 0,15 * TP + 0,25 * LP + 0,40 * LTW + 0,10 * OP)]

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

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**, Vison Libros,

Complementary Bibliography

ÁLVAREZ RUIZ DE OJEDA, L.J., **Diseño Digital con FPGAs**, Vision Libros,

Recommendations

Subjects that are recommended to be taken simultaneously

(*)Circuitos mixtos analógicos y digitales/10414-76030
(*)Sistemas electrónicos digitales avanzados/10414-76020

IDENTIFYING DATA				
(*)Diseño y fabricación de circuitos integrados				
Subject	(*)Diseño y fabricación de circuitos integrados			
Code	10414-76032			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Cao Paz, Ana María			
Lecturers	Cao Paz, Ana María			
E-mail	amcaopaz@uvigo.es			
Web	http://http://moovi.uvigo.gal			
General description	The objectives in mind are: 1) To know and understand the design methodologies of Integrated Circuits (ICs) based on CMOS technology. 2) To know the basic topologies used in analog electronic circuits. 3) To know how to analyze and dimensioning the devices of the basic topologies of analog circuits in CMOS technology. 4) To know and be capable to use software tools for the design of integrated circuits. 5) To know to specify an integrated circuit for manufacturing in CMOS technology.			

Training and Learning Results	
Code	
C6	Apply acquired knowledge and solve problems in new or unfamiliar environments within broader, multidisciplinary contexts, being able to integrate knowledge.
C8	Communicate (orally and in writing) the conclusions - and the knowledge and ultimate reasons that support them - to specialized and non-specialized audiences in a clear and unambiguous manner.
C9	Learn continuously, self-directedly, and autonomously.
D7	Design and manufacture integrated circuits.

Expected results from this subject	Training and Learning Results
Apply acquired knowledge and solve problems in new or unfamiliar environments within broader, multidisciplinary contexts, being able to integrate knowledge.	C6
Communicate (orally and in writing) the conclusions - and the knowledge and ultimate reasons that support them - to specialized and non-specialized audiences in a clear and unambiguous manner.	C8
Learn continuously, self-directedly, and autonomously.	C9
Design and manufacture integrated circuits.	D7

Contents	
Topic	
Chapter 1: Introduction.	1.1 Course introduction. Objectives and course planning. 1.2 Basic concepts of microelectronic design of integrated circuits (ICs).
Chapter 2: Manufacturing sequence for ICs.	2.1 Introduction to ICs manufacturing. Planar technology. 2.2 Manufacturing sequence of ICs in CMOS technology. Structure of MOS transistors. 2.3 Manufacturing example: CMOS inverter. Masks pattern (layout). Technological design rules. Methodologies and tools for design assistance.
Chapter 3: Physical structure of basic devices and routing strategies.	3.1 Specification of the physical structure of MOS transistor. 3.2 Specification of the physical structure of a resistor. 3.3 Specification of the physical structure of a capacitor. 3.4 Strategies for performing transistors with high aspect ratio. Strategies for matched transistors.
Chapter 4: Basic amplifier topologies.	4.1 Common source topology. Common drain topology. Common gate topology. Cascode topology. Push_Pull amplifier. 4.2 Physical design examples.

Chapter 5: Current mirror.	5.1 Current sources. Basic structure of a current mirror. Analysis of functioning. Frequency response. Cascode topology. 5.2 Physical design examples.
Chapter 6: Differential pair.	6.1 Differential pair structure. DC analysis. AC analysis. 6.2 Specifications and design of the physical structure of a self-biased differential amplifier topology. Common mode rejection ratio. Slew rate limitations. 6.3 Matching of transistors. Physical design examples.
Chapter 7: Operational amplifier.	7.1 Two stages operational amplifier. Design parameters. 7.2 Transconductance Amplifier (OTA). 7.3 Examples of physical designs.
Chapter 8: Preparing for manufacturing.	8.1 Distribution in the base plane. Pad and terminals. Specification formats. Packages.
Laboratory session 1: Introduction to design tools for ICs. First part: Schematic.	Introduction to design tools for analog ICs. Current mirror example. Design Rules Check (DRC) and electric simulation.
Laboratory session 2: Introduction to design tools for ICs. Second part: Layout.	Introduction to design tools for analog ICs. Current mirror example. Layout design, design Rules Check (DRC), ERC, NCC and layout simulation.
Laboratory session 3: Design of logic gate.	Design of a logic gate (NAND). Schematic and layout. Functional verification through simulation of the schematic and layout.
Laboratory session 4: Design of self-biased differential pair I.	Electrical specification. Characterization of DC operating parameters. Characterization of AC operating parameters.
Laboratory session 5: Design of self-biased differential pair II.	Physical design. Design rules check (DRC), ERC and layout versus schematic (NCC). Post-layout simulation.
Laboratory session 6: Design of a transconductance amplifier.	Electrical Specification. Physical specification. Functional check.
Laboratory session 7: Preparing for manufacturing.	Creation of the pad. Creation of the padframe. Incorporation of the design. Generation of the GDS file for fabrication.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	19	23	42
Laboratory practical	14	26	40
Mentored work	7	28	35
Problem and/or exercise solving	1	3	4
Problem and/or exercise solving	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
Lecturing	The professor will present the relevant concepts of the course. Before each lecture, students must carry out a preparation analysis of the topics to be addressed. The aim is to encourage active participation of students, who may ask questions or expose doubts during the session. For a better understanding of certain content, practical examples or case studies will be discussed. Learning outcomes C9 and D7 are worked in this methodology.
Laboratory practical	Students work with IC CAD tools for IC design, in which they will carried out the definition of an electronic circuit both electrical and physical level, the verification of compliance with specifications and design preparation for manufacturing. Attendance will be recorded and performance of each group in each lab assignment will be evaluated. Learning outcomes C6, C9 and D7 are worked in this methodology.
Mentored work	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. - Analysis and monitoring of the proposed solution for the project. - Report with the presentation and analysis of the obtained results. - Presentation and discussion of the results. Learning outcomes C6, C8, C9 and D7 are worked in this methodology.

Personalized assistance

Methodologies	Description

Lecturing	The teaching staff will attend doubts and enquiries of the students about the theoretical contents. Students will have the opportunity to attend personalized or group mentoring. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: Ana María Cao Paz: https://moovi.uvigo.gal/user/view.php?id=11331
Laboratory practical	The teaching staff will attend doubts and enquiries of the students about previous preparation of laboratory practices as well as its contents. Students will have the opportunity to attend personalized or group mentoring. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: Ana María Cao Paz:https://moovi.uvigo.gal/user/view.php?id=11331
Mentored work	The teaching staff will attend doubts and enquiries of the students about specifications, theoretical and practical aspects of the assigned project as well as those about the content and structure of the explanatory report. In addition, students will be guided about the structure and contents of the sessions of presentation and defense of the results achieved in the project. Students will have the opportunity to attend personalized or group mentoring. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: Ana María Cao Paz: https://moovi.uvigo.gal/user/view.php?id=11331

Assessment

	Description	Qualification	Training and Learning Results	
Laboratory practical	As part of the continuous assessment of the subject, each student will be evaluated for each of the practices. In the evaluation will take into account the work of preparation prior to the realization of the practice, assistance, punctuality and use of time. The total qualification of the practices will be obtained as an arithmetic average of the qualification of each of them. The internship note is not kept for successive academic courses	20	C6 C8 C9	D7
Mentored work	The evaluation of the work will be performed from memory supporting and public presentation of results. Each group of students you must submit a report of the work has been carried out, indicating expresses the contribution of each to the whole, as well as methodology followed for the distribution and coordination of tasks. The evaluation of the work will be based on the following aspects: - Analysis of alternatives - Correct implementation and design verification - Design compaction - Use of appropriate strategies to minimize the effects of imperfections in the manufacturing process and to ensure good matching of the electrical characteristics between components or devices that like this require it by functional reasons. - Information for integrated circuit manufacturing. - Formal aspects: clarity and order, including figures and appropriate and outstanding data, as well as explanations in a concrete and comprehensive way. Each student will have an individual public exposure of the project has personally performed (including tasks planning and coordination if applicable). The presentations of the students from each group will be out in the same session, 1 hour. Each student will have 5 minutes for their presentation. At the end of the presentation, students must answer questions from teachers and other students present. The evaluation will be based on both the content and formal aspects of the presentation and the answers to questions. It may also assess positively to students who perform relevant questions. The explanatory report should be submitted at least two days before public presentation of work. To pass the course, the student will need obtain at least a score of 5 over 10 in memory, and get to least a score of 5 out of 10 in public presentation. In the evaluation of the work, the memory has a weigh 70% and the presentation 30%.	40	C6 C8 C9	D7
Problem and/or exercise solving	As part of the continuous evaluation, it will take place in mid-course an individual written test of 60 minutes, in one of the lecture sessions. This test will involve 20% of the final grade. To pass the course, students must achieve a mark of 4 or higher in a 0-10.	20	C8	D7
Problem and/or exercise solving	At the end of the theoretical content, students will have a second 60-minute exam, during one of the lectures. This test will represent 20% of the final grade. To pass the subject it will be necessary to obtain at least a score of 4 out of 10.	20	C6 C8	D7

Other comments on the Evaluation

Continuos assessment:

The planning of the different evaluations will be notified to the students on the first day of classes.

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 test will be 50% of the overall grade of the course. It will consist of two parts: short answer questions and resolution of problems. The part of the questions will represent 50 % of the test qualification and the part of resolution of problems the other 50%. In order to calculate the grade it is necessary to obtain at least 50 % of the maximum score for each part.

- 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 evaluation). Reports are due two days before the public presentation. The project qualification will involve 50% of the overall grade of the course. In the final qualification of the project, the memory report has a corresponding percentage of 70% and the other 30% is obtained from the qualification of the presentation. In order to calculate the grade it is necessary to obtain at least 50 % of the maximum score for each part.

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.

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.

Extraordinary call:

Students who attend this call will be evaluated identically to the global assessment:

- Final test will be 50% of the overall grade of the course. It will consist of two parts: short answer questions and resolution of problems. The part of the questions will represent 50 % of the test qualification and the part of resolution of problems the other 50%. In order to calculate the grade it is necessary to obtain at least 50 % of the maximum score for each part.

- They must develop a project, and deliver the corresponding report and public presentation. Reports are due two days before the public presentation. The project qualification will involve 50% of the overall grade of the course. In the final qualification of the project, the memory report has a corresponding percentage of 70% and the other 30% is obtained from the qualification of the presentation. In order to calculate the grade it is necessary to obtain at least 50 % of the maximum score for each part.

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.

Sources of information

Basic Bibliography

R. Jacob Baker, **CMOS Circuits desing, Layout and Simulation**, 4º, John Wiley & Sons, 2019

Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer, **Analysis and Design of Analog Integrated Circuits**, 5º, Wiley, 2009

Behzad Razavi, **Design of Analog CMOS Integrated Circuits**, 2º, MC GRAW HILL, 2017

Stephen A. Campbell, **Fabrication Engineering at the micro-and nanoscale**, 4º, Oxford University Press, 2012

Complementary Bibliography

Recommendations

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				
(*)Comunicaciones digitales avanzadas				
Subject	(*)Comunicaciones digitales avanzadas			
Code	10414-76033			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Mosquera Nartallo, Carlos			
Lecturers	Gómez Cuba, Felipe Mosquera Nartallo, Carlos			
E-mail	mosquera@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This course presents advanced topics in digital communications with emphasis on modulations, coding and detection. The covered techniques are part of the state of the art in digital communications, and comprise novel aspects as MIMO systems and advanced waveforms. 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	
B1	Understand the mechanisms for launching, directing, and managing electronic and telecommunications equipment manufacturing processes, ensuring the safety of people and property, ensuring the final quality of the products, and ensuring their approval.
B4	Conceiving Engineering within a framework of sustainable development.
B8	Understand the limitations, risks, and implications of using Generative AI.
C1	Manage the tools necessary to manage telecommunication system construction and installations, complying with current regulations and ensuring service quality.
C2	Manage the tools necessary to direct, plan and supervise multidisciplinary teams
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.

Expected results from this subject	Training and Learning Results
Handle the mathematical tools needed to model, simulate and evaluate moderns communication systems.	A1 B1 B4 C1 C2 C3

Solve problems whose solution does not derive from the application of a standardized procedure.	A1 A1 A1 B1 B4 B18 B8 C1 C2 C3 C38 C38 C38 D10 D10 D10 D10 D10 D10
Understand the principles underlying modern communication standards.	B1 B4 B18 B8 B18 B18 B18 C1 C38 C2 C3 C38 C38 C38 C38 C38 C38 C38 D10 D10 D10
Design transmitters, receivers and measurement equipment for modern communication systems.	B1 B18 B18 B4 B8 B18 C1 C38 C2 C3 C38 C38 C38 C38 C38 C38 C38 C38 C38 D10

Contents	
Topic	
1. Channel modeling with multiple antennas	Line-of-sight MIMO channel. Non-line-of-sight MIMO channel. Statistical characterization.
2. Channel capacity	Capacity definitions. Channel capacity with CSIR. Channel capacity with CSIT. Diversity-multiplexing trade-off.

3. MIMO transceivers	MIMO architectures for transmission and reception. Space-time coding.
4. Wideband channels	Multicarrier MIMO. Practical implementation aspects.

Planning			
	Class hours	Hours outside the classroom	Total hours
Laboratory practical	19	30	49
Lecturing	21	25	46
Problem and/or exercise solving	0	14	14
Problem and/or exercise solving	2	8	10
Objective questions exam	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
Laboratory practical	Lab practices will cover different aspects of multiple-input multiple-output (MIMO) communications. This will allow students to practically implement and considerably expand some of the concepts seen in the lectures. Matlab will be used for simulation purposes. Competences: CG1, CG4, CE1, CE2, CE3
Lecturing	The course is structured in several advanced topics in digital communications with emphasis on multiple-input multiple-output (MIMO) communications. Competences: CG1, CG4, CG8, CE1, CE2, CE3

Personalized assistance	
Methodologies	**Description**
Lecturing	The instructors will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered in presential form (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: for contact information, see https://www.uvigo.gal/es/universidad/administracion-personal/pdi/carlos-mosquera-nartallo.
Tests	**Description**
Problem and/or exercise solving	The instructors will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered in presential form (during the work review sessions or during the office hours).
Problem and/or exercise solving	The instructors will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered in presential form (during the work review sessions or during the office hours).

Assessment				
	Description	Qualification	Training and Learning Results	
Problem and/or exercise solving	Discussion sessions will be held during class time on the solutions of different problems that will be proposed.	20	B1 B4 B8	C1 C2 C3
Problem and/or exercise solving	Intermediate test based on problem solving	40	B1 B4 B8	C1 C2 C3
Objective questions exam	Final exam with short questions and exercises.	40	B1 B4 B8	C1 C2 C3

Other comments on the Evaluation

The students need to obtain 50 out of 100 points to pass the course. Any student that chooses the continuous evaluation track will get a final score, regardless of her/his taking the final exam. A student will be considered to be following the continuous evaluation track if he/she does not say otherwise within one month from the beginning of the course. For the extraordinary and end-of-program examination sessions, the exam will constitute 100% of the final grade. All the homeworks and exam will be given in English.

After any assessment, teaching staff may call students for oral verification interviews, either at random or where there are indications of cheating, unauthorized use of artificial intelligence, or other fraudulent means in completing the exam. Grades

for the assessments shall remain provisional until any such interviews have been completed. During these interviews, students must demonstrate that they possess the knowledge and skills needed to adequately justify the solutions they submitted.

Sources of information
Basic Bibliography
Emil Björnson and Özlem Tugfe Demir, **Introduction to Multiple Antenna Communications and Reconfigurable Surfaces**, First, now Publishers Inc., 2024
David Tse and Pramod Viswanath, **Fundamentals of Wireless Communication**, First, Cambridge University Press, 2005
Complementary Bibliography
Jerry Hampton, **Introduction to MIMO Communications**, First, Cambridge University Press, 2013
Robert W. Heath Jr. and Angel Lozano, **Foundations of MIMO Communication**, First, Cambridge University Press, 2018
A. Artés, F. Pérez-González, J. Cid, R. López, C. Mosquera, F. Pérez-Cruz, **Principios de comunicaciones digitales**, Versión electrónica, Prentice-Hall, 2012

Recommendations

Subjects that it is recommended to have taken before
(*)Tratamiento de señal en comunicaciones/10414-76019

IDENTIFYING DATA				
(*)Codificación de fuente y canal				
Subject	(*)Codificación de fuente y canal			
Code	10414-76034			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Comesaña Alfaro, Pedro			
Lecturers	Comesaña Alfaro, Pedro			
E-mail	pcomesan@gts.uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	In the subject "Source and channel coding" information theory basic concepts are presented. Then, lattices are presented as both source coding and channel coding tools. After commenting some generalities about another source coding strategy, namely Trellis Code Quantization, more advanced coding problems, as distributed source coding and joint source-channel coding, are considered.			

Training and Learning Results	
Code	
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C14	Apply methods from information theory, adaptive modulation and channel coding, as well as advanced digital signal processing techniques to communications and audiovisual systems.
D1	Project, calculate, and design products, processes, and facilities in all areas of telecommunications engineering
D4	Design and dimension transport, broadcast and distribution networks for multimedia signals
D6	Model, design, implement, manage, operate, administer, and maintain networks, services, and content.

Expected results from this subject	Training and Learning Results
Understanding the fundamental characterisitcs of a lattice, and the properties we must take into account when facing a source coding problem and a channel coding problem.	C3 C14
Understand that a trellis code defines a lattice and why this construction is useful for source coding (Trellis-Code Quantization)	C3 C14
Understanding of the different distributed source coding schemes.	C3 C14 D1 D4
Implementation of a distributed source coding scheme.	C3 C14 D1 D6
Understading of the different schemes of joint source and channel coding.	C3 C14 D4 D6
Implementation of a joint and source channel coding scheme.	C3 C14 D1 D4 D6
Understanding of the characteristics of different ways of multimedia signal distribution, paying special attention to streaming schemes.	D1 D4 D6

Contents
Topic

1) Information theory.	1) Discrete case: Entropy. Conditional entropy. Joint entropy. Mutual information. Kullback-Leibler Divergence. 2) Continuous case: Entropy. Conditional entropy. Joint entropy. Mutual information. Kullback-Leibler Divergence. 3) Jensen's inequality. 4) Shaping gain. 5) Rate distortion.
2) Lattices	1) Definition 2) Basic properties
3) Advanced source coding	1) Lloyd-Max quantizer. 2) Trellis Code Quantization.
4) Distributed source coding	1) Lossless coding 2) Lossy coding
5) Joint source-channel coding	1) Shannon's separability principle 2) JSCC practical examples
6) Other schemes of source and channel coding.	

Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	19	49	68
Lecturing	20	34	54
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
Laboratory practical	19 hours of PC lab. Programming of computational simulations. The student will simulate, by using a numerical calculus programming language (as Matlab) the multimedia communications systems introduced in this subject. Learning results: C3, C14, D1, D4, D6. Software to be used: Matlab.
Lecturing	20 hours of theoretical lessons, where practical cases will be introduced. Furthermore, autonomous homework exercises will be proposed. Learning results: C3, C14, D1, D4, D6.

Personalized assistance

Methodologies	Description
Laboratory practical	Personalized assistance will be provided at the office hours. Individual feedback on the reports will be provided. The schedule of the office hours can be checked at the institutional website of the subject instructor: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/pedro-comesana-alfaro
Lecturing	Personalized assistance will be provided at the office hours.

Assessment

	Description	Qualification	Training and Learning Results	
Laboratory practical	Numerical simulation programming, including the analysis of the obtained results and report/s writing.	40	C3 C14	D1 D4 D6
Problem and/or exercise solving	Midterm exam.	20	C3 C14	D1 D4 D6
Problem and/or exercise solving	Final exam.	40	C3 C14	D1 D4 D6

Other comments on the Evaluation

- Continuous assessment: In order to do the weighted average of the different qualifications, the student should submit all the tasks (practical work/s with report, midterm exam and final exam.) Moreover, at least 40% of the maximum grade must

be obtained in the final exam and 40% of the maximum grade in each practical work. In case that these thresholds are not reached, the final grade will be the minimum of the weighted grade (using the weights indicated in the previous table) and 4.

- Global assessment: In order to do the weighted average of the different qualifications, the student should submit all the tasks (practical work/s with memory, and final exam.) Moreover, at least 40% of the maximum grade must be obtained in the final exam and 40% of the maximum grade in each practical work. In case that these thresholds are not reached, the final grade will be the minimum of the weighted grade (with a weight of 40% for the practical work/s and 60% for the final exam) and 4.

All the exams/test and practical works will be done individually and they can not be recovered.

The schedule of the midterm exams and the delivery of practical work/s will be published at the beginning of each academic semester.

After the publication of the grades of the midter exam the students will have a one-month period to resign continuous assessment.

The same rules will be applied to the second call, where the students will choose if they keep the qualification of the midterm exam and are assessed with continuous assessment, or if they prefer to be assessed by global assessment. The grade of the midterm exam will not be saved for subsequent years.

In case of early call, the assessment will be performed by final exam only.

After any assessment, teaching staff may call students for oral verification interviews, either at random or where there are indications of cheating, unauthorized use of artificial intelligence, or other fraudulent means in completing the exam. Grades for the assessments shall remain provisional until any such interviews have been completed. During these interviews, students must demonstrate that they possess the knowledge and skills needed to adequately justify the solutions they submitted.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the projects, tests or exams, or if extensive use of AI tools is detected in the project, 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

Cover and Thomas, **Elements of information theory**, 2, Wiley, 2006

Complementary Bibliography

Artículos científicos especificados por el profesorado,

Recommendations

Subjects that it is recommended to have taken before

Signal Processing in Communications/V05M145V01102

Other comments

Even if this subject has not a series of mandatory prerrequisites, it is highly recommended that the student has a minimal background on:

- Statistics.
- Signal Processing.
- Channel coding.
- Source coding.
- Internet networks and protocols.

IDENTIFYING DATA				
(*)Codificación y gestión de información multimedia				
Subject	(*)Codificación y gestión de información multimedia			
Code	10414-76035			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Martín Rodríguez, Fernando Martínez Solís, Diego			
Lecturers	Martínez Solís, Diego			
E-mail	fmartin@uvigo.es diego.martinez.solis@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	In this course we will describe the main compression and coding techniques for audiovisual signals, paying special attention to MPEG4 standard. We will also explain the main characteristics of MPEG7 standard for multimedia content description and retrieval.			

Training and Learning Results	
Code	
B12	Know the main standards in the field of audio and video coding.
C3	Perform mathematical modeling, calculations, and simulations in technology and engineering centers, particularly in research, development, and innovation tasks in all areas related to Telecommunications Engineering and related multidisciplinary fields.
C14	Apply methods from information theory, adaptive modulation and channel coding, as well as advanced digital signal processing techniques to communications and audiovisual systems.
D1	Project, calculate, and design products, processes, and facilities in all areas of telecommunications engineering

Expected results from this subject	Training and Learning Results
Learning to exploit perceptual effects and spatial/temporal redundancy to compress audiovisual information.	A1 B18 B18 B18 B12 B18 C3 C14 C38 C38 C38 C38 D1 D10 D10 D10
Understanding information structure into the MPEG4 standard and the reasons because it is needed.	B12 B18 C38 C38 D1 D10 D10

Understanding main processes applied on audio and video signals to guarantee perceptual quality while reducing bitrate. Knowledge of the main algorithms that are part of standards.	A1 A1 B18 B18 C38 C3 C38 C38 C38 C38 C14 D1 D10 D10 D10 D10 D10 D10 D10
Learning to handle audiovisual information to extract metadata and to use them in indexing and retrieval.	A1 A1 B18 B18 C38 C38 C38 C38 C38 D1 D10 D10 D10 D10 D10 D10 D10
Understanding structure and usefulness of MPEG7 standard.	A1 A1 B18 B18 B18 B18 B18 B12 B18 C38 C38 D1 D10 D10 D10 D10 D10 D10 D10 D10 D10 D10 D10 D10 D10 D10 D10

Contents	
Topic	
Introduction to audiovisual compression and coding.	Human perception, redundancy and importance. Compression standards history. Analysis and description of spatial/temporal video structure.

Video coding.	Video compression standards: MPEG 1, 2 & 4; H.261, H.263, H.264 (AVC), H.264 extensions, introduction to HEVC (H.265, MPEG-H part 2).
Audio coding.	Audio compression standards: MPEG 1, 2, 4 (MP3, AAC).
Advanced audiovisual description.	MPEG7. Advanced audiovisual description. Multimedia content management. Information retrieval.
Practical content.	Each year, three practical work assignments will be done on themes related with theory contents.

Planning

	Class hours	Hours outside the classroom	Total hours
Practices through ICT	14	22	36
Mentored work	10	38	48
Lecturing	16	16	32
Report of practices, practicum and external practices	0.5	3.5	4
Report of practices, practicum and external practices	0.5	3.5	4
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	Hands-on programming tasks on specific concepts from the theory (master) sessions, with the use of computer tools. Related competencies: B12, C3, C14, D1. Software: Matlab, Simulink, Python/OpenCV
Mentored work	Projects about the lectured concepts, sometimes in more detail. These projects are customarily initiated on computer-lab work and span over more than one week. Students (in pairs) have to find out (on their own or with teacher assistance) what they need to solve the problem. Results (or at least, part of them) will be presented in public. Related competencies: B12, C3, C14, D1.
Lecturing	Basic concepts exposition. Related competencies: B12, C3, C14, D1.

Personalized assistance

Methodologies	**Description**
Practices through ICT	Query and answer in the classroom and, if necessary, appointment for tutorial class (office A305). Query and answer via e-mail ((dmartinezsolis@com.uvigo.es, diego.martinez.solis@uvigo.gal))
Mentored work	Query and answer in the classroom and, if necessary, appointment for tutorial class (office A305). Query and answer via e-mail ((dmartinezsolis@com.uvigo.es, diego.martinez.solis@uvigo.gal))
Lecturing	Query and answer in the classroom and, if necessary, appointment for tutorial class (office A305). Query and answer via e-mail ((dmartinezsolis@com.uvigo.es, diego.martinez.solis@uvigo.gal))
Tests	**Description**
Report of practices, practicum and external practices	Answer to questions about laboratory reports. In assessment, a brief report with correct issues and found errors is sent.
Report of practices, practicum and external practices	Answer to questions about laboratory reports. In assessment, a brief report with correct issues and found errors is sent.

Assessment

	Description	Qualification	Training and Learning Results		
Report of practices, practicum and external practices	THEME: related with the first theory units. Specifications are provided by lecturer. The grade of guided works comprises: achievements, documentation and bibliography selection. Students can choose to do this project individually or in pairs. If done in pairs, the grade will be equal for both team members.	40	B12	C3 C14	D1

Report of practices, practicum and external practices	INDIVIDUAL ORIGINAL PROJECT. THEME: negotiated with lecturer starting from student's suggestions. The qualification of guided works comprises: achievements, documentation and bibliography selection.	40	B12	C3 C14	D1
Objective questions exam	These tests are based on theory classes concepts.	20	B12	C3 C14	D1

Other comments on the Evaluation

There will be a final exam for those students that did not pass under the continuous assessment, the date will be scheduled by the school officials. Students are also allowed to go directly to the final exam skipping all continuous assessment activities (global assessment). This exam will be assessed between 0 and 10 and includes all concepts in theory classes and also the techniques being explained commonly for the guided works.

Those students who did not pass in the ordinary call will be allowed to take an exam in the extraordinary one. The same rules as those for the exam in the first call will apply.

The "Objective questions exam" may be written or online. In any case, it will be held on the official exam date.

Sources of information

Basic Bibliography

Fernando Pereira and Touradj Ebrahimi, **The MPEG-4 book**, 1, MSC Press Multimedia Series, Pearson Education, 2002

Richardson, Iain E. G., **H.264 and MPEG-4 video compression: video coding for next generation multimedia**, 1, Wiley, 2003

Complementary Bibliography

Thiagarajan, Jayaraman, **Analysis of the MPEG-1 Layer III (MP3) Algorithm using MATLAB**, 1, Morgan and Claypool, 2011

Ze-Nian Li, Mark S. Drew, Jiangchuan Liu, **Fundamentals of Multimedia**, 2, Springer, 2014

Recommendations

Subjects that are recommended to be taken simultaneously

(*)Distribución de contenidos multimedia/10414-76025

Subjects that it is recommended to have taken before

(*)Tratamiento de señal en comunicaciones/10414-76019

IDENTIFYING DATA				
(*)Aprendizaje automático distribuido				
Subject	(*)Aprendizaje automático distribuido			
Code	10414-76037-S			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	-	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Burguillo Rial, Juan Carlos			
Lecturers	Burguillo Rial, Juan Carlos Díaz Redondo, Rebeca Pilar González Castaño, Francisco Javier			
E-mail	jrial@uvigo.es			

----- UNPUBLISHED TEACHING GUIDE -----

IDENTIFYING DATA				
(*)Diseño avanzado de misiones espaciales y de exploración				
Subject	(*)Diseño avanzado de misiones espaciales y de exploración			
Code	10414-76038			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	-	1st
Teaching language	English			
Department				
Coordinator	Aguado Agelet, Fernando Antonio			
Lecturers	Aguado Agelet, Fernando Antonio Marante Boado, María Martín Rodríguez, Fernando			
E-mail	faguado@uvigo.gal			
Web	http://moovi.uvigo.gal			
General description	This course focuses on the advanced design of satellite missions, covering mission analysis and the design of the space and ground segments at a system level. Students will delve into satellite subsystem engineering and design, including architecture, design, implementation, and AIV (Assembly, Integration, and Verification). The program also covers space robotics, autonomous systems, and innovative technologies in space exploration. Learning is consolidated through a final design project for a mission in Low Earth Orbit (LEO), Medium Earth Orbit (MEO), Geostationary (GEO), or Deep Space.			

Training and Learning Results	
Code	
B1	Understand the mechanisms for launching, directing, and managing electronic and telecommunications equipment manufacturing processes, ensuring the safety of people and property, ensuring the final quality of the products, and ensuring their approval.
C2	Manage the tools necessary to direct, plan and supervise multidisciplinary teams
C6	Apply acquired knowledge and solve problems in new or unfamiliar environments within broader, multidisciplinary contexts, being able to integrate knowledge.
C24	Develop, strategically plan, direct, coordinate, and technically and economically manage space projects in the terrestrial and deep space environments, applying Space Systems Engineering standards, with knowledge of satellite operating processes.

Expected results from this subject	Training and Learning Results
To develop, plan, and manage an advanced space mission project, applying space systems engineering standards.	B1 C2 C6 C24
To design the architecture of a satellite's main subsystems and define their Assembly, Integration, and Verification (AIV) procedures.	B1 C2 C6 C24
To analyze and apply the principles of space robotics and autonomous systems within the context of space exploration missions.	B1 C2 C6 C24
To perform system-level analysis for both the space and ground segments of a mission, including mathematical modeling and simulations	B1 C2 C6 C24
To integrate innovative technologies and solve complex problems in the design of a complete mission project (e.g., LEO, GEO, or Deep Space).	B1 C2 C6 C24

To develop sufficient autonomy to formulate, present, and communicate the technical and planning aspects of a comprehensive space mission project.	B1 C2 C6 C24

Contents	
Topic	
International space project standards (Theoretical and Practical).	ECSS, NASA, INCOSE.
Advanced Mission Analysis and Design (Theoretical and Practical)	- Mission requirements analysis. - System-level design of the space and ground segments.
Satellite Subsystem Engineering (Theoretical and Practical)	- Architecture, design, and implementation of subsystems. - Assembly, Integration, and Verification (AIV) plans and procedures.
Space Robotics and Autonomous Systems (Theoretical)	- Fundamentals of robotics applied to space exploration. - Control systems for autonomous operations in space
Innovative Technologies in Space Exploration (Theoretical)	Study of emerging technologies and their application in future space missions.
Space Mission Design Project (Practical)	- Development of a final project for a complete mission in Low Earth Orbit (LEO), Medium Earth Orbit (MEO), Geostationary (GEO), or Deep Space. - Practical application of mission analysis and the design of systems and subsystems.

Planning	Class hours	Hours outside the classroom	Total hours
Lecturing	14	14	28
Practices through ICT	21	21	42
Objective questions exam	3	14	17
Essay questions exam	2	0	2
Problem and/or exercise solving	2	13	15
Laboratory practice	0	21	21
*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 different theoretical aspects of each part of the subject are described, including the possibility of using the flipped learning methodology. With this methodology, competencies B1, C2, C6, and C24 are developed.
Practices through ICT	Theoretical knowledge will be applied to assess the technical feasibility of a small satellite project proposed by the students. This methodology will help develop competencies B1, C2, C6, and C24.

Personalized assistance	
Methodologies	**Description**
Lecturing	The students will have the opportunity to attend tutorial hours 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.
Practices through ICT	The students will have the opportunity to attend tutorial hours 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.
Tests	**Description**
Laboratory practice	The students will have the opportunity to attend tutorial hours 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

Objective questions exam	Final Exam: This consists of an assessment to evaluate the competencies acquired by students through solving simple problems and answering short theoretical questions.	15	B1	C2 C6 C24
Essay questions exam	Exams where enrolled individuals will have to solve, individually and autonomously, a series of exercises applying the acquired knowledge within the time and under the conditions established by the faculty. Depending on the chosen evaluation system, there will be one exam to be taken during the course or alongside the final exam.	60	B1	C2 C24
Problem and/or exercise solving	Exams where enrolled individuals will have to solve, individually and autonomously, a series of exercises applying the acquired knowledge within the time and under the conditions established by the faculty.	5		C2 C6 C24
Laboratory practice	Students participate in individual or group practicals and complete individual assignments during the course.	20	B1	C2 C6

Other comments on the Evaluation

In case of detection of plagiarism in any of the assessments (short quizzes, partial exams, or final exam), the final grade will be FAIL (0) and the fact will be communicated to the Center's management for appropriate action.

Students will have a minimum period of one month from the start of the course to choose the global assessment modality if they wish to renounce continuous assessment (CA), following the procedure established by the Center. Choosing the global assessment implies renouncing the grades obtained in the CA up to that point.

In the continuous assessment modality, the grade of anyone who presents themselves to any of the gradable tests cannot be "not presented." However, students may switch to global assessment up to one week before the final exam.

The extraordinary opportunity and the end-of-program exam will be evaluated by a global assessment test (100% of the final grade). Students who chose continuous assessment for the ordinary opportunity may, optionally, carry out this global assessment test for 65% of the final grade, retaining the 35% grade from the continuous assessment practicals.

The practical tasks carried out in the course are non-recoverable and are only valid for the current academic course.

IT-supported practical sessions (laboratory/TIC practicals) are compulsory, and it is necessary to submit at least 80% of the proposed practical reports to qualify for continuous assessment.

If a student exceeds 5 points in the global grade but does not reach any of the minimums established in the individual tests of the subject, they will be graded in the official records with a final grade of Fail (4.9).

1.- Ordinary opportunity:

Global assessment: The exam will include questions, problems, and practical exercises related to the content explained in both lectures, seminars, and supervised works. A 5 out of 10 will be required to pass the exam.

Continuous assessment: The subject will be evaluated throughout the course:

 Development questions exam: students will take 3 development exams (each with a weight of 20%), summing up to 60% of the final grade.

 Problem and exercise solving: a problem test of the theoretical subject will be carried out with a weight of 5% of the final grade.

 Short answer final test (objective questions): this exam will be the final test of the continuous assessment and will have a weight of 15% of the final grade.

 Laboratory practical (TIC practicals): it will be evaluated through reports of the IT practicals proposed throughout the course, and overall, they will have a weight of 20% of the final grade.

2.- Extraordinary opportunity:

Students will carry out a global assessment test that will include topics and/or problems related to the content taught in both lectures, seminars, and supervised works (100% of the final grade). Those who chose continuous assessment for the ordinary opportunity may, optionally, carry out this global assessment test for 65% of the final grade (retaining the 35% grade from the practicals).

3.- End-of-program exam:

Students will carry out a global assessment test that will include topics and/or problems related to the content taught in both lectures, seminars, and supervised works (100% of the final grade). Those who chose continuous assessment for the

ordinary opportunity may, optionally, carry out this global assessment test for 65% of the final grade (retaining the 35% grade from the practicals).

4.- Use of Generative Artificial Intelligence (GAI):

In the performance of the academic activities of this subject, the use of generative artificial intelligence (GAI) is permitted. Its use must be done ethically, critically, and responsibly. In the case of using GAI, any result it provides must be critically evaluated, and any generated citation or reference carefully verified. Likewise, it is recommended to declare the use of the tools used.

Sources of information
Basic Bibliography
Course documentation and slides,
James R. Wertz, David F. Everett and Jeffery J. Puschell, **Space Mission Engineering: The New SMAD**, 4,
http://www.ecss.nl,
Transparencias de la asignatura,
Complementary Bibliography
http://www.incose.org/,
NASA Systems Engineering Handbook, SP-2007-6105. Rev 1,
Peter Fortescue (Editor), John Stark (Editor), Graham Swinerd (Editor), **Spacecraft Systems Engineering**, 3,

Recommendations

Other comments

For PARS students, it's recommended to have passed or be currently enrolled in the following Bachelor's Degree subject: "Space Systems Engineering."

IDENTIFYING DATA				
(*)Forensía y seguridad de datos (Data Forensics and Security (D4S))				
Subject	(*)Forensía y seguridad de datos (Data Forensics and Security (D4S))			
Code	10414-76040			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	-	1st
Teaching language	English			
Department				
Coordinator	Pérez González, Fernando			
Lecturers	Pérez González, Fernando			
E-mail	fperez@gts.uvigo.es			
Web	http://faitic.uvigo.es			
General description	Multimedia security is an increasingly important topic as most of the information exchanged nowadays over the Internet is multimedia. Traditional data protection solutions like cryptography only solve the problem partially, because contents, once decrypted, are no longer protected. In addition, there is a rising concern over the integrity of multimedia contents: modern editing tools jeopardize our trust on video, images or audio. Fortunately, a number of research groups and companies have addressed these problems and ingenious solutions exist. This course presents advanced topics in multimedia security, with emphasis on cryptography, watermarking, forensics and signal processing in the encrypted domain. 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	Conceiving Engineering within a framework of sustainable development.
B8	Understand the limitations, risks, and implications of using Generative AI.
C31	Model, operate, manage, and address the complete lifecycle and packaging of networks, services, and applications, considering quality of service, direct and operational costs, the implementation plan, monitoring, security, scaling, and maintenance, managing and ensuring quality throughout the development process.

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Handle the use of different algorithms in current multimedia communications environments.	B4 B8 C38 C31 D10
Understand technical material in an autonomous way.	A1 A1 A1 B18 B18 B18 B4 B8 C38 C31 D10 D10

Contents
Topic

Introduction to cryptography.	Application to multimedia systems. Integration with source and channel coding. Block and stream ciphers. Hashing and MAC codes. Specific algorithms.
Conditional access systems.	Requirements. History and state of the art. Design of a conditional access system.
Secret sharing.	Simple secret sharing systems. Visual cryptography.
Data hiding and watermarking.	Basic concepts. Watermarking versus data hiding. Spread-spectrum watermarking. Quantization-based watermarking. Application to images and video. Application to copyright protection of deep learning models.
Forensic signal processing.	Quantization detection and estimation. Filtering detection and identification. Resampling detection and estimation. Camera attribution.
Signal Processing in the Encrypted Domain.	Privacy metrics and notions. Homomorphic encryption. Garbled cicruits. Signal representation and cipher blowup. Applications.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	19	27	46
Laboratory practical	14	13	27
Practices through ICT	7	13	20
Report of practices, practicum and external practices	0	15	15
Report of practices, practicum and external practices(Repetida non usar)	0	15	15
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	The course is structured in several topics in multimedia security, including cryptography, watermarking, forensics and signal processing in the encrypted domain. Competences: CG4, CG8, CE31
Laboratory practical	Lab practices will cover different aspects of multiple-input data hiding, watermarking and forensics. This will allow students to practically implement and considerably expand some of the concepts seen in the lectures. Competences: CG4, CG8, CE31
Practices through ICT	

Personalized assistance

Methodologies	Description
Lecturing	The teachers will provide individualized and personalized attention to students during the course, solving 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
Practices through ICT	The teachers will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered during the work review sessions or during the office hours. Contact: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-perez-gonzalez
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 work review sessions or during the office hours. Contact: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-perez-gonzalez
Report of practices, practicum and external practices(Repetida non usar)	The teachers will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered during the work review sessions or during the office hours. Contact: https://www.uvigo.gal/es/universidad/administracion-personal/pdi/fernando-perez-gonzalez

Assessment

	Description	Qualification	Training and Learning Results	
Report of practices, practicum and external practices	Reports of the practices and additional personal work that employ the techniques seen in the classroom: Practice 1: Watermarking/data hiding (35%) Quality of the reports and correctness of the results will be evaluated. Reports will be individual or collective, depending on the size of the unit that carried out the practices.	35	B4 B8	C31
Report of practices, practicum and external practices(Repetida non usar)	Reports of the practices and additional personal work that employ the techniques seen in the classroom: Practice 2: Forensics (35%) Quality of the reports and correctness of the results will be evaluated. Reports will be individual or collective, depending on the size of the unit that carried out the practices.	35	B4 B8	C31
Essay questions exam	Final exam with short questions on the contents of the subject.	30	B4 B8	C31

Other comments on the Evaluation

A minimum score of 30% with respect to the maximum possible score in the final exam is required to pass the course.

In those cases in which the student decides not to carry out the continuous evaluation tasks, the final score will be solely based on the exam with questions of the subject. This applies as well to the extraordinary opportunity.

In case the student does not achieve the minimum score in the final written exam, his/her global score will be obtained using the formula: 0.35*REP+0.15*TEST, where REP is the score achieved in the reports and TEST is the score achieved in the final exam.

In case of collective reports, the respective contribution of each student must be clearly stated, and the final score will be personalized as a function of such contribution. An interview with the lecturer may be required in order to assess the individual contributions.

Once the student turns in any of the deliverables, he/she will be considered to be following the continuous evaluation track. Any student that chooses the continuous evaluation track will get a final score, regardless of he/she takes the final exam.

Continuous evaluation tasks cannot be redone after their corresponding deadlines, and are only valid for the current year.

In the case that plagiarism or extensive and non-authorized use of AI tools is detected in any of the reports/exams done/taken, the final score for the subject will be 'fail' (0) and the teachers will inform the School authorities of the affaire so that they take the appropriate measures. Besides, the teachers will inform the School authorities of any conduct against ethics by the students, the possibility existing that the School authorities take the appropriate measures.

Sources of information

Basic Bibliography

A.J. Menezes, **Handbook of Applied Cryptography**, 1996,

Complementary Bibliography

Cox, Miller, Bloom, Fridrich, Kalker, **Digital Watermarking and Steganography**, 2nd,

Troncoso-Pastoriza, Perez-Gonzalez, **Secure Signal Processing in the Cloud: enabling technologies for privacy-preserving multimedia cloud processing**, Signal Processing Magazine,

A. Piva, **An Overview of Image Forensics**, Signal Processing,

Recommendations

IDENTIFYING DATA				
(*)Técnicas de optimización matemática en ingeniería				
Subject	(*)Técnicas de optimización matemática en ingeniería			
Code	10414-76043-S			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	-	1st
Teaching language	English			
Department				
Coordinator	Mosquera Nartallo, Carlos			
Lecturers	Gómez Cuba, Felipe Mosquera Nartallo, Carlos			
E-mail	mosquera@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This course covers the application of advanced mathematical tools to address optimization problems in Engineering, with special emphasis on Telecommunications.			

Training and Learning Results	
Code	
B4	Conceiving Engineering within a framework of sustainable development.
C22	Integrate technologies and systems specific to Telecommunications Engineering, both in a generalist capacity and in broader, multidisciplinary contexts such as bioengineering, photovoltaic conversion, nanotechnology, and telemedicine.

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Formulate telecommunications engineering problems as mathematical optimization models, identifying objective functions, decision variables, and constraints.	B18 B4 B18 B18 B18 C38 C38 C38 C38 C22
Evaluate the computational complexity, convergence properties, and numerical performance of optimization methods.	B4 B18 B18 C38 C22 D10 D10 D10
Use software tools and programming environments to solve practical optimization problems arising in telecommunications engineering.	B4 C22

Contents	
Topic	
Convex Optimization	- Introduction to optimization - Convex sets, convex functions - Convex optimization problems - Statistical estimation and detection - Software for convex optimization. - Vector optimization, scalarization - Duality

Non-Convex Optimization	- Principles of non-convex optimization - Convex-related methods: relaxation, fractional programming, sequential convex programming - Algorithms for unconstrained and constrained minimization - Discrete, graph, and heuristic-inspired algorithms - Decomposition, parallel and distributed methods - Multi-actor multi-objective optimization: game theory - Optimization in ML

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	20	25	45
Problem solving	20	46	66
Problem and/or exercise solving	2	6	8
Objective questions exam	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	Mathematical optimization tools will be introduced as background material to address problems commonly found in Engineering. Skills CG4 and CE22 are developed here.
Problem solving	Different optimization challenges will be discussed during class time, in many cases by resorting to software tools such as CVX as solvers. Skills CG4 and CE22 are developed here.

Personalized assistance

Methodologies	Description
Lecturing	Student support will be provided during office hours and by e-mail. For contact information, see https://www.uvigo.gal/es/universidad/administracion-personal/pdi/carlos-mosquera-nartallo.
Problem solving	Student support will be provided during office hours and by e-mail. For contact information, see https://www.uvigo.gal/es/universidad/administracion-personal/pdi/carlos-mosquera-nartallo

Assessment

	Description	Qualification	Training and Learning Results	
Problem solving	Discussion sessions will be held during class time on the solutions of different problems that will be proposed.	20	B4	C22
Problem and/or exercise solving	Intermediate test based on problem solving	40	B4	C22
Objective questions exam	Final exam with short questions and exercises.	40	B4	C22

Other comments on the Evaluation

The students need to obtain 50 out of 100 points to pass the course. Any student that chooses the continuous evaluation track will get a final score, regardless of her/his taking the final exam. A student will be considered to be following the continuous evaluation track if he/she does not say otherwise within one month from the beginning of the course. For the extraordinary and end-of-program examination sessions, the exam will constitute 100% of the final grade.

All the homeworks and exam will be given in English.

After any assessment, teaching staff may call students for oral verification interviews, either at random or where there are indications of cheating, unauthorized use of artificial intelligence, or other fraudulent means in completing the exam. Grades for the assessments shall remain provisional until any such interviews have been completed. During these interviews, students must demonstrate that they possess the knowledge and skills needed to adequately justify the solutions they submitted.

Sources of information

Basic Bibliography

Stephen Boyd, Lieven Vandenberghe, **Convex Optimization**, Cambridge University Press, 2004

Complementary Bibliography

Dimitri P. Bertsekas, **Convex Optimization Theory**, Athena Scientific, 2009

David G. Luenberger, Yinyu Ye, **Linear and Nonlinear Programming**, Fourth, Springer, 2016

Recommendations

Subjects that it is recommended to have taken before

(*)Comunicaciones digitales avanzadas/10414-76033
(*)Tratamiento de señal en comunicaciones/10414-76019

Other comments

Attendance to physical classes is mandatory. If a minimum 80% attendance is not fulfilled, the grade will be entirely based on the final exam.

IDENTIFYING DATA				
(*)Laboratorio de diseño de equipos electrónicos				
Subject	(*)Laboratorio de diseño de equipos electrónicos			
Code	10414-76048-S			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	-	1st
Teaching language	#EnglishFriendly Galician English			
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 addresses in a practical manner the design concepts of electronic equipment for telecommunication applications, structured around two fundamental pillars: compliance with regulations and electromagnetic compatibility (EMC) analysis, and design reliability analysis. Learning is developed practically through simulation in LTspice, the design and manufacturing of printed circuit boards (PCBs) with KiCAD, and experimental testing in the laboratory. Throughout the course, students will design an EMC filter for a specific application, produce the corresponding PCB, and validate compliance with EMC regulations through the relevant tests. In addition, students will perform a reliability analysis of the manufactured circuit. English Friendly programme course. International students may request from the teaching staff: a) materials and bibliographical references for following the course in English, b) tutorials in English, c) tests and evaluations in English.			

Training and Learning Results	
Code	
B1	Understand the mechanisms for launching, directing, and managing electronic and telecommunications equipment manufacturing processes, ensuring the safety of people and property, ensuring the final quality of the products, and ensuring their approval.
B4	Conceiving Engineering within a framework of sustainable development.
C2	Manage the tools necessary to direct, plan and supervise multidisciplinary teams
C8	Communicate (orally and in writing) the conclusions - and the knowledge and ultimate reasons that support them - to specialized and non-specialized audiences in a clear and unambiguous manner.
C12	Promote cooperative work, communication skills, organization, planning, and acceptance of responsibilities in a multilingual and multidisciplinary work environment that fosters education for equality, peace, and respect for fundamental rights.
C22	Integrate technologies and systems specific to Telecommunications Engineering, both in a generalist capacity and in broader, multidisciplinary contexts such as bioengineering, photovoltaic conversion, nanotechnology, and telemedicine.
C23	Apply methodologies for the development, direction, coordination, and technical and financial management of projects on: telecommunications systems, networks, infrastructures, and services, including the supervision and coordination of partial projects for related work; common telecommunications infrastructures in buildings or residential areas, including digital home projects; telecommunications infrastructures in transportation and the environment; with their corresponding energy supply installations and assessment of electromagnetic emissions and electromagnetic compatibility.
D1	Project, calculate, and design products, processes, and facilities in all areas of telecommunications engineering

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Know the fundamental aspects of EMC regulations (Directive 2014/30/EU) and international standards for the commercialisation and use of electronic equipment.	B1 C23
Know the fundamental concepts of reliability and the calculation and simulation methods necessary to estimate the reliability of an electronic system.	B1 D1
Be capable of identifying and selecting the appropriate passive components for the design of an EMC filter for a specific application.	B4 C22 D1

Be capable of designing electronic circuits for telecommunication applications, taking into account regulatory and reliability aspects.	B4 D1
Be capable of using electronic circuit simulation tools to verify the behaviour of the designs.	C22 D1
Be capable of using PCB design tools for the manufacturing of printed circuit boards.	B1
Be capable of performing experimental tests to validate compliance with EMC and reliability regulations.	B1 C23
Be capable of working cooperatively in groups, organising, planning, and assuming responsibilities in a multidisciplinary environment.	C2 C12
Be capable of delivering a technical public presentation and verbally communicating content, conclusions, and reasoning in a clear and unambiguous manner.	C8

Contents

Topic	
Introduction to electromagnetic compatibility (EMC) and regulations	- Concepts of noise and interference. Electromagnetic noise path and coupling methods. - EMC Directive 2014/30/EU. Basic publications and generic standards.
Design Techniques for EMC (grounding and filtering)	- Grounding systems and common impedance coupling. Cabling. - Balancing and filtering techniques for conducted noise.
Simulation and design of the EMC filter	- Simulation of conducted emissions with LISN using LTspice. - Behaviour of real passive elements at high frequency (ESR, ESL).
Design and production of printed circuit boards (PCBs)	- PCB design with KiCad focused on EMC. - Component placement and planning, layer assignment and hierarchy, ground planes. - Production of printed circuit boards.
Pre-compliance measurements and testing	- Operation and block architecture of the spectrum analyser. - Pre-compliance testing of conducted emissions in the laboratory
Introduction to the reliability of electronic systems	- Definitions and basic concepts. RAMS technologies. - Reliability parameters of electronic components. Reliability prediction and applicable technical standards. - Reliability models: series, parallel, and redundant systems
Design and optimisation of electronic systems	- Redundancy optimisation. - Maintainability and availability analysis.
Failure analysis	- Mathematical modelling using Markov chains and Petri nets. - Failure modes in electronic components. Determination of failure mechanisms and modes.
Fail-safe systems	- Specification of fail-safe systems. - Design methodologies for safe electronic systems.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	10	10	20
Project based learning	15	30	45
Portfolio / dossier	15	41	56
Presentation	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 teaching staff of the theoretical foundations of electromagnetic compatibility (EMC), directives, and applicable technical regulations, design techniques for EMC, and introduction to the reliability of electronic systems, serving as support and prior contextualisation for the laboratory practical sessions.
Project based learning	Students will develop a practical and real project in groups, applying the course contents: characterisation of passive components, design of EMC filters and simulation in LTspice, physical design of the PCB in KiCad, manufacturing of the filter, experimental testing of conducted emissions in the laboratory, and reliability analysis of the final equipment. The project planning, design quality, and teamwork will be evaluated.

Personalized assistance

Methodologies	Description

Lecturing	Teaching staff will personally address queries and consultations from students regarding the study of theoretical and practical concepts. Tutorials can be arranged through the University of Vigo website: 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
Project based learning	Design, modelling, and simulation in LTspice of EMC filters, physical design of the PCB in KiCad, manufacturing, and experimental validation through conducted emission tests in the laboratory, as well as equipment reliability analyses.	40	B1 B4 C2 C12 C22 C23 D1
Portfolio / dossier	Preparation of a portfolio/dossier collecting the design, simulation, manufacturing, analysis, and validation tasks of the developed EMC filter, as well as the autonomous work notebook with learning evidence.	40	B1 B4 C2 C12 C22 C23 D1
Presentation	Oral presentation and group defence of the developed technical project and laboratory test results, evaluating technical communication and synthesis skills before the teaching staff and other students.	20	C2 C8 C12

Other comments on the Evaluation

A minimum attendance of 80% to the laboratory practical sessions and mandatory attendance to the presentation test will be required. Failure to meet these requirements will mean that the student can obtain a maximum mark of 40% (fail).

Students opting for global assessment must notify the course coordinator in writing within one month from the start of the semester.

The end-of-degree session will be assessed via global assessment.

The global assessment will consist of an individual written test with theoretical questions, problems, and exercises evaluating all course contents (50%) and a practical exam to be held in the laboratory (50%).

In carrying out the academic activities of this course, the use of generative artificial intelligence (GenAI) is permitted in an ethical, critical, and responsible manner. Its use must be declared and the results verified.

In case of detection of copying or any type of plagiarism in any of the tests, the final mark will be fail (0) and the occurrence will be reported to the Head of the School for the appropriate action.

Sources of information

Basic Bibliography

Henry W. Ott, **Electromagnetic Compatibility Engineering**, 978-0-470-18930-6, 1, Wiley, 2011

Joan Pere López Veraguas, **Compatibilidad electromagnética y seguridad funcional en sistemas electrónicos**, 978-84-267-1643-9, 1, Marcombo, 2010

David J. Smith, **Reliability, Maintainability and Risk**, 978-0-08-096902-2, 8, Butterworth Heinemann, 2011

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**, 1, ISA, 2012

M. Goble, H. Cheddie, **Safety Instrumented Systems Verification**, 978-1-55617-909-9, 1, ISA, 2005

M. Goble, **Control Systems Safety Evaluation and Reliability**, 3, ISA, 2010

Michael D. Medoff, Rainer I. Faller, **Functional Safety: An IEC 61508 SIL 3 Compliant Development Process**, 3, Exida, 2014

Complementary Bibliography

T.I. Bajenescu, M.I. Bâzu, **Reliability of Electronic Components**, 978-3-540-65722-4, 1, Springer-Verlag, 1999

P. Kales, **Reliability**, 1, Prentice-Hall, 1998

Milton Ohring, **Reliability and Failure of Electronic Materials and Devices**, 978-0-12-088574-9, 2, Elsevier, 2015

Shahriyar Kaboli, **Reliability in Power Electronics and Electrical Machines: Industrial Applications and Performance Models**, 1, IGI Global, 2016

Recommendations

Other comments

The Spanish and English versions of this guide are translations of the original version in Galician. In the event of any discrepancies between them due to error, the Galician version shall prevail.

IDENTIFYING DATA				
(*)Prácticas en empresa				
Subject	(*)Prácticas en empresa			
Code	10414-76054-S			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Marcos Acevedo, Jorge			
Lecturers				
E-mail				

----- UNPUBLISHED TEACHING GUIDE -----

IDENTIFYING DATA				
(*)Gestión de proyectos de Telecomunicación I				
Subject	(*)Gestión de proyectos de Telecomunicación I			
Code	10414-76055-S			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	2nd	1st
Teaching language	English			
Department				
Coordinator	González Castaño, Francisco Javier			
Lecturers	González Castaño, Francisco Javier			
E-mail	javier@det.uvigo.es			
Web	http://https://moovi.uvigo.gal/			
General description	The course Telecommunications Project Management provides students with the knowledge, methodologies, and tools necessary to plan, organize, execute, and control projects in the field of telecommunications. It covers the fundamental principles of project management, including scope, time, cost, quality, risk, human resources, and communications management, with particular attention to the technological and regulatory specificities of the sector. Throughout the course, both traditional and agile management methodologies applied to engineering projects are studied, as well as tools that support planning, monitoring, and decision-making processes. It also includes aspects related to innovation, sustainability, current regulations, and the management of multidisciplinary teams. The main objective is to train students to effectively lead and participate in real telecommunications projects, from their conception to their completion, ensuring technical, economic, and organizational efficiency throughout the process.			

Training and Learning Results	
Code	
B1	Understand the mechanisms for launching, directing, and managing electronic and telecommunications equipment manufacturing processes, ensuring the safety of people and property, ensuring the final quality of the products, and ensuring their approval.
B2	Understand the ethical responsibility and professional ethics of the Telecommunications Engineering profession.
B3	Know, understand, and apply the legislation required to practice as a Telecommunications Engineer.
C1	Manage the tools necessary to manage telecommunication system construction and installations, complying with current regulations and ensuring service quality.
C2	Manage the tools necessary to direct, plan and supervise multidisciplinary teams
C5	Use tools specific to general management, technical management, and research, development, and innovation project management in companies and technology centers.
C7	Apply the principles of economics and human resources and project management, as well as telecommunications legislation, regulation, and standardization.
C10	Predict and control the evolution of complex situations by developing new and innovative work methodologies adapted to the specific scientific/research, technological, or professional field, generally multidisciplinary, in which they operate.
C11	Become aware of the need for continuous quality training and improvement, developing values inherent to the dynamics of scientific thought, demonstrating a flexible, open, and ethical attitude toward diverse opinions or situations, particularly regarding non-discrimination based on sex, race, or religion, respect for fundamental rights, accessibility, etc.
C22	Integrate technologies and systems specific to Telecommunications Engineering, both in a generalist capacity and in broader, multidisciplinary contexts such as bioengineering, photovoltaic conversion, nanotechnology, and telemedicine.
C23	Apply methodologies for the development, direction, coordination, and technical and financial management of projects on: telecommunications systems, networks, infrastructures, and services, including the supervision and coordination of partial projects for related work; common telecommunications infrastructures in buildings or residential areas, including digital home projects; telecommunications infrastructures in transportation and the environment; with their corresponding energy supply installations and assessment of electromagnetic emissions and electromagnetic compatibility.
D3	Integrate knowledge and face the complexity of formulating judgments based on information that, although incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of knowledge and judgments

Expected results from this subject	
Expected results from this subject	Training and Learning Results
New	B2 B3 C10 D3
New	B3 C1 C22
New	C2 C7 C10 D3
New	B1 C2 C5 C7 C10 C11 C22 C23 D3

Contents	
Topic	
The Telecommunications Company	- Career Development in the Company - Company Structure - Management Roles
Leadership of Human Teams and Transferable Skills	- Motivation Strategies - Performance Evaluation - Multidisciplinary Team Coordination
Methodologies for Innovative Project Management	- Best Practices Methodologies - Project Methodologies - Certifications
Financing of Entrepreneurship Projects	- Project Financing Needs - Sources of Financing - Financial and Economic Plan - Financial Viability Assessment
Legislation and Professional Ethics	- Specific Legislation for Telecommunications - Research and Development (R&D) Legislation - Other: Environmental Legislation, Professional Ethics...
Managing Innovation in Project Proposals	- Innovation as a Strategic Element - Identification of Innovation Opportunities - Innovation Planning and Management - Impact Assessment and Transfer of Results

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	21	28	49
Case studies	21	40	61
Essay questions exam	1	0	1
Essay	0	10	10
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
Lecturing	Course Content Development.
Case studies	Case Studies, Exercises, and Discussion.

Personalized assistance	
Methodologies	**Description**

Lecturing	Mentoring sessions scheduled on demand.
Case studies	Mentorng sessions scheduled on demand.

Assessment

	Description	Qualification	Training and Learning Results		
Essay questions exam	(*)Exame teórico incluindo casos prácticos.	40	B1 B2 B3	C1 C2 C5 C7 C10 C11 C22 C23	D3
Essay	(*)Baseado na teoría e nos casos de estudio.	40	B1 B2 B3	C1 C2 C5 C7 C10 C11 C22 C23	D3
Presentation	(*)Presentación pública do traballo.	30	B1 B2 B3	C1 C2 C5 C7 C10 C11 C22 C23	D3

Other comments on the Evaluation

Sources of information

Basic Bibliography

Complementary Bibliography

Eduardo Bueno Campos, **ORGANIZACION DE EMPRESAS: ESTRUCTURA, PROCESOS Y MODELOS**, 978-8436809763, 2, Pirámide, 2004

PMI, **PMBOK Guide**, 978-1628258295, 8, Project Management Institute, 2026

Francisco J. Galán, **Coaching inteligente. Método A.C.C.I.O.N**, 978-8417024680, 2, ESIC, 2017

Recommendations

IDENTIFYING DATA

(*)Gestión de proyectos de Telecomunicación II

Subject	(*)Gestión de proyectos de Telecomunicación II			
Code	10414-76056-S			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	2nd	1st
Teaching language	English			
Department				
Coordinator	Cuiñas Gómez, Íñigo			
Lecturers	Cuiñas Gómez, Íñigo			
E-mail	inhigo@uvigo.gal			
Web	http://moovi.uvigo.gal			
General description	This subject focuses on the development of transversal skills required for professional engineering practice, complementing the technical knowledge acquired in previous courses. While engineering education traditionally emphasizes analytical and technological competencies, many real-world problems require additional abilities related to understanding users, generating ideas, working in teams, organizing work, communicating effectively, making decisions, and considering the impact of solutions. The course is structured around a sequence of practical workshops, each addressing a key skill in the engineering process. These workshops follow a progression from problem understanding to solution development, and from individual thinking to collective responsibility. A central goal of the subject is to promote the development of the so-called T-shaped engineer: professionals with solid technical knowledge (vertical dimension) complemented by a set of transversal competencies (horizontal dimension) that enable them to apply their expertise effectively in complex, real-world contexts. The learning process is based on an active and participatory methodology. Students are expected to engage with preparatory materials before each session and to take part in in-class activities focused on applying concepts through practice, discussion, and collaboration. All activities are oriented towards the progressive development of a collective piece of work, which integrates the different skills addressed throughout the course. This final outcome reflects not only the technical aspects of the solution, but also the process followed, including idea generation, analysis, communication, and decision-making. The subject is taught in English.			

Training and Learning Results

Code	
B2	Understand the ethical responsibility and professional ethics of the Telecommunications Engineering profession.
B4	Conceiving Engineering within a framework of sustainable development.
B6	Possess and understand knowledge that provides a basis or opportunity for originality in the development and/or application of ideas, often in a research context.
B7	Know the procedures to innovate and manage ideas and creativity
B8	Understand the limitations, risks, and implications of using Generative AI.
C4	Apply methodologies for the development, strategic planning, direction, coordination, and technical and economic management of projects in all areas of telecommunications engineering, following quality and environmental criteria.
C8	Communicate (orally and in writing) the conclusions - and the knowledge and ultimate reasons that support them - to specialized and non-specialized audiences in a clear and unambiguous manner.
C9	Learn continuously, self-directedly, and autonomously.
C12	Promote cooperative work, communication skills, organization, planning, and acceptance of responsibilities in a multilingual and multidisciplinary work environment that fosters education for equality, peace, and respect for fundamental rights.
C13	Be able to use Generative AI in an ethical, critical and responsible manner
C22	Integrate technologies and systems specific to Telecommunications Engineering, both in a generalist capacity and in broader, multidisciplinary contexts such as bioengineering, photovoltaic conversion, nanotechnology, and telemedicine.
C23	Apply methodologies for the development, direction, coordination, and technical and financial management of projects on: telecommunications systems, networks, infrastructures, and services, including the supervision and coordination of partial projects for related work; common telecommunications infrastructures in buildings or residential areas, including digital home projects; telecommunications infrastructures in transportation and the environment; with their corresponding energy supply installations and assessment of electromagnetic emissions and electromagnetic compatibility.

Expected results from this subject

Expected results from this subject	Training and Learning Results
Analyse engineering problems from a user-centred perspective, identifying needs, constraints and implications in terms of ethics, sustainability and professional responsibility.	A1 A1 A1 B2 B4 B18 B18 C38 C9 C38 D10 D10 D10
Generate, evaluate and develop engineering solutions through structured creative processes, applying ideation techniques and integrating multidisciplinary knowledge.	A1 A1 A1 B6 B18 B7 B18 C38 C22 C38 D10 D10 D10
Plan, organise and coordinate work effectively in team environments, applying project-oriented methodologies, prioritisation strategies, and iterative execution processes.	A1 A1 A1 B18 B18 C4 C38 C12 C23 C38 D10 D10 D10
Communicate ideas, decisions and results clearly and effectively, both in team interactions and in written form, supporting arguments with evidence and critically assessing the limitations, risks and implications of using Generative AI.	A1 A1 A1 B18 B8 B18 C8 C38 C9 C13 C38 D10 D10 D10

Contents

Topic	
Introduction to the course	This introductory session presents the objectives, structure and methodology of the subject. It introduces the concept of the T-shaped engineer and the importance of transversal skills in engineering practice. The session also explains the learning approach based on workshops, preparatory materials and collaborative work, as well as the expectations regarding participation, reflection, and the development of a collective final outcome.

Understanding problems (Empathy)	This topic focuses on the importance of understanding problems from a user-centred perspective. It introduces basic concepts of empathy and observation as tools to identify real needs, behaviours and constraints. Students learn to recognise assumptions and to distinguish between perceived and actual problems as a starting point for engineering solutions.
Generating solutions (Creativity and ideation)	This topic introduces structured approaches to creativity in engineering, emphasising that idea generation is a process that can be guided and improved. It covers divergence and convergence strategies, basic ideation techniques such as brainstorming, and the use of frameworks such as Design Thinking to move from problem definition to potential solutions.
Teamwork and collaboration	This topic addresses the role of teamwork in engineering practice. It analyses the differences between groups and teams, the importance of shared goals and interdependence, and the stages of team development. The session also focuses on communication within teams, conflict management and the distribution of roles as key factors for effective collaboration.
Planning and execution	This topic focuses on task organisation and time management in project development. It introduces concepts such as prioritisation, planning, focus and iterative work cycles. Students learn strategies to break down complex tasks, organise work effectively, and move from reactive behaviour to structured execution, emphasising consistency over intensity.
Critical thinking	This topic develops the ability to analyse and evaluate information critically. It introduces the distinction between facts and opinions, the importance of evidence, and the need to question assumptions. Students learn to identify weak arguments, support their ideas rigorously, and approach problems with a structured and analytical mindset.
Communication and writing	This topic focuses on the clear and effective communication of ideas in an engineering context. It addresses the principles of structured writing, including coherence, clarity and conciseness. Students learn how to organise ideas into well-structured texts, developing the skills required to communicate arguments and results in a clear and professional manner.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	1	1	2
Workshops	24	16	40
Project based learning	0	40	40
Design Thinking	0	10	10
Self-assessment	0	8	8
Project	0	12	12
Essay	0	13	13

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

Methodologies

	Description
Lecturing	Introductory session devoted to presenting the objectives, structure and methodology of the subject, as well as the framework of transversal skills and the concept of the T-shaped engineer.
Workshops	The core of the subject is developed through practical workshops, where students actively apply concepts related to problem understanding, creativity, teamwork, execution, critical thinking, communication, decision-making and impact. These sessions are based on collaborative work, guided activities and discussion.
Project based learning	Students develop a collective piece of work throughout the course, integrating the different skills addressed in the workshops. This includes idea generation, analysis, organisation, writing and decision-making processes.
Design Thinking	The subject incorporates Design Thinking as a structured approach to problem-solving, particularly in activities related to ideation, prototyping and testing. This methodology is applied both in workshops and in the development of the final work.

Personalized assistance

Methodologies	Description
Lecturing	Time is allocated to resolve doubts related to the organisation, objectives and methodology of the subject, particularly at the beginning of the course. Students may also use tutorial sessions to clarify expectations and requirements.

Workshops	During workshop sessions, the instructor provides continuous support to the groups, guiding activities, facilitating discussions, and helping students to overcome difficulties related to teamwork, idea generation, planning and decision-making. Additional support may be provided through tutorial sessions when required.
Project based learning	The instructor supervises and supports the development of the group work, providing feedback on progress, structure, and content. Tutorial sessions are available to help students refine their analysis, organisation of ideas and overall approach to the project.
Design Thinking	Guidance is provided on the application of Design Thinking principles, particularly during ideation, prototyping and evaluation stages. Support focuses on helping students structure their process and improve their solutions through iteration.

Tests	**Description**
Self-assessment	Short reflections submitted before each workshop are evaluated as part of the continuous assessment. General guidance may be provided in class to address common difficulties and improve critical thinking and reflection skills.
Essay	Feedback is oriented towards improving the final written work, focusing on structure, clarity, argumentation and coherence. Tutorial sessions may be used to address specific issues related to the development of the document.

Assessment

	Description	Qualification	Training and Learning Results
Self-assessment	Short individual reflections submitted before each workshop. These reflections are based on the preparatory materials and aim to promote active engagement, critical thinking and autonomous learning. Students are expected to provide concise and thoughtful answers to the proposed questions.	20	B2 C9 B8
Project	Development of a group project throughout the course, integrating the different skills addressed in the workshops. This includes problem analysis, idea generation, evaluation of alternatives, structured decision-making and task organisation. The project reflects the process followed by the group, including collaboration, iteration and the progressive development of the solution.	40	B4 C4 B6 C8 B7 C13 C22 C23
Essay	Final group essay presenting the results of the project in a clear and structured written form. The essay focuses on the communication of the proposed solution, supporting arguments with evidence and explaining the reasoning behind decisions. It reflects the final outcome of the work and the ability to communicate ideas effectively in a professional context.	40	B4 C4 B6 C8 B7 C12 C13 C22 C23

Other comments on the Evaluation

Continuous assessment is applied. Both components (self-assessment and final essay) must be completed to pass the subject.

Students who do not follow the continuous assessment system may opt for a global assessment. This will consist of a final assignment equivalent to the final essay, in which the student must demonstrate the acquisition of the skills and competences defined in the subject. The conditions, deadlines and format of this assignment will be specified at the beginning of the course.

The extraordinary and end-of-program assessment will follow the global assessment scheme.

The subject language is English. All submissions must be written in English.

Particular attention must be paid to academic integrity. Plagiarism or any form of dishonest behaviour in submitted work will result in a fail grade and may lead to further disciplinary actions in accordance with university regulations.

The use of Generative Artificial Intelligence is allowed, but it must be carried out in an ethical, critical and responsible manner. Students are expected to assess the validity of the generated content and to ensure the originality and correctness of their work. The use of such tools should be clearly acknowledged when relevant.

Sources of information

Basic Bibliography

I. Cuiñas, I. Goicoechea, **Soft Skills for Engineering: Methodologies, Social Skills and Course Development**, 978-1-83724-017-3, 1, The IET, 2025

I. Cuiñas, M.J. Fernández Iglesias, **Design Thinking for Engineering: A Practical Guide**, 978-1-83953-502-4, 1, The IET, 2023

Complementary Bibliography

Recommendations

Other comments

The subject is going to be taught in English.
All the documents will be in English.

IDENTIFYING DATA				
(*)Trabajo fin de máster				
Subject	(*)Trabajo fin de máster			
Code	10414-76057-S			
Study programme	(*)Máster Universitario en Enxeñaría de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	10	Mandatory	2nd	1st
Teaching language	English			
Department				
Coordinator	Herrería Alonso, Sergio			
Lecturers	Herrería Alonso, Sergio			
E-mail	sha@det.uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The Master's Thesis (TFM) is part of the curriculum for the Master degree in Telecommunications Engineering. The TFM is an original and personal work that each student must autonomously complete under educational supervision and it must demonstrate the student's acquisition of the program's contents and competencies. The definition and contents of the TFM are explained in more detail in the normative for the realization of the TFM, which can be found on the website of the School of Telecommunication Engineering.			

Training and Learning Results	
Code	
B2	Understand the ethical responsibility and professional ethics of the Telecommunications Engineering profession.
B4	Conceiving Engineering within a framework of sustainable development.
B5	Acquire advanced knowledge and demonstrate, in a highly specialized or scientific and technological research context, a detailed and well-founded understanding of the theoretical and practical aspects and working methodology in one or more fields of study.
B6	Possess and understand knowledge that provides a basis or opportunity for originality in the development and/or application of ideas, often in a research context.
B8	Understand the limitations, risks, and implications of using Generative AI.
C4	Apply methodologies for the development, strategic planning, direction, coordination, and technical and economic management of projects in all areas of telecommunications engineering, following quality and environmental criteria.
C6	Apply acquired knowledge and solve problems in new or unfamiliar environments within broader, multidisciplinary contexts, being able to integrate knowledge.
C8	Communicate (orally and in writing) the conclusions - and the knowledge and ultimate reasons that support them - to specialized and non-specialized audiences in a clear and unambiguous manner.
C9	Learn continuously, self-directedly, and autonomously.
C13	Be able to use Generative AI in an ethical, critical and responsible manner
D2	Develop sufficient autonomy to participate in research projects and scientific or technological collaborations within their thematic scope, in interdisciplinary contexts and, where appropriate, with a high level of knowledge transfer.
D8	Once all the credits in the curriculum have been obtained, complete, present, and defend an original exercise carried out individually before a university panel, consisting of a comprehensive professional Telecommunications Engineering project that summarizes the skills acquired in the courses.

Expected results from this subject	Training and Learning Results
Research, classification and structuring of information on some topic relevant to Telecommunications engineering.	A1 B18 B18 B5 B6 C9 C38 D10 D2 D10

Design of prototypes, computer programs, circuits, procedures, algorithms, methods, etc, complying to specifications.	A1 A1 A1 A1 A1 B18 B2 B18 B18 B4 B18 B8 C4 C6 C13 C38 C38 D10 D2 D10 D10 D10 D8
Dissertation containing the fundamentals, the solution and an analysis of the results regarding the addressed problem. It should include a review of the state of the art, an explanation of the methodology or approach, and a discussion of the obtained results.	A1 A1 A1 A1 B18 B18 B18 B18 C8 C38 D10 D10 D10 D10 D10 D8

Contents	
Topic	
The contents of the Master's Thesis are established in the individual proposals offered by the advisors, according to the rules issued by the Academic Commission of the Master Programme.	The subject of each work is specific, given the individual character of the work.

Planning			
	Class hours	Hours outside the classroom	Total hours
Previous studies	0	25	25
Project based learning	0	200	200
Presentation	1	24	25
*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	Research, reading and work of documentation carried out by the students autonomously.
Project based learning	Study of the possible solutions to the scientific-technical problem proposed. Development of an original solution to the problem of interest in an individual and autonomous form.
Presentation	Writing a report with the hypotheses, the solution and the conclusions of the work. Presentation and defense of the work in front of an examining committee.

Personalized assistance	
Methodologies	**Description**

Project based learning	Each student will meet his/her advisors to receive guidance, orientation or academic assistance on the objectives, the methodology, the analysis of results and the presentation of the thesis. The TFM coordinator will establish tutoring hours at the beginning of the term. These hours could be checked at the subject website https://moovi.uvigo.gal/.

Assessment

	Description	Qualification	Training and Learning Results		
Project based learning	In the evaluation, the Committee might take into account the opinions or the report issued by the advisors, as well as the quality of the review of the state of the art, the quality of the technical proposal, the novelty and importance of the results, the capacity of initiative of the student, etc.	60	B2 B4 B5 B6 B8	C4 C6 C9 C13	D2 D8
Presentation	The Committee will consider the quality of the presentation (oral and written), as well as the ability of the student to defend his/her work during the discussion with the Committee members.	40		C8	D8

Other comments on the Evaluation

Use of Generative AI

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

Sources of information

Basic Bibliography

Complementary Bibliography

Recommendations