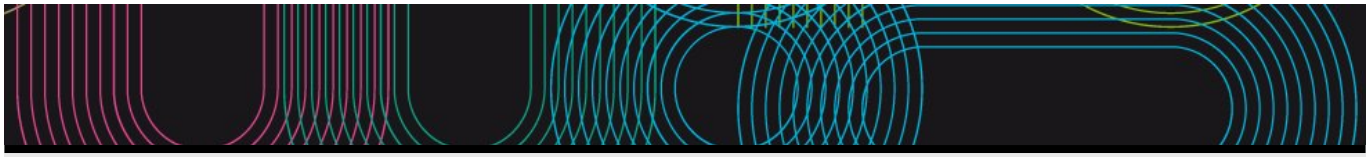

IDENTIFYING DATA				
Radio-communication systems				
Subject	Radio-communication systems			
Code	P52G381V01408			
Study programme	Grado en Ingeniería Mecánica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	4th	2nd
Teaching language	Spanish			
Department				
Coordinator	Nocelo López, Rubén			
Lecturers	Nocelo López, Rubén Núñez Ortuño, José María Troncoso Pastoriza, Francisco Manuel			
E-mail	rubennocelo@cud.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This course, which is part of the specialization module in Naval Technology, introduces the basic principles of radio communication, so much theoretical as practical. During the course we will review the physical phenomena and technological developments that made possible the transmission of information using electromagnetic waves. We discuss the propagation of radio-waves, the organization of the radio-electric spectrum, the operation and design of antennas, and the design criteria for a radio link. Finally, we review the radio-communication systems in use nowadays, with focus on those used in the Navy.			

Training and Learning Results	
Code	
B3	Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations.
C27	CITN1 To acquire the ability to understand the mechanisms of propagation of electromagnetic waves and the corresponding organization of the radioelectric space.
C28	CITN2 To know the mechanism of operation of antennas and their different types.
C29	CITN3 To acquire the ability to select equipment, media and transmission systems.
D1	Analysis and synthesis
D2	Problems resolution.
D3	Oral and written proficiency
D8	Decision making.
D9	Apply knowledge.
D10	Self learning and work.
D16	Critical thinking.
D17	Team working.

Expected results from this subject	Training and Learning Results		
To know the technological base of telecommunication systems	B3	C27 C29	D1 D2 D3 D8 D9 D10 D16 D17

To understand the fundamentals of electromagnetic wave propagation and the organisation of the radio-electric spectrum.	B3	C27	D1 D2 D3 D9 D10 D16 D17
To understand the basic mechanisms of operation of antennas	B3	C28 C29	D1 D2 D3 D9 D10 D16 D17
To understand the basic operation of naval communication systems	B3	C29	D1 D3 D8 D10 D16
ENAEE learning outcome: KNOWLEDGE AND UNDERSTANDING: LO1.3.- Be aware of the multidisciplinary context of engineering [level of achievement (basic (1), intermediate (2) and advanced (3)) of this learning outcome: Basic (1)].	B3	C27 C28 C29	
ENAEE learning outcome: ENGINEERING ANALYSIS: LO2.2.- Ability to identify, formulate and solve engineering problems in their field of study; to select and apply relevant methods from established analytical, computational and experimental methods; to recognize the importance of non-technical societal, health and safety, environmental, economic and industrial constraints [Intermediate (2)].			D1 D2 D8 D9 D16
ENAEE learning outcome: ENGINEERING PRACTICE: LO5.3.- understanding of applicable materials, equipment and tools, engineering technologies and processes, and of their limitations in their field of study [Advanced (3)].		C27 C28 C29	D8 D9
ENAEE learning outcome: COMMUNICATION AND TEAM-WORKING: LO7.2.- ability to function effectively in a national and international context, as an individual and as a member of a team and to cooperate effectively with engineers and non-engineers [Basic (1)].			D3 D8 D10 D17
ENAEE learning outcome: CONTINUOUS TRAINING: LO8.1.- Ability to recognize the need of continuous training, to be carried out along a their own career in an independent way [Advanced (3)].			D8 D10
ENAEE learning outcome: CONTINUOUS TRAINING: LO8.2.- Ability to be keep updated on the last developments in science and technology [Intermediate (2)].			D8 D10

Contents

Topic	
Chapter 1. Introduction	Aims and development: The aim of this chapter is to introduce basic concepts needed to understand the propagation of electromagnetic waves, and the tools needed to analyse the operation and characteristics of radio systems, tools such as spectral analysis and decibels units. Index of the subject 1.1 Historical Perspective: from Oersted to Marconi 1.2 Review of fundamental concepts 1.3 Equation of the travelling wave 1.4 Electromagnetic spectrum 1.5 Decibels
Chapter 2. Antennas	Aims and development: The aim of this chapter is to present the operation of antennas and how to characterize their performance, numerically and graphically. We will see different types of antennas and their application. Index of the subject 2.1 Radiation in free space 2.2 Parameters of the antennas 2.3 Radiation pattern 2.4 Types of antennas

Chapter 3. Link	Aims and development: The aim of this chapter is to present the radio communication system as a whole, and to quantify its feasibility and performance in real circumstances using the link budget. Index of the subject 3.1 Friis Equation 3.2 Noise 3.3 Interference 3.4 Availability
Chapter 4. Radio-propagation	Aims and development: The aim of this chapter is to introduce the mechanisms of propagation of electromagnetic waves in more complex and realistic scenarios. Different strategies are discussed for communication over long distances Index of the subject 4.1 Influence of the terrain. 4.2 Surface wave 4.3 Ionospheric wave 4.4 Space wave
Chapter 5. Modulations	Aims and development: The aim of this chapter is to explain how can electromagnetic propagation be harness to transport information. We introduce the concept of modulation, we discuss its types, characteristics and limitations. Index of the subject 5.1 Basic concepts 5.2 Analog modulation 5.3 A/D conversion 5.4 Digital modulation 5.5 Multiplexing
Chapter 6. Current systems	Aims and development: The aim of this chapter is to present and discuss some of the radio communication systems that are currently in use. Index of the subject 6.1 Management of radio-electric spectrum 6.2 Mobile communication systems 6.3 Satellite communication systems 6.4 Radio-navigation systems 6.5 Radio-communication systems in the Navy
R&D project	Aims and development: The aim of the R&D project is give the student the opportunity to tackle the study of a subject of his election, as long as it is compatible with the contents of the course. We encourage the student to find solutions to open problems using the methods and tools at hand. The R&D project encourages the student to synthesize the acquired results into a multimedia format. During this session the class will review and discuss a selection of the results of the R&D project. The selection criteria will be: quality and compatibility with the course curriculum.
Lab session 1. Introduction	Aims: This first session poses a number of challenges and open exercises that will reinforce some fundamental concepts and units. Virtual laboratories will be used to visualize the propagation of electromagnetic waves, and other fundamental parameters. Students will practice operation with natural and logarithmic units, often making conversions between them, using either manual calculator and Matlab for verification.
Lab session 2. Antennas	Aims: The Lucas-Nülle training station will be used to study the characteristic parameters of a number of antennas (monopole, dipole, Yagi-Uda, slot antenna, etc.). Array antenna will be experiences using simulation software.

Lab session 3. Link	Aims: The students will practice evaluating the radio link budget, identifying and manipulating all the terms involved in Friis equation, as well as other parameters that are used to characterize the performance and overall quality of a radio link, such as SNR, CIR, availability. A practical case will be considered using simulation software.
Lab session 4. Satellite	Aims: The students will establish communication with one or several geostationary satellites. They will have to locate the position of the satellite, aim the antenna, and describe the characteristics of the received signal.
Lab session 5. Radio-propagation	Aims: Students will experience the various modes of propagation of electromagnetic waves, and how that can impact the communication. Several modes of propagation will be studied. The students will identify the propagation mode with the help of a calibrated antenna and a field measuring unit. In case the instrumentation is not available, simulation software will be used to study radio propagation via ionospheric and surface wave.
Lab session 6. Analog modulation	Aims: Basic concepts such as base-band or transmission bandwidth will be reviewed from a practical perspective. Software-defined-radio (SDR) software will be used to compare various analog modulations in terms of quality and bandwidth efficiency. We will review also the demodulation AM and FM signals.
Lab session 7. Digital modulation	Aims: Using SDR software a number of concepts will be reviewed, such as the impact that the digital modulation has on the bit error rate (BER). The students will compare different modulation schemes (ASK, QPSK and QAM) and the differences between their respective characteristic parameters.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	26	26	52
Laboratory practical	14	14	28
Seminars	7	5	12
Project based learning	2	12	14
Seminars	15	8	23
Essay questions exam	13	8	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	Participatory master class. In these sessions, the contents of the program are presented. Examples are used to help students understand the matter. Computer presentations and the blackboard will be used as the main media for content transmission. As much as possible, results will be supported by experiments, either done inside the classroom or shown via videos or other interactive content. A copy of the slides will be available for students prior to the lecture, so that both the lecturer and the students can focus, respectively, on the transmission and reception of the concepts. The slides are provided not as a substitute for textbooks or lecture notes, but as supplementary material. Project-based learning. Two masterclass sessions are programmed to visualize and discuss the results of the R&D projects. A number of projects will be selected according to quality and fitness to the course curriculum, and discussed with the class. Resolution of problems and/or exercises. With these sessions we engage the student in problem solving activities, while boosting skills in collaborative work and interpersonal relations. Active methodologies will be used, as stated in section 4 of this Guide. The student will be presented with a number of problems and challenges that involve other engineering disciplines. This way, students will gain a transversal vision of the contents of the course and will see how it can help addressing the problems in other disciplines. If possible, some time each week will be reserved to group work, although the actual amount of time may vary along the course depending on the current load. During those activities a problem-solving learning method will be followed.
Laboratory practical	Small participatory lectures. Sometimes, it will be convenient to tackle some concepts before the laboratory sessions in this form, to review and expand on the concepts that will be used during the session. Guided laboratory sessions. The procedure in these sessions is as follows: smaller groups of students are formed to solve a number of challenges and problems, with minimal intervention by the lecturer. The aim is to let students arrive to solutions using the knowledge and the tools at their disposal. The lecturer will merely guide the work of the students, by adjusting the difficulty of the tasks to the capacity of each group.
Seminars	Problems sessions. These sessions seek to support the learning process by means of problem solving, either as a group activity or individually. Problems and challenges will be posed to the group. Students will have to reach a solution through discussion and collaboration. Sessions will be preferably held in groups of around 10 students, although individual sessions can also be arranged.
Project based learning	We propose a R&D project with an open topic to be carried out by a group of 2 students. The procedure is as follows: we provide the students with a list of videos, as reference. Said videos show demonstrations or tutorials related to the course curriculum; for example: the design and implementation of a AM receptor or an experimental demonstration of ionospheric refraction using a scale model. We ask the students to make a similar video, with free topic but within the course contents. The aim of this project is to encourage students to acquire knowledge by themselves, employing any tool or method at their disposal. On top of that, we boost skills for autonomous investigation, problem solving, and capabilities in synthesis and presentation.
Seminars	This corresponds to an intensive course that reviews the main concepts and problems in preparation for the extraordinary exam.

Personalized assistance

Methodologies	Description
Seminars	We offer students both group and individualized tutoring. In the former, students have access to tutoring hours where lecturers are available to discuss any topic related to the course content, organisation, and planning. During these hours the lecturer can propose problems related to the course curriculum, either to reinforce the contents already presented or to challenge and deepen the student mastery of the subject. In the latter, the lecturer is available to each student to address any issue that may be hindering the student performance, or preventing him/her to follow the course. The aim of these sessions is to find, between both, some solution to these problems. Using both types of tutoring we adapt for the different learning speeds, and we address diversity outreach. The course lecturers will respond personally to all the doubts and questions that the students may rise. This will be done either in face-to-face meetings, according to the schedule published in the website of the center, or through telematic means (such as email, videoconference, Moovi forums, etc.) if the course is held online

Assessment					
	Description	Qualification	Training and Learning Results		
Lecturing	It consists of 3 written exams: containing theoretical questions and problems covering the curriculum of the course. The distribution of the three exams is as follows: First mid-term: it covers chapters 1 and 2, and has a weight of 15% of the final grade. Second mid-term: covers chapters 3 and 4, and has a weight of 15% of the final grade. Final examination: covers all chapters (from 1 to 6) and has a weight of 40% of the evaluation. The R&D project grade is awarded by the lecturer in terms of quality and relevance to course curriculum. It has a weight of 10% of the final grade.	80	B3	C27 C28 C29	D1 D2 D3 D8 D9 D10 D16
Laboratory practical	Groups of 2/3 students follow the laboratory procedures and deliver a log of the work done in each lab session. The lecturers will grade each deliverable, in terms of correctness and mastery of the session contents. The lab grade, calculated as the arithmetic mean of the grades of all deliverable, has a weight of 20% of the final grade.	20	B3	C27 C28 C29	D1 D3 D9 D10 D17

Other comments on the Evaluation

On the lab sessions

If a lab session is missed, or if the log is not delivered before deadline, the grade for that deliverable would be 0.0. The student will be responsible for notifying the reason of absence before the publication of the session grades. It is up to the lecturer to decide whether the provided reason constitutes proper justification.

In case one session is missed, and it is properly justified, the final lab grade will be computed using the remaining grades. If more than one session is missed, and all are properly justified, the student will be given de opportunity to carry out the lab work on another date, or, alternatively, deliver an essay that covers the contents of the relevant lab work.

A minimum grade of 4,0 points over 10 is required in the lab sessions to pass the course.

Final grade and requirements to pass the course in continuous evaluation

To ensure that the student acquires the skills specified in the course plan a minimum grade is required in the following sections:

- 4,0 points over 10 in the final exam grade, and
- 4,0 points over 10 in the lab sessions grade.

The student will pass the course if, having complied with the requirements above, the calculation of the continuous evaluation grade (CEG) is equal or higher than 5,0 points over 10. Failing to comply with the requirements, the CEG cannot be greater than 4,0. If a student does no pass the course in the continuous evaluation modality, he/she will have to attend the regular exam. Students may decide to attend the regular exam to improve their grade.

Regular exam

The regular examination grade (REG) uses the same weights as in continuous evaluation: 80% for the theory and 20% for lab sessions.

It will consist of a single written exam, that will cover all the course curriculum, both theory and practical. The exam will have a duration of 3 hours, and can take the form of a multiple-choice test, a short answers test, a problem exam, or a combination of the former.

The student will pass the course if the REG is equal or greater than 5,0 points over 10. The student that fails the regular exam has to attend the make-up exam.

First call grade

The grade of the first call is calculated as the maximum of the continuous evaluation grade (CEG) and the regular examination grade (REG)

Second call grade (Make-up exam)

A make-up exam is offered for those that have not reached the course requirements in the first call. The format and requirements are the same than those of the regular exam.

ACADEMIC INTEGRITY: Students are expected to show adequate ethical behaviour, committing to act honestly. Based on article 42.1 of the *Regulation on the evaluation, qualification and quality of teaching and the student learning process of the University of Vigo*, as well as point 6 of the fifth rule of *Order DEF/711/2022, of July 18th, which establishes the*

requirements for evaluation, progress, and ongoing enrolment in military educational training centres for incorporation into the ranks of the Armed Forces, **any violation of academic integrity in the assessment process, as well as the cooperation in it will result in the assignment of a failing grade to the student (zero) for the entire course in the corresponding assessment opportunity,** regardless of the percentage of importance that the test in question had in the overall continuous assessment and independently of other disciplinary actions that may be applied.

Sources of information

Basic Bibliography

Hernando Rábanos, José María, **Transmisión por radio**, 6ª, Centro de Estudios Ramón Areces, 2008

Arias Acuña, Alberto Marcos; Rubiños López, José Oscar, **Radiocomunicación**, Andavira, 2011

Apuntes da asignatura,

Complementary Bibliography

Balanis, Constantine A., **Antenna Theory. Analysis and Design**, 4ª, John Wiley & Sons, 2016

Griffiths, John, **Radio wave propagation and antennas: an introduction**, Prentice Hall, 1987

Couch, Leon W., **Digital & analog communication systems**, 8ª, Pearson Education, 2013

Burillo Martínez, Vicente [et. al., **Comunicaciones analógicas y digitales Vol. I**, 1ª, UPM, Dpto. Ing. Sistemas Telem., 1991

Kim, John C.; Muehldorf, Eugene I., **Naval shipboard communications systems**, 1ª, Prentice Hall, 1995

Recommendations

Subjects that it is recommended to have taken before

Electronic technology/P52G381V01301