Universidad Rey Juan Carlos

TEACHING GUIDE

Signals and Systems

GRADO EN INGENIERÍA BIOMÉDICA (INGLÉS) (1º y 2º curso)

ACADEMIC YEAR 2026-27

Q2803011B UNIVERSIDAD REY JUAN CARLOS
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I.-Subject Identification	
Type	FORMACIÓN BÁSICA
Teaching period	2 course, 1Q semester
Nº of credits	6
Language in wich the subject is taught	English

II.-Presentation

In this course, you will learn to model complex systems so that you can calculate their response to any input or stimulus. In the equipment used in Biomedical Engineering, it is essential to be able to predict the response of a system (sensor, component, circuit, subsystem, or complete device) when it operates with different input information (signals). Once you understand how to model these systems, you will be able to design, optimize, and validate them.

To this end, you will analyze these signals both in their time evolution (time domain) and in their spectral components (frequency domain). As you will see, working in these domains can offer significant advantages through the use of new mathematical tools that facilitate the modeling, design, and analysis of a wide range of equipment (systems). Examples of these mathematical tools include convolution, the Fourier transform, and the Laplace transform.

Although the mathematical content may initially seem demanding, throughout the course it will become clear that modeling signals and systems in such ways helps simplify analysis and enhances the ability to design, optimize, and validate technical solutions.

The course will also address the difference between continuous and discrete signals, as well as the procedures for transforming one into the other. As an introduction, this distinction will help students understand the relationship between analog and digital signals.

Specifically, the course is designed to provide you with the necessary tools to analyze and design systems, as well as to understand the characteristics of the signals that enter and leave them.

You will begin with the concepts of “Signals in the Time Domain” and “Systems in the Time Domain,” which will lead to the study of “Linear and Time-Invariant Systems.” This type of system is a powerful working tool that enables the development of numerous technologies in fields such as automatic control, data processing, and Artificial Intelligence.

Once the fundamental properties of these systems have been covered, the concept of “Signals and Systems in the Frequency Domain” will be introduced. This section presents the Fourier transform for signals in continuous time and discrete time.

By completing this course, you will be able to: 1) understand the representation of information in the form of signals, together with their properties and basic operations; 2) apply linear systems as advanced operators on signals; and 3) calculate frequency-domain representations of signals and systems, as well as use them in signal processing.

To make the most of the course, it is highly recommended that students have a solid command of the mathematical **previous knowledge** acquired in first-year subjects (Mathematics I and Mathematics II). It is necessary for the student to master the algebra of complex numbers, integration and differentiation, the representation of functions and relationships and basic concepts of trigonometry.

III.-Learning outcomes

CON04. Understanding and mastery of basic concepts related to the general laws of mechanics, thermodynamics, fields and waves, and electromagnetism, as well as their application to solving engineering problems.

CON21. Knowledge and understanding of engineering fundamentals underlying their specialisation, at a level necessary to achieve the other programme outcomes, including some awareness at their forefront. (EURACE 1.2)

HAB08. Analyze and control dynamic biomedical systems in both continuous and discrete time, both linear and non-linear.

- Key for degrees not adapted to RD 822/21: **CB** - basic competences, **CG** - generic competences, **CE** - specific competences, **CT** - transversal competences.
- Key for degrees adapted to RD 822/21: **CON** - knowledge, **COM** - competences, **HAB** - skills.

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IV.-Contents

IV.A.-Syllabus

Topic 1 - Time-Domain Signals:
•Continuous-time and discrete-time signals.
•Transformations of the independent variable.
•Elementary signals.
•Signal properties.

Topic 2 - Time-Domain Systems:
•Continuous-time and discrete-time systems.
•Fundamental properties of systems.
•Linear Time-Invariant (LTI) systems in continuous and discrete time.
•Convolution in continuous-time and discrete-time systems. Fundamental properties.
•Properties of LTI systems.
•Causal LTI Systems Defined by Differential Equations and Difference Equations

Topic 3 - Continuous Signals and Systems in the Frequency Domain:
•Response of LTI systems to complex exponential signals.
•Fourier Series representation of continuous-time periodic signals.
•Properties of Fourier Series of periodic signals.
•Fourier Series of the most representative signals.
•Fourier Transform of continuous-time signals.
•Properties of the continuous-time Fourier Transform.
•Fourier Transforms of the most representative signals.
•Laplace Transform.
•Properties of the Laplace Transform.
•Laplace Transforms of the most representative signals.
•Systems in the frequency domain: frequency response and filter concepts.

IV.B.-Training activities

Type	Title
Theoretical sessions	Sessions in which the professor presents and explains the fundamental concepts of the course. The lectures are supported by slides and/or course notes. Lectures and/or notes will be available in advance in Aula Virtual to facilitate students' preparation of the class.
Resolution of exercises, problems, case studies	Classroom-based sessions dedicated to the resolution of exercises and practical problems. A set of exercises is provided to students in advance, and students are expected to work on and solve them during the sessions, with guidance and feedback from professors as needed.
Practical sessions	Guided laboratory sessions conducted by professors in computer laboratories. In these sessions, students will use specialized software tools to simulate and analyze signals and systems.

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Academic tutorials	On-site sessions designed to address students' questions related to the course content, practical sessions or assessment activities.
Group work	Collaborative problem-solving sessions, in which students work in groups to solve a set of exercises and problems related to the course content. Their solutions are presented and discussed during several class sessions, organized according to the corresponding course topics.
Test and/or exams	On-site exams designed to assess the knowledge and skills acquired by students throughout the course.
Other activities	Students are expected to study the course materials independently and complete the proposed exercises and problem sets.

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V.-Student workload	
Theoretical sessions	35
Resolution of exercises, problems, case studies, etc.	14
Practical sessions in experimental, technological and clinical laboratories, fieldwork, etc.	6
Tests and/or exams	5
Academic tutorials	8
Related activities: conferences, seminars, etc.	40
Preparation of theoretical sessions and self-study	15
Preparation of practical tasks, exercises, case studies, projects, etc.	27
Preparation for tests and/or exams	30
Total student workload	180

VI.-Methodology and academic programme

Type	Period	Content
Theoretical sessions	Week 1 to Week 15	Theory lectures are delivered through sessions that combine the explanation of fundamental concepts with practical examples. These sessions provide students with a theoretical foundation and should be complemented by subsequent independent study to consolidate understanding of the course contents.
Resolution of exercises, problems, case studies	Week 1 to Week 15	Sessions focused on solving problems in the classroom, enabling students to apply the theoretical concepts covered in the course.
Practical sessions	Week 4 to Week 15	Sessions guided by the professor in which students carry out practical activities related to the course contents.
Academic tutorials	Week 1 to Week 15	On-site sessions aimed at addressing questions and clarifying doubts raised by one or more students regarding specific course contents or learning activities.

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Tests and/or exams	Week 6 to Week 8	Midterm exam designed to evaluate the knowledge acquired in Topics I and II of the course.
Tests and/or exams	Week 15 to Week 20	Final exam designed to evaluate the acquisition of knowledge and skills related to all the theoretical and practical contents of the course. This exam is held in the official ordinary call exam.
Tests and/or exams	Week 4 to Week 15	Assessment of the skills acquired during the practical sessions.
Group work	Week 4 to Week 15	Students work independently in groups to solve the exercises assigned to them and present their solutions in class during a course session. The exercises are then analyzed and discussed collectively in the classroom.

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VII.-Assessment methods

The general assessment method is continuous as established in the *Regulation for the Assessment of Learning Outcomes* of Rey Juan Carlos University.
All the assessment systems established in the degree report must be employed, except for those that have a minimum weight of 0%, which can be used by professors in the academic years they consider relevant. Each assessment system may be applied through one or more assessment activities, consistent with the system. No assessment activity can exceed individually 60% of the overall grade for the subject.
The sum of non re-evaluable activities cannot exceed 40% of the overall grade for the subject and, in general, should not have an established minimum grade (except for practical activities in which, strictly speaking, the conditions of the ordinary call cannot be reproduced in the extraordinary call).
Those students who do not manage to pass the subject in the ordinary call, or do not attend this first call, may attend the extraordinary call only for failed re-evaluable assessment activities.
The distribution and characteristics of the assessment activities are described below.

VII.A.-Description and weight of the assessment activities

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1 - Ordinary assessment period

The assessment system for the ordinary assessment period is structured as follows:

Assessment System	Assessment Activity	Type	Weight	Minimum mark	Contents
SE 5	Assessment of Problem-Solving Activity 1 (Pr1)	Non-reassessable	10%	-	Topics I and II
SE 5	Assessment of Problem-Solving Activity 2 (Pr2)	Non-reassessable	10%	-	Topic III
SE 5	Laboratory Practices (LP)	Reassessable	10%	LP >= 2/10	Contents related to the laboratory sessions
SE 2	Partial Exam (ExP)	Reassessable	25%	Weighted average of ExP and ExF >= 4/10	Topic I and II
SE 2	Final Exam (ExF)	Reassessable	45%		Topics I, II and III

In order to pass the course, the student's performance must meet all of the following minimum requirements:

- The weighted average of ExP and ExF must be equal to or higher than 4/10, calculated as follows: (ExP × 0.25 / 0.70) + (ExF × 0.45 / 0.70) >= 4.
- The mark obtained in Laboratory Practice (LP) must be equal to or higher than 2/10.

Only when these minimum requirements have been met will the Final Mark (FM) be calculated according to the following formula:

- FM = Pr1 × 0.10 + Pr2 × 0.10 + LP × 0.10 + ExP × 0.25 + ExF × 0.45
- Students who obtain a Final Mark (FM) equal to or higher than 5/10 will be deemed to have acquired the competencies associated with the course and will receive the corresponding final grade (Pass, Good, Excellent, or Honors, as applicable).

Important considerations:

- If the minimum mark of 2/10 is not achieved in LP, or if the weighted average of ExP and ExF is lower than 4/10, the Final Mark (FM) will be the mark corresponding to the assessment activity for which the minimum requirement has not been met. In such cases, the final result for the assessment period will be Fail.
- A student will be recorded as Absent / No-show only if they do not take any of the following assessment activities: ExP, ExF, Pr1, Pr2, and LP. In all other cases, the final mark will be calculated in accordance with the criteria described above.
- The assessment activities Pr1 and Pr2 are not eligible for reassessment in the extraordinary assessment period.

2 - Extraordinary assessment period

The extraordinary assessment period is intended for students who have not met the minimum requirements in the ordinary assessment period in those assessment activities that are eligible for reassessment. Accordingly:

- Students must retake those reassessable assessment activities in which the required minimum mark was not achieved in the ordinary assessment period:
- ExP and ExF (if their weighted average is lower than 4/10),
- and LP (if its mark is lower than 2/10).

In addition:

- If the student has achieved the minimum required marks in ExP, ExF, and LP in the ordinary assessment period, but the Final Mark (FM) is still lower than 5/10, the student must retake ExP and/or ExF according to the following criteria:
- The student must retake any exam failed (mark <5) in the ordinary assessment period, namely ExP and/or ExF.
- If both exams were passed, the student must retake the exam with the lowest score.
- LP can also be reassessed if FM<5, however, students should take into account the low relative weight of this component in the calculation of the Final Mark (FM).

3 - Early assessment period

The assessment activities and grading criteria applicable to the early assessment period are the same as those established for the ordinary and extraordinary assessment periods.

Academic integrity and conduct

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- All exams must be completed individually and without any external assistance, except for materials or resources expressly authorized by the professors. Failure to comply with these rules will result in a failing grade in the corresponding assessment period, as well as to take pertinent actions established in the University regulations.
- If professors consider it appropriate, they may require any student to undertake an oral defense of any assessment activity or submitted work. The outcome of this oral defense may lead to the confirmation of the original mark or the assignment of a different mark. Failure to attend this oral defense when required will result in a failing grade (grade = 1) for the assessment activity concerned.

VII.B. Assessment of students with academic exemption from class attendance

Having Academic Exemption from Class Attendance (DAAC) does not imply that students are automatically exempt from participating in the continuous assessment activities or in the training activities of compulsory attendance as established in the teaching guide. Once the exemption has been granted, students must contact the subject's teaching staff, who will propose the adaptations he/she may consider relevant, as long as they guarantee the acquisition and adequate assessment of the learning goals established. Students must maintain adequate communication with the teaching staff so that they may provide information on the dates for training and assessment activities, if these are not established in the programme and available for students at the time of achieving the exemption.
Subject with possibility of academic exemption: Yes.

VII.C. Review of assessment activities

In accordance with the Regulation for the Assessment of Learning Outcomes of Rey Juan Carlos University.

VII.D.-Students with a disability or special educational needs

In order to guarantee equal opportunities, non-discrimination, universal accessibility and academic success, students with disabilities or especial education needs may request curricular adaptations to follow their studies. These adaptations will be provided by the Unit of Attention to People with Disabilities of Rey Juan Carlos University, in accordance with the regulation which regulates the service for the Attention of People with Disabilities at the University. This Unit will issue a report for curricular adaptations, so that students with disabilities or special education needs must contact the service (at e-mail discapacidad.programa@urjc.es) in order to provide relevant information for different educational alternatives.

VII.E.-Academic behaviour, academic integrity and honesty

Rey Juan Carlos University is fully committed to the highest standards of academic integrity and honesty, so studying at the URJC means assuming and subscribing to the values of integrity and academic honesty set out in the University's Ethical Code. To support this process, the University has Rey Juan Carlos University's Academic Conduct Regulation as well as different tools (anti-plagiarism, supervision...) that offer a collective guarantee for the full development of these essential values.

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VIII.-Teaching resources and materials
Basic bibliography
Oppenheim, A. V., Willsky, A. S., & Nawab, S. H. (1997). *Signals & systems*. Pearson Education.
Oppenheim, A. V., & Schafer, R. W. (2009). Discrete-time signal processing (3rd ed.). Pearson Education.
Consultation bibliography

IX.-Professors	
Name and surname	DAFNE LOZANO PAREDES
E-mail address	dafne.lozanop@urjc.es
Department	Teoría de la Señal y Comunicaciones y Sistemas Telemáticos y Computación
Campus	Fuenlabrada
Category	Investigador
Person responsible for the subject	No
Tutorial timetable	Para consultar las tutorias póngase en contacto con el/la profesor/a a través de correo electrónico
Number of quinquennia	0
Number of sexennia	0
No. of positive evaluations by Docentia	0
Name and surname	ENRIQUE FEITO CASARES
E-mail address	enrique.feito@urjc.es
Department	Teoría de la Señal y Comunicaciones y Sistemas Telemáticos y Computación
Campus	Fuenlabrada
Category	Investigador
Person responsible for the subject	No
Tutorial timetable	Para consultar las tutorias póngase en contacto con el/la profesor/a a través de correo electrónico
Number of quinquennia	0
Number of sexennia	0
No. of positive evaluations by Docentia	0

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Name and surname	SARA GARCÍA DE VILLA
E-mail address	sara.garcia.devilla@urjc.es
Department	Teoría de la Señal y Comunicaciones y Sistemas Telemáticos y Computación
Campus	Fuenlabrada
Category	Profesor/a Ayudante Doctor/a
Academic degree	Doctor
Person responsible for the subject	Yes
Tutorial timetable	Para consultar las tutorias póngase en contacto con el/la profesor/a a través de correo electrónico
Number of quinquennia	0
Number of sexennia	1
No. of positive evaluations by Docentia	1

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