Universidad Rey Juan Carlos

GUÍA DOCENTE

DISCRETE TIME SYSTEMS

(Extinción examen y tutorías)

GRADO EN INGENIERÍA BIOMÉDICA (INGLÉS) (3º y 4º curso) (2374)

CURSO 2026-27

Q2803011B UNIVERSIDAD REY JUAN CARLOS
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I.-Identificación de la Asignatura	
Tipo	OBLIGATORIA
Período de impartición	2 curso, 2Q semestre
Nº de créditos	6
Idioma en el que se imparte	Castellano

II.-Presentación

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Discrete Time Systems delves into the modelling (description) and analysis of signals and discrete systems both in the time domain and in the frequency domain, with an emphasis on biomedical signals. It focuses on understanding the relationship between signals and continuous systems and their discrete counterparts, both in the time domain (sampling, sub-sampling and overlapping), and in the frequency domain (introducing the Discrete Fourier Transform, which enables the calculation of transformed signals by digital processors). The final part of the subject is dedicated to presenting a new transform for signals and discrete systems—the Z transform—, as well as its application to the design of discrete filters.

The contents of this subject are fundamental for modelling, analysing and solving a large part of the problems that appear in the field of Engineering—such as analysing biomedical signals, information transmission through channels, coding and processing of audio-visual information,etc.—and are a basic for later subjects.

Prerequisites:

•Having passed *Linear Systems and Application to Circuits* (in the first semester of the second year).

•Having acquired the knowledge and competences in other subjects in the first and second years (first semester), specifically:

1. Analysis and signal processing tools for continuous systems: 1. Leveraging properties of signals and systems, specially linear, time-invariant systems; 2. Working out convolutions in continuous time; 3. Finding the Fourier Series Representation (FSR) and the Fourier Transform (FT) for continuous signals; 4. Knowing the properties of the DSR and TF of continuous signals.
2. Fundamentals of calculus: 1. Working our geometric series and integrals; 2. Polynomial factorization and continuous fraction expansion of polynomial quotients in the complex domain.
3. Fundamentals of algebra: 1. Working with vector spaces and their bases, and orthogonality between vectors; 2. Working with and representing functions of one complex variable; 3. Knowing how to represent additions or subtractions of complex exponentials as sinusoids.

Therefore, **we recommend that students who have not passed those subjects where these concepts are studied do not enroll in Discrete Time Systems**.

To ensure success in acquiring the competences and learning outcomes in the subject (see below) teaching will proceed using different formative and evaluation activities.

Formative activities will include: 1) lectures concerning theory for each unit; 2) Time-synchronous classes about solving some of the problems in the handouts for each unit; 3) lab sessions using appropriate SW; 5) the use of Fora to exchange remarks, problem solutions and doubts for each unit; and 5) individual/group tutoring sessions.

Assessment may include of: 1) two written tests (partial and final); 2) synchronous (immediate) test or hand-in of a notebook for each major unit and lab session using AV (the details will be explained by the lecturer during subject unfolding); 3) attendance to and taking part in class, active participation in fora---e.g. by solving doubts for classmates, proposing new projects beyond those of the handouts, supplying pieces of news or information about the subject, etc.

III.-Resultados de Aprendizaje

CG01 . Analyze and synthesize problems related to biomedical engineering, solve them and communicate them efficiently.
CG02. Use computational and experimental tools for the analysis and quantification of biomedical engineering problems
CE01 . Understand or acquire the principles of bioelectrical fundamentals, anatomy, physiology or pathophysiology needed to identify the most appropriate processing technologies for a given problem in biomedical engineering
CE07. Know and understand the principles of signals and biomedical systems in discrete time.
CE12. Analyze and control discrete and continuous time dynamic biomedical systems, both linear and non-linear

- Leyenda para las titulaciones no adaptadas al RD 822/21: **CB** - competencias básicas, **CG** - competencias generales, **CE** - competencias específicas, **CT** - competencias transversales.
- Leyenda para las titulaciones adaptadas al RD 822/21: **CON** - conocimientos, **COM** - competencias, **HAB** - habilidades.

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IV.-Contenido

IV.A.-Temario de la asignatura

Topic 1: Discrete-time Signals and Systems in the Time Domain

- Discrete-time Signals.
- Discrete-time Systems.
- Discrete-time System properties.
- Discrete-time convolution sum.

Topic 2: Discrete-time Signals and Systems in the Frequency Domain

- The discrete-time Fourier Series Representation for signals: definition, properties, Fourier series and Linear Time-Invariant (LTI) systems.
- The discrete-time Fourier transform for signals: definition, properties, frequency response of LTI systems.

Topic 3: Sampling

- Sampling of continuous signals: sampling theorem; continuous-time signal reconstruction through interpolation. •Discrete-time processing of continuous signals.
- Discrete-time signal sampling: decimation and interpolation.

Topic 4: Discrete Fourier Transform: frequency sampling

- Definition: the DFT as the sampling of the Fourier Transform.
- Properties.
- Circular convolution: definition, relationship with the DFT, relationship with convolution sum.

Topic 5: The z-Transform

- Definition and Region-of-Convergence (ROC).
- Properties.
- Pole-and-zero diagram.
- Analysis of discrete-time systems described by difference equations.
- Block diagrams.

Topic 6: Introduction to the design of discrete filters

- Fundamentals of digital filtering.
- Design of FIR filters.
- Overview of IIR filter design.

IV.B.-Actividades Formativas

Las actividades formativas de esta asignatura se adecúan al proceso de extinción de la titulación. El personal docente facilitará los materiales y/o bibliografía a través de Aula Virtual y programará (en Teams o presencialmente) las tutorías académicas grupales necesarias para resolución de problemas y dudas, prácticas y/o aclaración de contenidos que estime oportunas.

El personal docente puede programar otras actividades formativas auxiliares, si así lo estima oportuno, siguiendo las indicaciones dadas por los centros, si las hubiera. De ello se informa al alumnado a través de Aula Virtual al inicio del cuatrimestre.

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V.- Metodología

Las metodologías docentes se adecúan al proceso de extinción de la asignatura:

1. El personal docente programará (en Teams o presencialmente) tutorías académicas grupales necesarias para resolución de problemas y dudas, prácticas y/o aclaración de contenidos que estime oportunas.
2. El personal docente puede emplear otras metodologías docentes auxiliares, si así lo estima oportuno, siguiendo las indicaciones dadas por los centros, si las hubiera. De ello se informa al alumnado a través de Aula Virtual al inicio del cuatrimestre.

VI.- Método de evaluación

Los sistemas de evaluación se adecúan al proceso de extinción de la asignatura. Las actividades de evaluación mediante las que se desarrollan los sistemas de evaluación previstos en la memoria verificada del título se aplicarán de modo que el alumnado pueda atenderlas adecuadamente. Esta adecuación es la misma para todas las convocatorias de evaluación. Por tanto, las actividades de evaluación podrán programarse durante las convocatorias oficiales (ordinaria, extraordinaria y adelantada).

El uso de herramientas basadas en inteligencia artificial está prohibido en cualquier ejercicio y prueba de evaluación de la asignatura salvo que el profesor lo indique de forma explícita en el enunciado o en el material de esta. En caso de que esté permitido, se darán indicaciones precisas de qué usos están permitidos y cuáles no.

V.A.B.- Descripción de la metodología de las actividades de evaluación y su ponderación

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Los sistemas de evaluación aplicados en esta asignatura son los siguientes:

Continuous ordinary assessment:
The distribution and characteristics of the assessment tests are those described below. Only in exceptional case and for special reasons may the teacher add changes to the Guide. These changes will require the prior consultation with the Subject Head and the prior and explicit authorisation of the Degree Programme Coordinator, who will notify the Vice-Rector's office in charge of Academic Affairs of the modifications made. In any case, the changes proposed must take into account the stipulations of the verified report. In order for these changes to take effect, they must be duly communicated at the start of the course to the students using Aula Virtual.

Ordinary Evaluation Summary Table and Checklist

Assessment System	Assessment Activity	Re-assessable in Extraordinary Call	Weight	Minimal Grade	Contents	Dates
SE02 (written test)	Partial	Yes	20%	No	T1, T2 and T3	Weeks 8-10
SE02 (written test)	Final	Yes	50%	4.0	All syllabus	Ordinary Call
SE05 (Labs)	Solving SW-enabled practical cases	No	30%	NO	Computer-enabled practical applications	Weeks 1-14

• To pass the course students will have to obtain a grade above 4.0/10.0 in the ***Final test*** and an aggregate grade above 5.0/10.0
• The aggregate mark is grade = 0.2Partial Test + 0.3Lab Score + 0.5Final Test
• If the ***final test*** grade is less than 4.0 you may not pass the subject in the ordinary call, regardless what the average is. In such case, the official public grade will be as specified in the Evaluation Reglament.
• If a student does not turn up for **all** of the previous assessment tasks the final mark will be ***NO PRESENTADO***.
• Class attendance is compulsory (unless you obtain an academic exemption). In order for attendance to be acknowledged it may be controlled (a roll-call or signature form, etc.) and only **three** misses will be allowed.
• Students with academic exemption from class must refer to the Evaluation Reglament regarding non-reassessable activities.
Extraordinary assessment: Students who do not manage to pass the ordinary assessment, or who did not attend, will be subject to completion of an extraordinary assessment to verify their acquisition of the skills established in the guide, only for activities that are re-assessable.
Extraordinady assessment check list
• In the extraordinary call, only the ***Partial test*** and ***Final test*** grades may be subject to re-assessment, and only **if they were not passed**. They will both be re-assessed in the date and time designated by the university for extraordinary assessment. The extraordinary call aggregate grade formula is the same as in the ordinary call.
•To pass the course in the extraordinary call students will have to obtain a grade above 4.0/10.0 in the ***Final test*** and an aggregate grade above 5.0/10.0 with the same weighting scheme as in the ordinary call.
• If the ***extraordinary test*** grade is less than 4.0 you may not pass the subject, regardless of what the average is. In such case, the official public grade will be as specified in the Evaluation Reglament.
Advance evaluation call: For the September advance evaluation call, students will be required to sit for a written exam on the whole subject for a grade of 6.0/10 points, and a lab-theory exam for a grade of 4.0/10.0 points. Minimum grade for passing each is 5.0/10.
Final clarifications
• Professors may require the **defense of any of the assessment tests either written or orally (tests, labs or others)** if deemed necessary. The result of such defense may results in ratifying the assessment grade or a completely new assessment. Not turning up for the defense will result in a grade of 1.0/10 in the assessment being defended.
• Note that no assessment grades will be saved for later courses, nor will any previous courses' assessments be taken into consideration for the present course's assessment grades. Specifically, this applies to the Advance Evaluation during September.

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V.C.- Revisión y reclamación de las actividades de evaluación

Se realizará conforme al Reglamento de evaluación de los resultados de aprendizaje de la Universidad Rey Juan Carlos.

V.D.- Alumnado con discapacidad o necesidades educativas especiales

Con el fin de garantizar la igualdad de oportunidades, la no discriminación, la accesibilidad universal y la mayor garantía de éxito académico, las adaptaciones curriculares para alumnado con discapacidad o con necesidades educativas especiales serán pautadas por la Unidad de Atención a Personas con Discapacidad, de acuerdo con la normativa que regula el servicio de Atención a Estudiantes con Discapacidad, aprobada por Consejo de Gobierno de la Universidad Rey Juan Carlos.
Para que esas adaptaciones puedan realizarse, será requisito la emisión de un informe de adaptaciones curriculares por parte de dicha Unidad, por lo que el alumnado con discapacidad o necesidades educativas especiales deberán contactar con este servicio para analizar conjuntamente las distintas opciones.

V.E.- Conducta académica, integridad y honestidad académica

La Universidad Rey Juan Carlos está plenamente comprometida con los más altos estándares de integridad y honestidad académica, por lo que estudiar en la URJC supone asumir y suscribir los valores de integridad y la honestidad académica recogidos en el Código Ético de la Universidad.

Para acompañar este proceso, la Universidad dispone de la Normativa de Convivencia de la Universidad Rey Juan Carlos y de diferentes herramientas (antiplagio, supervisión) que ofrecen una garantía colectiva para el completo desarrollo de estos valores esenciales.

Las herramientas basadas en inteligencia artificial pueden mejorar la experiencia de aprendizaje, pero debe utilizarse de forma ética, legal, honesta y transparente. Por este motivo, deben seguirse las recomendaciones de uso adecuado indicadas por los docentes de la asignatura.

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VI.-Recursos y materiales didácticos

Bibliografía básica

Hwei P. Hsu, "Signals and Systems", Schaum's Outlines, McGraw-Hill, 1995. This basic text covers strictly and exactly what you need for this subject. Nothing is missing, nothing can be left out. It has a wealth of problems too.

Bibliografía complementaria

Alan V. Oppenheim and Ronald W. Schafer, "Discrete-Time Signal Processing", 3rd Ed. 2009. This book has an extensive coverage of all matters in the course. Perhaps a bit too verbose.

B. P. Lathi, "Signal Processing and Linear Systems ", Oxford University Press, 2nd Ed. 2004 This is an alternative to Oppenheim's text, following the same pattern of explanation, verbosity and depth.

Edward W. Kamen, Bonnie S. Heck. "Fundamentos de sen¿ales y sistemas usando la Web y MATLAB". Pearson education.

Monson H. Hayes. "Digital Signal Processing, 2nd Edition " Schaums Outlines, McGraw-Hill, 2011. This book can be used to train on further problems.

VII.-Profesorado

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