

340025 - EQDI-F2043 - Differential Equations

Coordinating unit:	340 - EPSEVG - Vilanova i la Geltrú School of Engineering
Teaching unit:	749 - MAT - Department of Mathematics
Academic year:	2019
Degree:	BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory) BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory) BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory) BACHELOR'S DEGREE IN INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING (Syllabus 2009). (Teaching unit Optional)
ECTS credits:	6
Teaching languages:	Catalan, Spanish

Teaching staff

Coordinator:	Carles Batlle Arnau
Others:	Immaculada Massana Hugas Ester Simó Mezquita Marisa Zaragoza Monroig

Prior skills

Ability to apply the basic tools of differential and integral calculus in one real variable.
Ability to operate with complex numbers, both in binomial form and exponential form.
Ability to factor polynomials over the real and complex numbers.
Ability to decompose rational functions into a sum of partial fractions.
Ability to use the basic tools of linear algebra for the study of systems of linear equations.

Degree competences to which the subject contributes

Specific:

1. CE1. Ability to solve arithmetic problems related to engineering. Aptitude to apply knowledge concerning: linear algebra, geometry, differential geometry, differential and integral calculus, differential and partial equations, numerical methods, numerical algorithms, statistics and optimization.

Transversal:

2. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.
3. EFFECTIVE USE OF INFORMATION RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.

Teaching methodology

In the lectures the instructor presents some motivating ideas, the fundamental concepts and some relevant developments, intermingled with key examples and the resolution of representative problems. In some sessions, one or more problems can be assigned to be individually solved in the classroom and to be graded.

In the lab classes the students learn how to solve some problems numerically, using MATLAB. These will be graded by means of written homework.

Learning objectives of the subject

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Calculate the Fourier series of a given periodic function, both in real and complex form, and represent and analyze its spectrum.

Understand the role of differential equations in engineering and science, and see some examples.

Compute the solution of the simplest classes of differential equations of first and second order in the time or Laplace domains, and use the appropriate numerical methods when necessary.

Compute and explain some characteristics, quantities and functions related to linear differential equations with constant coefficients, such as stability, characteristic time or transfer functions.

Study load

Total learning time: 150h	Hours large group:	52h 30m	35.00%
	Hours medium group:	0h	0.00%
	Hours small group:	7h 30m	5.00%
	Guided activities:	0h	0.00%
	Self study:	90h	60.00%

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Content

<p>1 - Differential equations</p>	<p>Learning time: 36h Theory classes: 8h Laboratory classes: 2h Self study : 26h</p>
<p>Description: Introduction to ordinary differential equations (ODE): what they are, what they are good for, what a solution is. Examples in modelling.</p> <ul style="list-style-type: none"> · What is an ordinary differential equation (ODE). · Solution of an ODE. · Classification of ODE. · Solution of ODE with separated variables. · Problems in mechanics, electricity and population growth models. · Numerical methods. Euler's method. <p>Related activities: A1, A3, A4</p> <p>Specific objectives: The student will learn how to</p> <ul style="list-style-type: none"> - identify an ODE and classify it. - check an ODE solution. - compute the arbitrary constants in a solution, given appropriate initial conditions. - recognize the ODE in simple problems from mechanics, electricity and population models. - solve ODE with separated variables. - explain the existence of different numerical methods for ODE, and the possible errors associated to their use. - transform an arbitrary ODE to a form suitable for the numerical computation of the solutions. - use MATLAB's commands and drivers for the numerical solution of ODE and the analysis of the solutions. 	

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2 - Laplace transform

Learning time: 40h

Theory classes: 16h

Self study : 24h

Description:

How to use the main properties of the Laplace transform to solve linear ODE with constant coefficients.

- Laplace transform of an admissible function. First examples.
 - Basic properties of the Laplace transform.
 - Tables of Laplace transforms. Inverse Laplace transform.
 - Further properties of the Laplace transform.
 - Using the Laplace transform to solve linear ODE with constant coefficients.
 - ODE with piecewise-defined right-hand sides. The Heaviside step function and the translation-in-time property.
 - Systems of linear first-order ODE with constant coefficients. Resolution using the Laplace transform.
- Characteristic polynomial of a system.

Related activities:

A1, A4

Specific objectives:

The student will be able to

- compute the Laplace transform of a function from the definition in simple cases.
- compute the Laplace transform of a function from known transforms and using the properties of the transform.
- compute inverse Laplace transforms using the properties of the transform and the partial fraction decomposition.
- compute the solution to linear ODE with constant coefficients using the Laplace transform.
- write a piecewise-defined function using the Heaviside function.
- compute the solution to linear constant-coefficient ODE with discontinuous with piecewise-defined right-hand sides.
- compute the solution to systems of first-order linear constant-coefficient ODE using the Laplace transform.

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3 - Analysis of the solutions of linear systems

Learning time: 38h

Theory classes: 12h
Laboratory classes: 2h
Self study : 24h

Description:

How to compute important properties, in the time and Laplace domains, of the solutions of linear constant-coefficient ODE (LCCODE), both for first-order and second-order equations and for first-order systems.

- General solution of a LCCODE.
- Computation of a solution for a LCCODE with sinusoidal right-hand side using phasors.
- Stability. Transient and stationary regimes. Characteristic time.
- Mechanical and electrical examples.
- Stability of LCCODE first-order systems.
- Control systems. Transfer function and impulse response of a linear input/output system.

Related activities:

A2, A3, A4

Specific objectives:

The student will learn how to

- compute the general solution of a LCCODE using the Laplace transform.
- decide the stability of a first-order or second-order LCCODE, and compute and explain the meaning of the characteristic time for the stable case.
- tell the stationary regime from the transient one for a stable LCCODE.
- compute the stationary regime of a LCCODE with sinusoidal right-hand side using phasors.
- decide the stability of first-order systems of LCCODE.
- compute the transfer function and the impulse response of a linear control system.

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<p>4 - Fourier series</p>	<p>Learning time: 36h Theory classes: 10h Laboratory classes: 2h Self study : 24h</p>
<p>Description: How to compute the Fourier series of a periodic function and how to understand it.</p> <ul style="list-style-type: none"> · Periodic signals. · Fourier series in real and complex form. · Spectrum of a periodic signal. Band-limited signals. · Comments on the convergence of Fourier series. Gibbs' phenomenon. · Discrete Fourier transform. Sampling and aliasing. <p>Related activities: A2, A3, A4</p> <p>Specific objectives: The student will be able to</p> <ul style="list-style-type: none"> - compute the period of a signal, if any, and decide whether the signal is band-limited or not. - compute the general term of the Fourier series of simple periodic functions, in real and complex form, and write down and simplify the series. - identify the relative weight of the several harmonics in a periodic function and explain the effect of the jump discontinuities. - compute, represent and understand the spectrum of a periodic function. - recognize from the spectrum whether a signal is band-limited or not. - use the FFT and recognize its problems. 	

Qualification system

A1=first partial exam (parts 1 and 2)
A2=second partial exam (parts 3 and 4)
A3= practical work with MATLAB/OCTAVE
A4=final exam (parts 1, 2, 3 and 4)
A4=laboratory exam with MATLAB/OCTAVE

$$\text{FINAL GRADE} = \text{MAX} (0.4 \cdot A1 + 0.4 \cdot A2 + 0.2 \cdot A3, 0.8 \cdot A4 + 0.2 \cdot A3)$$

(all scores on a 0-10 scale)

Regulations for carrying out activities

Activities A1, A2 and A4 are individual, written, problem-solving exams. Notes, books and digital devices are not permitted.

Activities A2 and A4 are simultaneous and incompatible.

Activity A3 is homework and can be done individually or in pairs.

Activity A4 is re-gradable.

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Bibliography

Basic:

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