UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

Course guide
320097 - AFED - Fourier Analysis and Differencial Equations

Last modified: 10/07/2023

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 749 - MAT - Department of Mathematics.

Degree: BACHELOR'S DEGREE IN AUDIOVISUAL SYSTEMS ENGINEERING (Syllabus 2009). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: VICTOR MAÑOSA FERNANDEZ

Others:

PRIOR SKILLS

As a general rule, it is considered highly desirable to have passed the first semester mathematics to be able to take the subject. Specifically, a basic knowledge of integral calculus is considered essential.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE01-ESAUD. Ability to solve mathematical problems that may arise in engineering. Aptitude to apply knowledge of linear algebra, geometry, differential and integral calculus, differential and partial differential equations, numerical methods, numerical algorithms, statistics, and optimization. (Basic training module)

Generical:
CG03-ESAUD. Knowledge of basic subjects and technologies, which enables learning of new methods and technologies, as well as providing great versatility to adapt to new situations.

TEACHING METHODOLOGY

- Face-to-face lecture sessions.
- Face-to-face practical work sessions.
- Independent learning and exercises.
- Preparation and completion of individual and/or group activities subject to assessment.

In the face-to-face lecture sessions, the lecturer will introduce the basic theory, concepts, methods and results for the subject and use examples to facilitate students' understanding.

Students will be expected to study in their own time so that they are familiar with concepts and are able to solve the exercises set, either manually or with the help of a computer.

The use of IT support tools will be encouraged: students will learn how to use a mathematical software package as a tool for performing numerical, symbolic and graphic calculations.

LEARNING OBJECTIVES OF THE SUBJECT

Familiarise students with the techniques inherent to Fourier Analysis and with the interpretation of signals in the frequency range.
Familiarise students with some of the techniques used in Differential Equations. They will be expected to use the deterministic modelling tool and interpret its answers.
Teach students how to apply these techniques properly for solving common practical problems encountered by engineers.
Use it software tools for approaching and solving problems. Develop the specific and transversal competencies associated with the academic work.

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	20.00
Hours medium group	30,0	20.00
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

Topic 1: FOURIER SERIES

Description:
1.1. Numerical series. Sequences and series of functions.
1.2. Fourier series.
1.3. Signal reconstruction. Spectrum.
1.4. Dirichlet's theorem. Pointwise and uniform convergence. Gibbs phenomenon.
1.5. Complex expression. Parseval's identity

Specific objectives:
For students to:
- Understand the concept of convergence of a numerical series, a sequence of functions and a series of functions.
- Understand the concept of Fourier series representation of a periodic signal and calculate it in real and exponential form.
- Understand the concepts of pointwise convergence vs. uniform convergence, Dirichlet's theorem and Gibbs phenomenon.
- Understand the concepts of spectrum and average signal strength.
- Understand and apply Parseval's theorem.
- Be able to calculate Fourier series and obtain the graphs of the partial sums and the spectra with the help of symbolic computation software.

Full-or-part-time: 45h
Theory classes: 9h
Practical classes: 9h
Self study : 27h

Topic 2: FOURIER TRANSFORM

Description:
2.1. Deduction and spectrum. Parseval's identity
2.2. Properties of the Fourier transform.
2.3. Frequency description of LTI systems and filters.

Specific objectives:
For students to:
- Understand the Fourier transform concept of a non-periodic signal and know how to calculate it.
- Understand the concepts of spectral energy density and Parseval's theorem.
- Understand the main properties of the Fourier transform: linearity, shifts, time scales and convolution.
- Understand the frequency description of LTI systems, in particular for describing filters.
- Calculate Fourier transforms and inverse Fourier transforms and use symbolic computation software to produce graphs of the corresponding spectra.

Full-or-part-time: 37h
Theory classes: 7h 30m
Practical classes: 7h 30m
Self study : 22h

Topic 3: ORDINARY DIFFERENTIAL EQUATIONS

Description:
3.1. General introduction to Ordinary Differential Equations (ODEs).
3.2. First-order linear ODEs.
3.3. Linear ODEs with constant coefficients.
3.4. Interpretation of results.

Specific objectives:
For students to:
- Understand the concept of ordinary differential equation and its solution. Understand the conditions for the existence and uniqueness of a solution to an initial value problem.
- Understand the concept of ODE problem modelling.
- Understand the techniques for the integration of simple ODEs, first-order linear ODEs (in particular the method of variation of parameters), and ODEs with constant coefficients.
- Use a linear ODE with constant coefficients to model the time description of an LTI system.
- Understand the concepts of resonance and stability.
- Solve ODEs and use symbolic computation software to obtain the corresponding graphs.

Full-or-part-time: 44h
Theory classes: 8h 30m
Practical classes: 8h 30m
Self study : 27h

Topic 4: LAPLACE TRANSFORM

Description:
4.1. Definition of the Laplace Transform (LT)
4.2. Derivative theorem, initial value problems.
4.3. Properties of the LT.
4.4. The inverse LT.

Specific objectives:
For students to:
- Understand the concept of and calculate Laplace transforms.
- Understand the main properties of the Laplace transform: linearity, shifts, time scales and convolution, derivative theorems and initial and final value theorems.
- Solve Initial Value Problems (IVP) manually using the Laplace transform.
- Use symbolic computation software to calculate Laplace transforms and inverse Laplace transforms and to solve IVP with the Laplace transform.

Full-or-part-time: 24h
Theory classes: 5h
Practical classes: 5h
Self study : 14h

GRADING SYSTEM

It is evaluated by partial assessments with the following weights:
- 1st exam: 45%
- 2nd exam: 45%
- Tasks: 10%

In the case that the 1st exam has a mark less than 5, the mark of the 1st partial exam can be renewed with a second change examination called that will be carried out on the same date as the day set for the 2nd exam. The final grade for the 1st exam will be: if the second change examination mark is less than 5, the first partial mark fill be substituted only if the second change examination mark is higher. If the redirection grade is greater than or equal to 5, the first partial grade will be a 5.

For those students who meet the requirements and submit to the re-evaluation examination, the grade of the re-evaluation exam will replace the grades of all the evaluation acts during the course. If the final grade after re-evaluation is lower than 5, it will replace the initial one only if it is higher. If the final grade after re-evaluation is greater or equal to 5, the final grade of the subject will be pass 5.0.

To access the re-evaluation, students must have a final grade higher or iqual to 2.0 but lower than 5.0 during the teaching period.

EXAMINATION RULES.

The assessment consists of the following acts of classroom assessment and/or other activities assessed as part of continuous assessment. If not done any of the events or activities will be considered qualified to zero.

BIBLIOGRAPHY

Basic:
- James, Glyn [et al.]. Matemáticas avanzadas para ingeniería. 2ª ed. México: Pearson Educación, 2002. ISBN 9702602092.
- Antonijuan, J.; Batlle, C.; Boza, S.; Prat J. Matemàtiques de la telecomunicació [on line]. Barcelona: Edicions UPC, 2001 [Consultation: 14/05/2020]. Available on: http://hdl.handle.net/2099.3/36249. ISBN 8483015757.
- Zill, Dennis G. Ecuaciones diferenciales con aplicaciones de modelado. Novena edición. México: CENGAGE Learning, 2009. ISBN 9708300551.

Complementary:

- Haberman, Richard. Ecuaciones en derivadas parciales : con series de Fourier y problemas de contorno. 3a ed. México: Pearson-Prentice Hall, 1996. ISBN 8420535346.
- Oppenheim, Alan V. Señales y sistemas. 2a ed. México: Prentice-Hall Hispanoamericana, 1997. ISBN 970170116X.
- Almira, J.M. Matemáticas para la recuperación de señales : una introducción. Jaén: Grupo Editorial Universitario, 2005. ISBN 8484915190.
- Zill, D.G.; Cullen, M.R. Ecuaciones diferenciales con problemas de valores en la frontera. 5a ed. México D.F: Thomson, 2002. ISBN 9706861335.
- Braun, Martin. Ecuaciones diferenciales y sus aplicaciones. México D.F: Grupo Editorial Iberoamérica, 1990. ISBN 9687270586.

RESOURCES

Other resources:

- Lists of exercises for the course.
- Scripts for using MAPLE software to solve problems.