

## Course guide

### 300015 - MT - Mathematics for Telecommunications

**Last modified:** 01/06/2023

<b>Unit in charge:</b>	Castelldefels School of Telecommunications and Aerospace Engineering	
<b>Teaching unit:</b>	749 - MAT - Department of Mathematics.	
<b>Degree:</b>	BACHELOR'S DEGREE IN NETWORK ENGINEERING (Syllabus 2009). (Compulsory subject). BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2009). (Compulsory subject).	
<b>Academic year:</b> 2023	<b>ECTS Credits:</b> 6.0	<b>Languages:</b> Catalan, Spanish

#### LECTURER

---

**Coordinating lecturer:** Definit a la infoweb de l'assignatura.

**Others:** Definit a la infoweb de l'assignatura.

#### PRIOR SKILLS

---

Students are expected to demonstrate the knowledge acquired in Calculus. Students should therefore be able to:

- Operate with complex numbers and understand complex exponentiation and the Euler formula.
- Use the differential and integral calculus of one or more variables.

It is advisable to have passed or taken simultaneously

-CALCULUS

#### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

---

##### Specific:

1. CE 1 TELECOM. Students will acquire the ability to solve mathematical problems for engineering. An aptitude for applying knowledge of linear algebra, geometry, differential geometry, differential and integral calculus, differential equations and partial differential equations, numerical methods, numerical algorithms, statistics and optimisation. (CIN/352/2009, BOE 20.2.2009)

##### Transversal:

2. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

3. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.

06 URI N1. 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

Participatory lectures and cooperative learning sessions are combined during large group sessions.

In problem-solving classes, the focus is on students solving the problems themselves, although the lecturer will provide guidance if they have any questions.

At the beginning of the course, students are divided into formal groups of three or four students and each group member is assigned a role (1, 2, 3). The groups carry out several types of activities:

### 1) Cooperative learning sessions (the Jigsaw technique)

Students download the material for the session, which is divided into three separate parts (1, 2 and 3), from the digital campus. They then individually prepare the part corresponding to their role (during the time allotted for independent learning). In the following class, the students get together in expert groups, which comprise those students who share the same role, to compare their findings and if necessary ask for the lecturer's advice. Later, the formal groups get together and students explain their part to the other members in the group. Finally, the groups apply the skills worked on during the session (or the directed activity) to a set of exercises and then hand in their solutions at the end of the class

### 2) Exercises

Students will be asked to complete exercises in class or in individual study hours. In some cases, students will carry out peer evaluation of exercises using a scoring rubric before handing them in to the lecturer.

Individual feedback is given to each student on all the coursework, tests and examinations, in the form of corrections and comments on his or her work, in person or via the digital campus.

Work groups' attendance, organisation and conflict resolution skills are monitored during the course, as is their reorganisation at the end of the course.

## LEARNING OBJECTIVES OF THE SUBJECT

On completion of Mathematics for Telecommunications, students will be able to:

- Define the Laplace transform and its main properties.

Calculate the Laplace transform of common functions and the inverse Laplace transform by the partial fraction decomposition of rational functions. Apply the Laplace transform to initial value problems. Solve initial value problems with general functions and continuous piecewise functions.

- Use exponential and trigonometric Fourier series to expand common periodic functions and represent discrete frequency spectra. Apply Parseval's relation.

- Obtain and use the Fourier transform and its main properties.

Obtain and interpret the frequency spectra of common aperiodic functions.

Apply the convolution theorem and Parseval's theorem. To use several general functions.

- Calculate the expectation and variance of a random variable Calculate the function density. Calculate the probability of uniform, exponential and normal random variables.

## STUDY LOAD

Type	Hours	Percentage
Hours large group	39,0	26.00
Hours medium group	13,0	8.67
Self study	84,0	56.00
Guided activities	14,0	9.33

Total learning time: 150 h

## CONTENTS

### 1.The Laplace transform

**Description:**

The Laplace transform. Definition. Properties Inverse of a rational function. Application to initial value problem solving. Heaviside function. Laplace transform of functions defined in intervals. Generalized functions, Dirac delta. Impulse response and transfer function. Convolution theorem

**Related activities:**

Cooperative learning sessions 1, 2 and 3

Test 1

Exam 1

**Full-or-part-time:** 46h

Theory classes: 12h

Practical classes: 4h

Guided activities: 4h

Self study : 26h

### 2.Fourier analysis

**Description:**

2.1 Sequences and numerical series. Sequences: monotone increasing and decreasing, and finite and infinite limits. Series: Definition and convergence. Geometric and p-series. Convergence criteria for series of positive terms.

2.2 Fourier series: introduction. Fourier series of periodic functions. Fourier series expansion of odd and even functions. Sinusoid and cosinusoid series. Convergence: The Gibbs phenomenon, convergence in quadratic mean. Bessel's inequality and Parseval's relation.

2.3 Fourier series in complex form. Frequency spectrum.

2.4 The Fourier transform. Definition and properties. Transform calculations. Properties of the transform of a real function. Sine and cosine transforms. Parseval's identity and the energy spectrum. The convolution theorem. Graphical convolution. Generalized functions: Transform of the step function, transform of a delta train, convolution with a delta or train of deltas. Relationship between Fourier and Laplace transforms. Introduction to the discrete Fourier transform.

**Related activities:**

Cooperative learning sessions 4, 5 and 6

Tests 2

Exam 1 and exam 2

Fourier transform lab exercises.

**Full-or-part-time:** 69h

Theory classes: 18h

Practical classes: 6h

Guided activities: 7h

Self study : 38h



### 3. Probability density functions

**Description:**

Introduction to probability in a space with continuous values. Continuous random variables. Distribution and density functions. Expected value and variance.

3.2 Most common probability distributions: Uniform, Exponential, Normal or Gaussian.

3.3 Functions of a random variable.

**Related activities:**

Exam 2

**Full-or-part-time:** 35h

Theory classes: 9h

Practical classes: 3h

Guided activities: 3h

Self study : 20h

## ACTIVITIES

### COOPERATIVE LEARNING SESSION TL1

**Description:**

Preparation of theory-based learning materials that include examples of the work (roles) students will carry out during the self-directed learning hours.

Students will work on theory-based material in the classroom, first in expert groups and then in formal groups. Work on questions among students or with the help of the lecturer.

Group work on applied problems in the classroom.

The lecturer will be available in class to answer students' questions and give instructions individually or to the group. The lecturer provides feedback on the activity to each group.

**Specific objectives:**

Calculate the Laplace transform by applying the properties of elementary transformations. Solve an initial value problem.

**Material:**

Materials TL1 (available on the digital campus)

**Delivery:**

Assignment 1: Applied problems solved in the classroom

Assessment: See section on directed activities

**Full-or-part-time:** 4h 30m

Theory classes: 1h 30m

Guided activities: 2h

Self study: 1h

### COOPERATIVE LEARNING SESSION TL2

**Description:**

Preparation of theory-based learning materials that include examples of the work (roles) students will carry out during the self-directed learning hours.

Students will work on theory-based material in the classroom, first in expert groups and then in formal groups. Work on questions among students or with the help of the lecturer.

Group work on applied problems in the classroom.

The lecturer will be available in class to answer students' questions and give instructions individually or to the group. The lecturer provides feedback on the activity to each group.

**Specific objectives:**

Calculate the inverse Laplace transform of rational functions with simple complex roots by partial fraction decomposition.

Compare the three methods according to the type of decomposition and the resulting function equations.

**Material:**

Materials TL2 (available on the digital campus)

**Delivery:**

Assignment 2: Applied problems solved in the classroom

Assessment: See section on directed activities

**Full-or-part-time:** 4h 30m

Theory classes: 1h 30m

Guided activities: 2h

Self study: 1h

### COOPERATIVE LEARNING SESSION TL3

**Description:**

Preparation of theory-based learning materials that include examples of the work (roles) students will carry out during the self-directed learning hours.

Students will work on theory-based material in the classroom, first in expert groups and then in formal groups. Work on questions among students or with the help of the lecturer.

Group work on applied problems in the classroom.

The lecturer will be available in class to answer students' questions and give instructions individually or to the group. The lecturer will provide feedback on the activity to each group.

**Specific objectives:**

Transform piecewise functions using the Heaviside function. Calculate the inverse transforms of functions that are a product of a  $F(s)$  for an exponential  $e^{-as}$ . Solve initial value problems involving the aforementioned functions.

**Material:**

Materials TL3 (available on the digital campus)

**Delivery:**

Assignment 3: Applied problems solved in the classroom

Assessment: See section on directed activities

**Full-or-part-time:** 4h 30m

Theory classes: 1h 30m

Guided activities: 2h

Self study: 1h

### COOPERATIVE LEARNING SESSION SN

**Description:**

Preparation of theory-based learning materials that include examples of the work (roles) students will carry out during the self-directed learning hours.

Students will work on theory-based material in the classroom, first in expert groups and then in formal groups. Work on questions among students or with the help of the lecturer.

Group work on applied problems in the classroom.

The lecturer will be available in class to answer students' questions and give instructions individually or to the group. The lecturer provides feedback on the activity to each group.

**Specific objectives:**

Apply basic criteria to determine the convergence of numerical series of positive terms.

**Material:**

Materials SN (available on the digital campus)

**Delivery:**

Assignment 4: Applied problems solved in the classroom

Assessment: See section on directed activities

**Full-or-part-time:** 4h 30m

Theory classes: 1h 30m

Guided activities: 2h

Self study: 1h

### COOPERATIVE LEARNING SESSION SF

**Description:**

Preparation of theory-based learning materials that include examples of the work (roles) students will carry out during the self-directed learning hours.

Students will work on theory-based material in the classroom, first in expert groups and then in formal groups. Work on questions among students or with the help of the lecturer.

The lecturer will be available in the classroom to answer students' questions individually or in groups. The lecturer provides feedback on the activity to each group.

**Specific objectives:**

Be familiar with the basic characteristics of periodic functions and the values of the integrals of sine and cosine products in the interval  $[-\pi, \pi]$ . Be familiar with the basic characteristics of odd and even functions and decomposition of a function of a function even more a function. In the Maple program, observe the graphic representation of a square wave and other signals and the first terms in their Fourier series, as well as the behaviour at the discontinuities.

**Material:**

Materials SF (available on the digital campus)

**Delivery:**

Students are not required to submit an assignment for this activity because the aim is for them to acquire an understanding of the expansion of the Fourier series of a periodic signal for later courses.

**Full-or-part-time:** 3h

Theory classes: 1h

Self study: 2h

### COOPERATIVE LEARNING SESSION TF1

**Description:**

Preparation of theory-based learning materials that include examples of the work (roles) students will carry out during the self-directed learning hours.

Students will work on theory-based material in the classroom, first in expert groups and then in formal groups. Work on questions among students or with the help of the lecturer.

Group work on applied problems in the classroom.

The lecturer will be available in class to answer students' questions and give instructions individually or to the group. The lecturer provides feedback on the activity to each group.

**Specific objectives:**

Understand and apply the basic properties of the Fourier transform.

**Material:**

Materials TF1 (available on the digital campus)

**Delivery:**

Assignment 5: Applied problems solved in the classroom

Assessment: See section on directed activities

**Full-or-part-time:** 4h 30m

Theory classes: 1h 30m

Guided activities: 2h

Self study: 1h

### COOPERATIVE LEARNING SESSION TF2

**Description:**

Preparation of theory-based learning materials that include examples of the work (roles) students will carry out during the self-directed learning hours.

Students will work on theory-based material in the classroom, first in expert groups and then in formal groups. Work on questions among students or with the help of the lecturer.

Group work on applied problems in the classroom.

The lecturer will be available in class to answer students' questions and give instructions individually or to the group. The lecturer provides feedback on the activity to each group.

**Specific objectives:**

For students to be familiar with the Fourier transform of a real function. For students to be familiar with sine and cosine transforms and their relationship with the Fourier transform in the case of odd and even functions. For students to be familiar with Parseval's relation.

**Material:**

Materials TF2 (available on the digital campus)

**Delivery:**

Assignment 6: Applied problems solved in the classroom

Assessment: See section on directed activities

**Full-or-part-time:** 4h 30m

Theory classes: 1h 30m

Laboratory classes: 1h

Guided activities: 2h

## FOURIER TRANSFORM EXERCISES

**Description:**

Practical session in the classroom with laptop.

**Specific objectives:**

Analysis of audio signals using Sonic Visualizer. Difference between wave and spectrum. Spectrogram. Detect periodic components and relate signals to series calculated in class.

**Material:**

Documentation on the practical assignment available on the digital campus

**Delivery:**

File with practical solutions submitted via Atenea.

Assessment: See section on laboratory practicals.

**Full-or-part-time:** 3h

Practical classes: 1h

Self study: 2h

## TEST 1

**Description:**

Individual test. Contents topic 1

**Specific objectives:**

Calculate the Laplace transform and inverse Laplace transform by applying properties to elementary transformations. Solve an initial value problem containing rational functions, Heaviside functions and the Dirac delta.

**Material:**

Lecture notes and list of the problems available on the digital campus

**Full-or-part-time:** 21h

Theory classes: 1h

Self study: 20h

## TEST 2

**Description:**

Individual test. Contents topics 2.3 and 2.4.

**Specific objectives:**

Apply the convergence criteria of numerical series of positive terms.

Calculate the trigonometric Fourier series expansion of a periodic function. Apply Dirichlet's theorem and Parseval's relation.

**Material:**

Lecture notes and list of the problems available on the digital campus

**Full-or-part-time:** 21h 30m

Theory classes: 1h

Self study: 20h 30m





### EXAM 1

**Description:**

Contents topics 1, 2.1 i 2.2

**Material:**

Lecture notes and list of the problems available on the digital campus

### EXAM 2

**Description:**

Contents topics 2.3, 2.4 i 3

**Material:**

Lecture notes and list of the problems available on the digital campus

## GRADING SYSTEM

The evaluation criteria defined in infoweb subject will be applied.

## EXAMINATION RULES.

Tests are taken in lectures and last approximately 60 minutes.

The first examination is sat halfway through the semester (week without lectures).

The second examination is sat a week after classes have ended.

The examinations last 90 minutes.

## BIBLIOGRAPHY

**Basic:**

- Braun, Martin. Ecuaciones diferenciales y sus aplicaciones. México, D.F.: Grupo Editorial Iberoamérica, 1990. ISBN 9687270586.
- Burillo, Josep; Miralles, Alícia; Serra, Oriol. Probabilitat i estadística [on line]. Barcelona: Edicions UPC, 2003 [Consultation: 15/04/2020]. Available on: <http://hdl.handle.net/2099.3/36808>. ISBN 8483016869.
- Hsu, Hwei P.; Mehra, Raj. Análisis de Fourier. Argentina [etc.]: Addison-Wesley Iberoamericana, cop. 1987. ISBN 9684443560.

**Complementary:**

- Lathi, B. P. (Bhagwandas Pannalal). Introducción a la teoría y sistemas de comunicación. México, [etc.]: Limusa : Noriega, 1974. ISBN 9681805550.
- Leon-Garcia, Alberto. Probability, statistics, and random processes for electrical engineering. 3rd ed. Upper Saddle River, N.J.: Pearson Education, 2009. ISBN 9780137155606.
- Spiegel, Murray R. Transformadas de Laplace. Mèxic: McGraw-Hill, 1991. ISBN 9684228813.

## RESOURCES

**Other resources:**

Material available on the digital campus (Atenea):

- 1) Specific materials for the cooperative learning (Jigsaw) sessions in three sections (roles).
- 2) Lecture notes
- 3) Sets of problems
- 4) Documentation for the Fourier transform practical.

