300015 - MATEL - Mathematics for Telecommunications

Coordinating unit: 300 - EETAC - Castelldefels School of Telecommunications and Aerospace Engineering

Teaching unit: 749 - MAT - Department of Mathematics

Academic year: 2017

Degree: BACHELOR’S DEGREE IN NETWORK ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)
BACHELOR’S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2009).
(Teaching unit Compulsory)

ECTS credits: 6

Teaching languages: Catalan, Spanish

Teaching staff
Coordinator: 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.

Requirements
Students must have taken or be taking 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.
300015 - MATEL - Mathematics for Telecommunications

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 three 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.

3) Group test

The last test has two parts. The first is an individual test (problems 1 and 2); the second is a test to be completed in groups (problems 2 and 3). The final mark will be the average of the two marks.

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

<table>
<thead>
<tr>
<th></th>
<th>Total learning time: 150h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group:</td>
<td>39h 26.00%</td>
</tr>
<tr>
<td>Hours medium group:</td>
<td>13h 8.67%</td>
</tr>
<tr>
<td>Hours small group:</td>
<td>0h 0.00%</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>14h 9.33%</td>
</tr>
<tr>
<td>Self study:</td>
<td>84h 56.00%</td>
</tr>
</tbody>
</table>
## The Laplace transform

### Learning time:
- Theory classes: 12h
- Practical classes: 4h
- Guided activities: 4h
- Self study: 26h

### Description:

### Related activities:
- Cooperative learning sessions 1, 2 and 3
- Test 1

## Fourier analysis

### Learning time:
- Theory classes: 18h
- Practical classes: 6h
- Guided activities: 7h
- Self study: 38h

### Description:


### Related activities:
- Cooperative learning sessions 4, 5 and 6
- Tests 2 and 3.
- Fourier transform exercises.
### Probability density functions

<table>
<thead>
<tr>
<th>Learning time: 35h</th>
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</thead>
<tbody>
<tr>
<td>Theory classes: 9h</td>
</tr>
<tr>
<td>Practical classes: 3h</td>
</tr>
<tr>
<td>Guided activities: 3h</td>
</tr>
<tr>
<td>Self study: 20h</td>
</tr>
</tbody>
</table>

**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:**
- Test 4
### Planning of activities

<table>
<thead>
<tr>
<th>COOPERATIVE LEARNING SESSION TL1</th>
<th>Hours: 4h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 1h 30m</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 2h</td>
</tr>
<tr>
<td></td>
<td>Self study: 1h</td>
</tr>
</tbody>
</table>

#### 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.

#### Support materials:
- Materials TL1 (available on the digital campus)

#### Descriptions of the assignments due and their relation to the assessment:
- Assignment 1: Applied problems solved in the classroom
- Assessment: See section on group assignments

#### Specific objectives:
- Calculate the Laplace transform by applying the properties of elementary transformations. Solve an initial value problem.

<table>
<thead>
<tr>
<th>COOPERATIVE LEARNING SESSION TL2</th>
<th>Hours: 4h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 1h 30m</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 2h</td>
</tr>
<tr>
<td></td>
<td>Self study: 1h</td>
</tr>
</tbody>
</table>

#### 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.

#### Support materials:
- Materials TL2 (available on the digital campus)

#### Descriptions of the assignments due and their relation to the assessment:
- Assignment 2: Applied problems solved in the classroom
- Assessment: See section on group assignments
### 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.

### COOPERATIVE LEARNING SESSION TL3

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes: 1h 30m</th>
<th>Guided activities: 2h</th>
<th>Self study: 1h</th>
</tr>
</thead>
</table>

**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.

**Support materials:**
Materials TL3 (available on the digital campus)

**Descriptions of the assignments due and their relation to the assessment:**
Assignment 3: Applied problems solved in the classroom
Assessment: See section on group assignments

### 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.

### COOPERATIVE LEARNING SESSION SN

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes: 1h 30m</th>
<th>Guided activities: 2h</th>
<th>Self study: 1h</th>
</tr>
</thead>
</table>

**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.

**Support materials:**
Materials SN (available on the digital campus)
### Description of the assignments due and their relation to the assessment:

- Assignment 4: Applied problems solved in the classroom
- Assessment: See section on group assignments

### Specific objectives:

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

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#### COOPERATIVE LEARNING SESSION SF

<table>
<thead>
<tr>
<th>Description:</th>
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</table>
| 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. |

<table>
<thead>
<tr>
<th>Support materials:</th>
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<tbody>
<tr>
<td>Materials SF (available on the digital campus)</td>
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</table>

<table>
<thead>
<tr>
<th>Description of the assignments due and their relation to the assessment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific objectives:</th>
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</thead>
</table>
| 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. |

<table>
<thead>
<tr>
<th>Hours:</th>
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<tbody>
<tr>
<td>3h</td>
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<tr>
<td>Theory classes: 1h</td>
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<tr>
<td>Self study: 2h</td>
</tr>
</tbody>
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#### COOPERATIVE LEARNING SESSION TF1

<table>
<thead>
<tr>
<th>Description:</th>
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| 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. |

<table>
<thead>
<tr>
<th>Hours:</th>
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</thead>
<tbody>
<tr>
<td>4h 30m</td>
</tr>
<tr>
<td>Theory classes: 1h 30m</td>
</tr>
<tr>
<td>Guided activities: 2h</td>
</tr>
<tr>
<td>Self study: 1h</td>
</tr>
</tbody>
</table>
Support materials:
Materials TF1 (available on the digital campus)

Descriptions of the assignments due and their relation to the assessment:
Assignment 5: Applied problems solved in the classroom
Assessment: See section on group assignments

Specific objectives:
Understand and apply the basic properties of the Fourier transform.

COOPERATIVE LEARNING SESSION TF2

Hours: 4h 30m
Theory classes: 1h 30m
Guided activities: 2h
Laboratory classes: 1h

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.

Support materials:
Materials TF2 (available on the digital campus)

Descriptions of the assignments due and their relation to the assessment:
Assignment 6: Applied problems solved in the classroom
Assessment: See section on group assignments

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.

FOURIER TRANSFORM EXERCISES

Hours: 3h
Practical classes: 1h
Self study: 2h

Description:
Practical session in the computer room using SAGE software.

Support materials:
Documentation on the practical assignment available on the digital campus

Descriptions of the assignments due and their relation to the assessment:
SAGE file with practical solutions submitted via internet.
Assessment: See section on laboratory practicals.
### Specific objectives:
Understand the functions of the SAGE program for graphic representation of samples of a signal and discrete Fourier transform. Apply them to the recovery of a signal from noise.

### TEST 1

<table>
<thead>
<tr>
<th>Hours: 10h 30m</th>
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</thead>
<tbody>
<tr>
<td>Theory classes: 0h 30m</td>
</tr>
<tr>
<td>Self study: 10h</td>
</tr>
</tbody>
</table>

**Description:**
Individual test. Two or three exercises similar to the ones in the list of problems worked on in class.

**Support materials:**
Lecture notes and list of the problems available on the digital campus

**Descriptions of the assignments due and their relation to the assessment:**
Test
Assessment: Section on tests (10%)

**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.

### TEST 2

<table>
<thead>
<tr>
<th>Hours: 10h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 0h 30m</td>
</tr>
<tr>
<td>Self study: 10h</td>
</tr>
</tbody>
</table>

**Description:**
Individual test. Two or three exercises similar to the ones in the list of problems worked on in class.

**Support materials:**
Lecture notes and list of the problems available on the digital campus

**Descriptions of the assignments due and their relation to the assessment:**
Test
Assessment: Section on tests (10%)

**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.

### TEST 3

<table>
<thead>
<tr>
<th>Hours: 10h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 0h 30m</td>
</tr>
<tr>
<td>Self study: 10h</td>
</tr>
</tbody>
</table>
TEST 4

Description: Individual test. Two or three exercises similar to the ones in the list of problems worked on in class.

Support materials: Lecture notes and list of the problems available on the digital campus.

Descriptions of the assignments due and their relation to the assessment:
Completed test (for the second part, one per group, signed by all members)
Assessment: Section on tests (10%)

Specific objectives:
- Calculate probability using distribution and density functions. Calculate expectation and variance. Apply the most common distributions to problems.

Qualification system

The evaluation criteria defined in infoweb subject will be applied.
Regulations for carrying out activities

Tests are taken in lectures and last approximately 30 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:


Complementary:


Others 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.