230460 - PE - Probability and Statistics

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Teaching unit Compulsory)
ECTS credits: 6
Teaching languages: Catalan, Spanish

Teaching staff
Coordinator: JOSEP FÀBREGA CANUDAS
Others: JOSEP FÀBREGA CANUDAS
JORGE LUIS VILLAR SANTOS

Prior skills
Derivatives and integrals of functions of one and several variables.

Degree competences to which the subject contributes

Specific:
2. Ability to select numerical and optimization methods suitable for solving physical and engineering problems. Ability to apply the knowledge of numerical algorithms and optimization.
1. Ability to solve math problems that may arise in engineering. Ability to apply knowledge about linear algebra, geometry, differential geometry, differential and integral calculus, ordinary and partial differential equations, probability and statistics.

General:
1. ABILITY TO IDENTIFY, FORMULATE, AND SOLVE PHYSICAL ENGINEERING PROBLEMS. Planning and solving physical engineering problems with initiative, making decisions and with creativity. Developing methods of analysis and problem solving in a systematic and creative way.

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.

Teaching methodology
There will be three theoretical and two practical weekly sessions. The theoretical lectures will be devoted to a careful presentation of the basic concepts and the main results which will be illustrated with some examples. The practical sessions will be devoted to the solution of a variety of exercises and problems.

Learning objectives of the subject
To study random variables and stochastic processes as main tools for modelling random phenomena. To present the applications of probability theory to statistical inference.

Learning outcomes:
- To use correctly the formal mathematical language of probability theory.
- To master probability calculus and the use of random variables an random vectors.
- To known the main ideas and methods of Statistics.
- To know the main concepts on stochastic processes.
- To understand the Poisson process and others of interest in physics and engineering.
# Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 65h</th>
<th>43.33%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Self study: 85h</td>
<td>56.67%</td>
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## Content

<table>
<thead>
<tr>
<th>Section</th>
<th>Learning time: 21h</th>
</tr>
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<tbody>
<tr>
<td>1. Basic Probability</td>
<td>Theory classes: 5h</td>
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<td></td>
<td>Practical classes: 4h</td>
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<tr>
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<td>Self study: 12h</td>
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### Description:
1.1 Deterministic and stochastic mathematical models. Random experiments. Classical and frequency definitions of probability.
1.2 Axiomatic definition of probability. Discrete and continuous probability spaces.
1.3 Independence and conditional probability. The law of total probability and Bayes' formula.

<table>
<thead>
<tr>
<th>Section</th>
<th>Learning time: 22h</th>
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<tbody>
<tr>
<td>2. Random Variables</td>
<td>Theory classes: 6h</td>
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<tr>
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<td>Practical classes: 4h</td>
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<tr>
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<td>Self study: 12h</td>
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### Description:
2.1 The notion of random variable. Probability distribution function.
2.2 Discrete random variables. Examples: Bernoulli, binomial, geometric, Poisson.
2.4 Conditional distribution and density functions.
2.5 Functions of a random variable.

<table>
<thead>
<tr>
<th>Section</th>
<th>Learning time: 10h</th>
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<tbody>
<tr>
<td>3. Statistical Parameters</td>
<td>Theory classes: 2h</td>
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<td></td>
<td>Practical classes: 2h</td>
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<tr>
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<td>Self study: 6h</td>
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</tbody>
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### Description:
3.1 Mean and variance.
3.2 Expectation theorem. Moments and central moments.
3.3 Markov and Chebyshev's inequalities. Frequency interpretation of probability.
### 4. Random Vectors

**Learning time:** 27h  
- Theory classes: 7h  
- Practical classes: 4h  
- Self study: 16h  

**Description:**  
4.1 Multidimensional random variables. Joint distribution and density functions.  
4.3 Functions of several random variables. Sum of independent random variables: convolution theorem.  
4.4 Expectation of sums and products. Covariance and correlation coefficient.  
4.5 Multidimensional Gaussian random variables.

### 5. Statistical Inference

**Learning time:** 42h  
- Theory classes: 12h  
- Practical classes: 7h  
- Self study: 23h  

**Description:**  
5.1 The weak law of the large numbers. The central limit theorem.  
5.2 Distributions arising from the normal law (chi-square, t, F).  
5.3 Sampling. Parameter estimation.  
5.4 Confidence intervals. Statistical hypothesis testing. Distribution fitting.  
5.5 Least squares estimation.

### 6. Introduction to Stochastic Processes

**Learning time:** 14h  
- Theory classes: 4h  
- Practical classes: 2h  
- Self study: 8h  

**Description:**  
6.1 The notion of stochastic process. Distribution and density functions of order n.  
6.2 Mean, autocorrelation and autocovariance of a process.  
6.2 Strict and wide sense stationary stochastic processes.  
6.3 Gaussian processes.
# 7. The Poisson Process

**Learning time:** 14h

- **Theory classes:** 4h
- **Practical classes:** 2h
- **Self study:** 8h

**Description:**

- 7.1 The Poisson process. Transitions statistics.
- 7.2 Processes arising from the Poisson process.
- 7.3 Introduction to time-continuous Markov processes.

## Qualification system

There will be a final exam (EF) and a partial exam (EP). The students' participation in practical sessions will be also taken into account (P). The final score will follow from:

$$\max(\text{EF}, 0.65 \times \text{EF} + 0.30 \times \text{EP} + 0.05 \times P)$$

Students who do not pass the subject in the ordinary call may do an extraordinary exam at the end of the academic year.

## Bibliography

**Basic:**


**Complementary:**


**Others resources:**

- Aroca, J.M. Probabilitat i Procesos Estocàstics, classnotes ETSETB.
- Aroca, J.M. Estadística, classnotes ETSETB.