Course guide
320106 - PPE - Probability and Stochastic Processes

Last modified: 19/04/2023

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: Mañosa Fernandez, Victor

Others:

PRIOR SKILLS

As a general rule, students are expected to have passed all the previous subjects with mathematical content in the first year to be able to take this subject. An understanding of integral calculus and Fourier analysis is particularly important.

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.

Transversal:
CT06 N2. Self-directed learning - Level 2Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.

Basic:
CB2. That students can apply their knowledge to their work or vocation in a professional manner and possess the competencies typically demonstrated through the development and defense of arguments and problem-solving within their field of study.

TEACHING METHODOLOGY

- Face-to-face lecture sessions.
- Face-to-face practical work sessions.
- Independent learning and work with exercises.

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

Students are expected to study in their own time in order to become familiar with concepts and be able to solve the exercises proposed, whether manually or with the help of a computer.

LEARNING OBJECTIVES OF THE SUBJECT

To familiarize students with techniques and methods of probabilistic modelling through random variables and stochastic processes. Teach students to apply with sound judgement these techniques to solve practical problems that engineers have to face in their professional everyday activity, and for which a probabilistic-statistical type of model may give a more suitable practical solution than a deterministic model. Use appropriate software to find solutions to problems tackled over the course. Build on the specific and transversal competences associated with coursework, as described below.

STUDY LOAD

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

Total learning time: 150 h

CONTENTS

TOPIC 1: Probability

Description:
1.1. The concept of probability. Axioms and properties.
1.2. Conditional probability. Independence.
1.3. Total probability and Bayes theorems.

Specific objectives:
- For students to:
- Describe the result of a random experiment in terms of the sample space and its subsets.
- Define the probability function.
- Apply the properties of the probability function.
- Become familiar with conditional probability.
- Become familiar with independent events.
- Apply total probability and Bayes theorems properly.

Full-or-part-time: 15h
Theory classes: 3h
Practical classes: 3h
Self study : 9h

TOPIC 2: One-dimensional random variables

Description:
2.1 Discrete and continuous random variables. Probability distribution of a random variable.
2.2 Distribution function. Probability density function.
2.3 Function of a random variable
2.4 Expectation, variance and standard deviation.
2.5 Binomial geometric, negative binomial and Poisson distributions.
2.6 Exponential, uniform, normal and gamma distributions.
2.7 Central limit theorem. Normal approximations.

Specific objectives:
-For students to:
- Understand the basic characteristics of probability models and acquire a working knowledge of how they work.
- Interpret expectation and variance of a random variable.
- Work with random variables.
- Understand and work with models commonly used in engineering.
- Use adequate software for probability calculations and solving inverse problems with random variables.
- Understand and apply the normal approximation concept.

Full-or-part-time: 30h
Theory classes: 6h
Practical classes: 6h
Self study : 18h

TOPIC 3: Multidimensional random variables

Description:
3.1 Joint distribution of two variables.
3.2 Marginal distributions.
3.3 Conditional distributions. Independence of two random variables.
3.4 Distribution of a function of a random vector. Expected value of a function of two random variables.
3.5 Conditional expectation
3.6 Covariance. Correlation coefficient.
3.7 Operating with random variables: sum, product and quotien. Central limit theorem revisited
3.8 Bivariate normal distribution.
3.9 n dimensional random vectors. Multivariate normal distribution.

Specific objectives:
For students to:
- Understand the usual characteristics and parameters to study multidimensional random variables, particularly in the case of two random variables.
- Understand the concept of conditional expectation and independence in random variables.
- Understand how to operate with random variables.
- Apply matrix notation for dimension n random vectors.

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

TOPIC 4: Estimation

Description:
4.1 Mean square estimation of a non observed random variable.
4.2 Parameter estimation on a random model.

Specific objectives:
For students to:
- Estimate the value of a variable not directly observable by observing an alternative variable.
- Know the usual estimators for expectation and variance, as well as the concept of efficient unbiased estimator.
- Find point estimators of a parameter through sample information.
- Understand the concept of confidence interval and how to use it to assess the estimation error.

Full-or-part-time: 20h
Theory classes: 4h
Practical classes: 4h
Self study : 12h

TOPIC 5: Stochastic processes

Description:
5.1 Stochastic Processes. Definition, general characteristics and properties.
5.2 Strictly stationary process (SS) and wide sense stationary (WSS). Properties.
5.3 Wide sense stationary gaussian process.
5.4 Ergodicity in the mean and in the autocorrelation.

Specific objectives:
For students to:
- Understand the definition, characteristics and standard parameters for the study of stochastic processes.
- Understand the concepts of stationary, wide sense stationary and ergodic processes.
- Understand some of the mainly used stochastic processes models in telecommunication and audiovisual systems engineering.

Full-or-part-time: 27h
Theory classes: 5h 30m
Practical classes: 5h 30m
Self study : 16h

TOPIC 6: Elements for random signal analysis and processing

Description:
6.1 Power spectral density of a WSS process.
6.2 Wiener-Kinchine theorem.
6.3 Power spectral density properties for a WSS process
6.4 Cross spectra for wide sense stationary processes.
6.5 LTI systems with stochastic inputs
6.6 Response expectation for a WSS input to an LTI system.
6.7 Autocorrelation and power spectral density of the response to an LTI system with a WSS input.

Specific objectives:
For students to:
- Understand the definition of power spectrum for a deterministic process and learn to establish analogies with deterministic processes.
- Understand linear processes and their application to random signal filtering.

Full-or-part-time: 13h
Theory classes: 2h 30m
Practical classes: 2h 30m
Self study : 8h

ACTIVITIES

(ENG) AVALUACIÓ

Full-or-part-time: 1h
Theory classes: 1h

(ENG) TREBALL ASSISTIT PER ORDINADOR

Description:
Over the course of the semester the student will be asked to make use of appropriate software, in order to better assimilate certain concepts and solve certain exercises.

Full-or-part-time: 1h
Theory classes: 1h

GRADING SYSTEM

The final mark Nf will be obtained by weighted aggregation of marks given for assessment items A1 A2 A3 and A4, with weights 10%, 40%, 10% and 40% respectively, through the following formula:

Nf=màx{0.1·a1+0.4·a2, 0.5·a2}+ màx{0.1·a3+0.4·a4, 0.5·a4}

where ai is the mark in Ai.

This allows overcoming unsatisfactory marks in A1 and A3 through accumulating the weight of A1 in A2, and the weight of A3 in A4, when needed.

The grade of the first partial exam (that is màx{0.1·a1+0.4·a2, 0.5·a2}) can be re-conducted with a second-chance examination that will be done on the same date and time of the second partial. Any student enrolled may be admitted to this test. The final qualification of the first partial will be the maximum of the one of the first partial exam and that of the second-chance examination, say test R.

The corrected final grade Nf (R), for the students who take the R test and obtain the r grade, will be:

Nf(R)=màx{màx{0.1·a1+0.4·a2, 0.5·a2}, 0.5·r}+ màx{0.1·a3+0.4·a4, 0.5·a4}

For those students who meet the requirements and submit to the reevaluation examination, the grade of the reevaluation exam will replace all the grades obtained during the course.

If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

EXAMINATION RULES.

The evaluation consists in face-to-face assessment acts. When not done they will be qualified with zero.

BIBLIOGRAPHY

Basic:
- Devore, Jay L. Probabilidad y estadística para ingeniería y ciencias. 6a ed. México: Thomson, 2005. ISBN 9706864571.
- Leon-Garcia, Alberto. Probability, statistics and random processes for electrical engineering. 3a ed. Upper Saddle River: Pearson Education, 2009. ISBN 9780137155606.

Complementary:
- Gubner, John A. Probability and random processes for electrical and computers engineers. 1st ed. Cambridge [etc]: Cambridge University Press, 2006. ISBN 9780521864701.
- Papoulis, Athanasios. Probability, random variables and stochastic processes. 4th ed. Boston: McGraw-Hill, 2002. ISBN 0073660116.
- Montgomery, Douglas C. Probabilidad y estadística aplicadas a la ingeniería. 2a ed. México: Limusa, 2002. ISBN 9789681859152.
- Forcada, Santiago. Elements d'estadística [on line]. Barcelona: Edicions UPC, 2007 [Consultation: 14/05/2020]. Available on: http://hdl.handle.net/2099.3/36675. ISBN 9788483019269.
- Alberola López, Carlos. Probabilidad, variables aleatorias y procesos estocásticos : una introducción orientada a las telecomunicaciones. Valladolid: Universidad de Valladolid. Secretariado de Publicaciones e Intercambio Editorial, cop. 2004. ISBN 848448307X.

RESOURCES

Other resources:
Lecture Notes. Available on Atena.
Collection of solved problems. Available Atena.
List of proposed problems. Available Atena.

Notes on theory of the whole subject. Available on Athena.
Collection of problems solved by each subject of the course. Available Athena
List of proposed problems. Available Athena.