Course guide
820002 - ES - Statistics

Last modified: 02/07/2025

Unit in charge: Barcelona East School of Engineering
Teaching unit: 749 - MAT - Department of Mathematics.

Degree: BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: LUIS EDUARDO MUJICA DELGADO - PABLO BUENESTADO CABALLERO

Others:

Tardor/Otoño/Autumn:
EDWIN SANTIAGO ALFÉREZ BAQUERO
ALEJANDRO CACERES DOMINGUEZ
ALBERTO FERNANDEZ BOIX
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REQUIREMENTS

ÀLGEBRA I CÀLCUL MULTIVARIABLE - Precorequisit
CÀLCUL - Prerequisit
CÀLCUL NUMÈRIC - EQUACIONS DIFERENCIALS - Precorequisit

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

Transversal:
2. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 2. Using strategies for preparing and giving oral presentations. Writing texts and documents whose content is coherent, well structured and free of spelling and grammatical errors.

TEACHING METHODOLOGY

The teaching methodology is distributed as follows:
- Lectures: 30%
- Practice classes with computer: 10%
- Study of didactic material: 35%
- Resolution of problems: 20%
- Exams 5%

LEARNING OBJECTIVES OF THE SUBJECT

Consolidate the fundamental concepts of statistics.

Identify the role of statistics in engineering problems.

Improve the students' skills in applying statistical tools to engineering modeling and problem-solving.

Use statistics to solve engineering problems or establish models.

STUDY LOAD

Type	Hours	Percentage
Hours large group	45,0	30.00
Self study	90,0	60.00
Hours small group	15,0	10.00

Total learning time: 150 h

CONTENTS

1. INTRODUCTION

Description:
Statistics in engineering.

Objectives of statistics.

Statistical method.

History of statistics.

Specific objectives:
Demonstrate the important role of Statistics as a methodology in the study and resolution of various problems in engineering.

Understand and appraise the possibilities of Statistics.

Review the historical evolution of Statistics.

Learn to install and start working with the statistical software R.

Related activities:
Practice 1: Introduction to R.

Full-or-part-time: 3h
Theory classes: 1h 30m
Laboratory classes: 1h
Self study : 0h 30m

2. DESCRIPTIVE STATISTICS

Description:
Definition of descriptive statistics (exploratory data analysis).

Objectives of descriptive statistics.

General concepts (population, sample, variable, observation).

Types of data.

Frequency distribution.

Graphic representations.

Measures of central tendency.

Measures of variability.

Boxplot.

Sample moments.

Chebyshev inequality.

Measures of skewness and kurtosis.

Linear regression.

Specific objectives:
Describe a methodology for organizing, representing and summarizing data sets to facilitate their evaluation and interpretation.

Know and appreciate the techniques for obtaining information from data.

Use the R software as a tool for the statistical descriptive analysis of a data set.

Build frequency tables.

Represent frequency tables.

Calculate and interpret the numerical descriptive measures of a data set.

Construct and interpret the boxplot.

Learn to calculate the parameters of the linear regression and evaluate the goodness of fit.

Related activities:
Practice 2: Descriptive statistics

Practice 3: Linear Regression

POA

Full-or-part-time: 14h
Laboratory classes: 4h
Self study : 10h

3. ELEMENTS OF PROBABILITY

Description:
Definition of probability.

Sample space of a random experiment.

Events. Types of events.

Operations with events.

Probability rules.

Conditional probability.

Independent events.

Total probability theorem. Bayes theorem.

Some counting rules: permutations, variations, combinations.

Specific objectives:
Describe the outcomes of a random experiment in terms of the sample space.

Define the probability function.

Know the probabilistic elements for modeling random systems.

Understand and apply the concepts of conditional probability and independent events.

Know the main probability rules and apply them judiciously in practical problem-solving.

Describe, motivating through practical examples, many of the concepts needed for the study of statistical inference.

Related activities:
Resolution of a report on probability problems

PEU

Full-or-part-time: 16h
Theory classes: 6h
Self study : 10h

4. DISCRETE RANDOM VARIABLES AND CONTINUOUS RANDOM VARIABLES

Description:
Definition of a discrete random variable.

Probability mass function.
Probability distribution function.
Measures of central tendency.
Measures of dispersion.
Moments of a random variable.
Chebychev theorem.
Transformation of random variables.

Definition of a continuous random variable.

Probability density function.
Probability distribution function.
Measures of central tendency.
Measures of dispersion.
Moments of a random variable.
Chebychev theorem.
Transformation of random variables.

Specific objectives:
Present the concept of discrete random variables.

Calculate and interpret the expectation and variance of random variables.
Understand and properly handle discrete random variables.
Relate the new concepts with those studied in descriptive statistics.

Present the concept of continuous random variables.

Calculate and interpret the expectation and variance of random variables.
Understand and properly handle discrete random variables.
Relate the new concepts with those studied in descriptive statistics.

Related activities:
Resolution of a report on discrete random variable problems

Resolution of a report on continuous random variable problems

PEU

Full-or-part-time: 20h 30m
Theory classes: 6h
Self study : 14h 30m

5. DISCRETE PROBABILISTIC MODELS AND CONTINUOUS PROBABILISTIC MODELS IN ENGINEERING

Description:
DISCRETE MODELS:

Uniform distribution.
Bernoulli, binomial, negative binomial, and hypergeometric distribution.
Poisson distribution.

CONTINUOUS MODELS:

Uniform distribution.
Exponential distribution.
Normal distribution.

Specific objectives:
Define and study the probability distributions most commonly used in engineering.

Use the R software as a computational tool for solving problems on probabilities and random variables.

Related activities:
Resolution of problems on probabilistic models

Practice 4: Discrets Probabilistic models

Practice 5: Continuous Probabilistic models

PDAI

Full-or-part-time: 24h
Theory classes: 6h
Laboratory classes: 4h
Self study : 14h

6. SAMPLING. CENTRAL LIMIT THEOREM

Description:
Types of sampling.

Statistical distributions.

Laws of large numbers.

Central Limit Theorem.

Distribution of the mean and sum of variables.

Distribution of the sample variance of the normal variable.

Specific objectives:
Present some basic theoretical elements associated with random sampling and statistical inference.

Know the most common techniques of data collection.

Illustrate different techniques that allow applying the inductive process of statistical inference to obtain useful and reliable results.

Learn some practical applications of the central limit theorem.

Use the normal distribution to approximate some discrete distributions.

Related activities:
Resolution of a report on sampling problems

Practice 6: Sampling. Sampling distributions of statistics

PDAI

Full-or-part-time: 20h
Theory classes: 6h
Laboratory classes: 2h
Self study : 12h

7. POINT ESTIMATION AND INTERVAL ESTIMATION

Description:
Point estimation: method of moments and method of maximum likelihood.

Estimators: definition and properties.

Confidence interval estimation of the mean, variance and proportion.

Specific objectives:
Estimate the value of a parameter from sample information.

Study the two most common methods for determining point estimates.

Study the most important properties of the estimators.

Know the sampling distributions of the estimators associated with normal, binomial and Poisson random variables.

Explain and apply interval estimation of the mean and variance of normal populations and approximately normal populations.

Use common sampling distributions, such as the Student's T distribution.

Know how to use the tables of the usual distributions associated with interval estimation.

Use the R software for calculating confidence intervals.

Related activities:
Resolution of problems on point estimation

Resolution of problems on interval estimation

Practice 7: Confidence intervals

PDU

Full-or-part-time: 23h
Theory classes: 9h
Laboratory classes: 2h
Self study : 12h

8. HYPOTHESIS TESTING

Description:
Hypothesis testing of parametric models.

Errors associated with hypothesis testing.

p-value computation.

Statistical power.

Model testing.

Specific objectives:
Study statistical hypothesis testing and its application to means, proportions and variances.

Be able to apply judiciously the most common statistical tests, appreciating their possibilities and limitations.

Calculate the p-value associated to a hypothesis test.

Understand the decision errors associated with hypothesis testing.

Use the R software as a computational tool to solve problems on statistical hypothesis tests.

Related activities:
Resolution of problems on statistical hypothesis testing

Practice 8: Hypothesis testing

PDU

Full-or-part-time: 29h 30m
Theory classes: 10h 30m
Laboratory classes: 2h
Self study : 17h

GRADING SYSTEM

The subject is governed by a continuous assessment system, where the final grade is obtained from the weighted sum of four tests:

POA: Asynchronous Online Test. A test taken on the virtual platform outside the classroom, available during a time window of a couple of days. (17%)

PEU: Unified Written Test. An in-person test taken on paper, at a single date and time for all groups of the subject. (25%)

PDAI: Digital Test in Computer Lab. An in-person computer-assisted test, conducted during regular class hours in the computer lab of each enrollment group. (20%)

PDU: Unified Digital Test. An in-person computer-assisted test, at a single date and time for all groups of the subject. Each person will attend with a laptop. (38%)

For more details, please carefully read the section on EXAMINATION RULES.

This subject does NOT have a re-evaluation test.

EXAMINATION RULES.

POA: Asynchronous Online Test
This assessment covers the following topics: Introduction to R, Descriptive Statistics, and Linear Regression.

Read the instructions carefully before starting the test.
Once started, you'll have 2 hours to complete and submit the questionnaire.
The questionnaire consists of 7 questions.
You have only one attempt to complete it.
Use the decimal point (.) to separate decimal figures.
Do not make approximations; enter all digits provided by R.
It's mandatory to attach the executed R code in the corresponding box at the end of each exercise.
The grade will be published upon the questionnaire's closing.
You have access to both the Spanish and Catalan versions. You must solve only one version. If you complete both questionnaires, your final grade will be the lower of the two recorded.

PEU: Unified Written Test
The first in-person Statistics exam is conducted in a continuous 60-minute session.
Students must be seated in their assigned classroom at the designated time and place their belongings against the wall, without disturbing anyone.
No one may leave the classroom until 30 minutes have passed from the start of the test.
This exam focuses on evaluating Probability and Random Variables topics and consists of 3 problems, each with several questions.

The rules for the in-person exam are as follows:
The use of a non-programmable calculator is permitted.
The use of digital material, notes, books, or tables is not permitted.
Professors will bring a stapled dossier for each student to the classroom. The dossier must not be unstapled at any time. Each dossier contains 5 single-sided printed sheets:

Sheet 1: Draft
Sheet 2: Form
Sheet 3: Problem 1
Sheet 4: Problem 2
Sheet 5: Problem 3

The exam form that will be included in the dossier can be found on the ATENEA metacourse.

Each person is free to start the exam by answering the problem they deem appropriate. It is advisable to organize time well throughout the test.
The exam consists of 3 problems that must be solved on the same sheets as the statements (each solution on its own sheet). Anything written on the draft or the form will not be graded.
Each person must write their full name in CAPITAL LETTERS, group, DNI/Pass, and Identifier on each exercise sheet, even if a problem is not answered.
It is mandatory to write a coherent development of the answers when solving the problems. In the evaluation of each problem's solution, a lack of development and/or its inconsistency will be penalized.
Submitting problem answers in pencil or red pen is not permitted.
It is mandatory to take the test in the assigned classroom and keep your DNI/Pass or UPC card visible on the desk during the test.
The form sheet can also be used as a draft.
Professors will not answer questions related to the subject during the session.
At the end of the test, students will collect their belongings and hand in the stapled dossier before leaving the classroom.

PDAI: Digital Test in Computer Lab
The test is conducted in the computer lab during each enrollment group's regular class hours on the day shown in ATENEA.

Test rules:
Each student must attend the group in which they are enrolled.
Students can choose to take the questionnaire in Catalan or Spanish, but not both. Those who use both will receive the lower score of the two questionnaires.

The test has a maximum duration of 90 minutes and consists of 3 problems.
The use of any additional physical support other than the computer and a pen is NOT allowed. If necessary, professors will provide blank sheets.
Calculators, tablets, additional computers, smartwatches, mobile phones, etc., are not permitted.
The use of any IT support is NOT allowed; only access to the ATENEA questionnaire and the R console is permitted.
The use of online communication tools, personal notes, calculation websites, or artificial intelligence tools is not permitted.
Students must keep their DNI or UPC card visible on the desk during the activity.
Professors will not answer conceptual questions during the assessment.
At the end of the test, students will collect their belongings and leave the classroom without disturbing the rest of the group.

PDU: Unified Digital Test
The test has a maximum duration of 90 minutes and consists of 4 problems: one on point estimation, one on confidence intervals, and two on hypothesis testing.

Test rules:
The exam is in-person and is solved on a laptop. Therefore, each person must attend the test with a laptop properly configured for internet access without inconveniences (eduroam installed, active access keys, etc.). The subject's teaching staff will not assume responsibility for technical issues that arise if the student does not use the university's WIFI connection to access the internet.
It is not permitted to attend the exam with support material, either on paper or in digital format (notes, books, forms, tables, algorithms, images, web links, etc.).
The use of Artificial Intelligence or messaging is not permitted during the exam.
Only the use of the test questionnaire, designed in Atenea, and the R console for its resolution is allowed.
Professors will bring blank sheets to the classroom to be distributed for use as scratch paper, which will not be assessment material.
Each person is free to start by answering the problem they deem appropriate, although it is advisable to tackle the simplest problem first. It is convenient to manage time well throughout the test.
It is mandatory to take the test in the assigned classroom and keep your DNI/pass or UPC card visible on the desk during the activity.
Professors will not answer questions related to the subject or technical issues during the session.
At the end of the test, students will collect their belongings and leave the classroom without disturbing the rest of the group.

IMPORTANT: Aspects to consider in the questionnaire:
Access the "PDU QUESTIONNAIRE" (Statistics Metacourse in Atenea).
Complete the test in a single browser session (do not close the window before submitting).
It is mandatory to submit the questionnaire before the test time ends.
Any answers you enter after 90 minutes will not be stored in the questionnaire and will not be considered for the exam.
Use the R console.
Calculate using the maximum number of decimal places in the different operations.
Enter at least 4 decimal places in each answer, rounding appropriately.
Use the decimal point and not the decimal comma.

The UPC's academic regulations define academic fraud as a serious offense, understood as any premeditated behavior intended to falsify the results of an exam or assignment that was completed as a requirement to pass a subject. This action will result in a descriptive grade of "Fail" and a numerical grade of 0 for the global evaluation of the subject, without prejudice to any disciplinary process that may arise as a consequence of the actions performed.

BIBLIOGRAPHY

Basic:
- Pujol Vázquez, G.; Gibergans Bàguena, J.; García Ciaurri, F. Problemes d'estadística amb aplicació a l'enginyeria. Barcelona: UOC, 2009. ISBN 9788497887748.
- Mújica Delgado, Luis Eduardo; Ruiz Ordoñez, Magda Liliana. Prácticas de estadística utilizando R : aplicaciones en problemas de ingeniería [on line]. Barcelona: Iniciativa Digital Politècnica. Oficina de Publicacions Acadèmiques Digitals de la UPC, 2021 [Consultation: 10/10/2022]. Available on: https://upcommons.upc.edu/handle/2117/353240. ISBN 9788498809459.
- Pozo Montero, F. [et al.]. Probabilitat i estadística matemàtica : teoria i problemes resolts [on line]. Barcelona: Iniciativa digital politècnica, 2010 [Consultation: 05/03/2012]. Available on: http://hdl.handle.net/2099.3/36649. ISBN 9788476535295.
- Montgomery, D. C.; Runger, G. C. Applied statistics and probability for engineers. 4th ed. New York [etc.]: John Wiley & Sons, cop. 2006. ISBN 9780471745891.
- Navidi, William; Murrieta Murrieta, Jesús Elmer; Martínez Velasco, Antonieta. Estadística para ingenieros y científicos. Quinta edición. Ciudad de México: McGraw Hill, 2022. ISBN 9781456293147.
- Devore, Jay L. Probabilidad y estadística para ingeniería y ciencias. 6ª ed. México [etc.]: Thomson, cop. 2005. ISBN 9706864571.

Complementary:
- Delgado de la Torre, R. Probabilidad y estadística para ciencias e ingenierías. Madrid: Delta, cop. 2008. ISBN 8496477746.
- Ipiña, S. L. Inferencia estadística y análisis de datos. Madrid: Pearson Educación, 2008. ISBN 9788483224045.
- Sawitzki, G. Computational statistics : an introduction to R. Boca Raton: CRC Press, cop. 2009. ISBN 9781420086782.
- Gonick, L.; Smith, W. La Estadística en comic. Barcelona: Zendrera Zariquiey, 1999. ISBN 8484180417.
- Horra Navarro, J. de la. Estadística aplicada. 3ª ed. Madrid: Díaz de Santos, 2003. ISBN 8479785543.
- Spiegel, M. R. Probabilidad y estadística. 3a ed. México [etc.]: McGraw-Hill, cop. 2010. ISBN 9786071502704.
- Pérez-Díaz, Sonia; Blasco, Ángel. Modelos aleatorios en ingeniería. Madrid: Paraninfo, cop. 2015. ISBN 9788428337236.
- Navidi, W.; García Hernández, A. E. Estadística para ingenieros. México [etc.]: McGraw-Hill, cop. 2006. ISBN 9701056299.
- Dodge, Yadolah. The concise encyclopedia of statistics. New York [etc.]: Springer, [2010]. ISBN 978-1-4419-1390-6.

RESOURCES

Audiovisual material:
- Nom recurs. Resource

Computer material:
- Probabilitat i estadística matemàtica : teoria i problemes resolts. https://discovery.upc.edu/discovery/fulldisplay?docid=alma991000642479706711&context=L&vid=34CSUC_UPC:VU1&lang=ca

Other resources:
Supporting teaching material that will be shown in ATENEA throughout the course:

NOTES AND SLIDES.
EXPLANATORY VIDEOS OF THE THEORETICAL FUNDAMENTS
SOLVED PROBLEMS
PROPOSED PROBLEMS
PROBLEM RESOLUTION FORUM
QUESTIONNAIRES
COMMUNICATION FORUM
VIDEOS FOR EACH OF LAB COMPUTER SESSION