Course guide
220109 - DECQ - Experimental Designs and Quality Control

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Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 715 - EIO - Department of Statistics and Operations Research.

Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2025 **ECTS Credits:** 4.5 **Languages:** Catalan

LECTURER

Coordinating lecturer: Algaba Joaquin, Ines M.

Others: Fernández Martínez, Daniel
Rivera Fusalba, Oriol

PRIOR SKILLS

This is an undoubtedly applied subject to the professional practice of engineering, which requires good theoretical and practical knowledge of statistics. It is recommended to have taken and passed the basic 6 ECTS subject "Statistics" taught in the second year.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE01-INDUS. Ability to solve mathematical problems that may arise in engineering. Aptitude to apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential and partial differential equations; numerical methods; numerical algorithms; statistics and optimization. (Basic training module)
CE24-GRETI. Applied knowledge of manufacturing systems and processes, metrology, and quality control. (Specific Technology Module)

Generical:
3. THE ABILITY TO ANALYSE AND SYNTHESISE: The ability to think abstractly about the fundamental concepts of a text or exposition and to intelligibly present the result of one's work.

TEACHING METHODOLOGY

Although this course is clearly applicable in professional engineering activities, it requires solid theoretical and practical knowledge of statistics. Therefore, a requirement to be able to succeed in the present course is having enrolled and passed the second year 6 ECTS course "Statistics"
A real problem to be addressed is introduced at the beginning of each theory lesson. The appropriate statistical tools and methods needed to solve the problem are presented together with a previous description of the concepts that are the basis of their development. The second part of each lesson is a real case study in which the student becomes conscious of the practical application of each method and can check if he/she has understood correctly the involved concepts. The lectures are complemented with a weekly session of exercises and problems.
Although there are a number of literature references regarding the course topics, only few of them have the needed precision and accuracy. The available manuals are often recipes collections with application examples. Generally, they lack of a rigorous explanation of the techniques that is essential for the engineers in order to be able to adapt to different situations and design their own custom-made technique. To achieve this objective, the techniques of quality control and design of experiments will be presented with the highest statistical accuracy in the lecturing sessions, although avoiding abstract theory, and will be illustrated with real examples of application.
Therefore, all the theoretical lectures (activity 1) are given using multimedia materials specially created by the teachers of the course which give special focus to the most important points and those that are more challenging. These materials are made available to all students in pdf format through the digital platform Atenea.
One way to consolidate the learnt concepts is through the development of problems and numerical exercises. For this reason, a collection of problems solved in detail is available for the students. They will know one week in advance the exercises that will be discussed in the classroom, so that they can work previously on them and thus participate and a discuss on the concepts and methodology required to deal with each situation. Although every week there is one session of problems (activity 2), theory lessons also include several numerical examples and case studies.
At the end of each topic of the syllabus, a collection of problems, exercises and theoretical questions is made available in Atenea, which should be used for self-assessment (activity 3). These exercises will not be solved in classroom and their detailed solution will not be given; only the numerical results will be published. Doubts that arise solving these problems, consulting the literature provided in this guide or the course notes, will be solved by the professors during attention hours.
In addition, since this subject has a strong computing component, the student will learn to use computers to solve problems. Despite there exists a large amount of statistical software it is not always available to all companies. In this course, by the completion of two projects (activities 4 and 5), the student learns how to resolve a number of statistical problems that he/she may face using a simple spreadsheet and the required statistical concepts.

LEARNING OBJECTIVES OF THE SUBJECT

The course has two main objectives. The first one is to introduce the students to the techniques of statistical quality control of industrial processes. The second is to enable them to carry out the planning and execution of the required experimentation, as well as its interpretation in order to model the behaviour of industrial processes, which will make possible the optimization, performance improvement, costs reduction, achievement of goals, reduction of environmental pollution, noise or waste water, etc.

STUDY LOAD

Type	Hours	Percentage
Self study	67,5	60.00
Hours medium group	14,0	12.44
Hours large group	31,0	27.56

Total learning time: 112.5 h

CONTENTS

Module 1. Quality Control - Introduction

Description:
1.1. Introduction to Statistical Quality Control
1.2. Graphical tools

Specific objectives:
The objective of this module is to introduce the concepts of quality, tolerances, defective parts, and process degradation. Graphical tools for quality management and statistical process control are presented.

Related activities:
Classes of theory
Classes of problems
Self-assessments
Midterm Exam

Full-or-part-time: 5h
Theory classes: 2h
Practical classes: 1h
Self study : 2h

Module 2. Quality Control - Quality Capability study

Description:
2.1. Quality Capability
2.2. Process Capability study
2.3. Machine Capability study

Specific objectives:
Considering that every industrial process is a random phenomenon, it is necessary to acquire the criteria to evaluate the different quality indexes and validate an industrial process as capable and stable.

Related activities:
Classes of theory
Classes of problems
Self-assessment exercises
Quality Control Project
Midterm Exam

Full-or-part-time: 10h 30m
Theory classes: 3h
Practical classes: 1h
Self study : 6h 30m

Module 3. Quality Control - Control techniques

Description:
3.1. Statistical Process Control: control charts
3.2. Control upon reception

Specific objectives:
Using statistical techniques as hypothesis testing and concepts such as decisions and risks, the goal is to present the different existing charts and learn how to calculate control limits and establish decision rules to decide whether a process is under control, whether received material is conforming, etc.

Related activities:
Classes of theory
Classes of problems
Self-assessments
Midterm Exam

Full-or-part-time: 23h
Theory classes: 6h
Practical classes: 3h
Self study : 14h

Module 4. Experimental Design - Linear regression

Description:
4.1. Linear Regression

Specific objectives:
The study of the results of an experiment and the modeling of the characteristic of interest of an industrial process require a thorough knowledge of statistical techniques such as linear modeling (multiple regression)

Related activities:
Classes of theory
Classes of problems
Self-assessment exercises
Quality Control Project
Midterm Exam
Final Exam

Full-or-part-time: 22h
Theory classes: 5h
Practical classes: 2h
Self study : 15h

Module 5. Experimental Design - Modelling the mean with constant variance

Description:
5.1. Factorial Designs
5.2. Fractional Factorial Designs

Specific objectives:
The objective of the module is to highlight the importance of experimental design when it is necessary to optimize a process. It is necessary to train the student to identify a problem, select the possible process control factors, and choose the most suitable experimental design to model the responses of interest, validate the assumptions, and determine the working conditions that lead to the optimum.

Related activities:
Classes of theory
Classes of problems
Self-assessment exercises
Final Exam

Full-or-part-time: 24h
Theory classes: 6h
Practical classes: 3h
Self study : 15h

Module 6. Experimental Design - Modelling the mean with non-constant variance

Description:
6.1. Modelling variability
6.2. Modelling the mean response by Weighted Least Squares

Specific objectives:
When there are factors that also influence variability, causing it not to remain constant, it is necessary to be able to conduct experimentation in such a way that these factors can be identified and the dispersion can be modeled. This requires knowledge of the technique of weighted least squares in order to model the mean, incorporating the available information on non-constant variability.

Related activities:
Classes of theory
Classes of problems
Self-assessment exercises
Final Exam

Full-or-part-time: 10h 30m
Theory classes: 3h
Practical classes: 1h
Self study : 6h 30m

Module 7. Experimental Design - Sequential Design

Description:
7.1. Sequential Design

Specific objectives:
The operational systematic for conducting sequential experiments and advancing based on the results obtained will be developed. Procedures are illustrated with different real cases.

Related activities:
Classes of theory
Classes of problems
Self-assessment exercises
Final Exam

Full-or-part-time: 17h 30m
Theory classes: 6h
Practical classes: 3h
Self study : 8h 30m

ACTIVITIES

ACTIVITY 1. THEORY LECTURES

Description:
Preparation before and after the theory sessions and attendance to them. Practical cases will be developed to encourage the acquisition of generic and specific competences.

Specific objectives:
The objective is to apply the knowledge and facilitate the acquisition of the necessary competencies for the correct use of the contents of the course.

Material:
Slides on the Atenea platform.
General bibliography for the course.

Delivery:
This activity is evaluated, together with activity 2, through the completion of the practical exercises (activities 4 and 5) and two written exams: midterm (activity 6) and final (activity 7).

Related competencies :
CE24-GRETI. Applied knowledge of manufacturing systems and processes, metrology, and quality control. (Specific Technology Module)
CE01-INDUS. Ability to solve mathematical problems that may arise in engineering. Aptitude to apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential and partial differential equations; numerical methods; numerical algorithms; statistics and optimization. (Basic training module)
08 CAS N3. THE ABILITY TO ANALYSE AND SYNTHESISE: The ability to think abstractly about the fundamental concepts of a text or exposition and to intelligibly present the result of one's work.

Full-or-part-time: 47h
Theory classes: 27h
Self study: 20h

ACTIVITY 2. PROBLEM SOLVING SESSIONS

Description:
Preparation before and after problem-solving sessions and attendance at these. This activity is aimed at complementing the theoretical knowledge for the correct interpretation and application of statistical techniques for quality control and experimental design in the field of engineering.

Specific objectives:
To acquire the necessary skills for the correct interpretation and resolution of quality control and experimental design problems in the field of engineering.

Material:
Slides on the Atenea platform.
Collection of problems with their detailed solutions on the Atenea platform.
General bibliography of the subject.

Delivery:
This activity is evaluated, together with activity 1, through the completion of the practical assignments (activities 4 and 5) and two written exams: midterm (activity 6) and final (activity 7).

Related competencies :
CE01-INDUS. Ability to solve mathematical problems that may arise in engineering. Aptitude to apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential and partial differential equations; numerical methods; numerical algorithms; statistics and optimization. (Basic training module)
CE24-GRETI. Applied knowledge of manufacturing systems and processes, metrology, and quality control. (Specific Technology Module)
08 CAS N3. THE ABILITY TO ANALYSE AND SYNTHESISE: The ability to think abstractly about the fundamental concepts of a text or exposition and to intelligibly present the result of one's work.

Full-or-part-time: 28h
Self study: 14h
Practical classes: 14h

ACTIVITY 3. SELF-ASSESSMENT EXERCISES

Description:
A list of exercises will be provided for each didactic unit of the theory and with their respective numerical solutions so that the student can work autonomously and validate their results.
Any doubts that arise can be discussed with the teaching staff during a period of time established in the list, with the objective of setting the pace of work for the student, adapting it to the temporal development of the subject.

Specific objectives:
The objective of this self-assessment system is to motivate students to keep up with the subject matter as a way to consolidate knowledge and assume concepts in a clear and solid manner that allows them to reach a satisfactory level. Students must be able to analyze the situation presented in the statement, structure the available information to formulate the problem in statistical terms, and solve it based on the knowledge acquired, which will help them develop their analytical and synthesis skills.

Material:
The exercise lists, for each theoretical unit, will be available on the subject's teaching intranet during the established period for each one.
To facilitate the resolution of these exercises, the student will have access to other materials such as theory notes, collections of problems with their respective detailed solutions, and statistical tables.

Delivery:
This is a strictly formative activity, without deliverables and without direct impact on the final grade.

Related competencies :
CE24-GRETI. Applied knowledge of manufacturing systems and processes, metrology, and quality control. (Specific Technology Module)
CE01-INDUS. Ability to solve mathematical problems that may arise in engineering. Aptitude to apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential and partial differential equations; numerical methods; numerical algorithms; statistics and optimization. (Basic training module)
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Full-or-part-time: 13h
Self study: 13h

ACTIVITY 4. PROJECT ON QUALITY CONTROL

Description:
The student will have to analyse the quality capability of an industrial process using a spreadsheet, based on data that simulates the situation.

Specific objectives:
The student must be able to analyse the situation posed by the data, structure the available information, and apply the necessary procedures to make decisions.

Material:
Individual data file and report template available on Atenea.
Additional material to facilitate the use of the necessary software for calculations (manuals, videos, notes, etc.).

Delivery:
The student must submit a printed personal report in accordance with the established template within the established deadline.
The report is graded with a numerical grade representing 10% of the final grade.
The "Analysis and Synthesis" competence is evaluated.

Related competencies :
CE01-INDUS. Ability to solve mathematical problems that may arise in engineering. Aptitude to apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential and partial differential equations; numerical methods; numerical algorithms; statistics and optimization. (Basic training module)
CE24-GRETI. Applied knowledge of manufacturing systems and processes, metrology, and quality control. (Specific Technology Module)
08 CAS N3. THE ABILITY TO ANALYSE AND SYNTHESISE: The ability to think abstractly about the fundamental concepts of a text or exposition and to intelligibly present the result of one's work.

Full-or-part-time: 5h
Self study: 5h

ACTIVITY 5. PROJECT ON EXPERIMENTAL DESIGN

Description:
Using a spreadsheet and simulated data from an experimentation situation, the student must estimate the model that relates the response to the process control factors and analyse the results obtained.

Specific objectives:
The student must be able to analyze the situation posed by the data, structure the available information, and apply the necessary procedures to make decisions.

Material:
Individual data file and report template available on Atenea.
Additional material to facilitate the use of the necessary software for calculations (manuals, videos, notes, etc.).

Delivery:
The student must submit a printed personal report in accordance with the established template within the established deadline.
The report is graded with a numerical grade representing 10% of the final grade.
The "Analysis and Synthesis" competence is evaluated.

Related competencies :
CE24-GRETI. Applied knowledge of manufacturing systems and processes, metrology, and quality control. (Specific Technology Module)
CE01-INDUS. Ability to solve mathematical problems that may arise in engineering. Aptitude to apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential and partial differential equations; numerical methods; numerical algorithms; statistics and optimization. (Basic training module)
08 CAS N3. THE ABILITY TO ANALYSE AND SYNTHESISE: The ability to think abstractly about the fundamental concepts of a text or exposition and to intelligibly present the result of one's work.

Full-or-part-time: 5h
Self study: 5h

ACTIVITY 6. MIDTERM EXAM

Description:
Individual multiple-choice test with questions about the contents of the material covered up to that point.

Specific objectives:
El estudiante should demonstrate, through this test, that he/she has acquired and assimilated the statistical concepts covered in the first modules and is capable of using them satisfactorily.

Material:
Statement of the exam.
Books, materials published on Atenea, and handwritten notes.

Delivery:
The student must only submit the exam sheet with the marked answers.
The grade obtained represents 40% of the final grade.

Related competencies :
CE01-INDUS. Ability to solve mathematical problems that may arise in engineering. Aptitude to apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential and partial differential equations; numerical methods; numerical algorithms; statistics and optimization. (Basic training module)
CE24-GRETI. Applied knowledge of manufacturing systems and processes, metrology, and quality control. (Specific Technology Module)
08 CAS N3. THE ABILITY TO ANALYSE AND SYNTHESISE: The ability to think abstractly about the fundamental concepts of a text or exposition and to intelligibly present the result of one's work.

Full-or-part-time: 6h 30m
Theory classes: 1h 30m
Self study: 5h

ACTIVITY 7. FINAL EXAM

Description:
Individual multiple-choice test on the contents of the course material not evaluated in the midterm exam.

Specific objectives:
The student must demonstrate, through this test, that he/she has acquired and assimilated the statistical concepts of the last modules and are able to use them satisfactorily.

Material:
Statement of the exam.
Books, materials published on Atenea, and handwritten notes.

Delivery:
The student must only submit the exam sheet with the marked answers.
The grade obtained represents 40% of the final grade.

Related competencies :
CE24-GRETI. Applied knowledge of manufacturing systems and processes, metrology, and quality control. (Specific Technology Module)
CE01-INDUS. Ability to solve mathematical problems that may arise in engineering. Aptitude to apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential and partial differential equations; numerical methods; numerical algorithms; statistics and optimization. (Basic training module)
08 CAS N3. THE ABILITY TO ANALYSE AND SYNTHESISE: The ability to think abstractly about the fundamental concepts of a text or exposition and to intelligibly present the result of one's work.

Full-or-part-time: 8h
Theory classes: 2h 30m
Self study: 5h 30m

GRADING SYSTEM

The final grade depends on 4 evaluations:
- Activity 4 (project on Quality Control), with a weight of 10%
- Activity 5 (project on Experimental Design) with a weight of 10%
- Activity 6 (partial exam) with a weight of 40%
- Activity 7 (final exam) with a weight of 40%

All students who cannot attend the midterm exam (activity 6), or who want to improve their grade, will have the option to recover it through an additional written test that will be held on the same day set for the final exam (activity 7). The grade of this second chance test will be between 0 and 10 and will replace the midterm exam grade if it is higher.

BIBLIOGRAPHY

Basic:
- Montgomery, D. C. Introduction to statistical quality control. 5th ed. New York: John Wiley & Sons, 2005. ISBN 9780471656319.
- Montgomery, D. C. Diseño y análisis de experimentos. 2ª ed. México: Limusa-Wiley, 2002. ISBN 9789681861568.

Complementary:
- Myers, R. H.; Montgomery, D. C. Response surface methodology: process and product optimization using designed experiments. New York: John Wiley & Sons, 1995. ISBN 0471581003.

RESOURCES

Other resources:
Teaching material, notes, problems, and scripts for the projects will be posted on Atenea.