Magnetic circuits and transformers

Academic Year: (2025 / 2026) **Review date: 23/05/2025 14:16:56**

Department assigned to the subject: Electrical Engineering Department

Coordinating teacher: GARCIA DE BURGOS, MARIA BELEN

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Physics II
Electrical Power Engineering Fundamentals

LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study
CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB3. Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.
CB5. Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.
CG1. Ability to solve problems with initiative, decision-making, creativity, critical reasoning and to communicate and transmit knowledge, skills and abilities in the field of Industrial Engineering.
CG3. Ability to design a system, component or process in the field of Industrial Technologies to meet the required specifications
CG4. Knowledge and ability to apply current legislation as well as the specifications, regulations and mandatory standards in the field of Industrial Engineering.
CG5. Adequate knowledge of the concept of company, institutional and legal framework of the company. Organisation and management of companies.
CG6. Applied knowledge of company organisation.
CG8. Knowledge and ability to apply quality principles and methods.
CG9. Knowledge and ability to apply computational and experimental tools for the analysis and quantification of Industrial Engineering problems.
RA1. Knowledge and understanding: Have basic knowledge and understanding of science, mathematics and engineering within the industrial field, as well as knowledge and understanding of Mechanics, Solid and Structural Mechanics, Thermal Engineering, Fluid Mechanics, Production Systems, Electronics and Automation, Industrial Organisation and Electrical Engineering.
RA2. Engineering Analysis: To be able to identify engineering problems within the industrial field, recognise specifications, establish different resolution methods and select the most appropriate one for their solution
RA3. Engineering Design: To be able to design industrial products that comply with the required specifications, collaborating with professionals in related technologies within multidisciplinary teams.
RA4. Research and Innovation: To be able to use appropriate methods to carry out research and make innovative contributions in the field of Industrial Engineering.
RA5. Engineering Applications: To be able to apply their knowledge and understanding to solve problems and design devices or processes in the field of industrial engineering in accordance with criteria of cost, quality, safety, efficiency and respect for the environment.
RA6. Transversal Skills: To have the necessary skills for the practice of engineering in today's society.

OBJECTIVES

The objective of the course is for students to:

- Understand the physical principles of magnetic circuits and be able to analyze and design simple magnetic circuits
- Understand the role of transformers in electrical systems
- Know the operating principle of a transformer in open circuit and under load and its representation by means of an equivalent circuit
- Learn to solve problems involving single-phase and three-phase transformers.
- Learn to perform tests to determine transformer parameters in the laboratory
- Acquire a basic knowledge of national and international regulations related to transformers
Understand the importance of performing maintenance on transformers to increase their reliability and learn about some predictive maintenance techniques.
- Be able to choose a transformer for a specific application

DESCRIPTION OF CONTENTS: PROGRAMME

Module 1: REVIEW OF BASIC CONCEPTS OF ELECTRICITY AND MAGNETISM. Maxwell's Equations. Analysis of magnetic circuits. Determination of self-inductance and mutual inductance between coils.

Module 2: PHYSICAL CONSTITUTION OF TRANSFORMERS AND MAINTENANCE. The magnetic circuit. The electric circuits. Insulation. Transformer cooling. Basic concepts of transformer maintenance.

Module 3: SINGLE-PHASE TRANSFORMERS. Operation in no-load conditions. Operation under load. Transformer overloads. Equivalent circuit. Voltage drops. Efficiency. Transformers in parallel. Short circuit current. Connection transient.

Module 4: THREE-PHASE TRANSFORMERS. Transformer banks and three-phase units. Connection groups. Harmonics in the no-load current. Equivalent circuit. Operation with balanced and unbalanced loads. Three-Winding transformers. Autotransformers. Voltage regulation. Field of application of different types of transformers.

LEARNING ACTIVITIES AND METHODOLOGY

- Lectures, individual guidance, and personal study aimed at acquiring theoretical knowledge.
- Problem-solving classes in small groups, individual tutorials, and personal study aimed at acquiring practical skills related to the course curriculum.
- Workshops on technological aspects and regulations.
- Industry speakers conferences.
- Laboratory practices.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

During the course, there will be three midterm exams. These midterm tests are eliminatory, and students will not need to take the parts they have already passed in the final exam of the regular session. The exam dates listed in the schedule are indicative. Throughout the course, other assessment activities may be proposed, such as short quizzes or assignments, which would be considered in the continuous assessment grade.

In the regular exam session, students only need to take the final exam for the parts of the subject they have failed. Students who take the subject in the resit (extraordinary) session must be examined on the entire subject.

Students who wish to may take the final exam to improve their grade.

The use of Artificial Intelligence tools is selectively permitted in this course. The instructor may provide a list of assignments and exercises that students are allowed to complete using AI tools, specifying how these tools may be used and how students should describe their use. If a student's use of AI results in academic fraud by falsifying the outcomes of an exam or assignment required to demonstrate

% end-of-term-examination/test:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

academic performance, the provisions of the Regulations of Universidad Carlos III de Madrid for the partial implementation of Law 3/2022, of February 24, on university coexistence, will be applied.
The practical sessions account for 10% of the final grade.

BASIC BIBLIOGRAPHY

- Kulkarni, S.V; Khaparde, S.A. Transformer engineering. Design and Practice, Marcel Dekker, 2012

ADDITIONAL BIBLIOGRAPHY

- S.Kulkarni; S Khaparde Transformer Engineering. Design and Practice, Marcel Dekker, 2012

BASIC ELECTRONIC RESOURCES

- Juan Carlos Burgos . OCW Circuitos Magnéticos y Transformadores: http://ocw.uc3m.es/ingenieria-electrica/circuitos-magneticos-y-transformadores