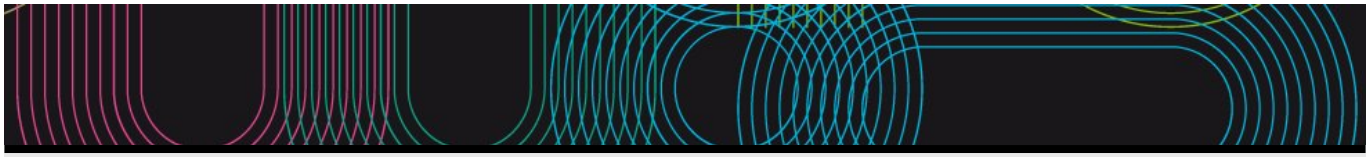

IDENTIFYING DATA				
Fundamentals of electrical engineering				
Subject	Fundamentals of electrical engineering			
Code	P52G381V01205			
Study programme	(*)Grao en Enxeñaría Mecánica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	Spanish			
Department				
Coordinator	Núñez Ortuño, José María			
Lecturers	Falcón Oubiña, Pablo González Prieto, José Antonio Núñez Ortuño, José María			
E-mail	jnunez@cud.uvigo.es			
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General description	The knowledge of electricity, its use and its protections is basic for the development of any kind of engineer, regardless of his branch. That is why Fundamentals of Electrical Engineering represents one of the most important pillars of the knowledge of the future technician, and given its broad spectrum, it will contain a theoretical part and a further part eminently practical. The main objective of this course is to transmit the fundamental concepts of the Theory of Circuits and Electrical Machines for application in the design of electrical distribution systems and electronic circuits. These concepts represent the basis of electrical engineering which brings together different aspects and technical sciences such as, among others, Electronics, Power Electronics, Control and Regulation, Automation Systems and Electrical Machines. All this forms the basis of the current field of action of industrial electricity.			

Competencies	
Code	
B3	Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations.
C10	Knowledge and use of the principles of circuit theory and electrical machines.
D1	Analysis and synthesis
D2	Problems resolution.
D6	Application of computer science in the field of study.
D10	Self learning and work.
D14	Creativity.
D16	Critical thinking.
D17	Working as a team.

Learning outcomes			
Expected results from this subject	Training and Learning Results		
To understand the basics of the operation of circuits and electrical machines	B3	C10	
Familiarisation with current techniques for the analysis of electrical circuits		C10	D6
Know the techniques of measure of electrical circuits			D6 D10

To acquire skills on the process of analysis of electrical circuits			D1 D2 D6 D10 D14 D16 D17
ENAEE learning outcome: KNOWLEDGE and UNDERSTANDING: LO1.2.- knowledge and understanding of the mathematics and other basic sciences underlying their engineering specialisation, at a level necessary to achieve the other programme outcomes [level of achievement (basic (1), intermediate (2) and advanced (3)) for this learning outcome: Intermediate (2)].	B3		
ENAEE learning outcome: KNOWLEDGE and UNDERSTANDING: LO1.3.- awareness of the wider multidisciplinary context of engineering [level of achievement (basic (1), intermediate (2) and advanced (3)) for this learning outcome: Intermediate (2)].		C10	
ENAEE learning outcome: ENGINEERING PRACTICE: LO5.2.- practical skills for solving complex problems, realising complex engineering designs and conducting investigations in their field of study [level of achievement (basic (1), intermediate (2) and advanced (3)) for this learning outcome: Intermediate (2)].			D2 D16
ENAEE learning outcome: ENGINEERING PRACTICE: LO5.3.- understanding of applicable materials, equipment and tools, engineering technologies and processes, and of their limitations in their field of study [level of achievement (basic (1), intermediate (2) and advanced (3)) for this learning outcome: Intermediate (2)].			D6
ENAEE learning outcome :COMMUNICATION and TEAM-WORKING: LO7.2.- ability to function effectively in a national and international context, as an individual and as a member of a team and to cooperate effectively with engineers and non-engineers [level of achievement (basic (1), intermediate (2) and advanced (3)) for this learning outcome: Intermediate (2)].			D10 D17

Contents

Topic	
Unit 1. Direct current circuits	This topic aims to study the techniques of analysis and resolution of basic DC circuits. 1.1 Introduction and general concepts. Common measurement units. 1.2 Electrical circuit. Elementary components. 1.3 Kirchhoff's Laws. 1.4 Voltage and current sources. Font conversion. 1.5 Voltage and current dividers. 1.6 Serial and parallel association. 1.7 Analysis of circuits by nodes and meshes. 1.8 Theorems of Thévenin and Norton.
Unit 2. Alternating current circuits	The objective of this topic is to study the techniques of analysis and resolution of basic alternating current circuits. 2.1 Periodic waveforms and associated parameters. 2.2 Phasorial representation. 2.3 Impedance and admittance concept. Elements of the circuit: Resistance, Capacitor and Inductor. 2.4 Active, reactive and apparent power. Triangle of powers. Power factor 2.5 Analysis of alternating circuits
Unit 3. Three-phase current circuits	This topic aims to study the techniques of analysis and resolution of basic circuits in three-phase current. 3.1 Definition and origin of three-phase systems. 3.2 Star-delta connection. 3.3 Balanced three-phase systems. 3.4 Power in three-phase systems. Measuring systems. 3.5 Power factor. Definition, use and correction.
Unit 4. Direct current machines	The objective of this topic is to understand the operation, parameters basic and utilities of a DC machine. 4.1 Basic constituent elements and operating principle. 4.2 Switching. Reaction of the armature. 4.3 Power balance and losses. 4.4 Excitation and equivalent circuits. Torque-speed curves. 4.5 Inversion of the direction of rotation and speed regulation.

Unit 5. Transformers	This topic aims to understand the operation, basic parameters and uses of a transformer. 5.1 Principle of operation of transformers and main parts 5.2 Real transformer. Equivalent circuit. 5.3 Running regime. 5.4 Open and short circuit tests. 5.5 Losses and performance. 5.6 Excitation and connection current. 5.7 Constructive characteristics.
Unit 6. Asynchronous machines	This topic aims to understand the operation, parameters and utilities of an asynchronous machine. 6.1 Principle of operation. Fundamental parts. 6.2 Equivalent circuit. 6.3 Open and short circuit tests. 6.4 Power balance. Rotational torque and maximum torque. 6.5 Start-up. Speed regulation
Unit 7. Synchronous machines	This topic aims to understand the operation, parameters and utilities of a synchronous machine. 7.1 Principle of operation. Fundamental parts. 7.2 Types of excitation. 7.3 Linear and non-linear analysis. Equivalent circuit. 7.4 Alternator. Characteristics and applications. 7.5 Active and reactive power. 7.6 Balance of power, performance and torque. 7.7 Starting a synchronous motor

Practices Block I	Practices related to electrical circuits The aim of this group of practices is that the student understands the basic concepts of continuous, alternating and three-phase circuits, as well as a methodology for solving them. To do this, electronic instrumentation equipment will be used, as well as basic circuits assembled on prototyping boards. In the practices of this block it will be proposed the assembly and analysis of electrical diagrams whose operation is not known a priori. Practice 1: Introduction to the handling of instrumentation and assembly of basic direct current circuits. The aim of this practice is to familiarize the student with the instrumentation equipment of the Electrotechnical Laboratory by means of the assembly of basic direct current circuits on a prototyping (or protoboard). These circuits will include assemblies for series and parallel voltage measurement, as well as voltage and current dividers. In this first practice of the subject, we will emphasize the precautions to be taken when handling electrical circuits, letting the student be aware of the dangers related to electric current, showing the basic electrical safety measures, the operation of the protective and safety equipment, and teaching hime/her how to manage dangers. Practice 2: Assembly of direct current circuits This practice aims to make more advanced circuits and aims to have the student experiment with resistive elements and sources on a prototype board. The student will check concepts seen in theory like Ohm's law, Thevenin's theorem, Boucherot's theorem, etc. Practice 3: Assembly and measurement of alternating current circuits In this practice, the assembly of alternating current circuits is carried out in prototyping board, as well as learning how to use the functions and make measurements with the oscilloscope. Practice 4: Simulation of PSIM circuits in alternating current The student will learn how to analyze a circuit in AC by means of the PSIM circuit simulation software. Practice 5: Three-phase energy systems The objective of this practice is to introduce students to the use of real three-phase systems. The sources in the lab will be used to feed passive loads and measure their consumption parameters with three-phase measuring equipment.

Practices Block II	The purpose of this group of practices is for the student to understand the basic concepts of motors and electric machines. Panels with different electrical machines will be used, as well as simulation software. In the practices of this block, tests or assemblies of machines without previous assembly guide will be proposed. Practice 6: Single-phase transformer tests The aim of this practice is to make the student aware of the main characteristics of a single-phase transformer. To this end, he will experimentally determine the parameters that govern its operation, using the so-called vacuum and short-circuit tests. The student must be able to carry out the appropriate assembly to perform these tests, measuring voltages, currents and powers. From the result of the measurements the student has to be able to interpret the obtained data and extract from them the necessary information to know and quantify the different power losses in a real transformer. With these data he must build the equivalent model of a real transformer. In this practice, the precautions to be taken when manipulating circuits and using electrical machines will be emphasized. In this sense, part of the practice will be dedicated to make the student aware of the dangers related to the electrical current, showing him the basic measures of electrical safety, the operation of the protection and safety devices, and teaching him how to manage the danger. Practice 7: Three-phase asynchronous motor The objective of this practice is that the student makes contact with an industrial asynchronous three-phase motor, identifying its windings, proposing its star and triangle connection, verifying its operation in no-load and making a change in the direction of rotation. Likewise, the problems originated by the loss of a phase in permanent regime and at the start will be analyzed.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	28	38	66
Laboratory practical	14	7	21
Seminars	7	3	10
Seminars	15	12	27
Essay questions exam	13	13	26

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Participatory master classes. In these sessions, the basic theoretical contents of the programme will be explained in detail, giving explanatory examples with which to deepen the understanding of the subject. Computer presentations and blackboard will be used. A copy of the slides will be given to the students prior to the exhibition, focusing lecturer's and student's efforts in the understanding of the topics. Anyway, the paper reproductions of slides should never be considered as substitutes for texts or notes, but as complementary material.
Laboratory practical	Practical set-ups corresponding to the contents seen in the classroom will be carried out in the laboratory, or complementary aspects not covered in the theoretical classes will be treated. The methodology used consists of the lecturer supervising the work carried out by the different groups into which the students are divided. The laboratory practices are aimed at reinforcing the theoretical concepts covered in the classroom sessions.
Seminars	Since the tutorial action is approached as a group support action to the learning process of the student, these sessions, carried out in seminars and under the format of small group meetings, will serve to solve questions and to raise problems and exercises that will be solved by the students themselves.
Seminars	Intensive course that is carried out as preparation for the extraordinary exams.

Personalized assistance

Methodologies	Description
Lecturing	Personalized answers to questions related to the exhibition by the teacher of the contents of the subject matter, theoretical bases and/or guidelines of a work or exercise that the student has to develop.
Seminars	In the field of tutorial action, there are academic tutoring actions as well as tutorial personalized actions. In the first case, students will have at their disposal tutorials to solve any question related to the contents, organization and planning of the subject, development of projects, etc. Tutorials can be individualized, but group tutoring is encouraged to solve problems related to the activities to be carried out in a group, or simply to inform the lecturer about the evolution of collaborative work. In the personalized tutorials, each student, individually, will be able to comment with the lecturer any questions he may have, problems that are preventing him from following up on the subject properly, in order to find some kind of solution. The aim of combining both types of tutorial action is to compensate the different learning rates through attention to diversity. The teachers of the subject will personally attend to the doubts and queries of the students, both in person, according to the timetable that will be published on the centre's website, and through telematic means (e-mail, videoconference, FAITIC forums, etc.) by appointment.
Laboratory practical	Individual attention will be given to the implementation activities of the knowledge in a given context and the acquisition of basic and procedural skills on the subject.

Assessment

	Description	Qualification	Training and Learning Results
Lecturing	The final grade will be determined from the grades obtained in: 1. Continuous evaluation, through the assessment of practical work and activities proposed throughout the course. 2. Final evaluation, by means of examinations carried out in the calls and dates set by the University and the Centre. In the framework of the continuous evaluation, it will be a first theoretical partial examination of the contents seen so far (circuits of direct and alternating current). This test will account for 15% of the total grade final of continuous assessment, there being no minimum score on this test. Before the final exam of the course, a second exam will be taken with contents related to three-phase systems and electrical machines seen up to that point. This test will account for 15% of the total the final mark for continuous assessment, there being no minimum mark in this proof. Throughout the four-month period, they will take place at different times, short questionnaires to check follow-up and commitment to subject by the students. The tests will be carried out with the support of the platform for the subject's tele-education. These tests will involve in total 10% of the final mark for continuous assessment, with no minimum mark. At the end of the four-month period, a final exam will be taken that will cover the all the contents of the course, both theoretical and practical, and which may include multiple choice tests, reasoning questions, resolution of problems and development of case studies. The examination, which will account for 40 per cent of the final continuous assessment score, will be based on the assessment of problem-based learning by the parties to the Block I: Circuit Theory (Direct Current, Alternating Current and three phase) and Block II: Electrical Machines. It will be distributed in trouble and/or theoretical questions, which can be about the theory and seminars seen in the classroom or about the practices seen in the laboratory. In order to pass the course, a mark of 5.0 points out of 10 will be required in the computation of the final Continuous Evaluation Note (NEC). Additionally is required: - A minimum of 40% of the score assigned to Block I (Theory of Circuits) - A minimum of 40% of the score assigned to Block II (Machines Electrical) Those students who do not reach the minimums established in any of the two parts, must be submitted to the Ordinary Examination. In this case, your the final continuous evaluation note (NEC) will be calculated as: NEC = min {4.0, NEC}	80	B3 C10 D1 D2 D14 D16

Laboratory practical	Laboratory practical will be evaluated on the basis of the work done by the student during the practice sessions and by evaluating the technical reports produced at the end of each one. The grade for this block of practices will represent 20% of the total grade end of continuous evaluation. The student must reach 40% of the score assigned to the practices of each of the blocks of the subject.	20	B3 C10	D1 D6 D10 D16 D17

Other comments on the Evaluation

Qualification Assurance Plan

Recovery plan of the final qualification in the First Call

This plan consists of the right to take a new exam, called the Ordinary exam, on the dates set by the centre, which will replace, if it is higher, the score previously obtained and will count for all purposes in the calculation of the final grade of the first call. This exam will be open to those students who:

- Have not passed the subject during the Continuous Assessment (NEC < 5.0)
- Wish to improve the grade obtained by the Continuous Assessment method.
- Have not fulfilled the ethical commitment that is developed below.

The ordinary examination will be based on the evaluation of problem-based learning in the parts of Block I: Circuit Theory (direct current, alternating current and three-phase current) and Block II: Electrical Machines. The practice part will also be evaluated with a test based on the circuit and machine simulation tool that will be used during the course.

The ordinary examination will contain a theoretical part and a practical part. The student will pass the course when the Note of the Ordinary Examination (NEO) is greater or equal to 5.0 points out of 10, being also necessary to overcome the minimums established in the following table:

Minimum Score		
Theory (T) 80%	Block I	40%
	Block II	40%
Practice(P) 20%	Blocks I+II	40%

Once the minimums for each of the parts are exceeded, the NEO will be calculated as:

NEO = 0.8-T + 0.2-P

If the minimums are not passed, the score of the ordinary examination will be calculated as:

NEO = min {4.0, NEO}

Finally, the corresponding First Call Note (NPC) will be calculated from the Note of the Ordinary Examination (NEO) and the Note of the Continuous Evaluation Examination (NEC) as

NPC = max {NEC, NEO}

Recovery plan of the final qualification in the Second Call

Students who have not passed the subject during the first call have the right again to a second exam, called Extraordinary or Second Call, on the dates set by the centre. It is understood that the mark obtained in the exam replaces, if it is higher, the mark obtained in the ordinary or first call exam. This exam will contain a practical part, in addition to the theoretical part. The evaluation system will be governed by the same scales and weightings as those established for the ordinary exam, so that the student will pass the subject when the score of the Extraordinary Examination (NEE) is greater than or equal to 5.0 points out of 10. Once the minimums for each of the parts have been passed, the Extraordinary Examination Note (NEE) will be calculated as:

NEE = 0.8-T + 0.2-P

If the minimums are not passed, the score of the extraordinary examination will be calculated as:

NEE = min {4.0, NEE}

Plan to improve the final rating

Each and every student can access a plan to improve their final grade. The improvement plan consists of the right to take a

new exam, coinciding with the ordinary or first call exam, on the dates set by the centre, whose grade will replace the one previously obtained, as long as it is higher than the one already obtained, and will count for all purposes as the only reference in the calculation of the final grade. It is understood that the mark obtained in the exam, in the event that it is higher than the mark obtained through the continuous assessment of the subject throughout the four-month period, replaces the aggregation of the marks of the partial tests of continuous assessment, the practice marks, the marks of the short questionnaires and the final exam of the subject.

Ethical commitment

If unethical behavior (copying, plagiarism, use of unauthorized electronic devices or others) is detected, either during a written test or in the completion of practice reports, you will be penalized as follows:

- *Continuous evaluation*: Given the diverse teaching methodology followed to evaluate each of the two blocks that make up the subject, different considerations will be taken into account. In this way:
- *Scoring tests (partial exams, short questionnaires and final exam)*: All points obtained up to this point will be automatically eliminated, without the possibility of recuperation, and will be excluded from the continuous assessment method. The student must pass the subject in the ordinary exam.

Practice reports: all students involved in copying all or part of a report (at the discretion of the subject's teachers) will be penalized in the final grade of the practice block with a mark of 0.0.

Ordinary exam: A grade of 0 will be given in all parts of the exam, and students must take the extraordinary exam.

Extraordinary exam: A grade of 0 will be given in all parts of the exam.

Sources of information

Basic Bibliography

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Complementary Bibliography

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Corrales Martín, J., **Cálculo Industrial de Máquinas Eléctricas, Tomo II**, 1ª, Marcombo Boixerau Editores, 1982

Duncan Glover, J. y Sarma, M., **Sistemas de Potencia. Análisis y Diseño**, 3ª, Cengage Learning Editores S.A., 2003

Kosow, I.L., **Máquinas Eléctricas y Transformadores**, 1ª, Pearson Educación, 1993

Casals Torrens, Pau, **Máquinas eléctricas. Aplicaciones de ingeniería eléctrica a instalaciones navales y marinas**, 1ª, Ediciones UPC, 2010

Recommendations

Subjects that continue the syllabus

Electronic technology/P52G381V01301
Fundamentals of automation/P52G381V01401
Naval engines and machines/P52G381V01409

Subjects that it is recommended to have taken before

Physics: Physics II/P52G381V01106

Other comments

The subject Fundamentals of Electrical Engineering has no associated prerequisites. However, in order to take this course successfully, the student must have:

- Written and oral comprehension skills
- Ability of abstraction, basic calculation and synthesis of information
- Skills for group work and group communication
- At least basic notions acquired in the subjects of Physics II and Mathematics in previous courses.

The most common learning difficulties are linked to a lack of such knowledge, but it can be overcome with a little effort and

the means of this Centre

Contingency plan

Description

In case of the possible appearance of extraordinary situations that imply the suspension of the face-to-face teaching activity and the change to an offline/online scenario, the following changes will be made:

CONTENTS

Programming: theoretical credits

The teaching of the theoretical content of the subject should not be affected by the transfer to non-presential online mode. If the number of hours to be taught is considerably reduced, the contents of each of the subjects in a way that ensures that learning outcomes and competences are achieved.

Programming: practical credits

Where appropriate, in the section on practical contents, the replacement of some laboratory practice will be proposed that can't be moved to the virtual stage.
Faced with an extraordinary situation, the replacement of the laboratory sessions with the following ones is considered:

Practice 1: Introduction to PSIM and basic circuit simulation example
The aim of this practice is to familiarize the student with the PSIM simulation software. This software is characterized by its simplicity, allows to mount a circuit and check its operation in an easy and fast way. At This practice will introduce the student to the use of this software with examples and proposed exercises.

Practice 2: Simulation of direct current circuits This practice aims to make more advanced circuits than the previous practice and to check the operation of these with the PSIM software. In this practice the student will be able to check concepts introduced in the master classes like Ohm's law, Thevenin's theorem, Boucherot's theorem, etc.

Practice 3: Simulation and measurement of AC circuits In this practice, non-resistive passive elements are introduced in the simulations of electrical circuits, such as coils and capacitors.

Practice 4: Simulation of PSIM circuits in AC The student will continue with the analysis of AC circuits with the electrical circuit simulator and will introduce power measurement elements, power factor, etc.

Practice 5: Practice of three-phase systems The student will learn to analyze three-phase AC circuits using the of PSIM circuit simulation, extending the concepts seen in previous practices and emphasizing the differences between three-phase and single-phase systems.

Practice 6: Simulation of single-phase transformer tests
The aim of this practice is to make the student aware of the main characteristics of a single-phase transformer. For This will determine by simulation with the PSIM tool, the parameters that govern its operation, using the performance of so-called open and short-circuit tests. The student must be able to carry out the assembly suitable for the realization of these tests, measuring voltages, currents and powers.
From the results of the simulated measurements the student must be able to interpret the data obtained and also know and quantify the different power losses in an actual transformer. With this data the student must compose the equivalent model of a real transformer.

Practice 7: Simulation of the behaviour of the three-phase asynchronous machine
The aim of this practice is that the student is able to verify the behaviour of a three-phase asynchronous machine, making its simulated connection to the grid, obtaining its current, power and nominal torque, and determining its Torque-speed characteristic. Finally, you will check the operation of the machine in its various modes.

TEACHING METHODOLOGY

A new teaching methodology will be incorporated into the existing ones.

Synchronous online meeting (theory or practical session):

These sessions will be given through a web videoconference platform within a virtual classroom. Each virtual classroom will

contain various display panels and components, whose design can be customized by the lecturer to adapt it to the needs of the class. In the virtual classroom, any presenter can share the screen or files of your computer, use a whiteboard, chat, stream audio and video or participate in interactive online activities (surveys, questions, etc.).

LEARNING ASSESSMENT

Faced with a change of scenario due to the emergence of extraordinary situations, learning assessment is will remain unchanged with respect to the contents described above in this teaching guide, weightings, minimum requirements, type and number of tests.
The only difference will be in the evaluation format, which in the online modality will take place by combining the FAITIC-Moodle online teaching platform with the Remote Campus of the University of Vigo (and/or similar platforms)