Course guide
330064 - SE - Electrical Systems

Last modified: 04/05/2023

Unit in charge: Manresa School of Engineering
Teaching unit: 709 - DEE - Department of Electrical Engineering.

Degree: BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN ELECTRICAL 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).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: JORDI CUNILL SOLA

Others: Cunill Solà, Jordi
Freijo Alvarez, Modesto

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Ability to know, understand and use the principles of theory of electrical circuits and electrical machines, as well as the its fundamental equations. Apply the fundamental concepts and theorems of electrical circuits to alternating current circuits. Implement measurement systems in basic electrical circuits.

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.
3. SELF-DIRECTED LEARNING - Level 2: Completing 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.

TEACHING METHODOLOGY

- Lecture sessions on theory and problems. The teacher will present the contents of the syllabus insisting on the key concepts and those that are more difficult to understand. We will try to motivate the student by raising questions that stimulate her participation and clarifying any doubts that may arise. Standard problems will also be proposed and solved step by step, emphasizing the sections in which more errors are usually made. The students will be able to have in the virtual campus, a part of the notes as well as the sentences of the proposed problems of each content or topic with the numerical result; thus, it is also intended to facilitate autonomous learning.
- Carrying out laboratory practices in small groups (two or three students). Preparation of individual reports. The students will carry out the assembly of the circuits with the appropriate measuring and protection devices for each case. It is intended that they experiment and verify the theoretical and practical aspects previously studied.
- Resolution and delivery of exercises and proposed problems.
- Personalized attention, study and personal and team work.
- Continuous assessment and written tests of theory and problems.

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course the student must be able to:
- Understand and apply the fundamental equations and theorems for solving electrical circuits.
- Solve electric circuits of direct current and sinusoidal alternating current.
- Calculate the phase and line parameters in balanced three-phase connections.
- Assemble circuits in the laboratory identifying all the components and verify the calculations previously made by electrical measurements.
- Understand the operation of some electrical machines as well as their basic control and protection devices.
- Manipulate the laboratory instrumentation, correctly collect data, process it and prepare a report.

STUDY LOAD

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

Total learning time: 150 h

CONTENTS

1. BASIC CONCEPTS OF ELECTRICAL CIRCUITS. DC. FUNDAMENTAL LAWS.

Description:
1. Introduction. Definition of electricity.
2. Concept of electric current.
3. Units. Performance.
4. Electromotive force and potential difference.
5. Ohm's Law. Electric resistance. Joule effect.
6. Association of resistors. Resistivity. Conductivity.
7. Variation of resistance with temperature. Superconductors.
8. Kirchhoff's Laws.
9. Real voltage generator. Maximum power transfer.
10. Grouping of generators.
11. Kennelly's theorem.
12. Thevenin's theorem.

Related activities:
A1, A2, A7 and A8

Full-or-part-time: 20h
Self study : 20h

2. SINGLE-PHASE ALTERNATING CURRENT CIRCUITS.

Description:
1. Classification of currents.
2. Generation of an f.e.m. alternates.
3. Parameters in alternating current.
4. Average and effective values.
5. Kirchhoff's laws in a.c.
6. Basic electrical elements; R, L and C.
7. Circuits with pure elements.
8. Association of inductances and capacitors.
9. Series and parallel circuits R-L and R-C. Phasor diagrams.
10. R-L-C series circuit, resonance.
11. Complex impedance.

Related activities:
A3, A7 and A8

Full-or-part-time: 29h
Theory classes: 9h
Laboratory classes: 2h
Self study : 18h

3. POWER IN ALTERNATING CURRENT.

Description:
1. Power in sinusoidal alternating current.
2. Apparent, active and reactive powers. Complex power.
3. Power at the various pure receptors.
4. Boucherot's theorem.
5. Correction power factor. Energy saving.

Related activities:
A4, A7 and A8

Full-or-part-time: 7h
Theory classes: 5h
Laboratory classes: 2h

4. THREE PHASE SYSTEMS.

Description:
1. The electrical power system. The transformer. Renewable and non-renewable energies. Wind, solar photovoltaic, mini hydroelectric plants.
2. Power plants. Electric energy demand curve.
3. Environmental impact of electric power production. Greenhouse effect.
4. Hydroelectric plants. Types of turbines.
5. Obtaining a three-phase system. Synchronism speed. Phase sequence.
6. Alternator-load connections. Star-star circuit. Star-delta circuit. Equivalent circuit per phase.
7. Star connection. Simple and compound electrical voltages. Phasor diagrams. Power of a balanced three-phase system.
8. Delta connection. Phase and line voltages and currents. Phasor diagrams. Three-phase power.
9. Possible connections in a four-wire distribution.
10. Unbalanced III loads. Neutral current.
11. Measurement of powers. Active and reactive powers in balanced and unbalanced three-phase systems, with three and four wires. Aron connection.
12. Improvement of the power factor in three-phase systems.

Related activities:
A5, A7 and A9

Full-or-part-time: 32h
Theory classes: 9h
Laboratory classes: 3h
Self study : 20h

5. FUNDAMENTALS OF ELECTRICAL MACHINES. THE INDUCTION MOTOR.

Description:
1. Basic principles of action of the magnetic field.
2. Coil within a magnetic field.
3. F.e.m. generated by a dynamo. Torque produced in a DC machine
4. Classification of electromagnetic machines.
5. Alternators. Pole pairs: synchronous speed. Rotating magnetic field.
6. Asynchronous motor. Physical description. Functioning. Winding and rotor cage. Glide Sliding.
7. Performance characteristics. Torque-speed.
8. Contactors and relays. Connections and start-up systems.

Related activities:
A6, A7 and A9

Full-or-part-time: 22h
Theory classes: 7h
Laboratory classes: 2h
Self study : 13h

6. BASIC CONCEPTS OF ELECTRICAL INSTALLATIONS IN B.T.

Description:
1. Distribution of electrical energy in low voltage.
2. Protection against overloads and short circuits. Magneto thermic and differential switches.
3. Protection of people.
4. Criteria to consider in the design of electrical installations.
5. Calculation of lines. Sections. Voltage drops, maximum current.

Related activities:
A5, A7 and A9

Full-or-part-time: 15h
Theory classes: 4h
Laboratory classes: 2h
Self study : 9h

ACTIVITIES

1. LABORATORY PRACTICE.

Description:
Laboratory practice, in pairs, lasting two hours. The students, after receiving the instructions from the teacher, have to assemble the circuits with the appropriate measuring devices in each case to experiment and check the theoretical and practical aspects previously studied.
Specific content of the practice: Electrical measuring devices. The multimeter. Identification of resistances.
Association of resistors. Checking Ohm's Law.

Specific objectives:
At the end of the activity, the student must be able to:
Identify the basic measurement devices in direct current circuits.
Connect and use the multimeter correctly to measure voltages, currents and resistances.
Interpret the physical concepts involved in the practice.

Material:
All the instrumentation and material necessary for the correct performance of the practice.

Delivery:
The student will prepare an individual report of each practice, according to the established guidelines, which will be delivered to the teacher within the indicated period. Each practice will be evaluated individually. Represents 1/6 of the laboratory grade.

Full-or-part-time: 6h
Laboratory classes: 2h
Self study: 4h

2. LABORATORY PRACTICE.

Description:
Laboratory practice, in pairs, lasting two hours. The students, after receiving the instructions from the teacher, have to assemble the circuits with the appropriate measuring devices in each case to experiment and check the theoretical and practical aspects previously studied.
Specific content of the practice: Circuits in direct current. Verification of Kirchhoff's Laws and of Thevenin and Kennelly theorems.

Specific objectives:
At the end of the activity, the student must be able to:
Make the serial and parallel connections correctly.
Measure voltages and currents in a two-mesh circuit.
Verify experimentally some basic theorems of circuits in direct current.

Material:
All the instrumentation and material necessary for the correct performance of the practice.

Delivery:
The student will prepare an individual report of each practice, according to the established guidelines, which will be delivered to the teacher within the indicated period. Each practice will be evaluated individually. Represents 1/6 of the laboratory grade.

Full-or-part-time: 6h
Laboratory classes: 2h
Self study: 4h

3. LABORATORY PRACTICE.

Description:
Laboratory practice, in pairs, lasting two hours. The students, after receiving the instructions from the teacher, have to assemble the circuits with the appropriate measuring devices in each case to experiment and check the theoretical and practical aspects previously studied.
Specific content of the practice: Measurements in alternating current. Determination of the capacitance of a capacitor and the inductance of a coil. R-L series circuit. Association of capacitors.

Specific objectives:
At the end of the activity, the student must be able to:
Use the variable autotransformer to adjust the voltage and / or current of the circuit.
Connect and use the multimeter correctly to measure alternating currents and voltages.
Interpret the physical concepts involved in the practice.

Material:
All the instrumentation and material necessary for the correct performance of the practice.

Delivery:
The student will prepare an individual report of each practice, according to the established guidelines, which will be delivered to the teacher within the indicated period. Each practice will be evaluated individually. Represents 1/6 of the laboratory grade.

Full-or-part-time: 6h
Laboratory classes: 2h
Guided activities: 4h

3. LABORATORY PRACTICE.

Description:
Laboratory practice, in pairs, lasting two hours. The students, after receiving the instructions from the teacher, have to assemble the circuits with the appropriate measuring devices in each case to experiment and check the theoretical and practical aspects previously studied.
Specific content of the practice: Study of the series R-L-C circuit. Visualization of voltage and current waves by means of the oscilloscope.

Specific objectives:
At the end of the activity, the student must be able to:
Using the oscilloscope, check the parameters of the alternating current (period, frequency, effective value)
Obtain the phasor diagram of the circuit with both the theoretical and measured values.
Interpret the physical concepts involved in the practice.

Material:
All the instrumentation and material necessary for the correct performance of the practice.

Delivery:
The student will prepare an individual report of each practice, according to the established guidelines, which will be delivered to the teacher within the indicated period. Each practice will be evaluated individually. Represents 1/6 of the laboratory grade.

Full-or-part-time: 6h
Laboratory classes: 2h
Self study: 4h

5. LABORATORY PRACTICE.

Description:
Laboratory practice, in pairs, lasting two hours. The students, after receiving the instructions from the teacher, have to assemble the circuits with the appropriate measuring devices in each case to experiment and check the theoretical and practical aspects previously studied.
Specific content of the practice: Circuit breakers, thermal magneto and differential. Star and delta connections in triphasic receivers. Balanced and unbalanced star. Neutral current.

Specific objectives:
At the end of the activity, the student must be able to:
Correctly connect the basic protection devices of a simple electrical installation.
Take measurements in three-phase circuits by interpreting the line and phase values.
Correctly connect star and delta loads.

Material:
All the instrumentation and material necessary for the correct performance of the practice.

Delivery:
The student will prepare an individual report of each practice, according to the established guidelines, which will be delivered to the teacher within the indicated period. Each practice will be evaluated individually. Represents 1/6 of the laboratory grade.

Full-or-part-time: 6h
Laboratory classes: 2h
Self study: 4h

6. LABORATORY PRACTICE.

Description:
Laboratory practice, in pairs, lasting two hours. The students, after receiving the instructions from the teacher, have to assemble the circuits with the appropriate measuring devices in each case to experiment and check the theoretical and practical aspects previously studied.
Specific content of the practice: The contactor. Protections of electrical machines. Direct starting of a three-phase motor. Turning reversal.

Specific objectives:
At the end of the activity, the student must be able to:
Assemble the control and power circuits to drive a motor III using start and stop buttons.
Correctly interpret the data on the motor's nameplate.

Material:
All the instrumentation and material necessary for the correct performance of the practice.

Delivery:
The student will prepare an individual report of each practice, according to the established guidelines, which will be delivered to the teacher within the indicated period. Each practice will be evaluated individually. Represents 1/6 of the laboratory grade.

Full-or-part-time: 6h
Laboratory classes: 2h
Self study: 4h

7. DELIVERIES (THEORY AND / OR PROBLEMS OF ALL THE CONTENTS).

Description:
Set of individual or team deliveries with a part of the theoretical concepts of the subject, and solving exercises and problems related to the learning objectives.

Specific objectives:
At the end of the activity, the student must be able to:
Know, understand and use the basic principles of direct and alternating current electrical circuits (single-phase and three-phase), of working independently and in a team, and of communicating results effectively. Know the main characteristics of induction motors and installations in B. T.

Material:
Statements of exercises and problems (available in the Digital Campus) and notes of the subject.

Delivery:
Delivery of the exercises and problems proposed within the established deadlines.
5% of the final grade for the course.

Full-or-part-time: 15h
Laboratory classes: 3h
Self study: 12h

8. FIRST INDIVIDUAL TEST OF CONTINUOUS EVALUATION (CONTENTS 1 AND 2).

Description:
Individual test in class with a part of the theoretical concepts and problems related to the learning objectives.

Specific objectives:
At the end of the activity, the student must be able to:
Know, understand and apply the concepts studied in the theoretical and problem sessions taught so far.

Material:
Theoretical part: just the statement. Problem part: statement, form (an A4 sheet) and calculator.

Delivery:
Delivery first of the result of the theoretical written test (test) and at the end delivery of the part of problems.
Test score: 0.4 x theory score + 0.6 x problem score.
The weight of this test is indicated in the section corresponding to the qualification system.

Full-or-part-time: 12h
Theory classes: 2h
Self study: 10h

9. SECOND TEST AND / OR INDIVIDUAL FINAL OF CONTINUOUS EVALUATION (CONTENTS 3, 4, 5 AND 6 OR ALL).

Description:
Individual test in class with a part of the theoretical concepts and problems related to the learning objectives.

Specific objectives:
At the end of the activity, the student must be able to:
Know, understand and apply the concepts studied in the theoretical and problem sessions taught so far.

Material:
Theoretical part: just the statement. Problem part: statement, form (an A4 sheet) and calculator.

Delivery:
First delivery of the result of the theoretical written test and at the end delivery of the part of problems.
Test score: 0.4 x theory score + 0.6 x problem score.
The weight of this test is indicated in the section corresponding to the qualification system.

Full-or-part-time: 15h
Theory classes: 3h 30m
Self study: 11h 30m

GRADING SYSTEM

- Partial and final tests of theory and problems (Activities 8 and 9).
- Average mark of theory and problems: Nmtp = 0.40 N first test + 0.60 N second test; or be Nmtp = N final test.
- The second test and the final will take place on the same day and on the date set by the Head of Studies.
- If the mark of the first part is less than 3.5, it is advisable to take the complete final test.
- Compulsory performance of laboratory practices (Activities 1, 2, 3, 4, 5 and 6): Nlab
- Deliverables of exercises and / or problems (Activity 7): Nlli
- Final note of the subject: NF

If Nmtp> = 4: NF = 0.75 Nmtp + 0.20 Nlab + 0.05 Nlli
If Nmtp = 4: NF = 0.75 Nmtp + 0.20 Nlab + 0.05 Ne
If Nmtp

EXAMINATION RULES.

- It is considered very convenient to have previously passed the Physics II subject.
- It is an essential condition to pass the course to have done the practices with sufficiency.
- The reports of the laboratory practices will be individual and original. If copies are detected, the activity note will be suspended.
- Students must follow the indications and deadlines specified on the digital campus.
- Both the reports of the practices and the deliveries (exercises and problems) will be delivered within the established deadlines. Late delivery has a negative impact on the grade obtained, even the document may not be accepted.
- A form (an A4 sheet) will be available only in the problem part of the tests.

BIBLIOGRAPHY

Basic:
- Durán Moyano, José Luis; Domingo Peña, Joan; ; Martínez García, Herminio; Morón Romera, Juan; Bargalló Perpiñá, Ramón. Electrotècnia [on line]. Segona edició. Barcelona: Marcombo, 2020 [Consultation: 08/06/2022]. Available on: https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=9514. ISBN 9788426728333.
- Castejón Oliva, Agustín; Santamaría Herranz, Germán. Tecnología eléctrica. Madrid: McGraw-Hill, 1993. ISBN 8448100786.

Complementary:
- Lagunas Marqués, Ángel. Instalaciones eléctricas de baja tensión comerciales e industriales : cálculos eléctricos y esquemas unifilares. 6ª ed. Madrid: Paraninfo, cop. 2005. ISBN 8428329117.
- Moreno, N.; Bachiller, A.; Bravo, J. C. Problemas resueltos de tecnología eléctrica. Madrid: International Thomson, 2003. ISBN 8497321944.
- Svoboda, J. A., Dorf, Richard C. Circuitos eléctricos [on line]. 9ª ed. México: Alfaomega, 2016 [Consultation: 10/06/2022]. Available on: https://search-ebscohost-com.recursos.biblioteca.upc.edu/login.aspx?direct=true&AuthType=ip,uid&db=nlebk&AN=2749665&site=ehost-live&ebv=EB&ppid=pp_Cover. ISBN 9788426729583.
- Reglament electrotècnic per a baixa tensió: amb les guies tècniques d'aplicació. 3a ed. Barcelona: Marcombo, 2012. ISBN 9788426714916.
- Cunill Solà, Jordi. Problemes de fonaments de tecnologia elèctrica. Manresa: EUPM, 1998.
- Fraile Mora, Jesús. Máquinas eléctricas. 8ª ed. Madrid: Ibergarceta, 2016. ISBN 9788416228669.
- García Trasancos, José. Electrotécnia: incluye más de 350 conceptos teóricos y 800 problemas. 7ª ed. Madrid: Paraninfo, 2002. ISBN 8428322848.

RESOURCES

Other resources:
Documentation available at ATENEA