



Universitat de Lleida

# DEGREE CURRICULUM

# **ELECTRIC MACHINERY IN**

# **INDUSTRY**

Coordination: GREGORIO LOPEZ, EDUARD

Academic year 2023-24

## Subject's general information

Subject name	ELECTRIC MACHINERY IN INDUSTRY			
Code	14538			
Semester	2nd Q(SEMESTER) CONTINUED EVALUATION			
Typology	Degree	Course	Character	Modality
	Master's Degree in Industrial Engineering	2	OPTIONAL	Attendance-based
Course number of credits (ECTS)	6			
Type of activity, credits, and groups	Activity type	PRAULA	TEORIA	
	Number of credits	3	3	
	Number of groups	1	1	
Coordination	GREGORIO LOPEZ, EDUARD			
Department	AGRICULTURAL AND FOREST SCIENCES AND ENGINEERING			
Teaching load distribution between lectures and independent student work	60 h class (40%) 90 h independent student work (60%)			
Important information on data processing	Consult <a href="#">this link</a> for more information.			
Language	English			

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
GREGORIO LOPEZ, EDUARD	eduard.gregorio@udl.cat	6	To arrange.

## Subject's extra information

This course presents the electric machines more commonly used in the industry (transformers, induction motors, generators, dc motors, etc.). Principles of operation, main features, uses and required calculations are explained for each machine. It is recommended to have basic background of circuit theory analysis.

It is an optional subject that is delivered in the 2nd semester of the 2nd year of the Master in Industrial Engineering. According to the structure of the degree, this optional subject is part of the Optional formation module, and the Energetic Systems module, along with the subject "Analysis of Industrial Thermal Equipment."

It is **COMPULSORY** that the students bring the following elements of individual protection (EPI) to the practices at the laboratory.

- Laboratory gown from UdL (unisex)
- Protection glasses
- Mechanical protection gloves

They can be purchased through the shop Údels of the UdL:

C/ Jaume II, 67 baixos  
Centre the Cultures i Cooperació Transfronterera

<http://www.publicacions.udl.cat/>

The use of other elements of protection (for example caps, masks, gloves of chemical or electrical risk, etc.) will depend on the type of practice to be done. In that case, the teacher will inform of the necessity of specific EPI.

Not bringing the EPI's described or not fulfilling the norms of general security that are detailed below imply that the student can not access to the laboratories or have to go out of them. The no realisation of the practices for this reason imply the **consequences in the evaluation** of the subject that are described in this course guide.

## GENERAL NORMS OF SECURITY IN LABORATORY PRACTICES

- Keep the place of realisation of the practices clean and tidy. The table of work has to be free from backpacks, folders, coats...
- No short trousers or short skirts are allowed in the laboratory.
- Closed and covered footwear is compulsory in the laboratory.
- Long hair needs to be tied.
- Keep the laboratoy gown laced in order to be protected from spills of chemicals.
- Bangles, pendants or wide sleeves are not allowed as they can be trapped.
- Avoid the use of contact lenses, since the effect of the chemical products is much bigger if they enter between the contact lense and the cornea. Protection over-glasses can be purchased.
- No food or drink is allowed in the laboratory.
- It is forbidden to smoke in the laboratories.

- Wash your hands whenever you have contact with a chemical product and before going out of the laboratory.
- Follow the instructions of the teacher and of the laboratory technicians and ask for any doubt on security.

For further information, you can check the following document of the *Servei de Prevenció de Riscos Laborals de la UdL*: <http://www.sprl.udl.cat/alumnes/index.html>

## Learning objectives

To provide students with the knowledge and techniques, tools, skills and abilities required to effectively develop professional activities related to the selection and use of electric machines. The achievement of this overall objective is based on:

- To identify the main electric machines used in the industry.
- To calculate single and three phase circuits.
- To calculate and select single and three phase transformers for an application.
- To calculate and select induction motors by an application.
- To use an inverter to control an induction motor .
- To calculate and select an application for synchronous generators .
- To calculate and select DC motors for an application.
- To implement various electric connections in the laboratory from a scheme .

## Competences

General competences (EPS):

- CG3 Capacity to convey information, ideas, problems and solutions both to a specialised and no specialised public.
- CG4 Capacity to conceive, design and implement projects and/or provide new solutions, using the tools that the engineering offers.
- CG7 To project, calculate and design products, processes, installations and plants
- CG9 To do research, development and innovation in products, processes and methods.

Degree-specific competences (Orden CIN/311/2009, de 9 de febrero):

- CE1 Knowledge and capacity for the analysis and design of systems of generation, transportation and distribution of electrical energy.

Degree-transversal competences (UdL):

- CT1 Appropriate skills in oral and written language.
- CT2 Command of a foreign language.

## Subject contents

### 1. Principles of electric machinery

#### 1.1. Introduction to electric machinery

Review: Rotational motion and power. The magnetic field. The Faraday's law. Production of induced force on a wire. Induced voltage on a conductor moving in a magnetic field. Real, reactive and apparent power in ac circuits.

#### 1.2. Three-phase circuits

Generation of three-pase voltages and currents. *Voltages and currents in a three-phase circuit. Power relationships in three-phase circuits. Analysis of balanced three-phase systems. One-line*

*diagrams. Using the power triangle.*

## 2. Transformers

Why transformers are important. Types and construction of transformers. The ideal transformer. The equivalent circuit of a transformer. The per-unit system of measurements. Transformer voltage regulation and efficiency. Transformer taps. *The autotransformer. Three-phase transformers. Instrument transformers.*

## 3. Power converters

Rectifiers. Choppers. Inverters. Variable-frequency drive. AC regulators. Cycloconverters.

## 4. Induction motors

Induction motor construction. Basic induction motor concepts. The equivalent circuit of an induction motor. Power and torque in induction motors. *Induction motor torque-speed characteristics. Variation in torque-speed characteristics. Starting induction motors. Speed control of induction motors.*

## 5. Synchronous machines

Introduction: Synchronous machines. Synchronous machine construction. The internal generated voltage. Equivalent circuit of a synchronous generator. *The phasor diagram of a synchronous generator. Power and torque in synchronous generators. Operation of the synchronous generator.*

## 6. DC motors

Introduction: DC motors. Equivalent circuit of a dc motor. Separately excited and shunt dc motors. The permanent-magnet dc motor. *The series dc motor. The compounded dc motor.*

## 7. Special-purpose electric machines

## Methodology

- **Lectures:** Classes to explain the theory and problem solving on the blackboard.
- **Resolution of problems:** Students solve problems individually during these sessions under the supervision of teachers of the subject.
- **Delivery of exercises:** Students deliver exercises proposed by the teacher (to solve in class or at home).
- **Laboratory:** operation and control of electrical machines using the equipment available in the lab. It is imperative that students take the PPE indicated in each lab class and follow the risk prevention rules specified in each case.
- **Works.** Among others, could include: analysis or resolution of cases, or if appropriate practical works.

## Development plan

The following plan may be subject to change depending on the number of students and the evolution of the group.

Week	Methodology	Contents	Class hours	Hours of autonomous work
1-3	Lectures Resolution of problems Delivery of exercises	1. Principles of electric machinery	10	18
3-5	Lectures Resolution of problems Delivery of exercises	2. Transformers	10	16
6	Lectures	3. Power converters	2	4

6-7	Practices	2. Transformers 3. Power converters	4	4
7-10	Lectures Resolution of problems Delivery of exercises	4. Induction motors	10	18
9	1st exam (PA1)	1. Principles of electric machinery 2. Transformers 3. Power converters	2	
11-14	Lectures Resolution of problems Delivery of exercises	5. Synchronous machines	8	14
14-15	Lectures Resolution of problems Delivery of exercises	6. DC motors	3	6
15	Lectures	7. Special-purpose electrical machines	1	2
11-15	Practices	4. Induction motors 5. Synchronous machines 6. DC motors	8	8
16-18	2nd exam (PA2)	4. Induction motors 5. Synchronous machines 6. DC motors 7. Special-purpose electrical machines	2	
20-21	Recovery exam	All the contents of the subject	2	

## Evaluation

Guidelines for the evaluation of the course.

Evaluation blocks	%
PA 1. Exam (units 1, 2 and 3 )	37.5
PA 2. Exam (units 4, 5, 6 and 7)	37.5
Exercises and practices	25
Recovery exam	75

### Guidelines for the evaluation of the subject.

- To pass the course it is necessary at least a grade of 5 over 10 of the final grade.

### Exams

- In the 8th and 16-18th weeks the scheduled exams will be performed (PA1 and PA2). Exam PA1 has a weight of 37.5% and exam PA2 has also a weight of 37.5% over the final grade of the course.

- The scheduled exams (PA1 and PA2) can be recovered by completing an exam of each part or a joint exam of both parts (20-21th week).

## Exercises and practices

- During the course, it will be proposed several exercises to solve that must be delivered on the established date.
- During the course, it will be conducted several lab practices. The lab reports must be delivered on the established date.
- The exercises and practices grade represents the 25% of the final grade of the course.
- The exercises and practices grade can not be recovered by performing other recovery activities.

## Alternative evaluation.

- The student who is granted the option of alternative evaluation must take an exam where all the contents of the subject will be assessed. This exam will be held on the date set for the PA2 exam in the school's exam calendar. This exam has a weight of 87.5% over the final grade of the course. This exam can be recovered by taking a recovery exam on the date set in the school's exam calendar.
- The student who is granted the option of alternative evaluation must also attend the practices sessions that will take place throughout the course and must deliver the reports corresponding to these sessions. Attendance at these practices and delivery of the corresponding reports has a weight of 12.5% over the final grade of the course. The practices grade cannot be recovered by performing other recovery activities.

## Bibliography

### Basic bibliography

- Stephen J. Chapman, "Máquinas Eléctricas", 4a edición, McGraw-Hill, 2012.
- Jesús Fraile Mora, "Máquinas Eléctricas", 6a edición, McGraw-Hill, 2008.

### Complementary bibliography

- Jesús Fraile Mora y Jesús Fraile Ardanuy, "Problemas de Máquinas Eléctricas", McGraw-Hill, 2005.
- Pedro Ponce Cruz y Javier Sampé López, "Máquinas Eléctricas y Técnicas Modernas de Control", Alfaomega, 2008.
- Guzmán Díaz González, Arsenio Barbón Álvarez y Javier Gómez-Aleixandre Fernández, "Variación de la Velocidad de los Motores Eléctricos", Universidad de Oviedo, 2002.