Universitat de Lleida

DEGREE CURRICULUM

ELECTRIC MACHINERY IN INDUSTRY

Coordination: GREGORIO LÓPEZ, EDUARD

Academic year 2017-18

Subject's general information

Subject name	ELECTRIC MACHINERY IN INDUSTRY
Code	14538
Semester	2nd Q(SEMESTER) CONTINUED EVALUATION
Typology	<table><tr><th>Degree</th><th>Course</th><th>Typology</th><th>Modality</th></tr><tr><td>Master's Degree in Industrial Engineering</td><td>2</td><td>OPTIONAL</td><td>Attendance-based</td></tr></table>
ECTS credits	6
Groups	1GG
Theoretical credits	3
Practical credits	3
Coordination	GREGORIO LÓPEZ, EDUARD
Department	ENGINYERIA AGROFORESTAL
Teaching load distribution between lectures and independent student work	60 h lectures (40%) 90 h independent student work (60%)
Important information on data processing	Consult this link for more information.
Language	English
Office and hour of attention	To arrange with the professor

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
GREGORIO LÓPEZ, EDUARD	egregorio@eagrof.udl.cat	6	By appointment Office: CREA 1.02

Subject's extra information

This course presents the electric machines more commonly used in the industry (transformers, induction motors, generators, dc motors). Principles of operation, main features 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.

- Blue 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 engines continues for an application.
- To implement various electric connections in the laboratory from a scheme .

Competences

General competences

- 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.

Basic competences

- 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

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

Degree-transversal competences

- 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.

    1.2 Review: Rotational motion and power.

    1.3 The magnetic field.

    1.4 The Faraday's law.

1.5 Production of induced force on a wire.

1.6 Induced voltage on a conductor moving in a magnetic field.

1.7 Real, reactive and apparent power in ac circuits.

A.1 Generation of three-pase voltages and currents.

A.2 Voltages and currents in a three-phase circuit.

A.3 Power relationships in three-phase circuits.

A.4 Analysis of balanced three-phase systems.

A.5 One-line diagrams.

A.6 Using the power triangle.

2. Transformers.

2.1 Why transformers are important.

2.2 Types and construction of transformers.

2.3 The ideal transformer.

2.4 The equivalent circuit of a transformer.

2.5 The per-unit system of measurements.

2.6 Transformer voltage regulation and efficiency.

2.7 Transformer taps.

2.8 The autotransformer.

2.9 Three-phase transformers.

2.10 Instrument transformers.

3. Induction Motors.

B.1 The rotating magnetic field.

B.2 Induced voltage in ac machines.

B.3 Induced torque in ac machines.

3.1 Induction motor construction.

3.2 Basic induction motor concepts.

3.3 The equivalent circuit of an induction motor.

3.4 Power and torque in induction motors.

3.5 Induction motor torque-speed characteristics.

3.6 Variation in torque-speed characteristics.

3.7 Starting induction motors.

3.8 Speed control of induction motors.

3.9 Induction motor drives.

4. Synchronous Machines.

4.1 Introduction: Synchronous machines.

4.2 Synchronous machine construction.

4.3 The internal generated voltage.

4.4 Equivalent circuit of a synchronous generator.

4.5 The phasor diagram of a synchronous generator.

4.6 Power and torque in synchronous generators.

4.7 The synchronous generator operating alone.

5. DC Motors.

5.1 Introduction: DC motors.

5.2 Equivalent circuit of a dc motor.

5.3 Separately excited and shunt dc motors.

5.4 The permanent-magnet dc motor.

5.5 The series dc motor.

5.6 The compounded dc motor.

Methodology

- **Lectures:** Classes to explain the theory and problem solving on the blackboard.
- **Resolution of problems:** Students solve poblems individually during these sessions under the supervision fo teachers of the subject.
- **Delivery of exercices:** Students deliver exercices proposed by the teacher (to solve in clar or at home), who corrects and returns it to the student.
- **Laboratory:** assembly and control of electric circuits and 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.
- **Project:** concepts adquired along the course are applied to select or design an application that involves electric machines.
- **Exam:** Two written tests are held during the semester. There is also a final retrieval test.

Development plan

Week	Methodology	Temari	Hours at classroom	Hours of autonomous work
1-3	Lectures Resolution of problems Delivery of exercices	1. Principles of Electric Machinery	10	15
3-5	Lectures Resolution of problems Delivery of exercices	2. Transformers	8	12

5-11	Lectures Resolution of problems Delivery of exercices	3. Induction Motors	10	15
7-8	Laboratory	2. Transformers 3. Induction Motors 4. Synchronous Machines 5. DC Motors	8	12
9	1st test of evaluation (exam)	1. Principles of Electric Machinery 2. Transformers	2	
12-14	Lectures Resolution of problems Delivery of exercices	4. Synchronous Machines	5	7.5
12-15	Laboratory	3. Induction Motors	6	9
14-15	Lectures Resolution of problems Delivery of exercices	5. DC Motors	3	4,5
16-17	2nd test of evaluation (exam)	3. Induction Motors 4. Synchronous Machines 5. DC Motors	2	
19	Retrieval test	All the contents of the subject	2	

Evaluation

Guidelines for the evaluation of the course.

Evaluation activities	%	Dates
PA 1. Written exam	40	Week 9
PA 2. Written exam	40	Weeks 16 and 17
Exercices in class and at home	10	Along the course
Laboratoy	10	Along the course
Recovery exam	80	Week 19

Guidelines for the evaluation of the subject.

Exams

- In the weeks 9 and 16 / 17 evaluation tests are carried out (written exams) PA1 and PA2 . Each of these tests has a weight of 40% of the final grade for the course.
- To pass the course it is required a final grade of 5 and simultaneously a grade equal to or higher than 3 at each of the blocks (PA1 and PA2).

- At the 19th week a recovery exam is scheduled . Students may recover / improve note of two blocks of the subject either of a single block. To pass the course, it is required a final grade of 5 and simultaneously a grade equal to or higher than 3 at each of the blocks

Exercices

- During the course it will be proposed several exercises in class or at home and must be delivered on the established date. This mark represents the 10% of the final grade for the course.
- The exercices can not be recovered / improved by performing another activity.

Laboratory and project

- During the course, it will be conducted several lab practices. This mark represents the 10% of the final grade for the course.
- Attendance at the laboratory and the delivery of the reports is required. The marks of the laboratory can not be recovered / improved by performing another activity.

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.