Course guide
240IEL32 - 240IEL32 - Design of Electric Machines and Electric Drives

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 709 - DEE - Department of Electrical Engineering.
Degree: MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Optional subject).
Academic year: 2023
ECTS Credits: 4.5
Languages: Catalan

LECTURER

Coordinating lecturer: PERE ANDRADA GASCON

Others:

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEELEC2. Calculate and design machines and electric actuators, with suitable knowledge on the efficient management of electrical systems and effective control of electrical actuators.

TEACHING METHODOLOGY

In the theory classes, the lecture method will be used combined with the participatory lecture class.
In the problem classes, the participatory lecture class will be combined with solving exercises and problems and problem-based learning.
In the computer simulation practical classes, case studies will be combined with cooperative learning.

LEARNING OBJECTIVES OF THE SUBJECT

Introduce to electric drives using a modern perspective, based on power electronics and control systems, which provide a solid theoretical basis and at the same time, enables the selection of control equipment suitable for each application. Initiate in calculation and design of electrical machines following a systematic and rational process, based more in-depth study of the common characteristics than in the calculation of the different types of electrical machines. Provide the basis for finite element analysis of electric machines.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>27,0</td>
<td>24.00</td>
</tr>
<tr>
<td>Self study</td>
<td>72,0</td>
<td>64.00</td>
</tr>
<tr>
<td>Hours small group</td>
<td>13,5</td>
<td>12.00</td>
</tr>
</tbody>
</table>

Total learning time: 112.5 h
## CONTENTS

### TOPIC 1.- Overview about electric drives

**Description:**
- 1.1.- Drives. Definition and types.
- 1.2.- Dynamics of motor-load system. Mechanical considerations.
- 1.4.- Power electronics and electrical machines.
- 1.5.- Current and position / speed sensors.

**Full-or-part-time:** 18h 30m
- Theory classes: 5h
- Laboratory classes: 1h 30m
- Self study: 12h

### TOPIC 2.- Basic principles of design of electric machines

**Description:**
- 6.1.- Procedures for calculating electric machines and electrical drives.
- 6.2.- Constructive aspects (standardization / regulations).
- 6.3.- Parametric equations of torque, power and voltage of rotating electrical machines.
- 6.4.- Sizing of rotating electrical machines.
- 6.5.- Scaling laws in electrical machines.

**Full-or-part-time:** 12h
- Theory classes: 4h
- Self study: 8h

### TOPIC 3.- Materials

**Description:**
- 2.1.- Conducting materials.
- 2.2.- Insulation materials.
- 2.3.- Magnetic materials.
- 2.4.- Other types of materials.

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

### TOPIC 4.- Magnetic circuits

**Description:**
- 4.1.- Magnetic circuits with magnetization currents.
- 4.2.- Magnetic circuits with permanent magnets.
- 4.3.- Flux leakage.
- 4.4.- Calculation of specific leakage permeances in electric machines.

**Full-or-part-time:** 19h 30m
- Theory classes: 6h
- Laboratory classes: 1h 30m
- Self study: 12h
TOPIC 5.- Windings.

Description:
5.1.- Windings, fundamental principles.
5.2.- Armature windings of alternating current machines.
5.3.- Different types of armature windings of alternating current machines.
5.4.- Winding factors.
5.5.- Squirrel cage. Phase resistance of a squirrel cage.
5.6.- Phase resistance of an armature winding of alternating current.
5.7.- Armature winding of direct current machines. Different types of windings. Resistance of a direct current armature winding.
5.8.- Excitation windings. Resistance of an excitation winding.

Full-or-part-time: 17h 30m
Theory classes: 6h
Laboratory classes: 1h 30m
Self study : 10h

TOPIC 6. Losses and heating/cooling of electric machines

Description:
6.1.- Losses, basic principles.
6.2.- Iron losses.
6.3.- Copper losses.
6.4.- Mechanical losses.
6.5.- Thermal considerations. Heating/cooling of electrical machines.
6.6.- Thermal circuits.

Full-or-part-time: 12h
Theory classes: 4h
Self study : 8h

TOPIC 7.- Introduction to finite element calculation of electric machines

Description:
7.1.- Determination of electromagnetic fields in electrical machines
7.2.- Introduction to numerical calculation methods.
7.3.- Examples of application.

PRACTICAL WORK 1.- Programs of analysis of machines and electrical devices with finite elements: introduction to the FEMM program
PRACTICAL WORK 2.- Simulation with finite elements of a c.c. with permanent magnets.
PRACTICAL WORK 3.- Design of an electric driver for light electric vehicle

Full-or-part-time: 27h
Laboratory classes: 9h
Self study : 18h
**GRADING SYSTEM**

The final grade will be obtained according to the following formula:

\[
\text{FINAL GRADE} = \max(N1, N2)
\]

With:

\[
N1 = 0.25 \times \text{MARK OF FIRST TEST} + 0.15 \times \text{MARK OF PRACTICAL WORKS} + 0.15 \times \text{MARK OF ASSESSMENT EXERCISES} + 0.45 \times \text{MARK OF FINAL TEST}
\]

\[
N2 = 0.15 \times \text{MARK OF PRACTICAL WORKS} + 0.15 \times \text{MARK OF ASSESSMENT EXERCISES} + 0.70 \times \text{MARK OF FINAL TEST}
\]

If the final grade is less than 5, then there is the "REAVALUACIÓ" TEST, therefore the final grades will be obtained according to the following formulas:

Final grade = \( \max(N1, N2) \)

\[
N1 = 0.25 \times \text{MARK OF FIRST TEST} + 0.15 \times \text{MARK OF PRACTICAL WORKS} + 0.15 \times \text{MARK OF ASSESSMENT EXERCISES} + 0.45 \times \text{MARK OF "REAVALUACIÓ" TEST}
\]

\[
N2 = 0.25 \times \text{MARK OF "REAVALUACIÓ" TEST} + 0.15 \times \text{MARK OF PRACTICAL WORKS} + 0.15 \times \text{MARK OF ASSESSMENT EXERCISES}
\]

The mark of "reavaluació" test substitutes the mark of the final test and/or the mark of the first term. The practical works and assessment exercises are not object of "reavaluació"

**EXAMINATION RULES.**

The three tests will be written and individual (a three-page form may be taken to the tests). The problems and questions of the final test and the re-evaluation will be mainly the syllabus done in class. It is allowed to use a scientific calculator. It is not permitted to use laptops of any kind, tablets, smartphones, and the like.

**BIBLIOGRAPHY**

**Basic:**