# 820143 - EMDEE - Electrical Machines Design

<table>
<thead>
<tr>
<th>Coordinating unit:</th>
<th>295 - EEBE - Barcelona East School of Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching unit:</td>
<td>709 - EE - Department of Electrical Engineering</td>
</tr>
<tr>
<td>Academic year:</td>
<td>2019</td>
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<tr>
<td>Degree:</td>
<td>BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)</td>
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<tr>
<td>ECTS credits:</td>
<td>6</td>
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<tr>
<td>Teaching languages:</td>
<td>Catalan</td>
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## Teaching staff

- **Coordinator:** Ramon Bargalló Perpiña
- **Others:** Ramon Bargalló Perpiña

## Prior skills

- Matrix analysis.
- Fourier Methods.
- Electromagnetics.
- Electrical Machines 1 and 2.
- Use of scientific calculator (HP 50G, CFX9950, other)
- Use of MATLAB

## Requirements

- Electrical Machines 1 and 2.

## Degree competences to which the subject contributes

### Specific:

1. Carry out calculations for the design of electrical machines.
2. Apply regulations and standards based on sound criteria.
3. Summarise information and undertake self-directed learning activities.

### Transversal:

4. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.

## Teaching methodology

- Expositive methodology for theory classes.
- PBL for exercises classes.
- Training on FE software on laboratory classes.

## Learning objectives of the subject
820143 - EMDEE - Electrical Machines Design

- To do to the student a general scope in the field of electrical machines and drives. The main treated aspects are their modelling and design.
- To put into practice the FE method to analyse and design electrical machines and apparatus
- Explain general rules and methods for size electrical machines.
- Explain the main characteristics for materials used in the electrical machines to obtain an optimal design (technical, economical, environmental, etc. criterions are used)

<table>
<thead>
<tr>
<th>Study load</th>
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<tbody>
<tr>
<td><strong>Total learning time:</strong> 150h</td>
<td>Hours large group:</td>
<td>30h</td>
</tr>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
</tr>
<tr>
<td></td>
<td>Hours small group:</td>
<td>30h</td>
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<tr>
<td></td>
<td>Guided activities:</td>
<td>0h</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>90h</td>
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## Content

| **Electrical machines modeling using electromagnetic equations.** | **Learning time:** 19h  
Theory classes: 6h  
Laboratory classes: 3h  
Self study: 10h |
<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Related activities:</strong> Inductance analysis using FE software. Actuator analysis using FE software.</td>
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</table>

| **Windings for electrical machines** | **Learning time:** 18h  
Theory classes: 6h  
Laboratory classes: 2h  
Self study: 10h |
<table>
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<tbody>
<tr>
<td><strong>Description:</strong> Basis: salient pole windings, slot windings, end windings. Phase windings. MMF and EMF. Fractional windings. Other windings.</td>
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<tr>
<td><strong>Related activities:</strong> Winding design for a AC machine. Analysis of MME and EMF.</td>
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| **General concepts and limitations in the design of electrical machines.** | **Learning time:** 16h  
Theory classes: 6h  
Self study: 10h |
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<tbody>
<tr>
<td><strong>Description:</strong> General expressions for torque. Standards. Scale laws. Flux constant and weakening field work of electrical machines.</td>
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</table>
### Optimal design methods.

**Description:**
- Problem formulation.
- Restrictions.
- Solve methods.
- Examples.

**Related activities:**
- Optimal design of an actuator.

**Learning time:** 18h
- Theory classes: 6h
- Laboratory classes: 2h
- Self study: 10h

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### Parameter and losses calculation

**Description:**
- FE determination of: losses, emf, cogging torque, torque, inductance, resistance, capacitance, etc.

**Related activities:**
- Transformer analysis.

**Learning time:** 15h
- Theory classes: 3h
- Laboratory classes: 2h
- Self study: 10h

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### Heat transfer

**Description:**
- Thermal equivalent circuits.
- FE calculation of heat.

**Related activities:**
- Thermal analysis of a transformer: steady state calculation, transient calculation.
- Combined electromagnetic + thermal analysis.

**Learning time:** 18h
- Theory classes: 6h
- Laboratory classes: 2h
- Self study: 10h
### Design process

**Description:**
General formulation for sizing electrical machines. Application to: asynchronous, synchronous and permanent magnet machines. Every course one or more detailed process design will be developed.

**Related activities:**
- FE analysis of:
  - asynchronous machine. Steady state characteristics
  - synchronous PM machine. Torque-angle characteristic, cogging torque, EMF determinations.
  - Radial forces. Noise analysis.

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>33h</th>
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<tbody>
<tr>
<td>Theory classes</td>
<td>9h</td>
</tr>
<tr>
<td>Laboratory classes</td>
<td>4h</td>
</tr>
<tr>
<td>Self study</td>
<td>20h</td>
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### Insulation of electrical machines

**Description:**
Insulation materials. Monitoring insulation. Statistical analysis. Predictive analysis

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>13h</th>
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</thead>
<tbody>
<tr>
<td>Theory classes</td>
<td>3h</td>
</tr>
<tr>
<td>Self study</td>
<td>10h</td>
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### Qualification system

- Final test: 20%
- Laboratory: 20%
- Homework exercises + class exercises: 20%
- Homework project (design an electrical machines): 40%

### Regulations for carrying out activities

Final test with open books. NO final reexam.
Bibliography

Basic:


Complementary:

