820143 - EMDEE - Electrical Machines Design

Coordinating unit: 295 - EEBE - Barcelona East School of Engineering
Teaching unit: 709 - DEE - Department of Electrical Engineering
Academic year: 2019
Degree: BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
ECTS credits: 6

Teaching staff
Coordinator: Ramon Bargalló Perpiña
Others: Primer quadrimestre: RAMON BARGALLO PERPIÑA - T11

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.
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Learning objectives of the subject

- 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)

Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 30h</th>
<th>20.00%</th>
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</thead>
<tbody>
<tr>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td>Hours small group:</td>
<td>30h</td>
<td>20.00%</td>
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<tr>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
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### Content

#### Electrical machines modeling using electromagnetic equations.

**Learning time:** 19h  
Theory classes: 6h  
Laboratory classes: 3h  
Self study: 10h

**Description:**  

**Related activities:**  
Inductance analysis using FE software.  
Actuator analysis using FE software.

#### Windings for electrical machines

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

**Description:**  
Basis: salient pole windings, slot windings, end windings. Phase windings. MMF and EMF. Fractional windings. Other windings.

**Related activities:**  
Winding design for a AC machine. Analysis of MME and EMF.

#### General concepts and limitations in the design of electrical machines.

**Learning time:** 16h  
Theory classes: 6h  
Self study: 10h

**Description:**  
General expressions for torque. Standards. Scale laws. Flux constant and weakening field work of electrical machines.
<table>
<thead>
<tr>
<th>Optimal design methods.</th>
<th><strong>Learning time:</strong> 18h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Problem formulation. Restrictions. Solve methods. Examples.</td>
</tr>
<tr>
<td><strong>Related activities:</strong></td>
<td>Optimal design of an actuator.</td>
</tr>
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<thead>
<tr>
<th>Parameter and losses calculation</th>
<th><strong>Learning time:</strong> 15h</th>
</tr>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>FE determination of: losses, emf, cogging torque, torque, inductance, resistance, capacitance, etc.</td>
</tr>
<tr>
<td><strong>Related activities:</strong></td>
<td>Transformer analysis.</td>
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<tr>
<th>Heat transfer</th>
<th><strong>Learning time:</strong> 18h</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Heat removal: conduction, convection, radiation. Thermal equivalent circuits. FE calculation of heat.</td>
</tr>
<tr>
<td><strong>Related activities:</strong></td>
<td>Thermal analysis of a transformer: steady state calculation, transient calculation. Combined electromagnetic+thermal analysis.</td>
</tr>
</tbody>
</table>
### Design process

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 33h</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>Theory classes: 9h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 4h</td>
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<td>Self study: 20h</td>
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<table>
<thead>
<tr>
<th>Related activities:</th>
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<tbody>
<tr>
<td>FE analysis of:</td>
<td></td>
</tr>
<tr>
<td>- asynchronous machine. Steady state characteristics</td>
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<tr>
<td>- synchronous PM machine. Torque-angle characteristic, cogging torque, EMF determinations.</td>
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<td>- Radial forces. Noise analysis.</td>
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### Insulation of electrical machines

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<tr>
<th>Description:</th>
<th>Learning time: 13h</th>
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<tr>
<td>Insulation materials. Monitoring insulation. Statistical analysis. Predictive analysis</td>
<td>Theory classes: 3h</td>
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<td></td>
<td>Self study: 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:

