860015 - 21004SIE - Electrical Systems

Coordinating unit: 860 - EEI - Igualada School of Engineering
Teaching unit: 709 - EE - Department of Electrical Engineering
Academic year: 2013
Degree: DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)
DEGREE IN INDUSTRIAL SCHEDULING (Syllabus 2011). (Teaching unit Compulsory)
ECTS credits: 6

Teaching staff
Coordinator: JORDI ROGER RIBA RUIZ

Degree competences to which the subject contributes

Specific:
3. Knowledge and use of circuit theory and electric machines.

General:
1. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.
2. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

Teaching methodology

Learning activities ECTS credits
Expository lectures by the teacher with the explanation of concepts, materials and work plan 2,0
Exercises solved individually or in teams, searching for information, autonomous learning and study. 3,0
Lab sessions and subsequent oral or written presentation, individually or in groups. 0,5
Tutoring and evaluation 0,5

Learning objectives of the subject

Once finished the course the student should be able to:

- Understand the fundamentals, laws and basic methods to analyze and solve DC electric circuits, single phase AC circuits and three phase AC circuits.
- Understand the fundamentals, laws and basic methods to analyze and to solve DC circuits, single phase and three phase AC circuits.
- Understand the physical laws and principles of operation of various electrical machines such as single and three phase transformers, DC and three-phase AC electric machines.
- Solve simple problems involving single-phase and three-phase transformers, AC and DC machines taking into account their equivalent circuit.
- Calculate the electric protections to be applied in low-voltage electric installations.
- Understand the use of equipment found in an electric laboratory.
- Know how to develop in an electric laboratory.
- Team-working making a proper division of tasks and resolve any conflicts arising in the work situation.
- Use of scientific terminology of the subject in English.
# Study Load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Theory classes: 20h 13.33%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Practical classes: 20h 13.33%</td>
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<tr>
<td></td>
<td>Laboratory classes: 15h 10.00%</td>
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<tr>
<td></td>
<td>Guided study: 5h 3.33%</td>
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<tr>
<td></td>
<td>Self study: 90h 60.00%</td>
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</tbody>
</table>
## Content

### Direct current circuits

**Description:**
- Circuit elements
- Ohm's law
- Kirchoff's laws
- The mesh-current method
- The node-voltage method
- Thevenin and Norton equivalent circuits
- Resolution of exercises and computer simulation
- Lab session 1: DC circuits measurements

**Learning time:** 20h
- Theory classes: 3h
- Practical classes: 3h
- Laboratory classes: 2h
- Self study: 12h

### Alternating current circuits

**Description:**
- Importance of AC circuits
- Phasors
- Average and root-mean square (RMS) value
- Ohm's law for AC circuits
- AC pure resistive, pure inductive and pure capacitive circuits
- AC power: instantaneous, complex, apparent, active and reactive power
- The power triangle
- Power factor and \( \cos \phi \)
- Power factor improvement
- Resolution of exercises and computer simulation
- Lab session 2: AC circuits measurements

**Learning time:** 20h
- Theory classes: 3h
- Practical classes: 3h
- Laboratory classes: 2h
- Self study: 12h
### AC Three-phase circuits

**Description:**
- Importance of three-phase AC circuits
- Generation of three-phase voltages
- Three-phase loads: balanced and unbalanced, wye and delta-connected loads
- Three-phase AC power: instantaneous, complex, apparent, active and reactive power
- Active power measurement. Aaron connection.
- Power factor improvement in three-phase systems
- Resolution of exercises and computer simulation
- Lab session 3: AC three-phase circuits measurements

**Learning time:** 27h 30m
- Theory classes: 4h 30m
- Practical classes: 4h 30m
- Laboratory classes: 2h
- Guided activities: 1h
- Self study: 15h 30m

### Transformers

**Description:**
- Importance of single-phase and three-phase transformers
- Physical structure of transformers
- Magnetic Materials
- The ideal transformer
- The practical transformer
- Equivalent circuit
- Standard no-load and short circuit tests
- Efficiency
- Three-phase transformers
- Types of connections
- Resolution of exercises
- Lab session 4: Transformers measurements and connection types

**Learning time:** 27h 30m
- Theory classes: 4h 30m
- Practical classes: 4h 30m
- Laboratory classes: 2h
- Guided activities: 1h
- Self study: 15h 30m
### The induction machine

**Description:**
- Importance of induction machines
- Physical structure of three-phase induction machines
- Interpretation of the nameplate characteristics.
- Star and delta connection
- Direction of rotation
- Creation of a rotating magnetic field
- Principle of operation
- Equivalent circuit
- Operational modes
- Torque and efficiency characteristics
- Standard no-load and short circuit tests
- Starting methods
- How to get variable speed
- Resolution of exercises
- Lab session 5: Three-phase induction motors, measurements and connections

**Learning time:** 27h 30m  
Theory classes: 4h 30m  
Practical classes: 4h 30m  
Laboratory classes: 2h  
Guided activities: 1h  
Self study: 15h 30m

### Other types of electric machines

**Description:**
- DC electric machines
- Permanent magnet synchronous machines
- Switched reluctance machines
- Stepping motors
- Claw-pole generators
- Lab session 6: DC machines, measurements and connections

**Learning time:** 12h 30m  
Theory classes: 3h  
Laboratory classes: 2h  
Guided activities: 1h  
Self study: 6h 30m
The final grade for the course (Nfinal) is calculated as follows:

\[ N_{\text{final}} = 0.8 \times (N_{\text{theory}}) + 0.2 \times (N_{\text{lab}}) \]

where,

\( N_{\text{lab}} \) is the lab mark and \( N_{\text{theory}} \) is the theory mark.

where,

\[ N_{\text{theory}} = 0.50 \times N_{\text{final\_exam}} + 0.30 \times N_{\text{partial\_exam}} + 0.10 \times N_{\text{exercises}} \]

where,

\( N_{\text{final\_exam}} \) is the final exam mark
\( N_{\text{partial\_exam}} \) is the average mark obtained from the partial exams
\( N_{\text{exercises}} \) is the average mark obtained from the exercises delivered during the semester

\( N_{\text{lab}} = 0.33 \times N_{\text{attitude}} + 0.33 \times N_{\text{report}} + 0.33 \times N_{\text{exam}} \)

where:

\( N_{\text{attitude}} \) is the lab skills and attitude mark
\( N_{\text{report}} \) is the average reports marks
\( N_{\text{exam}} \) is the average mark obtained from the lab exams

### Electrical installations and low-voltage protection

**Learning time:** 15h

- Theory classes: 3h
- Laboratory classes: 3h
- Guided activities: 2h
- Self study: 7h

**Description:**
- Low-voltage protection
- Fuses
- Circuit breakers, thermal protection, short-circuit protection
- Residual current protection
- System earthing
- Over-voltage protection
- Electrical conductors sizing
- Low-voltage regulations
- Lab session 7: low-voltage protection, measurements and connections

### Qualification system

The final grade for the course (Nfinal) is calculated as follows:

\[ N_{\text{final}} = 0.8 \times (N_{\text{theory}}) + 0.2 \times (N_{\text{lab}}) \]

where,

\( N_{\text{lab}} \) is the lab mark and \( N_{\text{theory}} \) is the theory mark.

where,

\[ N_{\text{theory}} = 0.50 \times N_{\text{final\_exam}} + 0.30 \times N_{\text{partial\_exam}} + 0.10 \times N_{\text{exercises}} \]

where,

\( N_{\text{final\_exam}} \) is the final exam mark
\( N_{\text{partial\_exam}} \) is the average mark obtained from the partial exams
\( N_{\text{exercises}} \) is the average mark obtained from the exercises delivered during the semester

\( N_{\text{lab}} = 0.33 \times N_{\text{attitude}} + 0.33 \times N_{\text{report}} + 0.33 \times N_{\text{exam}} \)

where:

\( N_{\text{attitude}} \) is the lab skills and attitude mark
\( N_{\text{report}} \) is the average reports marks
\( N_{\text{exam}} \) is the average mark obtained from the lab exams

### Regulations for carrying out activities

The students are required to delivery all the practice reports in order to pass the subject.
Bibliography

Basic:


Complementary:


### Planning of activities

<table>
<thead>
<tr>
<th>Lectures</th>
<th>Hours: 45h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 45h</td>
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<tr>
<td>Lectures with explanation of concepts, materials and work plan.</td>
<td></td>
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<tr>
<td><strong>Support materials:</strong></td>
<td></td>
</tr>
<tr>
<td>Notes and bibliography.</td>
<td></td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>At the end of this activity the student should be able to:</td>
</tr>
<tr>
<td>- Applying the basic methods to analyze and solve DC circuits, alternating current single phase and three phase alternating current.</td>
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<tr>
<td>- To understand the physical laws and principles of operation of single and three phase transformers, electrical machines and three-phase alternating current to direct current.</td>
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<tr>
<td>- Solve problems involving simple on single and three phase transformers, AC machines and DC machines from the equivalent circuit.</td>
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<td>- Know how to calculate electrical protection to be applied in low voltage installations and know the system electricity rates and to understand a given power.</td>
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<table>
<thead>
<tr>
<th>Exercises and Self-Learning</th>
<th>Hours: 54h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Self study: 54h</td>
</tr>
<tr>
<td>Written assignments individually or in teams, research of information, self-study and self-learning.</td>
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<tr>
<td><strong>Support materials:</strong></td>
<td></td>
</tr>
<tr>
<td>Notes and bibliography.</td>
<td></td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>At the end of this activity the student should have improved these skills:</td>
</tr>
<tr>
<td>- Problem solving</td>
<td></td>
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<tr>
<td>- Reading comprehension</td>
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<td>- Sense of reality of the results</td>
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<tr>
<td>- Self-learning</td>
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<tr>
<td>- Deductive and analytical capacity</td>
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</table>
Planning of activities

<table>
<thead>
<tr>
<th>TUTORING AND EVALUATION</th>
<th>Hours: 6h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Guided study: 6h</td>
</tr>
<tr>
<td>Several control tests during the course and a final exam.</td>
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<tr>
<td>Individual tutoring all along the course</td>
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</tbody>
</table>

Descriptions of the assignments due and their relation to the assessment:

Deliverables: the partial exams (30% of the theory grade) and the final exam (50% of the theory grade).
Exercises of each subject to do in class during 15 minutes.
These exercises have a weight of 20% of the theory.

Specific objectives:

At the end of this activity the student should have improved these skills:
- Problem solving
- Deductive and analytical capacity
- Sense of reality of the results
- Reading comprehension
- Oral and written communication
### Planning of activities

#### ELECTRICAL LABORATORY

| Description: | Activities that should be taken to the laboratory in pairs, during two hours each session. In the laboratory, after reading the script, students will make the appropriate measurements and calculations. The following week the students will give the report to the professor. |
| Support materials: | All materials and equipment necessary for performing the measurements in the laboratory. Detailed scripts with the questionnaire of the measures that students have to do. |
| Descriptions of the assignments due and their relation to the assessment: | The following week after each practise session each student must deliver an individual report with all data, calculations and results of the measurements. This delivery represents one third of the activity. For the evaluation of all activities the professor will take into account the attitude, attendance and students' working and that represents one third of the activity. The remaining third is for written exams. |
| Specific objectives: | - Understand the use of materials and equipment found in an electrical laboratory.  
- Learn to make basic electrical measurements.  
- Work in teams, distribute the work properly and solve potential conflicts.  
- Use the terminology of the scientific and technical matters. |