

## 820149 - ASM - Actuators and Sensors for Mechatronics

|                     |  |
|---------------------|--|
| Coordinating unit:  | 295 - EEBE - Barcelona East School of Engineering  |
| Teaching unit:      | 709 - EE - Department of Electrical Engineering  |
| Academic year:      | 2015   |
| Degree:             | BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)<br>BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)<br>BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)<br>BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Teaching unit Optional)<br>BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)<br>BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Teaching unit Optional) |
| ECTS credits:       | 6  |
| Teaching languages: | English  |

### Teaching staff

|              |                        |
|--------------|------------------------|
| Coordinator: | Ramón Bargalló Perpiñà |
| Others:      | Jordi Sust             |

### Opening hours

|            |   |
|------------|---|
| Timetable: | UR1- BA17, usually I am on my room on mornings. |
|------------|---|

### Prior skills

- Some knowledge of:
- physical concepts: electromagnetism, mechanics.....
  - Electrical circuits: DC, AC and transient analysis (Sistemas Electricos)
  - Matlab (not compulsory, but recommended)

### Requirements

Not necessary

### Degree competences to which the subject contributes

Transversal:

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

Theory sessions to show fundamental principles, Problem sessions to show how apply theory concepts to basic and advanced calculation, Practical sessions to train the student to use and postprocessing FE software to design electromechanical actuators and sensors. Every student must solve a set of homework exercises and design a sensor or actuator using these FE tools.

### Learning objectives of the subject



## 820149 - ASM - Actuators and Sensors for Mechatronics

Electromagnetism theory applied to actuators design.

### Study load

|                           |                     |     |        |
|---------------------------|---------------------|-----|--------|
| Total learning time: 150h | Hours large group:  | 30h | 20.00% |
|                           | Hours medium group: | 0h  | 0.00%  |
|                           | Hours small group:  | 15h | 10.00% |
|                           | Guided activities:  | 15h | 10.00% |
|                           | Self study:         | 90h | 60.00% |

## 820149 - ASM - Actuators and Sensors for Mechatronics

### Content

|  |   |
|--|---|
| <p>(ENG) -Electromagnetism principles.</p>   | <p>Learning time: 16h<br/>Theory classes: 4h<br/>Laboratory classes: 2h<br/>Guided activities: 4h<br/>Self study : 6h</p> |
| <p>Description:<br/>Overview of magnetic actuators and sensors. Basic electromagnetics. Maxwell's equations.</p> <p>Related activities:<br/>Analytical and numerical solution of some typical problems in electromagnetism</p>   |   |
| <p>(ENG) -Magnetic materials, Permanent magnets, Conductors.</p>   | <p>Learning time: 20h<br/>Theory classes: 6h<br/>Laboratory classes: 2h<br/>Guided activities: 4h<br/>Self study : 8h</p> |
| <p>Description:<br/>Materials for magnetic devices. Coils: wire and conductor characteristics. Magnetic steel: magnetic characteristics, hysteresis and eddy current losses, laminations. Permanent magnets: magnetization process, magnetic characteristics, MAXimum energy product. Temperature effects. LEakage paths.</p> <p>Related activities:<br/>Modelling magnetic materials. Experimental determination of magnetic and losses characteristics</p> |   |
| <p>(ENG) -Magnetic circuit approach.</p>   | <p>Learning time: 19h<br/>Theory classes: 6h<br/>Laboratory classes: 1h<br/>Guided activities: 4h<br/>Self study : 8h</p> |
| <p>Description:<br/>mmf, flux and reluctance. Laws of magnetic circuits. Magnetic circuit elements. Magnetic equivalent circuits.</p> <p>Related activities:<br/>Magnetostatic Inductor analysis using magnetic circuit approach.</p>  |   |

## 820149 - ASM - Actuators and Sensors for Mechatronics

|   |   |
|---|---|
| <p>(ENG) -Finite elements approach.</p>   | <p>Learning time: 19h<br/>Theory classes: 5h<br/>Laboratory classes: 2h<br/>Guided activities: 4h<br/>Self study : 8h</p> |
| <p>Description:<br/>Energy conservation and Functional minimization. Triangular elements. Matrix equation. Finite-element models. FE software: preprocessing unit, processing unit, postprocessing unit. Postprocessed quantities.</p> <p>Related activities:<br/>1. Magnetostatic Inductor analysis using FE software.<br/>2. Automatic analysis of transformer. Link between FEMM and OCTAVE.</p> |   |
| <p>(ENG) -Electromechanical conversión principles.</p>  | <p>Learning time: 20h<br/>Theory classes: 6h<br/>Laboratory classes: 2h<br/>Guided activities: 4h<br/>Self study : 8h</p> |
| <p>Description:<br/>Inductance and Speedance. Magnetic Energy. Magnetic force. Equations of motion.</p> <p>Related activities:<br/>Linear actuator analysis using FE methods. Making animations.</p>  |   |
| <p>(ENG) -Permanent magnet actuators.<br/>Characteristics. Applications</p>   | <p>Learning time: 20h<br/>Theory classes: 6h<br/>Laboratory classes: 2h<br/>Guided activities: 4h<br/>Self study : 8h</p> |
| <p>Description:<br/>Permanent magnet devices: classification. Modeling. Magnetic sensors. Magnetic linear actuators. Rotating actuators. Stepper motors. Voice-coil motors. Brushless motors.</p> <p>Related activities:<br/>Voice-coil design and optimization. Link between FEMM and OptiY</p>  |   |

## 820149 - ASM - Actuators and Sensors for Mechatronics

|  |   |
|--|---|
| <p>(ENG) -Losses and Cooling of electromagnetic devices.</p>   | <p>Learning time: 20h<br/>Theory classes: 6h<br/>Laboratory classes: 2h<br/>Guided activities: 4h<br/>Self study : 8h</p> |
| <p>Description:<br/>Losses in magnetic devices: Joule losses, magnetic losses, other losses. Heating and cooling of electromechanical devices.</p> <p>Related activities:<br/>Thermal analysis of devices using FE methods.</p>                                      |   |
| <p>(ENG) -Actuators design. Restrictions. Limits. Initial sizing. Optimization.</p>  | <p>Learning time: 16h<br/>Theory classes: 6h<br/>Laboratory classes: 2h<br/>Guided activities: 2h<br/>Self study : 6h</p> |
| <p>Description:<br/>Sizing of some magnetic actuators and sensors. Initial sizing. Main dimensions. Design using FE methods.</p> <p>Related activities:<br/>Simultaneous, thermal and electromagnetic analysis of devices using FE methods. Design Optimization.</p> |   |

### Qualification system

- Homework exercises: 20 %
- Project Design: 35%
- Laboratory sessions: 20%
- Final test: 20%
- Generic Competences: 5%

### Regulations for carrying out activities

Open Book final exam

## 820149 - ASM - Actuators and Sensors for Mechatronics

### Bibliography

#### Basic:

Brauer, J. R. Magnetic actuators and sensors. Hoboken, N.J.: IEEE Press : Wiley-Interscience, cop. 2006. ISBN 9780471731696.

Brandao Faria, J. A. Electromagnetic foundations of electrical engineering. Chichester: Wiley, 2008. ISBN 9780470727096.

#### Complementary:

Pawlak, A. M. Sensors and actuators in mechatronics : design and applications. Boca Raton: CRC/Taylor & Francis, cop. 2007. ISBN 9780849390135.

Chai, H.-D. Electromechanical motion devices. Upper Saddle River, NJ: Prentice Hall, cop. 1998. ISBN 0132634198.

#### Others resources:

Bargallo. Finite elements for electrical engineering. EUETIB-UPC- 2008