295903 - PFFM - Physical and Functional Properties of Materials

Coordinating unit: 295 - EEBE - Barcelona East School of Engineering
Teaching unit: 748 - FIS - Department of Physics
Academic year: 2018
Degree: BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 6
Teaching languages: Catalan, Spanish, English

Coordinator: Tamarit Mur, Jose Luis

Others: Macovez, Roberto
Lloveras Muntane, Pol Marcel

Opening hours
Timetable: Mo 15-17
Wd 15-17

Requirements
Students should have attended the courses of Physical Metallurgy, Electric and Magnetic Properties of Materials, Mechanical Properties of Materials, and Optical, Thermal and Acoustic Properties of Materials.

Degree competences to which the subject contributes

Transversal:
02 SCS N3. SUSTAINABILITY AND SOCIAL COMMITMENT - Level 3. Taking social, economic and environmental factors into account in the application of solutions. Undertaking projects that tie in with human development and sustainability.
06 URI N3. EFFECTIVE USE OF INFORMATION RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.
07 AAT N2. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.

Teaching methodology
Theory classes: the teacher introduces fundamental concepts and few proofs, complementing them with key examples and demonstrations, as well as with the discussion of some applications.
Problem solving and guided activities: the teacher carries out the resolution of representative problems; students review fundamental concepts and solve some problems under the teacher's supervision.

Learning objectives of the subject

At the end of the course, the student must be able to:
- describe the physical foundations of material properties, and their response to applied external fields.
- possess the capability to approach the conceptual problems underlying current challenges in material science and
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technology.

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<tr>
<th>Study load</th>
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<tbody>
<tr>
<td><strong>Total learning time:</strong> 60h</td>
<td>Hours large group:</td>
<td>60h</td>
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### Content

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<tr>
<th>Item 1. Physical Foundations of the Thermal Properties of Materials</th>
<th>Learning time: 70h</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 24h</td>
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<tr>
<td></td>
<td>Guided activities: 4h</td>
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<td>Self study: 42h</td>
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**Item 1. Physical Foundations of the Thermal Properties of Materials**

**Learning time:** 70h

- **Theory classes:** 24h
- **Guided activities:** 4h
- **Self study:** 42h

**Description:**

Topic 1.1 Basic concepts

Topic 1.2 Applications. First part

Topic 1.3 Applications. Second part
- Systems with magnetic ions: classical and quantum paramagnetism.
- Metallic crystals: electron gas, Fermi level, and work function.

**Related activities:**

- Learning time: 70 h
- Theory classes: 20 h
- Problem-solving classes: 4 h
- Guided activities: 4 h
- Self study: 42 h

**Learning time:** 40h  
- Theory classes: 15h  
- Guided activities: 1h  
- Self study: 24h  

### Description:
Topic 2.1 Charge transport and linear response to time-dependent electric fields  
- Classification of conductors in terms of the majority charge carriers: electron/holes, ions, protons; temperature dependence of the dc conductivity. Applications of ion and proton conductors, electrochemical devices. Effect of disorder and of electron repulsion on electronic properties; electron correlation and connection with magnetism; metal-insulator transitions.  
- Linear response theory, complex permittivity and complex conductivity. Polarization mechanisms with time-varying electric fields: conduction and space-charge effects in non-homogeneous media; glasses: relaxation dynamics, Debye model and derived phenomenological models; response at optical frequencies, plasmons and excitons; Drude-Lorentz model and Rayleigh-Lorentz model for optical and vibrational transitions.

Topic 2.2 Molecular and macromolecular materials: dynamic and electrical properties, and applications  
- Properties that are specific to organic materials: orientational and conformational degrees of freedom, isomerism and polymorphism. Dependence of the crystal structure and morphology on crystal growth conditions, molecular self-assembly, crystal design. Mesophases: orientationally disordered solids, plastic crystals, thermotropic and lyotropic liquid crystals, polymers, binary and colloidal systems.  
- Experimental techniques: dielectric spectroscopy, dynamic mechanical analysis, optical techniques. Relevance and applications of organic materials: mesophases in biological systems; encapsulation of pharmaceutical compounds, drug delivery; conjugates polymers and doped conducting polymers; applications in optoelectronics and electrochemistry: OLED, organic solar cells, liquid crystal displays, supercapacitors.

Topic 3.3 Functional properties of ferroic and multiferroics systems  
### Qualification system

The student's final mark will be calculated as a weighted average of the marks obtained in the midterm exam, during the guided activities, and from the student's mark on a report to be handed in and dealing with a relevant scientific or engineering topic, to be agreed upon between the student and the teachers. The relative weight of each mark will be as follows:

- **Midterm Exam** 30%
- Guided activities/Problem-solving classes 20%
- Research Report 50%

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<tr>
<th>Item 3: Phase transitions in multiferroic materials</th>
<th>Learning time: 28h</th>
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<tr>
<td>Description:</td>
<td>Theory classes: 16h</td>
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<td>Self study: 12h</td>
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**Description:**


- Topic 3.2 Ferroic systems

- Topic 3.3 Functional properties of ferroic and multiferroics systems
Bibliography

Basic:


Complementary:


Others resources:

During the course, the teachers will provide students with study material and sometimes recommend material available on-line, both from general sources such as Wikipedia or from specific websites such as that of the research group of the teachers (https://gcm.upc.edu/en).