Course guides
230469 - ES - Solid State

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics.
Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Compulsory subject).
Academic year: 2021  ECTS Credits: 6.0  Languages: Catalan

LECTURER
Coordinating lecturer: DANIEL CRESPO ARTIAGA
Others: ELOI PINEDA SOLER

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Knowledge of the structure of matter and its properties at molecular and atomic level. Ability to analyze the behavior of materials, electronics and biophysical systems, and the interaction between radiation and matter.
2. Knowledge of the interactions at different matter scales. Ability to analyze functional capabilities of physical systems at various scales.
3. Knowledge of structural and functional applications of materials. Knowledge of the physical systems of low dimensionality. Ability to identify systems and/or materials suitable for different engineering applications.

General:
3. ABILITY TO IDENTIFY, FORMULATE, AND SOLVE PHYSICAL ENGINEERING PROBLEMS. Planning and solving physical engineering problems with initiative, making decisions and with creativity. Developing methods of analysis and problem solving in a systematic and creative way.

Transversal:
2. 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.
1. EFFECTIVE USE OF INFORMATION RESOURCES - Level 2. Designing and executing a good strategy for advanced searches using specialized information resources, once the various parts of an academic document have been identified and bibliographical references provided. Choosing suitable information based on its relevance and quality.

TEACHING METHODOLOGY

There will be three theoretical and two practical weekly sessions. The theoretical lectures will be devoted to a careful presentation of the basic concepts and the main results which will be illustrated with some examples. The practical sessions will be devoted to the solution of a variety of exercises and problems.

LEARNING OBJECTIVES OF THE SUBJECT

Be familiar with the atomic structure of crystalline and non-crystalline solids.
Recognize the global relationship between the macroscopic properties of solids and their crystalline structure and atomic bond.
Have knowledge of the vibrational properties and solids, and their influence on the thermal and acoustic properties of materials.
Have knowledge of the electronic structure of solids and the bands theory. Relate them to the properties of insulators, semiconductors and conductors.
STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>65,0</td>
<td>43.33</td>
</tr>
<tr>
<td>Self study</td>
<td>85,0</td>
<td>56.67</td>
</tr>
</tbody>
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**Total learning time:** 150 h

CONTENTS

1. **Crystalline structures.**

   **Description:**
   1.1. Periodic arrays of atoms.
   1.2. Two and three-dimensional crystal structures.
   1.3. Crystal coordinates and indexes.
   1.4. Wave diffraction in a crystal.
   1.5. Reciprocal lattice and Brillouin zone.

   **Full-or-part-time:** 37h
   Theory classes: 15h
   Self study: 22h

2. **Dynamics of the crystal lattice.**

   **Description:**
   3.2. Vibrations in diatomic crystals.
   3.3. Quantum Description: energy quantization.
   3.4. Momentum of phonons. Inelastic scattering.

   **Full-or-part-time:** 25h
   Theory classes: 11h
   Self study: 14h

3. **Phonons.**

   **Description:**
   4.2. Heat capacity.
   4.3. Anharmonic interactions.
   4.3.1. Thermal expansion.
   4.3.2. Thermal conductivity.
   4.3.3. Phonon-Phonon collisions.

   **Full-or-part-time:** 25h
   Theory classes: 11h
   Self study: 14h
### 5. Electrons in solids.

**Description:**
- 5.2. Three dimensional free-electron gas.
- 5.3. Heat capacity of the electron gas. Heat capacity of metals.
- 5.4. Electrical conductivity and Ohm’s law. Electron-Phonon collisions. Hall effect.

**Full-or-part-time:** 31h 30m

Theory classes: 13h 30m  
Self study: 18h


**Description:**
- 6.2. Bloch theorem.
- 6.3. Kröning-Penney model.
- 6.4. Wave equation of an electron in a periodic potential.
- 6.5. Metals and insulators.
- 6.6. Semiconductors.
- 6.7. Electrons and holes. Effective mass.
- 6.8. Concentration of intrinsic carriers.
- 6.9. Impurities: doped semiconductors.

**Full-or-part-time:** 31h 30m

Theory classes: 13h 30m  
Self study: 18h

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**GRADING SYSTEM**

There will be a final exam (EF) and a partial exam (EP). The students’ participation in practical sessions will be also taken into account (P). The final score will follow from:

$max\{EF, 0.60\times EF + 0.40\times EP\}$

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**BIBLIOGRAPHY**

**Basic:**

**Complementary:**