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: 2020  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.
Have knowledge of the dielectric response of materials and its relationship to their optical properties.
Recognize and distinguish imperfections on crystalline structures.
STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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</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>
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</tbody>
</table>

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.
1.6. Fourier analysis.
1.7. Quasicrystals.

Full-or-part-time: 21h
Theory classes: 6h
Practical classes: 4h
Guided activities: 3h
Self study : 8h

2. Atomic bonding.

Description:
2.1. Van der Waals interaction.
2.2. Ionic bonding. Electronic affinity.
2.3. Covalent bonding. Electronegativity.
2.4. Metallic bonding.
2.5. Elastic constants.

Full-or-part-time: 15h
Theory classes: 3h
Practical classes: 2h
Self study : 10h

3. 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: 19h
Theory classes: 6h
Practical classes: 3h
Self study : 10h
4. 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:** 22h
Theory classes: 6h
Practical classes: 4h
Self study: 12h

5. Electrons in solids.

Description:
5.2. Three dimensional free-electron gas.
5.3. Heat capacity of the electron gas. Heat capacity of metals.

**Full-or-part-time:** 21h
Theory classes: 6h
Practical classes: 3h
Self study: 12h


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.

**Full-or-part-time:** 24h
Theory classes: 6h
Practical classes: 4h
Self study: 14h
7. Optical and electrical properties of solids.

**Description:**
7.1. Dielectric function of the electron gas.
7.2. Plasmons.
7.3. Optical reflectance.

**Full-or-part-time:** 15h
Theory classes: 3h
Practical classes: 2h
Self study: 10h

8. Crystalline defects.

**Description:**
8.1. Point defects:
8.1.1. Vacancies and interstitial atoms.
8.1.2. Diffusion.
8.2. One-dimensional defects:
8.3. Two-dimensional defects:
8.3.1. Grain boundaries.

**Full-or-part-time:** 13h
Theory classes: 3h
Practical classes: 2h
Self study: 8h

**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
\[ \max\{EF, 0.65\times EF + 0.30\times EP + 0.05\times P\} \]

**BIBLIOGRAPHY**

**Basic:**

**Complementary:**