Last update: 06-05-2019

230469 - ES - Solid State

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics
Academic year: 2019
Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Teaching unit Compulsory)
ECTS credits: 6 Teaching languages: Catalan

Teaching staff

Coordinator: DANIEL CRESPO ARTIAGA

Others: ELOI PINEDA SOLER

Opening hours

Timetable: By appointment

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.

Generical:

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:

1. EFFECTIVE USE OF INFORMATI0N 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.
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.

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

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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

Total learning time: 150h	Hours large group:	65h	43.33%
	Self study:	85h	56.67%

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Content

1. Crystalline structures.

Learning time: 21h

Theory classes: 6h
Practical classes: 4h
Guided activities: 3h
Self study : 8h

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.

2. Atomic bonding.

Learning time: 15h

Theory classes: 3h
Practical classes: 2h
Self study : 10h

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.

3. Dynamics of the crystal lattice.

Learning time: 19h

Theory classes: 6h
Practical classes: 3h
Self study : 10h

Description:

3.1. Vibrations in monatomic crystals. Classical description. Sound speed. Phonons.
3.2. Vibrations in diatomic crystals.
3.3. Quantum Description: energy quantization.
3.4. Momentum of phonons. Inelastic scattering.

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4. Phonons.

Learning time: 22h

Theory classes: 6h
Practical classes: 4h
Self study : 12h

Description:

4.1. Energy and density of states. Debye and Einstein models.
4.2. Heat capacity.
4.3. Anharmonic interactions.
4.3.1. Thermal expansion.
4.3.2. Thermal conductivity.
4.3.3. Phonon-Phonon collisions.

5. Electrons in solids.

Learning time: 21h

Theory classes: 6h
Practical classes: 3h
Self study : 12h

Description:

5.1. Free-electron gas. Energy levels in one dimension. Fermi-Dirac distribution.
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.

6. Energy bands in solids.

Learning time: 24h

Theory classes: 6h
Practical classes: 4h
Self study : 14h

Description:

6.1. Quasi-free electron model. Conduction and valence bands. Energy gap.
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.

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7. Optical and electrical properties of solids.	Learning time: 15h Theory classes: 3h Practical classes: 2h Self study : 10h

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

8. Crystalline defects.	Learning time: 13h Theory classes: 3h Practical classes: 2h Self study : 8h

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

Qualification 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*EF + 0.30*EP + 0.05*P}

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Bibliography

Basic:

Simon, Steven H. The Oxford solid state basics [on line]. Oxford: Oxford University Press, 2013 [Consultation: 12/01/2016]. Available on: <http://lib.myilibrary.com?id=499038>. ISBN 9780199680771.

Ibach, Harald; Lüth, Hans. Solid-state physics : an introduction to principles of materials science [on line]. 4th ed. Berlin [etc.]: Springer, 2010 [Consultation: 15/09/2015]. Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10351731>. ISBN 9783540938040.

Kittel, Ch. Introduction to solid state physics. 8th ed. New York [etc.]: John Wiley & Sons, 2005. ISBN 047141526X.

Mihály, L. Solid state physics: problems and solutions. 2nd ed, revised and enlarged. Weinheim ; Chichester: Wiley, 2009. ISBN 9783527408559.

Grosso, G.; Pastori Parravicini, G. Solid state physics [on line]. San Diego: Academic Press, 2000 [Consultation: 04/07/2012]. Available on: <http://www.sciencedirect.com/science/book/9780123044600>. ISBN 9780123044600.

Complementary:

Callister, W. D. Introducción a la ciencia e ingeniería de los materiales. 2a ed. México, D.F.: Limusa Wiley, 2009. ISBN 9786075000251.

Ashcroft, N. W;. Mermin, N. D. Solid state physics. Philadelphia: Saunders College, 1981. ISBN 0030493463.