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230473 - FISES - Statistical Physics

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, Spanish, English

Teaching staff

Coordinator: LAUREANO RAMÍREZ DE LA PISCINA MILLÁN

Others: ROSENDO REY ORIOL

Opening hours

Timetable: By appointment

Requirements

It is considered essential to have previously taken the following courses: Mechanics, Probability and Statistics, Quantum Physics, Thermodynamics.

Degree competences to which the subject contributes

Specific:

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.
2. Knowledge of the interactions at different matter scales. Ability to analyze functional capabilities of physical systems at various scales.
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.

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. 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.
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

There will be three theoretical and two practical weekly sessions. The theoretical sessions will be devoted to a careful presentation of the basic concepts and 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

Understanding of the foundations of Statistical Physics, and their application to problems of basic and applied interest.

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Study load

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

Content

1.- KINETIC THEORY.	Learning time: 27h 45m Theory classes: 7h Practical classes: 4h Guided activities: 0h 45m Self study : 16h

Description:
1.1.- Pressure. Ideal Gas.
1.2.- Maxwell-Boltzmann distribution.
1.3.- Collisions. Mean free path.
1.4.- Transport properties.
1.5.- Brownian motion.
1.6.- Supplement: Boltzmann equation.

2.- CLASSICAL STATISTICAL MECHANICS	Learning time: 47h 15m Theory classes: 12h 30m Practical classes: 8h Guided activities: 0h 45m Self study : 26h

Description:
2.1.- Microstates and macrostates. Phase space. Liouville's Theorem.
2.2.- Equiprobability principle and thermodynamic equilibrium.
2.3.- Boltzmann's principle. Ideal gas: discrete model.
2.4.- Quantum states and phase space. Classical ideal gas. Gibbs paradox.
2.5.- Ensemble theory. Microcanonical ensemble.
2.6.- Canonical ensemble. Ideal gas, classical harmonic oscillators.
2.7.- Theorem of equipartition of energy. Virial theorem.
2.8.- Chemical potential. Law of mass action.
2.9.- Grand Canonical ensemble.
2.10.- Fluctuations. Equivalence of ensembles.
2.11.- Maximum entropy principle.
2.12. Supplement: Molecular Dynamics.

3.- QUANTUM STATISTICAL MECHANICS	Learning time: 47h 15m Theory classes: 12h 30m Practical classes: 8h Guided activities: 0h 45m Self study : 26h

Description:
3.1.- Quantum Mechanics and density matrix.
3.2.- Statistical density matrix.
3.3.- Microcanonical, canonical and grand-canonical ensembles.
3.4.- Harmonic quantum oscillators. Einstein solid.
3.5.- Quantum paramagnetism. Schottky anomaly.
3.6.- Quantum ideal gases. Photon gas.
3.7.- Fermi-Dirac statistics. Fermi energy.
3.8.- Bose-Einstein statistics. Bose-Einstein condensation.
3.9.- Molecular gases. Born-Oppenheimer approximation.
3.10.- Molecular rotations and vibrations.
3.11.- Supplement: Symmetry and diatomic molecules.

4.- PHASE TRANSITIONS	Learning time: 27h 45m Theory classes: 7h Practical classes: 4h Guided activities: 0h 45m Self study : 16h

Description:
4.1.- Thermodynamics of magnetic systems.
4.2.- Ising model in one dimension. Transfer matrices.
4.3.- Ising model in two dimensions.
4.4.- Mean Field theories for the Ising model.
4.5.- Landau theory.
4.6.- Renormalization group in one dimension.
4.7.- Supplement: Monte Carlo simulation.

Qualification system

There will be a final exam (FE) and a midquarter partial exam (PE).
Problem solving (P) by the studends will also be taken into account.

The final score will follow from: max(FE;0.65*FE+0.30*PE+0.05*P).

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Bibliography

Basic:

Chandler, D. Introduction to modern statistical mechanics. New York: Oxford University Press, 1987. ISBN 0195042778.

Gould, H.; Tobochnik, J. Statistical and thermal physics: with computer applications [on line]. Princeton: Princeton University Press, 2010 [Consultation: 23/10/2012]. Available on: <http://www.compadre.org/STP/>. ISBN 9780691137445.

Hill, T.L. Statistical mechanics: principles and selected applications. New York: Dover, 1987. ISBN 0-486-65390-0.

Huang, K. Statistical Mechanics. 2nd ed. New York: Wiley, 1987. ISBN 0471815187.

McQuarrie, D.A. Statistical mechanics. Sausalito: University Science Books, 2000. ISBN 189138915-7.

Pathria, R.K.; Beale, E.D. Statistical mechanics [on line]. 3rd ed. Academic, 2011 [Consultation: 04/07/2012]. Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10467734>. ISBN 9780123821881.

Complementary:

Fernández Tejero, C.; Rodríguez Parrondo, J.M. 100 Problemas de física estadística. Madrid: Alianza Editorial, 1996. ISBN 8420686344.

Kubo, R. Statistical mechanics: an advanced course with problems and solutions. 2nd ed. Amsterdam: Elsevier, 1988. ISBN 0444871039.