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.

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:
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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<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>65h</th>
<th>43.33%</th>
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<tbody>
<tr>
<td>Total learning time: 150h</td>
<td>Self study:</td>
<td>85h</td>
<td>56.67%</td>
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Last update: 06-05-2019
## 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

<table>
<thead>
<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>3.1.- Quantum Mechanics and density matrix.</td>
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<tr>
<td>3.2.- Statistical density matrix.</td>
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<td>3.3.- Microcanonical, canonical and grand-canonical ensembles.</td>
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<td>3.4.- Harmonic quantum oscillators. Einstein solid.</td>
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<td>3.5.- Quantum paramagnetism. Schottky anomaly.</td>
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<td>3.6.- Quantum ideal gases. Photon gas.</td>
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<td>3.7.- Fermi-Dirac statistics. Fermi energy.</td>
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<td>3.9.- Molecular gases. Born-Oppenheimer approximation.</td>
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<td>3.10.- Molecular rotations and vibrations.</td>
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<td>3.11.- Supplement: Symmetry and diatomic molecules.</td>
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**Learning time:** 47h 15m  
Theory classes: 12h 30m  
Practical classes: 8h  
Guided activities: 0h 45m  
Self study : 26h

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# 4.- PHASE TRANSITIONS

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<tbody>
<tr>
<td>4.1.- Thermodynamics of magnetic systems.</td>
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<td>4.2.- Ising model in one dimension. Transfer matrices.</td>
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<tr>
<td>4.3.- Ising model in two dimensions.</td>
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<td>4.4.- Mean Field theories for the Ising model.</td>
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<td>4.5.- Landau theory.</td>
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<td>4.6.- Renormalization group in one dimension.</td>
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<td>4.7.- Supplement: Monte Carlo simulation.</td>
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**Learning time:** 27h 45m  
Theory classes: 7h  
Practical classes: 4h  
Guided activities: 0h 45m  
Self study : 16h

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## Qualification system

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

The final score will follow from: \( \text{max}(\text{FE}; 0.65 \times \text{FE} + 0.30 \times \text{PE} + 0.05 \times P) \).
Bibliography

Basic:


Complementary:
