2018/2019

Structure of Matter and Thermodynamics

Code: 100139
ECTS Credits: 6

Degree	Type	Year	Semester
2500097 Physics	FB	2	2

Contact

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Use of languages

Principal working language: spanish (spa)

Some groups entirely in English: No

Some groups entirely in Catalan: No

Some groups entirely in Spanish: No

Teachers

Vicenç Mendez Lopez

Lluís Font Guiteras

Daniel Campos Moreno

Prerequisites

It is recommended a basic knowledge of physics and mathematics; and be eager to work and learn

Objectives and Contextualisation

This course provides an introduction to the microscopic and macroscopic view of matter. It starts with a microscopic description, from elementary particles to superconductors, passing from atomic nuclei, atoms, molecules and solids. It follows a thermodynamic description, almost independent of the microscopic details of the system. The microscopic part of the course is introductory. The macroscopic one is given in more depth, establishing and working the fundamental laws of thermodynamics.

Objectives:
1) Understand the basic concepts of the structure of matter (kinetic theory of gases, elementary particles, quantum physics, atomic physics, nuclear physics, physics of solids) at an introductory level.
2) Understand the fundamental laws of thermodynamics, and to know how to apply them.
3) Identify and solve characteristic problems of these areas of physics
4) Show some aspects of the unity of physics, and the relationship between macroscopic and microscopic descriptions
5) To relate the physical aspects of everyday life and nature around us
6) Discuss the relationship between theoretical models and real physical systems

Skills

- Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals

- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Develop critical thinking and reasoning and know how to communicate effectively both in the first language(s) and others
- Develop independent learning strategies
- Develop strategies for analysis, synthesis and communication that allow the concepts of physics to be transmitted in educational and dissemination-based contexts
- Formulate and address physical problems identifying the most relevant principles and using approximations, if necessary, to reach a solution that must be presented, specifying assumptions and approximations
- Know the fundamentals of the main areas of physics and understand them
- Respect the diversity and plurality of ideas, people and situations
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation

Learning outcomes

1. Analyse and interpret the main experiments related to basic physics.
2. Analyse certain open questions in contemporary physics and explain them clearly.
3. Apply quantum physics in simple devices of industrial interest (diodes, light-emitting diodes, lasers, solar cells).
4. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
5. Contrast the sharpness of mathematical results with margins of error in experimental observations.
6. Describe the basis of heat engines, refrigerators and heat pumps.
7. Describe the structure of the atom and molecules, and corresponding spectra.
8. Develop critical thinking and reasoning and communicate ideas effectively, both in the mother tongue and in other languages.
9. Develop independent learning strategies.
10. Identify the consequences of the second law of thermodynamics.
11. Interact across diverse areas of basic physics.
12. List and describe the four principles of thermodynamics.
13. Make mathematical rigor compatible with approximate physical modelling.
14. Relate nuclear interaction with radioactivity and nuclear reactions.
15. Relate quantum physics with the electrical conductivity properties of materials.
16. Relate the basic concepts of physics with scientific, industrial and everyday subjects.
17. Respect diversity in ideas, people and situations.
18. Select good variables and carry out correct simplifications.
19. Use complex numbers.
20. Use differential and integral calculus.
21. Use linear transformations and matrix calculus.
22. Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals

Content

Structure of Matter
Kinetic theory: pressure and temperature
Equipartition Theorem and specific heats
Planck and Einstein-de Broglie Relations
Bohr model of the hydrogen atom
Pauli exclusion and periodic table of chemical elements
Atomic nuclei. Nuclear forces. Nuclear reactions. Radioactivity.
Elementary particles, quarks, leptons, intermediary bosons
Semiconductors and metals. Diodes, transistors, solar cells, LEDs, lasers.
Macroscopic coherent effects. Bose-Einstein condensates, superconductors

Thermodynamics
Heat transport. Conduction, convection and radiation
Zero Principle. Temperature. Equations of state
First law of thermodynamics. Heat, work, internal energy. Heat engines
Second Law of Thermodynamics (I). Statements of Clausius and Kelvin-Planck. Carnot's theorem. Absolute temperature
Second Law of Thermodynamics (II). Entropy. Degradation of energy. Thermodynamic potentials. Gibbs equation

Methodology

This course provides an introduction to the microscopic and macroscopic view of matter. In some subjects, which are relatively simple equations, the description is quantitative; in others, it is more qualitative endeavoring to introduce a clear conceptual framework, which can naturally raise questions and bring interest in the development of the courses offered by the subjects later. The thermodynamic block is exposed in higher depth, establishing the solid grounds of its principles.

It seeks to allow the subject into contact with some of the most active borders of physics today, so that the student may already have the feeling that it is a living science. And it will highlight the relationship between physics and nature, everyday life and technology.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Master class	30	1.2	2, 1, 3, 13, 5, 6, 7, 9, 8, 12, 10, 16, 15, 14, 11, 17, 18, 20, 19, 21
Problems class	22	0.88	2, 1, 3, 13, 5, 6, 7, 9, 8, 12, 10, 16, 15, 14, 11, 17, 18, 20, 19, 21
Type: Supervised			
Delivery activities	5	0.2	2, 1, 3, 13, 5, 6, 7, 9, 8, 12, 10, 16, 15, 14, 11, 17, 18, 20, 19, 21
Type: Autonomous			
Personal work	64	2.56	2, 1, 3, 13, 4, 5, 6, 7, 9, 8, 12, 22, 10, 16, 15, 14, 11, 17, 18, 20, 19, 21

Evaluation

The evaluation consists of:

1. Delivered problems and projects. (15% of the overall score)

It will consist of the presentation of selected problems solved and projects on divulgative articles.

2. Exams. (85% of the overall score)

- There will be two partial exams, one for each block of the course. Each of these tests has the same weight.

- Retake exam.

Important: To pass the course the mark of each partial exam must be greater than 4 (in a scale of 10) and the average grade of the course greater than 5.

Retake exam: in order to attend the retake exam the student must have attended the two partial exams
For students who have not passed the subject through partial exams or for those who wish to improve the grade, they can go to the final exam and do each part separately. The grade on the final exam will replace the previously obtained if it is higher, but not if it is smaller in more than 1.5 points. The student has the option not to release the exam.

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Delivered exercises	15%	20	0.8	4, 22
Final exam	85%	3	0.12	2, 1, 3, 13, 4, 5, 6, 7, 9, 8, 12, 22, 10, 16, 15, 14, 11, 17, 18, 20, 19, 21
Two partial exams	85%	6	0.24	2, 1, 3, 13, 4, 5, 6, 7, 9, 8, 12, 22, 10, 16, 15, 14, 11, 17, 18, 20, 19, 21

Bibliography

In the microscopic part, we will follow P. Tipler and A. Mosca, Física, 6 edició, Editorial Reverté, Barcelona, 2010.

In the Thermodynamics part we will go deeper:

- M. Criado-Sancho y J. Casas-Vázquez, *Termodinámica química y de los procesos irreversibles*, 2ª edición, Addison Wesley, Madrid, 2004

- M.W. Zemansky y R.H. Dittman, *Calor y termodinámica*, sexta edición, McGraw-Hill, Madrid, 1990

- C.J. Adkins, Termodinámica del equilibrio, Reverté, Barcelona, 1977.

- D. Kondepudi & I. Prigogine, *Modern Thermodynamics,* Wiley (1998).

- H. Callen, T*ermodinámica*, Editorial A.C, Madrid, 1985