

**COURSE DATA****DATA SUBJECT****Code:** 34246**Name:** Statistical physics**Cycle:** Undergraduate Studies**ECTS Credits:** 4.5**Academic year:** 2026-27**STUDY (S)**

Degree	Center	Acad. year	Period
1105 - Degree in Physics	Facultat de Física	3	Second quarter, First quarter
1928 - Double Degree Program Physics-Mathematics	Facultat de Física	5	First quarter
1929 - Double Degree Program in Physics and Chemistry	Facultat de Química	4	Second quarter, First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1105 - Degree in Physics	Thermodynamics and statistical physics	COMPULSORY
1928 - Double Degree Program Physics-Mathematics	Quinto Curso (Obligatorio)	COMPULSORY
1929 - Double Degree Program in Physics and Chemistry	Cuarto Curso (Obligatorio)	COMPULSORY

COORDINATION

CERVERA MONTESINOS JAVIER

MANZANARES ANDREU JOSE ANTONIO

GARCIA MORALES VLADIMIR

SUMMARY

This document is a guide to the Statistical Physics course, a third-year, 4.5-credits core course of the Physics degree and the Double Degrees in Physics-Chemistry and Physics-Mathematics. The subject has strong links with other courses of the degrees, especially with Thermodynamics (Statistical Physics and Thermodynamics constitute the Thermal Physics core of the Physics degree), but also with Mechanics, Waves, Atmospheric Physics, Quantum Physics and Solid State Physics.

Statistical Physics has one primary objective: to show how the macroscopic properties of systems with



many particles can be related to the microscopic states of the system making use of statistical methods. A strong emphasis will be placed on understanding the relationship between macroscopic behavior and microscopic characteristics. The course is based on the Gibbs ensemble theory and the Boltzmann entropy. The applications covered include classical (Maxwell-Boltzmann) and quantum (Fermi-Dirac and Bose-Einstein) ideal gases as well as an introduction to systems of interacting particles and phase transitions based on the mean field approach.

No matter what area of physics you pursue in your career, the concepts (entropy, temperature, chemical potential, etc.) and tools (the partition function formalism, computer simulations, etc.) in this course are core knowledge for any physicist. Indeed, Statistical physics finds application in Nuclear Physics, Nanotechnology, Molecular Biophysics, Condensed Matter Physics, Quantum Optics, Earth Physics and Astrophysics. The fundamental nature and applicability of statistical physics have been emphasized throughout the course. The concepts and tools developed are immediately applied to a broad range of multidisciplinary problems. This applied focus is expected to encourage the study of the subject and facilitate further application of the concepts to other fields of physics.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

It is highly recommended to have acquired the contents of the subject 34245 Thermodynamics, which forms, together with this, the subject "Thermodynamics and Statistical Physics" of the study plan. Some essential concepts are: degrees of thermodynamic freedom, entropy and principle, representations and thermodynamic potentials, thermodynamic stability, phase transitions, etc.

Prior knowledge of the subjects Calculus I and II, and Mathematical Methods II (differential and integral calculus, successions and series, Taylor series, etc.), as well as Quantum Physics I (uncertainty principle, atomic spectra, bound states and harmonic oscillator), is highly recommended.

COMPETENCES / LEARNING OUTCOMES

1105 - Degree in Physics

Basic & applied Research: acquire an understanding of the nature and ways of physics research and of how physics research is applicable to many fields other than physics, e.g. engineering; be able to design experimental and/or theoretical procedures for: (i) solving current problems in academic or industrial research; (ii) improving the existing results.

Be able to understand and master the use of the most commonly used mathematical and numerical methods.

Communication Skills (written and oral): Being able to communicate information, ideas, problems and



solutions through argumentation and reasoning which are characteristic of the scientific activity, using basic concepts and tools of physics.

Foreign Language skills: Have improved command of English (or other foreign languages of interest) through: use of the basic literature, written and oral communication (scientific and technical English), participation in courses, study abroad via exchange programmes, and recognition of credits at foreign universities or research centres.

Knowledge and understanding of the fundamentals of physics in theoretical and experimental aspects, and the mathematical background needed for its formulation.

Learning ability: be able to enter new fields through independent study, in physics and science and technology in general.

Modelling & Problem solving skills: be able to identify the essentials of a process / situation and to set up a working model of the same; be able to perform the required approximations so as to reduce a problem to an approachable one. Critical thinking to construct physical models.

Problem solving: be able to evaluate clearly the orders of magnitude in situations which are physically different, but show analogies, thus allowing the use of known solutions in new problems .

Students must be able to apply their knowledge to their work or vocation in a professional manner and have acquired the competences required for the preparation and defence of arguments and for problem solving in their field of study.

Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.

Students must have acquired knowledge and understanding in a specific field of study, on the basis of general secondary education and at a level that includes mainly knowledge drawn from advanced textbooks, but also some cutting-edge knowledge in their field of study.

Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.

Students must have the ability to gather and interpret relevant data (usually in their field of study) to make judgements that take relevant social, scientific or ethical issues into consideration.

Theoretical understanding of physical phenomena: have a good understanding of the most important physical theories (logical and mathematical structure, experimental support, described physical phenomena).

To know how to apply the knowledge acquired to professional activity, to know how to solve problems and develop and defend arguments, relying on this knowledge.

DESCRIPTION OF CONTENTS

1. Foundations and postulates of statistical physics.



Combinatorics. Probability distributions. Thermodynamic representations. Fundamental postulates of statistical physics. Phase space. Microcanonical collective and entropy. Irreversibility.

2. Partition function and ensemble theory.

Ensembles and partition functions. Mean values and fluctuations. Thermodynamic limit. Classical limit. Classical ideal systems. Equivalence theorem. Equivalence between collectives.

3. Quantum ideal gases.

Statistics of occupation numbers: Fermi-Dirac and Bose-Einstein. Classical limit: Maxwell-Boltzmann distribution. Thermodynamic properties of quantum ideal gases. Systems of fermions and degenerate bosons. Free electron gas. Bose-Einstein condensation. Bosons with zero chemical potential.

4. Systems of interacting particles. Phase transitions.

Configurational partition function. Real gases and interaction potentials. Virial equation. Mean-field approximation. Van der Waals fluid. Transfer matrix. Magnetic phase transitions. Ising model. Landau theory. Critical exponents and scaling transformations. Monte Carlo method.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	7,00
Theory	38,00
Total hours	45,00

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	3,50
Independent study and work	32,50
Preparation of lessons	19,50
Preparation for assessment activities	12,00
Resolution of case studies	0,00
Total hours	67,50

TEACHING METHODOLOGY

In-person teaching 40%:



Theoretical and practical classes. They address the conceptual and formal aspects of the subject and the resolution of problems or cases with the application of theoretical concepts. It is based mainly on the masterful dialogue of teachers with experimental demonstrations, animations or videos, etc.).

Sessions of group tutorials or work in groups reduïts: focused on the work of the students and on the active participation: resolution of the collection of problems proposed and distributed prior to the students, resolution of doubts related to confronting the theoretical concepts and the resolution of problems, etc.

Student personal work 60%:

- Study the theoretical backgrounds.
- Resolution of problems, questions and, eventually, tasks (individuals or in groups)
- Individual tutorials: primarily aimed at solving doubts and difficulties encountered by students during the study of theory and problem solving, discussing bibliography, etc.

EVALUATION

The assessment methods are as follows:

- Written Examination (EE, grade between 0 and 10): This will assess understanding of the theoretical and conceptual aspects, the formalism of the subject through conceptual and numerical exercises, the ability to apply the formalism through problem-solving, and critical analysis of the results obtained. Clarity of expression, sound logical reasoning, and justification of the approaches used will be evaluated.
- Continuous Assessment (EC, grade between 0 and 10): This will include written tests administered in class, assignments and problems submitted by students, oral presentations of solved problems, or any other method that allows for the assessment of student progress.

The final grade (F, between 0 and 10) is calculated as follows:

- If $EE \geq 3.5$ and $EC \geq 3.5$, then $F = \max(0.7EE+0.3EC, EE)$ or $F = EE + 0.2 EC [1 - (EE/10)^3]$ (depending on the group).
- If $EE < 3.5$ or $EC < 3.5$, then $F = EE$.

The same criteria apply in the second exam session as in the first.

REFERENCES



Basic

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- D. V. Schroeder, *An introduction to thermal physics*, Oxford U. P., 2021.

Complementary

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- Yu. M. Belousov, S. N. Burmistrov y A. I. Ternov, *Problem solving in theoretical physics*, Wiley, 2020.
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- S. A. Kivelson, J. M. Jiang y J. Chang, *Statistical mechanics of phases and phase transitions*, Princeton UP, 2024.
- T. Engel, *Physical chemistry: Thermodynamics, statistical thermodynamics, and kinetics*, Pearson, 2021.