Bachelor in Physics
(Academic Year 2024-25)

Statistical Physics		**Code**	800514	**Year**	3rd	**Sem.**	1st
Module	General Core	**Topic**	Quantum physics and statistics	**Character**	Obligatory		

	Total	**Theory**	**Exercises**
ECTS Credits	6	3.5	2.5
Semester hours	55	30	25

Learning Objectives (according to the Degree's Verification Document)

By the end of this course, students will be able to:

- Understand the fundamental hypothesis of statistical mechanics.
- Apply the equilibrium probabilistic states (microcanonical, canonical, and grand canonical ensembles) to different physical situations and understand their connection with thermodynamic potentials.
- Use and understand the basic features of Bose-Einstein and Fermi-Dirac statistics.

Brief description of contents

Fundamental hypothesis: statistical models and thermodynamic properties of ideal systems; statistics of indistinguishable particles; introduction to interacting systems.

Prerequisites

Classical and quantum mechanics. Thermodynamics.

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Theory/Exercises – Schedule and Teaching Staff

Group	Lecture Room	Day	Time	Professor	Period/ Dates	Hours	T/E	Dept.
B	4A	Mo Tu We	9:00 – 10:00 9:30 – 11:00 9:00 – 10:30	Juan Manuel Rodríguez Parrondo	Full term	55	T/E	EMFTEL

T: Theory, E: Exercises

Office hours				
Group	**Professor**	**Schedule**	**E-mail**	**Location**
B	Juan Manuel Rodríguez Parrondo	L y M: 11:30-13:30	parrondo@ucm.es	03.216.0

Syllabus

- Introduction

Overview and goals of the course. Mechanical and thermodynamical description of macroscopic systems. Probability.

- Foundations

Fundamental hypothesis: classical and quantum systems. Phase space and quantum states of a macroscopic system. Ergodicity. Thermodynamic limit.

- Microcanonical ensemble.

Entropy and temperature. Applications: the classical ideal gas and paramagnetism.

- Canonical ensemble.

Boltzmann distribution. Partition function. Helmholtz potential. Equipartition theorem. Applications: classical ideal gas, photons, and phonons.

- Grand canonical ensemble.

Chemical potential. Grand canonical distribution. Grand canonical potential. Average and dispersion of the number of particles. Equivalence among ensembles.

- Quantum ideal gases.

Quantum statistics: bosons and fermions. Occupation numbers. Classical limit. Virial expansion.

- Bose-Einstein ideal gas

Bose-Einstein condensation. Critical density and temperature. Thermodynamic properties of the Bose-Einstein gas.

- Fermi-Dirac ideal gas.

Fermi function and Fermi temperature. Electrons in metals. Sommerfeld expansion.

Bibliography

Basic:

• W. Greiner, L. Neise y H. Stöcker, Thermodynamics and Statistical Mechanics, Springer (1995).
• R. K. Pathria, Statistical Mechanics, Butterworth (2001).
• J. Ortín y J. M. Sancho, Curso de Física Estadística, Publicacions i Edicions, Universitat de Barcelona

(2006).
• C. F. Tejero y J. M. R. Parrondo, 100 Problemas de Física Estadística, Alianza Editorial (1996)

Complementary:
• K. Huang, Statistical Mechanics, Wiley (1987).
• C. F. Tejero y M. Baus, Física Estadística de Equilibrio. Fases de la Materia, ADI (2000).
• H.B. Callen, Thermodynamics and an introduction to thermostatistics, 2ª edition, John Wiley & Sons (1985)

Online Resources

Methodology

The following learning activities will be used:

• Theoretical lectures where concepts and theoretical developments will be explained,

• Practical lectures and discussion sessions for resolution of exercises. Students will be given the list of exercises in advance.

Evaluation Criteria

Exams	Weight:	80%
A final exam consisting of practical exercises.		
Other Activities	**Weight:**	20%
Several activities, like exercises and deliverables, will be proposed to the students during the semester.		

Final Mark

The final grade is the maximum of a) the mark of the final exam and b) a weighted average of the final exam (80%) and the rest of the activities (20%).

However, to pass the course it is always necessary a mark of the exam higher than 4.5 (over 10).

These evaluation criteria are valid both for the ordinary and extraordinary call.