STATISTICAL PHYSICS

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES		
ACADEMIC UNIT	PHYSICS DEPARTMENT		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	**M113**	**SEMESTER**	**1ST**
COURSE TITLE	STATISTICAL PHYSICS		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
	5	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	General background, specialized general knowledge
PREREQUISITE COURSES:	BASIC STATISITCAL PHYSICS, QUANTUM PHYSICS, SOLID STATE PHYSICS
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek or English
IS THE COURSE OFFERED TO ERASMUS STUDENTS	ΥΕΣ
COURSE WEBSITE (URL)	https://ecourse.uoi.gr/course/view.php?id=1755

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

This course, after presenting a brief review of undergraduate Statistical Physics to postgraduate students, aims to introduce them to advanced concepts and methodologies of this scientific discipline. Upon completion of the course, each graduate student will be able to:

1. To be familiar with the tools and concepts of Statistical Physics at an advanced level with an emphasis on handling (q,p) space, building partition functions, density matrix, Liouville equations, density of states.
2. Recall and comfortably use the derivation of the basic Thermodynamic parameters through Statistical Physics based on the tools of probability distributions (S/Ω, pi, Z, F, Φ, μ).
3. To know the basic principles of Quantum Statistical Physics and to apply them to a multitude of fermionic and bosonic systems.
4. To choose the appropriate statistical distribution (micro-normal, normal and large-normal) depending on the limitations that apply to the physical system.
5. To use the appropriate statistical distribution to fully describe a variety of physical systems with μ=0, from the photonic gas to lattice oscillations.
6. To describe phenomena in realistic systems such as phase changes, Van der Waals interactions and symmetry breaking.

7. To know the basic principles and methods of describing modern phenomena such as super-conductivity and super-fluidity.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology
Adapting to new situations
Decision-making
Working independently
Team work
Working in an international environment
Working in an interdisciplinary environment
Production of new research ideas
Project planning and management
Respect for difference and multiculturalism
Respect for the natural environment
Showing social, professional and ethical responsibility and sensitivity to gender issues
Criticism and self-criticism
Production of free, creative and inductive thinking
...
Others...

Search, analysis and synthesis of data and information, using the necessary technologies
Adaptation to new situations
Decision making, Autonomous work
Teamwork Work in an interdisciplinary environment
Generation of new research ideas
Project planning and management
Exercise criticism and self-criticism
Promotion of free, creative and inductive thinking

(3) SYLLABUS

Part-A: Basic Statistical Physics and Thermodynamic tools. Ergodicity, H-Boltzman theorem/irreversibility. Statistical distributions (micro-canonical, canonical and grand-canonical). Numerical understanding-use of partition function, probabilities (1/Ω,pi). Liouville theorem (classical, quantum) Density-matrix, pure/mixed states, the approach to equilibrium. Lagrange multipliers and their application to Statistical distributions (micro-canonical, canonical and grand-canonical).
Part-B: Fluctuations, Fluctuation-dissipation theorem, Applications to interacting systems (Van der Waals gases, phase changes, critical phenomena).
Part-C: Applications of Quantum Statistical Physics,: quantum phenomena in molecular gases, phonons, Ising magnetic solid model. Understanding chemical potential in degenerate quantum gases, fermionic fluids. Blackbody photons/photons from other light sources (lasers, LEDs) (distinction photons $\mu=0$, $\mu\neq0$). Bose-Einstein condensation, superfluidity, superconductivity.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	- Use of the course web page on http://ecourse.uoi.gr - to post notes and exercise sheets - Use of DropBox to deposit teaching notes, instructions, per-chapter practicum exams, and the students' works - Use of electronic mail to communicate with the students
TEACHING METHODS *The manner and methods of teaching are described in detail. Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational*	see table below

Activity	*Semester workload*
Lectures	55
Problem Solving	15
Independent Study	100
Homeworks	45

visits, project, essay writing, artistic creativity, etc. *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	Students' Presentations	30
	Exams	5
	Course total	**250**
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Problem solving (every second week), submission for assessment and training-presentation (35%) One overall oral presentation by the students during the semester on untaught material (25%) End-of-semester written exams during which the students are asked to solve problems related to the material taught at the course (40%)	

(5) ATTACHED BIBLIOGRAPHY

Suggested bibliography:

1. "Statistical Mechanics", R.K. Pathria, Paul D. Beale, Academic Press; 4th ed.(2021)
2. "Statistical Mechanics", Kerson Huang, 2nd Edition, Wiley (1987).
3. "Density Matrix Theory and Applications" Karl Blum, Springer Series on Atomic, Optical, and Plasma Physics, 3rd Edition (2012).
4. "Statistical Physics of Particles" Mehran Kardar, Cambridge University Press; 1st Edition (2007)