COURSE OUTLINE

(1) GENERAL

SCHOOL	School of Science		
ACADEMIC UNIT	Physics		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	**10EKO04**	**SEMESTER**	**6**
COURSE TITLE	**Statistical Physics II**		

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**
Lectures (theory and exercises)	5	7

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Special Background
PREREQUISITE COURSES:	No
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes, in the English language for Erasmus students
COURSE WEBSITE (URL)	https://eclass.uoa.gr/courses/PHYS260/

(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*

The aim of the course is the introduction of the physics of phase transitions for interacting particle systems. After an introduction in the concepts of symmetry breaking, its causes, and the order parameter, the simple Ising model within the Curie-Weiss approximation, where all spins interact with each other, is analyzed. In this context, the important concepts of critical exponents and the mean field are introduced. Subsequently, the above results are generalized in systems with local interactions, for which various approximations are used. These methods are used in multiple system models. Furthermore, the phenomenological Landau Theory of phase transitions is developed. This method highlights the importance of symmetries and their breaking, the order parameter and the concept of universality. to the thermodynamics of phase-transitions, two basic mean-field theories (Weiss and Bragg-Williams) are analyzed, in which the crucial role of interactions is showcased. These methods are applied to several systems. Subsequently, the Landau phenomenological theory for phase changes is developed. This method highlights the importance of symmetries and their breaking, the class parameter and the concept of universality. Also, the significance of fluctuations in phase transitions is analyzed, as well as and their role in invalidating the predictions of mean-field theory. Finally, the importance of the quantum nature in phase transitions is discussed.

With the completion of the course the student is able to :

- Describe phase transition phenomena in the context of mean-field theory of interacting systems.
- Identify physical laws underlying phase transitions in various condensed matter systems.
- Explain the role of symmetry and symmetry breaking at phase transitions.
- Find the order parameter of a transition and construct the Landau free energy expansion.
- Comprehend the notion of fluctuations and the conditions under which they invalidate mean-field theory.
- Evaluate physical quantities related with critical phenomena in different physical systems.
- Calculate critical exponents in the context of mean-field theory.
- Combine concepts and physical laws of correlations to interpret the critical behavior of condense matter.

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

By successfully attending and completing the course the student will acquire the following skills:

- Ability to search, analyze and compose data and information, using the appropriate technological tools.
- Ability to work autonomously.
- Train free, creative and inductive thinking.
- Train analytical and synthetic thinking.
- Ability to solve problems.

(3) SYLLABUS

- Ferromagnetism. Exchange Interaction. Ising Model. Curie-Weiss Model
- Bragg-Williams Approximation. Applications.
- Bethe Approximation. Bethe Lattices. Applications.
- Symmetry. Order parameter. Construction of Landau functional.
- 1^{st} order and 2^{nd} order phase transitions. Critical Points. Critical Exponents. Correlation Length. Scaling Laws. Fluctuations. Response functions.
- Linear response in external time-dependent excitation. Fluctuation-Dissipation Theorem.
- Phase – transitions in quantum systems. Superfluids, Stoner magnetism.

(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*	Yes Electronic communication with the students using ICT (Information and Communications Technology) eclass platform
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 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*	see table below
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.*	Final written exams in Greek Open-ended questions, Problem solving

Activity	Semester workload
Lectures	39
Exercises	26
Individual Study/ Study and Analysis of bibliography / Preparation	110
Course Total	**175**

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography

- STATISTICAL PHYSICS, F. Mandl
- STATISTICAL PHYSICS AND THERMODYNAMICS , E. N. EconomouE.N. Οικονόμου

- Related academic books:

- K.Huang, Statistical Mechanics, Wiley (1987)
- Principles of condensed matter physics P.M. Chaikin, T.C. Lubensky, Cambridge University Press 1995.
- R.K. Pathria, Statistical Mechanics, Butterworth-Heinemann, 1996
- J. P. Sethna, Statistical Mechanics, Oxford University Press, 2010
- M. Kardar, Statistical Physics of Particles, Cambridge University Press
- M. Kardar, Statistical Physics of Fields, Cambridge University Press