<table>
<tr><td>Course Title</td><td colspan="5">STATISTICAL PHYSICS</td></tr>
<tr><td>Course Code</td><td colspan="5">PHY 641</td></tr>
<tr><td>Course Type</td><td colspan="5">Compulsory</td></tr>
<tr><td>Level</td><td colspan="5">Graduate</td></tr>
<tr><td>Year / Semester</td><td colspan="5">1st year / 2nd semester of graduate studies</td></tr>
<tr><td>Teacher’s Name</td><td colspan="5">Spiros S. Skourtis</td></tr>
<tr><td>ECTS</td><td>10</td><td>Lectures / week</td><td>2 (2 hours each)</td><td>Laboratories / week</td><td></td></tr>
<tr><td>Course Purpose and Objectives</td><td colspan="5">To explain the underlying assumptions of quantum and classical equilibrium and non-equilibrium statistical mechanics. To understand the concept of entropy and of the second law of thermodynamics. To survey applications of statistical mechanics in different fields of physics. To apply the tools of equilibrium and non-equilibrium statistical mechanics to physical problems</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">The students will:
Apply combinatorics arguments relevant to the Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics and to random walks
Solve constrained-optimization problems using the method of Lagrange multipliers
Formulate stochastic processes in terms of random walks
Describe the law of large numbers
Discuss the concepts of microstate, macrostate and ensemble
Discuss the concept of equilibrium
Examine the concept of entropy
Calculate the entropy of different physical models
Derive the distributions of the microcanonical, canonical and grand canonical ensemble with entropy as the starting point
Appraise the concepts of temperature and chemical potential
Connect the laws of thermodynamics to the statistical mechanics for the canonical and grand canonical ensembles
Apply the canonical and grand canonical ensembles to ideal gases of distinguishable and indistinguishable particles: Bosons and Fermions
Analyze the phenomenon of Bose-Einstein condensation
Compare quantum to classical phase-space formulations of statistical mechanics
Apply the concept of chemical potential to solve diffusive equilibrium
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<tr><td></td><td colspan="3">problems
Derive the different thermodynamic potentials
Formulate the virial expansion method for interacting particles
Discuss the physics of phase transitions
Solve the one-dimensional Ising model
Describe the approach to equilibrium using Markov chain ideas
Relate the approach to equilibrium to increase in entropy
Use Langevin equation methods to describe non-equilibrium processes
Use Fokker-Planck equation methods to describe non-equilibrium processes</td></tr>
<tr><td>Prerequisites</td><td>Undergraduate-level Statistical Physics, Classical Physics and Quantum Mechanics</td><td>Required</td><td>None</td></tr>
<tr><td>Course Content</td><td colspan="3">Useful mathematical topics: combinatorics, probability distributions, random walks and processes, Lagrange multipliers. Entropy. Derivation of the microcanonical, canonical, grand canonical probability distributions for classical and quantum systems with emphasis on the concept of entropy. Derivation of thermodynamics from statistical mechanics. Thermodynamic potentials. Ideal gases of distinguishable and indistinguishable particles (Fermions and Bosons), and applications to photons, phonons and electrons. Bose-Einstein condensation. From quantum to classical statistical mechanics. The chemical potentials and its use in diffusive-equilibrium and chemical equilibrium problems. Statistical mechanics of interacting particles. Phase transitions. Ising model. Topics in non-equilibrium statistical mechanics (approach to equilibrium from the point of view of stochastic processes, Langevin and Fokker-Planck equations)</td></tr>
<tr><td>Teaching Methodology</td><td colspan="3">The lectures introduce and develop the material following lecture notes and the relevant chapters chosen form the suggested books. The lectures focus on the most important concepts and methods (mathematical and physical) and also solve example problems in order to enhance comprehension. The lectures are done on a blackboard.

The students receive regular take-home problem sets. The students are required to work on the problem-sets prior to seeing their solutions. Student questions on the lectures and on the problem sets are also discussed during the regular lecture hours and during office hours.

During the lectures there is also discussion of the assigned reading material. At the end of each major thematic section the main ideas and methods of the section are summarized and discussed.</td></tr>
<tr><td>Bibliography</td><td colspan="3">Lecture notes</td></tr>
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	Books: C. Kittel and H. Kroemer, *Thermal Physics*, W. H. Freeman; 2nd edition (1980) F. Reif, Fundamentals *of Statistical and Thermal Physics,* Mc Graw-Hill; (1965) I. Ford, *Statistical Physics: An Entropic Approach,* John Wiley and Sons (2013) R.K. Pathria *Statistical Mechanics* Oxford; Boston : Butterworth-Heinemann (1996) (eBook in UCY library) R. Kubo, M. Toda, N. Hashitsume, *Statistical Physics I: Equilibrium Statistical Mechanics. Statistical Physics II: Nonequilibrium Statistical Mechanics,* Springer Series in Solid-State Sciences) 2nd Edition (1992)
Assessment	Two exams • Mid-term 40% • Final 60%
Language	English/Greek (depending on the audience).