Aims

The fundamental concepts of thermodynamics and statistical mechanics are being used increasingly in new areas of the mathematical and physical sciences; for example, in the explosively growing fields of information theory and network science. This course aims to equip students with the key approaches and mathematical techniques involved in order that they can rapidly deploy them in their chosen careers, be they in the physical sciences, financial mathematics, information technology or many other directions.

Syllabus

**Thermodynamics:** Fundamental ideas; the zeroth law and the concept of temperature; the first law - energy, work and heat; the second law - entropy, reversible and irreversible processes; specific heat and latent heat; applications to ideal gases and thermal radiation; thermodynamic potentials - Legendre transforms and Maxwell’s relations; phase changes - phases diagrams, the Gibbs function, critical behaviour and higher order phase transitions; magnetic systems; the third law. *(20 lectures)*

**From Microscopic to Macroscopic:** Key ideas and goals; mechanical systems; Liouville’s Theorem; the Boltzmann entropy and the connection with thermodynamics; the partition function; the Ising model; equilibrium - the Boltzmann, Bose and Fermi distributions; Shannon entropy and information science; quantum information. *(13 lectures)*

Teaching and Assessment

**Contact Hours:** 3 lectures and 1 tutorial per week
**Assessment:** 0% by class tests or other continuous assessment
100% by end of course 3-hour exam
**Resit Type:** exam for MSc
By the end of the course, students should be able to:

- understand the basic concepts and purpose of classical thermodynamics
- understand the definition and use of the concept of temperature
- understand the first law of thermodynamics and its many uses
- understand and relate different statements of the second law
- understand the thermodynamic definition of entropy, and its behaviour in reversible and irreversible processes
- understand, manipulate and compute specific and latent heats
- derive the basic thermodynamic potentials using Legendre transformations
- derive and use Maxwell’s relations
- understand the concepts of phases and phase diagrams, and recognise the order of a phase transition
- understand the form of the first law and the concepts of adiabatic and isothermal magnetisation for a magnetic system
- understand the key ideas and philosophy of statistical mechanics
- appreciate the meaning and consequences of Liouville’s theorem for mechanical systems
- compute the Boltzmann entropy for simple distributions
- derive Boltzmann, Bose and Fermi distributions from fundamental principles
- understand the appearance and use of entropy in information science
- understand the density matrix for a quantum system

Content: September 2010