PHYS 708 Statistical Mechanics and Stochastic Processes 2015

Offered: Semester - 1
Credit: 15 points
Pre-/Co-requisites: None

Description

The course provides basics of classical thermodynamics (continuous mechanics), statistical mechanics and stochastic processes

Aims

The basic is to study the macroscopic properties of systems with a large number of degrees of freedom on the basis of the microscopic laws of physics, to study the systems containing a very large of particles and to calculate the macroscopic properties; to apply statistical arguments to summarize such microscopic behavior putting statistical arguments; to derive the macroscopic properties and to expect that in the limit of large numbers of particles they will accurately describe the macroscopic behavior of the system

Skills and knowledge to be gained

Students who pass this course should be able to:

- understand the concept of microstates and macrostates, the idea of thermodynamic variables and thermodynamic interactions, the idea of an isolated system;
- understand the "fundamental postulate of statistical mechanics", viewed from the quantum point of view of discrete states;
- understand how the probabilistic arguments are formalised and how this leads naturally to the concept of entropy;
- understand how the statistical description of a system changes when one moves from an isolated system to one whose extensive variables are specified only "on average"; students must know how the concept of temperature (and chemical potential) relates to this;
- students should be familiar with the partition function and the grand partition function; they should be able to evaluate the partition function for simple systems and to know how thermodynamic quantities may be found from the partition function; they should know about the connection with the Helmholtz free energy and the so-called thermodynamic potential pV; they should also have a familiartiy with the idea of fluctuations, and the connection with thermal capacity;
- understand how the symmetry of wave functions under the interchange of particles leads to the existence of Fermions and Bosons. They should be familiar with the use of the grand partition function to obtain the Bose-Einstein and the Fermi-Dirac distributions;
- familiar with the way the properties of an ideal gas may be found from an evaluation of the classical partition function;
- should be familiar with the formal expression for the partition function for an interacting system;
- understand the thermodynamic consequences of interactions in gases;
- understand and use calculation methods: Monte-Carlo method, Metropolis-Hastings algorithm, path integral Monte-Carlo
- should be familiar with stochastic methods; the Fokker-Plank equation; the master

equation; Markov process; Wiener process; stochastic integration and differentiation; approximation methods

Syllabus

- **Statistical mechanics** – ensemble theory, microcanonical ensemble, classical ideal gas, harmonic oscillator, quantum states, phase space, the canonical ensemble, the partitition function, thermodynamic function, energy fluctuations, the statistics of paramagnetism, the grand canonical ensemble, imperfect classical gas, viral expansion of the equation of state
- **Thermodynamics** – the central problem of thermodynamics, entropy, heat and work, the fundamental equation, thermodynamic potentials, free energy, Maxwell relations, Gibbs free energy, enthalpy, Clausius-Clapeyron equation,
- **Phase transitions** – condensation and thermodynamic limit, liquid-gas coexistence, critical point, Van der Waals equation, the Maxwell construction, the Ising model
- **Quantum gases** – quantum mechanical ensembles, ideal bose gas, ideal Fermi gas
- **Stochastic methods** – Brownian motion, Einstein's method, Langevin's method, fluctuation-dissipation theorem, diffusion, Markov processes, the Fokker-Plank equation, the master equation, Wiener process, Ornstein-Uhlenbeck process, stochastic integration, stochastic differential equations, Ito's formula, Stratonovich stochastic differential equations, approximation methods

Learning activities and teaching methods

Description	Study time
Lectures 13	13 hours
Tutorials	5 hours
Project	2 hours
Private study (lectures/assignments/project)	60 hours

Inclusive learning
Students are urged to discuss privately any impairment-related requirements face-to-face and/or in written form with the course convenor/lecturer and/or tutor.

Assessment

Form	Weight	Time	When
Assignments	25% (5 × 5%)	5 hours	weeks 3, 4,5,6,7
Project	25% (1 × 25%)	2 hours	week 11
Exam	50%	3 hours	exam period

Academic Integrity
The University of Auckland will not tolerate cheating, or assisting others to cheat, and views cheating in coursework as a serious academic offence. The work that a student submits for grading must be the student's own work, reflecting his or her learning. Where work from other sources is used, it must be properly acknowledged and referenced. This requirement also applies to sources on the world-wide web. A student's assessed work may be reviewed against electronic source material using computerised detection mechanisms. Upon reasonable request, students may be required to provide an electronic version of their work for computerised review. Please visit the below link for further information:
https://www.auckland.ac.nz/en/about/learning-and-teaching/policies-guidelines-and-procedures/academic-integrity-info-for-students.html

Resources

Prescribed text

- Statistical Mechanics in a Nutshell. Luca Peliti.
- Fundamentals of Statistical and Thermal Physics. Reif.
- Statistical Physics. F. Mandl.
- Introductory Statistical Mechanics, R. Bowley and M. Sánchez, Oxford University Press, 2nd edition, 1999
- Statistical mechanics, R. P. Feynman, W.A. Benjamin. (1972).
- An introduction to Statistical Thermodynamics, T. L. Hill, Addison-Wesley. (1960).
- Statistical Mechanics, K. Huang, J. Wiley. (1963).
- A Modern Course in Statistical Physics, L. E. Reichl, Arnold. (1980).

Recommended reading: From various books

Feedback

Marked script and model solutions to assignments; marked exam script (if requested)

Enrolment

Typical enrolment Semester 1: