PX366-7.5 Statistical Physics

20/21

Department
Physics
Level
Undergraduate Level 3
Module leader
Gareth Alexander
Credit value
7.5
Module duration
5 weeks
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

The collective behaviour of large numbers of interacting particles, or components, in a system can lead to the emergence of novel structures and patterns. Phase transitions, the configurations taken up by polymers, and stock market trends are examples. This module looks at how we classify this behaviour, how the different classes of behaviour come about, and how we model it quantitatively.

We will revise the statistical material from Thermal Physics II, as statistical mechanics is the natural starting point for describing how patterns are nucleated and grow from initial fluctuations. We will then discuss how collective behaviour can be related to order parameters and how these can change across phase transitions.

Module web page

Module aims

The module should illustrate the important concepts of statistical physics using simple examples. It should give an appreciation of the fundamental role played by fluctuations in nature.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Review of the fundamental principles underlying conventional statistical mechanics and thermodynamics.

Introduce ideas in non-equilibrium statistical physics leading to the flucutation-dissipation theorem and a description of Brownian motion based on Langevin's equation. Focus on the meaning and importance of ensemble averages.

Motivate a treatment of polymers based on statistical physics emphasising an insensitivity to the chemistry. Calculate the statistics of ideal and self-avoiding chains. Give the ideas behind the reptation and tube models for the dynamics of overlapping chains.

Explain the definition and role of an order parameter using examples including ferromagnets and liquid crystals. Introduce the notion of broken symmetry and the Ginzburg-Landau theory of phase transitions explaining carefully its structure. Obtain solutions for the simple phase transitions and discuss the results.

Calculate the kinetic energy of a gas molecule. Extend the result to obtain the law of equipartition of energy.

Look at the role of fluctuations and how they relate to the law of equipartition of energy. Examples including fluctuating interfaces. Qualitative discussion of the importance of fluctuations in phase transitions.

Learning outcomes

By the end of the module, students should be able to:

- Work with equilibrium thermodynamics
- Describe the statistical mechanics of long chain molecules (polymers)
- Characterise phase transitions
- Explain and work with the Ginzburg-Landau theory of continuous symmetry breaking
- Use the law of equipartition of energy to solve problems where the statistics of fluctuations is important

Indicative reading list

F. Mandl, Statistical Physics, Wiley;
D. Chandler, Introduction to Modern Statistical Mechanics, OUP;
J.M. Yeomans, Statistical Mechanics of Phase Transitions, Oxford Science Publications;
P.G. de Gennes, Scaling Concepts in Polymer Physics, Cornell Univ. Press;
R.A.L. Jones, Soft Condensed Matter, OUP

View reading list on Talis Aspire

Subject specific skills

Knowledge of mathematics and physics. Skills in modelling, reasoning, thinking

Transferable skills

Analytical, communication, problem-solving, self-study

Study

Study time

Type	Required
Lectures	15 sessions of 1 hour (20%)
Private study	60 hours (80%)
Total	75 hours

Private study description

Working through lecture notes, solving problems, wider reading, discussing with others taking the module, revising for exam, practising on past exam papers

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group B1

	Weighting	Study time	Eligible for self-certification
Assessment component			
In-person Examination Answer 2 questions out of 3	100%		No

- Answerbook Green (8 page)
- Students may use a calculator

	Weighting	Study time	Eligible for self-certification

Reassessment component is the same

Feedback on assessment

Personal tutor, group feedback

[Past exam papers for PX366]

Availability

Courses

This module is Option list A for:

- Year 3 of UMAA-G100 Undergraduate Mathematics (BSc)
- Year 3 of UMAA-G103 Undergraduate Mathematics (MMath)
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year
- Year 3 of UPXA-F300 Undergraduate Physics (BSc)
- Year 3 of UPXA-F303 Undergraduate Physics (MPhys)
- Year 4 of UPXA-F301 Undergraduate Physics (with Intercalated Year)

This module is Option list B for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
    - Year 3 of G105 Mathematics (MMath) with Intercalated Year
    - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- UMAA-G103 Undergraduate Mathematics (MMath)
    - Year 3 of G103 Mathematics (MMath)
    - Year 4 of G103 Mathematics (MMath)
- UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
    - Year 3 of G106 Mathematics (MMath) with Study in Europe
    - Year 4 of G106 Mathematics (MMath) with Study in Europe
- Year 3 of UPXA-FG33 Undergraduate Mathematics and Physics (BSc MMathPhys)
- Year 3 of UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
    - Year 3 of GF13 Mathematics and Physics
    - Year 3 of FG31 Mathematics and Physics (MMathPhys)
- Year 4 of UPXA-GF14 Undergraduate Mathematics and Physics (with Intercalated Year)
- Year 3 of UPXA-F303 Undergraduate Physics (MPhys)