

PX366-7.5 Statistical Physics

22/23

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 fluctuation-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
In-person Examination	100%	
Answer 2 questions out of 3		

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

Feedback on assessment

Personal tutor, group feedback

Availability

Courses

This module is Option list A for:

- UMAA-G100 Undergraduate Mathematics (BSc)
 - Year 3 of G100 Mathematics
 - Year 3 of G100 Mathematics
 - Year 3 of G100 Mathematics
- Year 3 of UMAA-G103 Undergraduate Mathematics (MMath)
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercolated Year
- UPXA-F300 Undergraduate Physics (BSc)
 - Year 3 of F300 Physics
 - Year 3 of F300 Physics
 - Year 3 of F300 Physics
- UPXA-F303 Undergraduate Physics (MPhys)
 - Year 3 of F300 Physics
 - Year 3 of F303 Physics (MPhys)
- Year 4 of UPXA-F301 Undergraduate Physics (with Intercolated Year)
- Year 3 of UPXA-F3FA Undergraduate Physics with Astrophysics (MPhys)

This module is Option list B for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercolated Year)
 - Year 4 of G105 Mathematics (MMath) with Intercolated Year
 - Year 5 of G105 Mathematics (MMath) with Intercolated Year
- UMAA-G103 Undergraduate Mathematics (MMath)
 - Year 3 of G103 Mathematics (MMath)
 - Year 3 of G103 Mathematics (MMath)
 - Year 4 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)
- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
 - Year 3 of GF13 Mathematics and Physics
 - Year 3 of GF13 Mathematics and Physics
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
 - Year 3 of FG31 Mathematics and Physics (MMathPhys)
 - Year 3 of FG31 Mathematics and Physics (MMathPhys)
- Year 4 of UPXA-GF14 Undergraduate Mathematics and Physics (with Intercolated Year)
- Year 3 of UPXA-F303 Undergraduate Physics (MPhys)