

# PX449-10 Kinetic Theory

**23/24**

**Department**

Physics

**Level**

Undergraduate Level 4

**Module leader**

Nicholas d'Ambrumenil

**Credit value**

10

**Module duration**

10 weeks

**Assessment**

100% exam

**Study location**

University of Warwick main campus, Coventry

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## Description

### Introductory description

Kinetic Theory is the theory of how distributions change. It is based on Boltzmann's equation (the same Boltzmann who sorted out the equilibrium statistical mechanics you met in Thermal Physics II) and other PDEs. These study the evolution in time of a distribution function, which gives the density of particles in the system's phase space. (Phase space is the space of states which specify particles' position and momenta.) The module establishes relations between conductivity, diffusion constants and viscosity in gases. It looks at applications to financial modelling (many of the concepts are also the basis for models of the 'motion' of stock and option prices in financial markets).

An additional motivation of this module is to illustrate how some of the mathematics you learnt in second year applied mathematics modules is used in theoretical physics.

[Module web page](#)

### Module aims

To introduce Maths/Physics students to non-equilibrium statistical physics and to give them an appreciation of mathematical physics as separate sub-discipline

### 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.

Time dependent distribution functions: Notation, phase space coordinates and volumes. Liouville's theorem. Boltzmann equation and the assumption of molecular chaos.

Collisions: Connection between microscopic particle mechanics and the distribution function. Detailed balance, scattering cross section for a rigid ball and classical binary collision integral. Mean free path.

Equilibrium: Derivation of equilibrium statistical mechanics via phase space distributions. Hamilton's equations as a symplectic transformation.

Transport in gases: Linear transport theory and the Einstein relation between conductivity and diffusion coefficient. Thermal transport, viscosity in gases.

Diffusion: Derivation of the diffusion equation from the Boltzmann equation. Validity of the diffusion approximation. Example boundary problems for the diffusion equation. Mention of Fokker-Planck equation and connection to Langevin dynamics. Applications in molecular simulation and financial modelling.

Some of:

Derivation of Euler equations from kinetics and discussion of viscosity in Navier-Stokes, Fokker-Planck equation

Non Hamiltonian dynamics: Outline treatment of connection to phase space distributions. Extended 'thermostat' systems obeying the canonical distribution within the particle subspace. Pathogenic failure in the absence of molecular chaos.

## **Learning outcomes**

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

- Derive and solve the Boltzmann equation
- Set up and solve boundary value problems describing the time-development of distributions in phase space
- Apply the theory to model systems

## **Indicative reading list**

Physical Kinetics, EM Lifshitz and LP Pitaevskii : Chapters 1-3

Statistical Mechanics: Theory and molecular simulation, ME Tuckerman : Chapters 4, 13 and 15.

[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

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## Study

### Study time

Type	Required
Lectures	20 sessions of 1 hour (20%)
Private study	80 hours (80%)
Total	100 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.

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## Assessment

You must pass all assessment components to pass the module.

### Assessment group B1

	Weighting	Study time
In-person Examination	100%	
Answer 2 questions		

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

### Feedback on assessment

Personal tutor, group feedback

[Past exam papers for PX449](#)

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## Availability

### Courses

This module is Core for:

- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
  - Year 3 of FG31 Mathematics and Physics (MMathPhys)
  - Year 3 of FG31 Mathematics and Physics (MMathPhys)

This module is Option list B for:

- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
  - Year 3 of GF13 Mathematics and Physics
  - Year 3 of GF13 Mathematics and Physics