PX385-15 Condensed Matter Physics

24/25

Department
Physics
Level
Undergraduate Level 3
Module leader
Rachel Edwards
Credit value
15
Module duration
10 weeks
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

Condensed matter is matter in which particles have come together to form solids or fluids or (in nuclei and some stars) nuclear matter. These are systems with large numbers of particles interacting with each other. Of course we can't solve the full equations of motion for all these particles. Instead we construct and solve quantum and statistical mechanical models of their behaviour and test the predictions they make against experiment. In other words, we do physics.

The module covers models of the energy levels of the electrons and ions in crystals, how these explain some of the materials' properties and how we measure them. One interesting aspect we will touch on is the role of collective excitations (where large numbers of the particles act in "unison"). These are behind such phenomena as magnetic ordering, superconductivity and the quantized Hall resistance observed in 2D semiconductors.

Module web page

Module aims

To provide an understanding of phenomena in condensed matter, both from an experimental and theoretical perspective.

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.

1. How materials behave.
   Types of bonding (ionic, covalent etc.); the periodic table; one dimensional models of solids; crystal structures, defects & disorder; thermal vibrations; how to measure crystal structure.

2. Free electrons.
   Free electron model; ground state, Fermi energy, transport properties; Wiedemann-Franz law;
   Peltier effect; where this breaks down.

3. Band structure.
   Nearly free electron model: the effect of a periodic potential; Bloch's theorem; scattering; band
   gaps; metal, insulator or semiconductor; density of levels; tight binding model. Moving beyond
   1D: Brillouin zones and Fermi surfaces; real metals; electrons in magnetic fields; how to measure
   the Fermi surface, and it is important (de Haas van Alphen, cyclotron resonance, etc.)

4. Semiconductors in more detail.
   Effective mass; impurities in semiconductors; holes; designing band gaps; Hall effect; p-n junctions; other applications, such as LEDs, lasers, solar cells.

5. Magnetism & magnetic order.
   Origins of magnetic behaviour; paramagnetism and magnetic resonance measurements; diamagnetism; magnetic ordering such as ferromagnetism and antiferromagnetism;
   Curie temperature; domains, hysteresis; applications - magnetic memory, refrigeration, single
   molecule magnets & quantum computation…

6. Other Topics.
   Superconductivity; low dimensional systems (2DEG, quantum Hall effect, quasi-1D and 2D systems); insulators; glasses.

Learning outcomes

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

- Describe the quantum and statistical mechanics of condensed matter
- Solve quantum and statistical mechanical models to determine properties of condensed matter systems
- Discuss the role of the microscopic structure in determining the properties of macroscopic samples
- Explain magnetic and conductivity phenomena, and how to measure these experimentally

Indicative reading list

The Oxford Solid State Basics, Steven H Simon, OUP 2013

[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	30 sessions of 1 hour (20%)
Private study	120 hours (80%)
Total	150 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 B2

	Weighting	Study time
In-person Examination	100%	
Answer all 3 questions		

- Answerbook Pink (12 page)
- Students may use a calculator

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX385

Availability

Courses

This module is Option list A for:

- 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 Intercalated Year)
- UPXA-F3F5 Undergraduate Physics with Astrophysics (BSc)
  - Year 3 of F3F5 Physics with Astrophysics
  - Year 3 of F3F5 Physics with Astrophysics
- Year 3 of UPXA-F3FA Undergraduate Physics with Astrophysics (MPhys)

This module is Option list B for:

- 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 Intercalated Year)
- Year 3 of UPXA-F303 Undergraduate Physics (MPhys)