PX263-7.5 Electromagnetic Theory and Optics

22/23

Department
Physics
Level
Undergraduate Level 2
Module leader
Timothy Gershon
Credit value
7.5
Module duration
10 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

The module develops the ideas of first year electricity and magnetism into Maxwell's theory of electromagnetism. Maxwell's equations pulled the various laws (Faraday's law, Ampere's law, Lenz's law, Gauss's law and the "law with no name") into one unified and elegant theory. Establishing a complete theory of electromagnetism has proved to be one the greatest achievements of physics. It was the principal motivation for Einstein to develop special relativity, it has served as the model for subsequent theories of the forces of nature and it has been the basis for all of electronics (radios, telephones, computers, the lot...).

The module shows that Maxwell's equations in free space have time-dependent solutions, which turn out to be the familiar electromagnetic waves (light, radio waves, X-rays etc), and studies their behaviour at material boundaries (Fresnel Equations). The module also covers aspects of optical instruments.

Module web page

Module aims

The module should study Maxwell's equations and their solutions.

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.

Refresher on vector calculus

Ampere's law, Faraday/Lenz's law, Gauss's law in differential form. Need for the displacement current. Statement of Maxwell's equations.

Maxwell equations in vacuum and in matter. Magnetisation and polarization of materials. Relation of E and P, B and M.
Solutions to Maxwell equations in vacuum. Electromagnetic waves, Poynting vector, intrinsic impedance, polarisation. Boundary conditions. Interfaces between dielectrics, separation into perpendicular and parallel components. Refractive index. Ohm's law. Interface with a metal, skin effect.

Optics: reflection and refraction. Wavefronts at plane and spherical surfaces. Lenses. Basics of optical instruments, resolution.

Learning outcomes

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

- Write down and manipulate Maxwell's equations in integral or differential form and derive the boundary conditions at boundaries between linear isotropic materials
- Derive the plane-wave solutions to Maxwell's equations in free space, dielectrics and ohmic conductors
- Describe the interaction of light with optical materials and explain aspects of geometrical optics

Indicative reading list

Young and Freedman, University Physics 11th Edition
IS Grant and WR Phillips, Electromagnetism
E Hecht, Optics

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	18 sessions of 1 hour (24%)
Other activity	7 hours (9%)
Private study	50 hours (67%)
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

Other activity description

7 problem classes

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Assessment group D3

	Weighting	Study time
Coursework Assessed work as specified by department	15%	
On-campus Examination Answer 2 questions	85%	

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

Assessment group R2

	Weighting	Study time
On-campus Examination - Resit	100%	
Answer 2 questions		

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

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX263

Availability

Courses

This module is Core for:

- Year 2 of UPXA-FG33 Undergraduate Mathematics and Physics (BSc MMathPhys)
- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
  - Year 2 of GF13 Mathematics and Physics
  - Year 2 of GF13 Mathematics and Physics
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
  - Year 2 of FG31 Mathematics and Physics (MMathPhys)
  - Year 2 of FG31 Mathematics and Physics (MMathPhys)
- UPXA-F300 Undergraduate Physics (BSc)
  - Year 2 of F300 Physics
  - Year 2 of F300 Physics
  - Year 2 of F300 Physics
- UPXA-F303 Undergraduate Physics (MPhys)
  - Year 2 of F300 Physics
  - Year 2 of F303 Physics (MPhys)
- Year 2 of UPXA-F3N1 Undergraduate Physics and Business Studies
- UPXA-F3F5 Undergraduate Physics with Astrophysics (BSc)
  - Year 2 of F3F5 Physics with Astrophysics
  - Year 2 of F3F5 Physics with Astrophysics
- Year 2 of UPXA-F3FA Undergraduate Physics with Astrophysics (MPhys)
- Year 2 of UPXA-F3N2 Undergraduate Physics with Business Studies

This module is Option list B for:

- Year 2 of UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
- UMAA-G100 Undergraduate Mathematics (BSc)
    - Year 2 of G100 Mathematics
    - Year 2 of G100 Mathematics
    - Year 2 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
    - Year 2 of G100 Mathematics
    - Year 2 of G103 Mathematics (MMath)
    - Year 2 of G103 Mathematics (MMath)
- Year 2 of UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
- Year 2 of UMAA-G1NC Undergraduate Mathematics and Business Studies
- Year 2 of UMAA-G1N2 Undergraduate Mathematics and Business Studies (with Intercalated Year)
- Year 2 of UMAA-GL11 Undergraduate Mathematics and Economics
- Year 2 of UECA-GL12 Undergraduate Mathematics and Economics (with Intercalated Year)
- Year 2 of UMAA-G101 Undergraduate Mathematics with Intercalated Year