PX384-7.5 Electrodynamics

21/22

Department
Physics
Level
Undergraduate Level 3
Module leader
David Leadley
Credit value
7.5
Module duration
5 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

Einstein's 1905 paper was called "On the electrodynamics of moving bodies". It derived the transformation of electric and magnetic fields when moving between inertial frames of reference. This module works through this transformation and looks at its implications. The module starts by covering the magnetic vector potential, A, which is defined so that the magnetic field B=curl A and which is a natural quantity to consider when looking at relativistic invariance.

The radiation (EM-waves) emitted by accelerating charges are described using retarded potentials, which are the time-dependent analogs of the usual electrostatic potential and the magnetic vector potential, and have the wave-like nature of light built in. The scattering of light by free electrons (Thomson scattering) and by bound electrons (Rayleigh scattering) will also be described. Understanding the bound electron problem led Rayleigh to his celebrated explanation of why the sky is blue and why sunlight appears redder at sunrise and sunset.

Module web page

Module aims

To introduce the magnetic vector potential and to show that electromagnetism is Lorentz invariant.

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. Revision of special relativity. Revision of Maxwell's Equations in vacuum and in a macroscopic medium. Simple models of polarization. Displacement current; Potentials ϕ and A. Coulomb and Lorenz gauge. Laplace's and Poisson's equations and the solution of Maxwell's equations. Retarded potentials.
2. Lorentz invariance of Maxwell's equations. Four vectors. Covariant and contravariant representation. Minkowski's metric tensor. Four vector formulation of Maxwell's equation.
3. Generation of EM waves and retarded potentials. The power radiated by accelerating charges.
4. The scattering of EM waves. Rayleigh scattering and Thompson scattering.

Learning outcomes

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

- Work with the vector potential and Lorentz invariant form of Maxwell's equations
- Manipulate Maxwell's equations and solve representative problems using 4-vectors
- Describe physics of EM radiation and scattering and be able to describe the propagation of EM waves through free space
- Solve Maxwell's equations to calculate the EM field from known source distributions

Indicative reading list

Classical Electrodynamics, JD Jackson
Electromagnetism, I.S. Grant and W.R. Phillips

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

Assessment group D2

	Weighting	Study time	Eligible for self-certification
Coursework	15%		No
Reassessment based on written examination only			
In-person Examination	85%		No
Answer 2 questions			

Assessment group R1

	Weighting	Study time	Eligible for self-certification
In-person Examination - Resit	100%		No

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX384

Availability

Courses

This module is Core for:

- Year 3 of UPXA-FG33 Undergraduate Mathematics and Physics (BSc MMathPhys)
- Year 3 of UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
- Year 3 of UPXA-F303 Undergraduate Physics (MPhys)

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-GF13 Undergraduate Mathematics and Physics (BSc)
- Year 3 of UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
- Year 4 of UPXA-GF14 Undergraduate Mathematics and Physics (with Intercalated Year)