Imperial College London

Module Specification (Curriculum Review)

Basic details

UID		Cohorts covered	Earliest cohort: 2024-25	Latest cohort:

Long title: Differential Equations and Electromagnetism

New code: PHY50003

New short title: Diff Eq & Electromagnetism

Brief description of module *(approx. 600 chars.)*:

This module covers topics in electromagnetism (EM): how moving electrons create fields, and how these fields propagate & interact with particles. It explores Maxwell's equations, applying them to EM fields & waves both in vacuum & in matter including dielectrics, plasmas and conductors.
Students will also advance their understanding of linear differential equations (DEs), including an introduction to techniques for solving partial DEs & eigenvalue problems, general properties of linear DEs & their solutions, and how these underpin the behaviour of key equations in EM & in physics more widely.

599 characters

Available as a standalone module/ short course? N

Statutory details

	ECTS	CATS	Non-credit
Credit value	10	20	N

HECOS codes:

FHEQ level: 5

Allocation of study hours

	Hours	
Lectures	45	
Group teaching	15	*Incl. seminars, tutorials, problem classes.*
Lab/ practical	0	
Other scheduled	44	*Incl. project supervision, fieldwork, external visits.*
Independent study	146	*Incl. wider reading/ practice, follow-up work, completion of assessments, revisions.*
Placement	0	*Incl. work-based learning and study that occurs overseas.*
Total hours	250	
ECTS ratio	25.00	

Project/placement activity

Is placement activity allowed? No

Module delivery

Delivery mode	Taught/ Campus	Other	
Delivery term	Year-long	Other	

Ownership

Primary department: Physics

Additional teaching departments	None

Delivery campus	South Kensington

Collaborative delivery

Collaborative delivery?	N

External institution	N/A
External department	N/A
External campus	N/A

Associated staff

Role	CID	Given name	Surname
Module Leader		Carlo	Contaldi
		Jaroslaw	Pasternak
		Matthew	Foulkes

Learning and teaching

Module description

Learning outcomes

On completion of this module you will be able to:
- Use Maxwell's equations to describe electromagnetic fields and waves in free space
- Explain the meaning of the fields D & H, and apply the forms of Maxwell's equations appropriate to material media
- Describe the behaviour of electromagnetic waves in simple media, and at boundaries between different media, both qualitatively and mathematically.
- Solve linear 1st-order ordinary differential equations (ODEs), 2nd-order ODEs with constant and variable coefficients and separable partial DEs including the diffusion, wave, Poisson and Laplace equations.
- Apply Green's function methods for DEs.

Module content	The module will cover both mathematical and physics content: Electromagnetism: • Maxwell's Equations in a vacuum: Particles and fields; Gauss's, Ampère's and Faraday's Laws; Displacement current • EM waves in a vacuum: Vacuum solutions; EM waves; Energy conservation and Poynting's theorem. • Potentials: Electrostatic potential; Vector potentials; Potential, charge and current; Solving for potentials, retarded potentials; Solving for time-harmonic problems • EM fields in matter: Foundations; Dielectrics; Magnetic materials; Conductors; Plasmas • EM waves in matter: Theoretical formalism; Waves in dielectrics; Waves in plasmas; Waves in conductors • EM waves at boundaries: Theoretical formalism; Snell's law and the Fresnel equations; Boundaries between various media Differential equations: • Additional techniques for solving 1st-order ordinary differential equations (ODEs): - transformation of variables; method of variation of parameters; an introduction to singular solutions • Solving linear 2nd-order ODEs: with constant coefficients; with variable coefficients • Linear independence of functions: its meaning; using the Wronskian determinant to check for linear independence and variation of parameters to obtain a 2nd independent solution • Solving Legendre's equation and Bessel's equation; using the solutions (Legendre polynomials and Bessel functions) to deal with the Laplacian in spherical and cylindrical coordinates • Identification of separable partial differential equations (PDEs), including the diffusion, wave, Poisson, and Laplace equations, and the technique of separation of variables; boundary conditions (BCs) and relation to the separation constant as a discrete set of eigenvalues • The solution and properties of self-adjoint and Sturm-Liouville eigenvalue problems: ODE with BCs that form a Sturm-Liouville problem having real eigenvalues and orthogonal eigenfunctions; application to representing an arbitrary function as a series of orthogonal eigenfunctions (generalising methods previously seen in Fourier analysis) • The Green's function method for solving inhomogenous DEs; Fourier methods for DEs
Learning and Teaching Approach	Students will be taught using a combination of lectures, small-group teaching, office hours, study groups and directed exercises on theoretical and computational work, and via a Discussion Board.
Assessment Strategy	An exam in term 3 covering all learning outcomes forms the major part of the summative assessment and will comprise of the module mark. In-course assessments comprising online tests and handwritten problems will comprise 20% of the mark.
Feedback	Formative feedback will be provided throughout the module following formative assessment in forms such as in-class quizzes, marking of handwritten problems sheets and verbal feedback for any practical exercises. Feedback for any continuous assessment will be provided within two weeks of the submission date. General feedback on written examinations for each module is provided in the form of written reports from the examiners for the students.
Reading list	The module is self-contained and no additional books are required to be purchased by the students. Further discussion of material covered by the module, along with relevant problems can be found in: •Mathematical methods in the physical sciences (3rd ed.); Boas, M. •Mathematical methods for physics and engineering (3rd ed.); Riley, Hobson & Bence •Elementary differential equations and boundary value problems (12th ed.); Boyce, DiPrima & Mead •The Cambridge Handbook of Physics Formulas (2003 Ed.); Woan, G. •Schaum's outline of theory and problems of differential equations; Bronson & Ayres •Introduction to electrodynamics; Griffiths. •Electromagnetic fields and waves : including electric circuits; Lorrain. •Electricity and magnetism : an introduction to the theory of electric and magnetic fields; Jefimenko •Electromagnetic theory; Stratton •Classical electrodynamics; Jackson

Quality assurance

Date of first approval

Office use only

QA Lead

Date of last revision		Department staff	
Date of this approval		Date of collection	
		Date exported	
Module leader	Carlo Contaldi	Date imported	
Notes/ comments			

Template version 16/06/2017

Programme structure
Associated modules

UID	Legacy code	Module title	Requisite type

UID	Legacy code	Module title	Requisite type

Assessment details

Grading method	Numeric	Pass mark 40%

Assessments

Assessment type	Assessment description	Weighting	Pass mark	Must pass?
Examination	2-hour exam	80%		N
Coursework	In-course assessment	20%		N
		100%		