PX275-15 Mathematical Methods for Physicists

23/24

Department
Physics
Level
Undergraduate Level 2
Module leader
Anne-Marie Broomhall
Credit value
15
Module duration
20 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

The module reviews the techniques of ordinary and partial differentiation and ordinary and multiple integration. It develops vector calculus (Term 1). The theory of Fourier transforms and the Dirac delta function are also covered. Fourier transforms are used to represent functions on the real line using linear combinations of sines and cosines and are the basis for describing many interference and diffraction phenomena in optics (Term 2).

Module web page

Module aims

To teach mathematical techniques needed by second, third and fourth year physics modules.

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: Functions of more than one variable; partial differentiation; the chain rule; change

of coordinates; total differential; directional derivative
2. Lagrange Multipliers: Maxima/minima of a function subject to a constraint
3. Multiple Integrals: Integration and choice of coordinate system: basis vectors; area and volume elements; Jacobians; path, area and volume integrals
4. Vector calculus: Scalar and vector fields; grad, div, curl operators and their physical interpretation
5. Vector Integration: Green’s Theorem in the plane; Divergence Theorem in 2D and physical interpretation
6. Stokes’s Theorem: The curl and its interpretation. Conservative fields, irrotational fields. Stokes’s theorem and its derivation
7. PDEs: The wave equation, Poisson's equation, Schrödinger's equation. The diffusion equation and Fick's law. The role of boundary conditions. Separation of variables
8. Fourier Transforms. Definition of Fourier transform, case of Gaussian and Lorentzian. Delta function and properties, Fourier's Theorem. Convolutions, example of instrument resolution, convolution theorem
9. Interference and diffraction phenomena: the Huygens-Fresnel principle. Criteria for Fraunhofer and Fresnel diffraction. Fourier relationship between an object and its diffraction pattern. Convolution theorem demonstrated by diffraction patterns. Fraunhofer diffraction for single, double and multiple slits. Diffraction at a circular aperture; the Airy disc. Image resolution, the Rayleigh criterion and other resolution limits

Learning outcomes

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

- Deal with multiple integrals and know how to evaluate the length of a curve and the volume of a three dimensional object
- Define and calculate the gradient, divergence and curl of a vector field and understand Gauss’s and Stokes’ theorems
- Define a partial differential equation and solve the wave and diffusion equations using the method of separation of variables
- Represent simple functions using Fourier transforms
- Demonstrate a good understanding of diffraction and interference phenomena and solve problems involving Fraunhofer diffraction

Indicative reading list

KF Riley,MP Hobson and SJ Bence, Mathematical Methods for Physics and Engineering: a Comprehensive Guide, Wadsworth, H D Young and R A Freedman, University Physics 11th Edition, Pearson.

View reading list on Talis Aspire

Subject specific skills

Mathematical methods including: Vector calculus, separation of variables, Fourier transforms and their application to describe diffraction

Transferable skills

Analytical, communication, problem-solving, self-study

Study

Study time

Type	Required
Lectures	40 sessions of 1 hour (27%)
Other activity	20 hours (13%)
Private study	90 hours (60%)
Total	150 hours

Private study description

Working though lecture notes, solving problems, wider reading, discussing with others taking the module, revising for exam, practising on past exam papers

Other activity description

20 Example 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 D2

	Weighting	Study time
Assessed Coursework	20%	
In-person Examination	80%	
Answer 4 questions		

	Weighting	Study time

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

Assessment group R1

	Weighting	Study time
In-person Examination - Resit Answer 4 questions	100%	

Feedback on assessment

Personal tutors, group feedback

Past exam papers for PX275

Availability

Courses

This module is Core for:

- 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