Imperial College London

Module Specification (Curriculum Review)

Basic details

			Earliest cohort	Latest cohort
UID		Cohorts covered	2020	2021-22

Long title: Mathematical Methods

New code: PHYS50007 | New short title: Mathematical Methods

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

The module covers several mathematical techniques fundamental for performing computations across physics and necessary for a proper formulation of its foundations. This includes analytic continuation, residues, Fourier transform, the least action principle, Lagrangian formalism, and tensor calculus. Basic numerical methods for solving nonlinear algebraic and differential equations are also discussed. The module will enable students to appreciate the universality of mathematical concepts employed and gain a sound basis for more advanced mathematical techniques encountered in later studies.

595 characters

Available as a standalone module/ short course? N

Statutory details

	ECTS	CATS	Non-credit
Credit value	5	10	N

HECOS codes:

FHEQ level: 5

Allocation of study hours

	Hours	
Lectures	22	
Group teaching	0	*Incl. seminars, tutorials, problem classes.*
Lab/ practical	0	
Other scheduled	22	*Incl. project supervision, fieldwork, external visits.*
Independent study	81	*Incl. wider reading/ practice, follow-up work, completion of assessments, revisions.*
Placement	0	*Incl. work-based learning and study that occurs overseas.*
Total hours	125	
ECTS ratio	25.00	

Project/placement activity

Is placement activity allowed? No

Module delivery

Delivery mode	Taught/ Campus	Other	
Delivery term		Other	Terms 2 and 3

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		Sam	Brzezicki

Learning and teaching

Module description

Learning outcomes

On completion of this module you will be able to:
- Select and use appropriate mathematical methods in physics
- Perform analytic continuation and use the residue method for evaluating integrals
- Use the Fourier transform to solve linear equations
- Demonstrate basic understanding of the least-action principle and Lagrangian/Hamiltonian formalism
- Make simple use of tensor calculus
- Apply basic numerical methods

Module content

The module is split into five parts:
- Calculus Of Variations: Euler-Lagrange equation as a stationarity condition; Hamilton's Principle (Lagrangian mechanics); generalised coordinates and momenta, cyclic coordinates; Lagrangian for a charged particle using scalar and vector potentials; Lagrange multipliers; isoperimetric problems; Geodesics and the metric tensor.
- Complex Variables: Complex differentiation, analytic functions, Cauchy-Riemann equations, entire functions; Complex integration, Cauchy's integral formula and applications, Taylor's theorem; poles and branching points; Residue theorem and application to computing real integrals.
- Fourier Transforms: Review of Fourier transforms and Fourier integrals, computation of Fourier transforms using contour integration. Heaviside and sign function, delta function and Green's functions. Application of Fourier transforms to solving linear ODEs and PDEs (eg. driven oscillator ODEs and Laplace's equation in an infinite strip and half-plane).
- Tensors: Definition of vectors via their transformation properties, cartesian tensors, tensor algebra, contraction of tensor indices. Vectors and pseudo-vectors (or polar and axial vectors), cartesian tensors, LeviCivita symbol, cross product, grad, div, curl and Laplacian. Physical examples of Cartesian tensors. Contravariant and covariant vectors. Contravariant, covariant and mixed tensors.
- Numerical Methods: Numerical integration (trapezium rule and Simpson's rule), Newton-Raphson method, Runge-Kutta algorithm.

Learning and Teaching Approach	Students will be taught using a combination of lectures, office hours, study groups and directed exercises on theoretical and computational work
Assessment Strategy	An exam in term 3 covering all learning outcomes will comprise the summative assessment and will contribute 100% of the module mark.
Feedback	Formative feedback will be provided throughout the module following formative assessment in forms such as in-class quizzes, online tests, marking of handwritten problems sheets and verbal feedback for any computational 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: •Churchill. Complex variables and applications. •Churchill. Fourier series and boundary value problems. •KF Riley, MP Hobson and SJ Bence, Mathematical Methods for Physics and Engineering.

Quality assurance

Date of first approval	
Date of last revision	
Date of this approval	
Module leader	Sam Brzezicki
Notes/ comments	

Office use only

QA Lead	
Department staff	
Date of collection	
Date exported	
Date imported	

Template version 16/06/2017

Assessment details

Grading method	Numeric	Pass mark	40%

Assessments

Assessment type	Assessment description	Weighting	Pass mark	Must pass?
Examination	2-hour exam	100%	40%	N
		100%		