

Basic details

UID	<input type="text"/>	Cohorts covered	Earliest cohort 2025-26	Latest cohort <input type="text"/>
Long title	Research Methods for Plasma Physics			
New code	PHYS70074	New short title	<input type="text"/>	
Brief description of module <i>(approx. 600 chars.)</i>	<p>This module provides an introduction to essential simulation tools and experimental diagnostics that are ubiquitous in fusion and plasma physics research. It provides both a conceptual understanding and the opportunity to gain practical experience in using plasma simulation codes. Practical experience in working with data from experimental and synthetic diagnostics will also be provided. The aim is to elevate skills needed for the MSc project and ultimately to improve students' readiness for embarking on research in fusion plasmas.</p>			
Available as a standalone module/ short course?	N			

538 characters

Statutory details

Credit value	ECTS 7.5	CATS 15	Non-credit N	HECOS codes	<input type="text"/>
FHEQ level	Level 7				<input type="text"/>
					<input type="text"/>
					<input type="text"/>

Allocation of study hours

	Hours	
Lectures	16	
Group teaching	8	<i>Incl. seminars, tutorials, problem classes.</i>
Lab/ practical	26	
Other scheduled	3	<i>Incl. project supervision, fieldwork, external visits.</i>
Independent study	134.5	<i>Incl. wider reading/ practice, follow-up work, completion of assessments, revisions.</i>
Placement	0	<i>Incl. work-based learning and study that occurs overseas.</i>
Total hours	187.5	
ECTS ratio	25.00	

Project/placement activity

Is placement activity allowed?

Module delivery

Delivery mode	Taught/ Campus	Other	<input type="text"/>
Start term	<input type="text"/>	Other	Autumn and Spring

Ownership

Primary department	Physics
Additional teaching departments	None
	<input type="text"/>
Delivery campus	South Kensington

Collaborative delivery

Collaborative delivery?

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

### Associated staff

Role	CID	Given name	Surname
Module Leader		Robert	Kingham
Lecturer		Sergey	Lebedev

### Learning and teaching

#### Module description

**Learning outcomes**

By the end of this module students will be able to:

- Compare and choose numerical algorithms and simulation approaches based on their characteristics, strengths and weaknesses
- Determine computational parameters to ensure simulation run stability and efficiency, and assess the accuracy of a simulation
- Setup and run a simulation on a remote HPC facility using a Linux terminal and retrieve numerical data
- Recommend an appropriate experimental diagnostic to measure a given physical property of a particular fusion device or plasma experiment and explain how that diagnostic works
- Apply common data processing techniques to experimental and synthetic data to extract useful measurements and gain insight into system dynamics
- Plan and run a plasma simulation using both a pre-existing fluid and kinetic code and use the simulation tools to undertake a scientific investigation relevant to fusion

**Module content**

The module will cover:

1. Conceptual: simulation codes and numerical methods
  - Essential numerical methods.
  - Finite difference (FD) methods.
  - Fourier transform and spectral methods.
  - Anatomy of a fluid code for fusion and plasma research.
  - The particle in cell (PIC) method for simulation of kinetic effects in plasmas.
  - Verification and validation of simulations.
2. Practical: running exemplar codes and analysing data
  - How to setup and run fluid and PIC codes.
  - How to select suitable computational parameters for numerical stability and how to determine the accuracy of the codes.
  - How to load code output files into Python, extract fields and variables.
  - Postprocessing techniques for simulation data and raw experimental diagnostic output including: frequency/wavenumber filtering, smoothing, obtaining derived quantities.
  - Essential Linux commands and tools (e.g. SSH, job scheduler, text editor) needed to use a remote HPC system.
3. Diagnostics methods for measuring key plasma properties (density, temperature, velocity, magnetic field, particle energy distribution, neutrons, fluctuations)
  - Laser probing
  - Self-emission
  - Charged particle
  - Neutronics
  - Magnetic field pick-up
  - Langmuir probes

Learning and Teaching Approach	<p>The conceptual content on simulation codes, numerical methods and experimental diagnostic techniques will be covered in lectures. These will be supported by demonstrated/supervised practical sessions where students work through provided Jupyter (or similar) exercise worksheets to gain hands on experience with basic numerical methods and processing of raw experimental diagnostic output. There will also be some problem sheets for students to work through in their own time.</p> <p>Mastering the practical use of fluid &amp; PIC codes, and the supporting skills needed, will be taught in seminar classes and augmented by demonstrated practical sessions where students can continue working through the exercise scripts.</p> <p>Towards the end of the module, students will undertake a project - a fusion relevant scientific investigation via numerical simulations - that will involve both the practical skills and conceptual knowledge gained earlier on. Demonstrated practical sessions will be available to support the project.</p> <p>For the practical classes, students will use the laptop provided as part of the MSc programme, which will be pre-configured with required codes, numerical libraries and applications.</p> <p>A basic proficiency in the Python programming language is a pre-requisite for this module. Students without it will be expected to learn in their own time. Support will be available, including access to the Physics UG Python course-materials (prior to the module), some dedicated Python office-hours (early on in the module) and the pre-existing Physics &amp; Coding Helpdesk (throughout the module). There will be a short diagnostic test to gauge proficiency and highlight gaps (needing attention) at the start of the module.</p>
Assessment Strategy	<p>Summative assessment: The conceptual and diagnostic-methods parts will primarily be assessed through a combination of assessed questions (approximately three) on problem sheets and the completion and submission of designated exercises (approximately two) on Jupyter worksheets. This will be spread throughout the module.</p> <p>The practical code mastery part will mainly be assessed via submitted coursework on the project: A written report detailing the scientific investigation undertaken using a code and accompanied by code run-decks and postprocessing programs/scripts created to obtain the presented results.</p> <p>Formative assessment: Some of the work carried out in the seminars and practical sessions will provide formative assessment. This will include checkpoints in worksheets where students can discuss their work with a demonstrator and supervised informal peer assessment of exercises in seminars.</p>
Feedback	<p>Written individual feedback will be given on the components used for summative assessment (i.e. questions, exercises, project report) upon return of marked material. The formative assessment elements will provide individual verbal feedback. Group feedback (e.g. common mistakes, or praise) will be given in the practical sessions. Further individual verbal feedback can be obtained in the practical sessions and from assessors.</p>
Reading list	<p>"Principles of plasma diagnostics", 2nd Ed., I.H. Hutchinson (Cambridge University Press)  "Numerical methods for engineers and scientists", J.D. Hoffman (New York : Marcel Dekker)  "Plasma physics via computer simulation", C.K. Birdsall and A.B. Langdon (Taylor and Francis)</p>

## Quality assurance

Date of first approval	
Date of last revision	
Date of this approval	

Notes/ comments