Imperial College London

Module Specification (Curriculum Review)

Basic details

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

Long title: Plasma Physics

New code: PHYS60013

New short title: Plasma Physics

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

We live in a largely neutral world in which plasmas are seemingly rare. By contrast, the majority of visible material in the universe exists at sufficiently high temperatures or rarefied densities to be at least partially ionised, and is therefore plasma. Importantly, plasmas behave differently to other states of matter and exhibit so-called "collective effects". The physics of plasmas is important to a wide range of phenomena: the evolution of stars and galaxies, the interaction of the solar wind with the Earth's magnetic field, industrial processes such as computer chip fabrication and the generation of intense sources of electromagnetic radiation and energetic particles. Plasma physics is also central to attempts to achieve controlled thermonuclear fusion as a future energy source.

795 characters

Available as a standalone module/ short course? N

Statutory details

	ECTS	CATS	Non-credit
Credit value	7.5	15	N

HECOS codes:

FHEQ level: Level 6

Allocation of study hours

	Hours	
Lectures	26	
Group teaching	0	*Incl. seminars, tutorials, problem classes.*
Lab/ practical	0	
Other scheduled	12	*Incl. project supervision, fieldwork, external visits.*
Independent study	149.5	*Incl. wider reading/ practice, follow-up work, completion of assessments, revisions.*
Placement		*Incl. work-based learning and study that occurs overseas.*
Total hours	187.5	
ECTS ratio	25.00	

Project/placement activity

Is placement activity allowed? No

Module delivery

Delivery mode	Taught/ Campus	Other	
Delivery term	Term 2	Other	Exam in term 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		Stuart	Mangles

Learning and teaching

Module description

Learning outcomes

On completing the Plasma Physics module, students will:
- Understand the broad range of physical phenomena which determine the behaviour of plasmas and the importance of collective effects.
(Develop a qualitative understanding and an understanding of theoretical models - including commonly used approximations)
- Have started learning how to think like a plasma physicist
(Develop intuition for plasma behaviour; Pinpoint the key physics/phenomena for a particular system/application; Understand conditions spanning over 20 orders of magnitude. Simplification of theoretical models)
- Learn problem-solving skills for plasma physics
(Linearisation of PDEs to facilitate tractable, quantitative solutions; enhance their analytical abilities and physics problem-solving in general)
- Understand the principles and challenges involved in energy generation by thermonuclear fusion.
- Understand the role of plasmas in a range of naturally occurring phenomena and laboratory applications

Module content	1. Basic properties of plasmas - Definition, occurrence and importance of plasmas, Debye shielding - Quasi-neutrality, plasma parameter, plasma frequency, Larmor orbits (basics) - Non-ideal plasmas 2. Thermonuclear fusion - Nuclear reactions and cross sections, ignition and break-even 3. Single particle motion - Guiding centre drifts; E × B, curvature, gradient - Magnetic moment (μ), conservation of μ, magnetic mirrors 4. Collisions - Coulomb collisions; mean-free-path and collision time (single and cumulative collisions) - Resistivity, particle diffusion, bremsstrahlung 5. Magneto-hydrodynamics (MHD) - MHD equations; mass continuity, momentum, energy, Ohm's law - The convective derivative, MHD validity and assumptions - B-field dynamics; flux freezing, resistive diffusion, magnetic Reynolds number - Magnetic pressure and tension 6. Waves - Electromagnetic, Langmuir, MHD (Alfv´en, magnetosonic) 7. Magnetic confinement - MHD equilibria; flux surfaces, Z-pinches - MHD instabilities and the safety factor, 8. Kinetic theory - Vlasov and Boltzmann equations, obtaining fluid/MHD equations from Boltzmann - Langmuir waves, resonant particles and trapping, Landau damping - Laser-Plasma particle accelerators 9. Main Approaches to Controlled Fusion - Overviews magnetic confinement fusion (MCF) and inertial confinement fusion (ICF)
Learning and Teaching Approach	Students will be taught over one term using a combination of lectures and office hours.
Assessment Strategy	100% Summative assessment based on final 2hr written exam.
Feedback	A series of problem sheets are provided. Example answers will also be provided. These are not assessed but provide practice and guidance on material similar to the exam. Students can receive guidance on approaches to solution of these questions as well as feedback on their answers through office hours.
Reading list	Lecture notes are provided to students. The notes are designed to be self-contained, and there is no designated textbook required for this course. There are however also some textbooks that are suggested

as supplementary or complementary reading:

"Introduction to Plasma Physics and Controlled Fusion, Volume 1: Plasma Physics" , F. Chen, 2nd Ed. (Springer, 1984)
- Excellent introductory text. Very accessible with good explanations. Covers most of the course.

"The Physics of Plasmas", Boyd & Sanderson, (Cambridge University Press, 2003)
- Available as eBook via library. Quite advanced & formal treatment with much more material than in this module.

"Plasma Physics: An Introductory Course", R.O. Dendy (Ed.), (Cambridge University Press, 1993)
- From the "Culham Summer School". Good, if concise treatment of sections 3, 5, 8. Lots of interesting material on MCF and some ICF.

"Introduction to Plasma Physics", Goldston & Rutherford (IoP Press, 1995)

Specialist books –
"Tokamaks", J. Wesson, (Oxford University Press, 2004)
"The Physics of Inertial Confinement Fusion: beam plasma interaction, hydrodynamics, hot dense matter", S. Atzeni, (Oxford University Press, 2004)
- The definitive text books on MCF (via tokamaks) & ICF, respectively! These are advanced and intended as a resource for researchers. However the basic concepts are covered at suitable level for the course.

Quality assurance

Date of first approval	
Date of last revision	
Date of this approval	
Module leader	Stuart Mangles
Notes/ comments	

Office use only

QA Lead	
Department staff	
Date of collection	
Date exported	
Date imported	

Template version 16/06/2017

Programme structure
Associated modules

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	Written exam over 2 hours	100%	40%	N
		100%		