Imperial College London

Module Outline

Plasma Physics

Module Code	PHYS96031	FHEQ Level	Level 6
Pre-requisites	None	Co-requisites	None
Primary Department	Physics		
Module Leader	Prof Jeremy Chittenden		
Additional Teaching Departments	None		
Teaching Staff	Prof Jeremy Chittenden + Associate		
Programmes on which the Module is delivered			Core/Elective
All UG Physics programmes (F300, F303, F309, F325, F390, F3W3)			Elective

Learning Outcomes	On completing the Plasma Physics course, students will :
	• Understand the broad range of physical phenomena which determine the behaviour of plasmas and the importance of collective effects.
	  ○ Qualitative understanding
	  ○ Theoretical models (often have to be simplified)
	• Start learning how to think like a plasma physicist
	  ○ Develop intuition for plasma behaviour
	  ○ Pin-point 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
	  ○ Linearization of PDEs
	  ○ …to facilitate tractable, quantitative solutions
	  ○ Enhance their analytical abilities and physics problem-solving, in general
	• Understand the principles and challenge involved in energy generation by thermonuclear fusion.
	• Understand the role of plasma in a range of naturally occurring phenomena and laboratory application.		

Description of Content	**Basic properties of plasmas** • Definition, occurrence & importance of plasmas, Debye shielding • Quasi-neutrality, plasma parameter, plasma frequency, Larmor orbits (basics) • Non-ideal plasmas **Thermonuclear fusion** • Nuclear reactions & cross sections, ignition & break-even **Single particle motion** • Guiding centre drifts; E×B, curvature, gradient • Magnetic moment (μ), conservation of μ, magnetic mirrors **Collisions** • Coulomb collisions; mean-free-path and collision time (single & cumulative collisions)		

- Resistivity, particle diffusion, bremsstrahlung

Magnetohydrodynamics (MHD)

- MHD equations; mass continuity, momentum, energy, Ohm's law
- The convective derivative, MHD validity & assumptions
- B-field dynamics; flux freezing, resistive diffusion, magnetic Reynolds number
- Magnetic pressure & tension

Waves

- Electromagnetic, Langmuir, MHD (Alfv́ en, magnetosonic)

Magnetic confinement

- MHD equilibria; flux surfaces, Z-pinches
- -MHD instabilities & the safety factor, energy confinement in tokamaks
- Tokamak requirements – summary

Kinetic theory

- Vlasov & Boltzmann equations, obtaining fluid/MHD equations from Boltzmann
- Langmuir waves, resonant particles & trapping, Landau damping
- Laser-Plasma particle accelerators

Main approaches to controlled fusion

- Overviews; magnetic confinement fusion (MCF) & tokamaks, inertial confinement fusion (ICF)

Assessment	Assessment Type	Weighting
Written exam	Exam1	100%

Learning & Teaching Hours	Independent Study Hours	Placement Hours	Total Hours
47	103	0	150
ECTS Credit	6	CATS Credit	12
Date of introduction	October 2016	Date of Last Revision	April 2020