Imperial College London

Module Specification (Curriculum Review)

Basic details

			Earliest cohort	Latest cohort
UID		Cohorts covered	2025-26	

Long title: Hydrodynamics

New code	PHYS70016	New short title	Hydrodynamics

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

This module provides an introduction to classical fluid dynamics, covering both incompressible and compressible aspects. It first establishes the fundamental equations, stemming from conservation laws, that describe a continuous deformable substance; gases, liquids; even solids when subjected to severe force. It then explores key hydrodynamic phenomena, starting with the simplest model – Bernoulli's equation – then gradually adding properties of fluids (viscosity, vorticity, compressibility) to expand the range considered. Phenomena include boundary layers, vortices, surface waves and instabilities, turbulence and shock waves. A range of contexts are considered, e.g. subsonic/supersonic aerodynamics, shock physics in materials science and inertial fusion research.

776 characters

Available as a standalone module/ short course? N

Statutory details

	ECTS	CATS	Non-credit
Credit value	5	10	N

HECOS codes:

FHEQ level: Level 7

Allocation of study hours

	Hours	
Lectures	18	
Group teaching	0	*Incl. seminars, tutorials, problem classes.*
Lab/ practical	0	
Other scheduled	10	*Incl. project supervision, fieldwork, external visits.*
Independent study	97	*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	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		Robert	Kingham

Learning and teaching

Module description

Learning outcomes	On completing the Hydrodynamics module, students will be able to: 1. Explain the significance of terms in the fundamental fluid equations (mass continuity, Navier-Stokes and energy) and outline how these equations relate to conservation laws. 2. Simplify the above key equations and apply the resulting reduced models (e.g. Bernoulli's equation, potential flow, Poiseuille flow, Rankine-Hugoniot/shock-jump conditions) in simplified cases to qualitatively or quantitatively describe fluid velocities, pressures and densities. 3. Use key dimensionless quantities (Mach number, Reynolds number) to characterise a hydrodynamic system (e.g. compressible/incompressible, turbulent/laminar). 4. Explain the structure of a vortex, describe simple vortex dynamics and obtain some simple quantitative estimates. 5. Describe surface waves (and associated phenomena) and related hydrodynamic instabilities; and outline how its dispersion relation is obtained and use it to calculate wave properties. 6. Broadly explain the roles of boundary layers, circulation, turbulence and shocks with regard to aerodynamic lift and drag. 7. Outline how the shock-jump conditions are obtained from the fundamental fluid equations and apply them to determine properties of shocks, particularly in gases. 8. Perform dimensional analysis to obtain power-law scalings for some complex hydrodynamics phenomena where direct solution is intractable, thereby elucidating important behaviour.
Module content	1. Concepts and approximations in Fluid Dynamics Flow lines & stream lines; Material and advective derivatives; Fluid equations from conservation laws (continuity, Navier Stokes equation, energy); Drag & ram pressure; Sound speed in fluids; Incompressible flow; 2. Applications of Bernoulli's principle Bernoulli's principle; Venturis and cavitation; Potential flow (point sources, around spheres); The Magnus effect. 3. Viscosity Boundary layer; Reynolds number; Stokes flow; Poiseuille flow; Viscosity and the stress tensor 4. Vorticity Vorticity equation; Types of vortex; Circulation and Kelvin's theorem; Vortex dynamics (e.g. vortex shedding, drift, bending and stretching) 5. Surface waves Linear or Airy wave theory, shallow and deep water waves; Shoaling & breaking, Tsunamis; Generalised dispersion relation for surface waves 6. Instabilities Rayleigh-Taylor instability; Kelvin-Helmholtz instability; Turbulence 7. Aerodynamics Lift and circulation; Types of aircraft drag; Streamlining; Stall 8. Supersonic and Hypersonic Flight Transonic flight & wave drag; Supersonic flight (Mach's construction, oblique shocks, aircraft design, Lavall nozzles); Hypersonic flight & detached shocks 9. Shocks in Gases & Solids Shocks formation (introduction to Characteristics) ; The Rankine-Hugoniot, or shock 'jump' conditions (for ideal gases, entropy change, ; the Hugoniot curves and isentropes, oblique shocks); shocks in solids (key solid thermodynamics properties, shock measurement. 10. Shocks in Plasmas Blast waves & Sedov-Taylor scaling; Radiation cooling, radiation transport and radiative precursors; Inertial Confinement Fusion
Learning and Teaching Approach	Students will be taught over one term using a combination of lectures and office hours.
Assessment Strategy	100% of summative assessment is based on a final exam: single written exam of 2 hours.

Feedback	Five 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 module. There are however also some textbooks that are suggested as supplementary or complementary reading. The following is a list of useful texts that cover the material in more depth than the lectures. Physical Fluid Dynamics by D.J. Tritton Fluid Dynamics for Physicists by T. E. Faber Extreme Physics: Properties and Behaviour of Matter at Extreme Conditions by Jeff Colvin, Jon Larsen The Physics of Inertial Fusion: Beam Plasma Interaction, Hydrodynamics, Hot Dense Matter (International Series of Monographs on Physics) by Stefano Atzeni, Jurgen Meyer-ter-Vehn Physics of Shock Waves and High-Temperature Hydrodynamic Phenomena by Zel'dovich, Ya. B., Raizer, Yu. P., Radiation Hydrodynamics by John I. Castor

Quality assurance

Date of first approval	
Date of last revision	
Date of this approval	
Module leader	Robert Kingham
Notes/ comments	

Office use only

QA Lead	
Department staff	
Date of collection	
Date exported	
Date imported	

Programme structure
Associated modules

UID	Legacy code	Module title	Requisite type

UID	Legacy code	Module title	Requisite type

Assessment details

			Pass mark
Grading method	Numeric		50%

Assessments

Assessment type	Assessment description	Weighting	Pass mark	Must pass?
			50%	
Examination	2 hour written examination.	100%	50%	
		100%		