Imperial College London

Module Specification (Curriculum Review)

Basic details

UID		Cohorts covered	Earliest cohort: 2022-23	Latest cohort:
Long title	Hydrodynamics			
New code	PHYS70016	New short title		

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

We use classical fluid dynamics to describe familiar everyday fluid effects using the Navier Stokes equation or more simply using Bernoulli's principle. We show how compressibility, viscosity or vorticity lead to counter-intuitive effects. We examine surface waves both using Bernoulli's principle and by deriving a generalised dispersion relation. This introduces the relation between waves and instabilities which leads into turbulent flows. We study sub-sonic flight but highlight the differences with supersonic/hypersonic flight due to shock formation, and heat dissipation. We highlight differences between shocks in gases and solids and introduce the Rankine-Hugoniot conditions. We describe the use of shock physics in materials science, planetary science and fusion research and the extreme states generated by shocks in plasmas.

839 characters

Available as a standalone module/ short course? N

Statutory details

	ECTS	CATS	Non-credit
Credit value	5	10	N

FHEQ level: Level 7

HECOS codes:

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		Other	Term 2, 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		Jeremy	Chittenden

Learning and teaching

Module description

Learning outcomes

On completing the Hydrodynamics module, students will have:
- A thorough understanding of subsonic incompressible fluid dynamics phenomena through use of the Navier Stokes equation and Bernoulli's principle.
- An understanding of the effects of viscosity and vorticity on sub-sonic flows.
- A deep understanding of the relationship between waves and fluid instabilities and the origins of turbulence.
- An appreciation of the principles of flight and how aircraft design is modified for supersonic and hypersonic flight.
- A thorough understanding of compressible flow and its importance in supersonic motion.
- An understanding of the fundamental principles involved in the description of shocks physics relating to solids.
- An appreciation of the influence of energy loss and transport on the structure of shocks in plasmas.
- An appreciation of the role of hydrodynamics phenomena in inertial confinement fusion, laboratory astrophysics and other laboratory applications.

Module content	1. Concepts and approximations in Fluid Dynamics Fluids, liquids & gases; Flow lines & stream lines; Navier Stokes equation; Drag & ram pressure; Incompressible flow; Ideal flow, Potential flow 2. Applications of Bernoulli's principle Bernoulli's principle; Venturis; The Magnus effect, Spinning balls & Flettner ships; Cavitation, sono-luminescence & the pistol shrimp 3. Viscosity Viscosity; Reynolds number; Stokes flow; Boundary layers; Coanda effect; Poiseuille flow 4. Vorticity Vorticity; Types of vortex; Vortex shedding, Vortex streets; Wingtip vortices; Structure of a cyclone 5. 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 Solids Shocks formation in a steepening non-linear sound wave; Shocks due to impact (particle model); The Rankine-Hugoniot, or shock 'jump' conditions; The Hugoniot curve, the adiabat & isentropic compression 10. Shocks in Plasmas Strong shocks conditions, Noh's problem, driven implosions (snowploughs & slugs); Blast waves & Sedov-Taylor scaling; Radiation cooling, radiation transport and radiative precursors
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	

Office use only

QA Lead	
Department staff	
Date of collection	

		Date exported	
Module leader	Jeremy Chittenden	Date imported	

Notes/ comments	

Template version 16/06/2017

Programme structure

Associated modules

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?
Examination	2 hour written examination.	100%	50%	N
		100%		