# MTH737U, Fluid Dynamics

## Description

We are all familiar with fluids – the tea we drink, the atmosphere that governs our weather and the oil that lubricates our car engine. Fluid Dynamics is the study of how fluids behave and is one of the central themes of modern applied mathematics. Mathematical modelling of fluids can deal with a vast range of phenomena, and plays a vital role in science and engineering. This course provides an introduction to the fascinating diversity of fluids, showing how mathematical techniques such as differential equations and vectors can be used to describe some of the types of flow and waves that are seen in fluids from treacle to the Earth's oceans.

## Parameters

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| **Unit value** | 1 cu |
| **Level** | 7 |
| **Semester** | 7 |
| **Timetable** | Provisional (** subject to change **):<br>Lectures/Tutorial<br>Tuesday 10 Maths 203 Lec<br>Tuesday 12 Maths 513 Tut<br>Thursday 11 Maths 203 Lec<br>Thursday 4 Maths 513 Tut<br>Friday 10 Maths 203 Lec |
| **Website** | http://www.maths.qmul.ac.uk/~cho/MTH737U |
| **Prerequisites** | MTH5102 Calculus III, MTH5106 Dynamics of Physical Systems; (a course in differential equations or waves – e.g., MTH4102, MTH6129 – helpful; consult the module organiser) |
| **Assessment** | 10% exercises, 90% final exam |
| **Organiser** | Dr. J. Cho<br>Office: Maths 353<br>Tel: 020 7882 5498<br>Email: J.Cho@qmul.ac.uk |

## Syllabus

- Introduction
  - Mathematical preliminaries: vector identities, integral theorems, tensors and index notation.
  - Lagrangian and Eulerian descriptions, material derivative and stream line.
  - Euler and vorticity equations, conservation of mass and momentum, equation of state
- Viscosity
  - Reynolds number – swimming tadpoles, disappearing windows and galaxies
  - Poiseuille and boundary layer flows
  - Diffusion of shear and vorticity

- Waves
  - Wave dispersion, dispersion relation, phase and group velocities, linearisation
  - Shallow- and deep-water waves, sound: tsunamis and shouting upwind
  - Planetary and gravity waves, the weather and the ozone hole
  - Nonlinear behaviour: characteristics, hydraulic jumps, shocks and solitons
- Vortices and vorticity
  - Kelvin and Helmholtz theorems, vortex lines, pairs and shedding, flying
  - Vortex sheets and Kelvin-Helmholtz instability, billow clouds

- Advanced topics
  - Instabilities
  - Chaos and turbulence

## Aims and Learning Outcomes

### Aims

- To introduce students to the mathematical and physical concepts used to describe fluids.
- To illustrate the use and analysis of equations that arises in fluid dynamics.
- To explain and illustrate concepts such as advection, viscosity, waves, vorticity, etc.
- To reinforce material and concepts introduced in earlier courses, such as *Dynamics of Physical Systems*, *Calculus I-III*, *Differential Equations* and *Oscillations, Waves and Patterns*, to give experience in solving problems from the physical and mathematical worlds.

### Learning Outcomes

By the end of this course, the successful student should:

- Show understanding of basic concepts of the mathematical modelling of fluids, such as fluid velocity, material derivative, vorticity, etc.
- Be able to apply a range of mathematical techniques, such as solution of ordinary and partial differential equations, to solving simple problems in viscous and inviscid flow and in fluid wave theory.
- Demonstrate knowledge of some types of nonlinear behaviour in fluid flows and waves, such as hydraulic jumps and shocks.

## Texts

- D. Acheson, *Elementary Fluid Dynamics* (Clarendon Press, Oxford)

J. Cho
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