# MA50215 Specialist Reading Course
# The Dynamics of Fluids

**J.H.P. Dawes. Semester 2, 2009-10**

**Outline**. This is a course in the *dynamics* of incompressible viscous Newtonian fluids: it concentrates on describing the solution of real flow problems and attempts to provide both physical and mathematical insights. The material is organised into four sections of roughly equal length, with the number of lectures for each section indicated below. The course revolves around the simplifications of the Navier–Stokes equations which describe very slow (section 2) and very fast (section 4) flows. Section 1 provides an introduction and links the description of 2D potential flow to complex variable theory. Section 3 discusses the generation of vorticity at boundaries. The style overall will be very 'applied': few, if any, theorems will be proved and no functional analysis will intrude.

**Arrangements**. Problems will be given out on worksheets, one per week and students will be strongly encouraged to attempt the problems. **The unit will be assessed entirely by written examination**. There will be a single examination paper containing four questions, of which complete answers to three will be enough to obtain full marks.

**Prerequisites**:

- MA20013 (streamlines, incompressibility, irrotationality, Bernoulli's equation for steady flow)
- MA20010 (vector calculus, solution of PDEs by separation of variables)
- MA40065 (definition of a Newtonian fluid, Navier–Stokes equations)

## Course schedule

**1. Inviscid flow and streamfunctions**. Streamlines, particle paths. Potential flow. Bernoulli's equation for *unsteady* flow. The bubble equation. Streamfunctions and the complex potential. Examples. [5]

**2. Slow Flows**. The Reynolds number. Stokes flow. Linearity, reversibility, uniqueness. The Minimum Dissipation Theorem. Relaxation to Stokes flow. 2D Stokes flows and the biharmonic equation. The 'paint-scraper' problem and corner eddies. Computation of the drag on a sphere. Thin films and gravitational spreading. [5]

**3. Dynamics of Vorticity**. The vorticity equation. Vorticity boundary layers: impulsively started plate, suction at a wall, stagnation point flows. [4]

**4. Flow at high Reynolds number**. The Euler limit and the boundary layer equation. Flow past a semi-infinite plate/wedge/corner. The Falkner-Skan equation and solutions in particular cases. [4]