Engineering Tripos Part IIB, 4A10: Flow Instability, 2019-20

Module Leader

Prof G R Hunt

Lecturers

Prof G R Hunt and Prof M Juniper

Timing and Structure

Lent term. 16 lectures + examples class. Assessment: 100% exam

Prerequisites

3A1 assumed.

Aims

The aims of the course are to:

- develop physical insight into the unsteady behaviour of fluid flows through a range of practical examples, videos and demonstrations
- introduce flow effects not covered in the third year, such as including the interaction between flexible structures and fluids, rotating flow and the effects of convection and surface tension.

Objectives

As specific objectives, by the end of the course students should be able to:

- understand that even a fluid flow with nominally steady boundary conditions may be unsteady due to flow instability
- analyse the stability of flows by determining whether small disturbances grow or decay with time
- understand how a liquid jet breaks up under the destabilising influence of surface tension
- analyse the stability of inviscid rotating flows
- be aware that concepts in modern nonlinear dynamics, including phase space diagrams and chaos, can be useful in the description of fluid flows
- analyse the instability of simple inviscid shear flows, including the effects of density stratification and surface tension, to discuss the effects of viscosity and the transition to turbulence
- understand the destabilising influence of convection in a fluid heated from below, be able to describe the cellular flow pattern formed (Bénard cells) and the effects of variations in surface tension
- discuss external flow around flexible structures

Content

Instability of fluid flows

- The break up of a liquid jet in air, surface tension effects, mean droplet size
- The stability of rotating flows: Rayleigh's criterion; flow between rotating cylinders; different flows according
to parameter range, ranging from Taylor vortices to chaotic flow; relationship to streamwise vortices in boundary layers

- Shear flow instability, temporal and spatial; the Kelvin-Helmholtz instability; the effects of viscosity and transition to turbulence
- Convection due to surface heating, formation of cellular patterns, effect of variations in surface tension
- External flow, flow-induced oscillations of structures, control of oscillations by passive techniques

**Booklists**

Please see the Booklist for Group A Courses [2] for references for this module.

**Examination Guidelines**

Please refer to Form & conduct of the examinations [3].

**UK-SPEC**

The UK Standard for Professional Engineering Competence (UK-SPEC) [4] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the ‘Accreditation of Higher Education Programmes’ (AHEP) document [5] which sets out the standard for degree accreditation.

The Output Standards Matrices [6] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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**Links**

[1] mailto:grh20@cam.ac.uk