Engineering Tripos Part IIB, 4A10: Flow Instability, 2022-23

Module Leader

Prof G R Hunt [1]

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 refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [2].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [3] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

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Links
[1] mailto:grh20@cam.ac.uk
[2] https://teaching26-27.eng.cam.ac.uk/content/form-conduct-examinations
[3] https://teaching26-27.eng.cam.ac.uk/content/uk-spec