

Engineering Tripos Part IIA, 3A3: Fluid Mechanics II (double module), 2018-19

Module Leader

[Prof RS Cant](#) [1]

Lecturers

Dr A Agarwal, Prof RS Cant, Dr J Jarrett and Dr J Longley

Lab Leaders

Prof H Babinsky and Prof R Miller

Timing and Structure

Michaelmas and Lent. 32 lectures.

Aims

The aims of the course are to:

- To understand fluid flows to a level such that the pressures and resultant forces acting can be estimated in situations involving complex geometries of industrial interest at both subsonic and supersonic speed.
- To understand the effects of viscosity and heat transfer, where relevant

Objectives

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

- Know the concepts of stagnation temperature and stagnation pressure and be able to determine their values from a knowledge of static temperature, static pressure and Mach number.
- Know how conservation principles determine the behaviour of normal shock waves and be able to use tables to quantify that behaviour.
- Evaluate Mach number of a flow from measurements of Pitot and static pressures.
- Determine flow patterns in nozzles under the assumption of one dimensionality, using tables.
- Know how Mach number and other flow properties change under the influence of friction or heat exchange, and be able to quantify this using tables.
- Know how to construct and interpret x-t diagrams for unsteady ID flow.
- Quantify the behaviour of hydraulic jumps and infinitesimal waves in shallow water.
- Understand the influence of the speed of sound on two-dimensional compressible flow behaviour.
- Apply the two-dimensional method of characteristics for simple flows and flows involving reflection/cancellation.
- Understand the origin of oblique shock waves and their reflection.
- Apply the preceding ideas to practical flows via shock-expansion theory, linearised method of characteristics and linearised potential theory.
- Know how to construct and use numerical solution methods for the equations of fluid flow using finite difference and finite volume approximations
- Know how to estimate the accuracy and analyse the stability of numerical schemes

- Identify and understand the operation of different types of turbomachinery.
- Analyse turbomachinery performance.
- Understand the causes of irreversibilities within the blade passages and their affects on the overall efficiency.
- Analyse compressible flow through turbomachines.

Content

One-dimensional Compressible Flow (12L): 2 lectures/week, weeks 1-6 Michaelmas term (Prof RS Cant)

- Steady, adiabatic and inviscid flow; speed of sound; reversibility; the stagnation state; the effect of area variation on subsonic/supersonic flow, choking; normal shock waves; flow patterns in nozzles; use of table for isentropic flow and for shock waves.
- Fanno and Rayleigh line processes for the effects of friction and heat exchange.
- Introduction to unsteady flow. hydraulic analogy for steady compressible flow; speed of waves in shallow water; the hydraulic jump; the venturi flume; weirs.

Two-dimensional Compressible Flow (8L): 2 lectures/week, weeks 7-8 Michaelmas term and weeks 1-2 Lent term (Dr JP Jarrett)

- Method of characteristics, expansion fan and compression ramp.
- Oblique shock waves, strong and weak solutions.
- Shock-expansion theory
- Potential equation and linearisation.

Equations of Fluid Flow and their Numerical Solution (6L): 2 lectures/week, weeks 3-5 Lent term (Dr A Agarwal)

- Numerical solution techniques; finite difference approximations; finite volume approximations; order of accuracy, diffusion and dispersion errors; stability considerations for time iterative techniques
- Classification of equations; numerical solution of the Euler equations, nonlinearity and shock waves

Turbomachinery (6L): 2 lectures/week, weeks 6-8 Lent term (Dr JP Longley)

- Identify and understand the operation of different types of turbomachinery.
- Analyse turbomachinery performance.
- Understand the causes of irreversibilities within the blade passages and their affects on the overall efficiency.
- Analyse compressible flow through turbomachines.

Coursework

Turbomachinery

Nozzle and supersonic tunnel

Learning objectives:

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Practical information:

- Sessions will take place in [Location], during week(s) [xxx].
- This activity [involves/doesn't involve] preliminary work ([estimated duration]).
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Full Technical Report:

Students will have the option to submit a Full Technical Report.

Booklists

Please see the [Booklist for Part IIA 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:rsc10@eng.cam.ac.uk>

[2] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=46231>

[3] <http://teaching.eng.cam.ac.uk/content/form-conduct-examinations>

[4] <http://www.engc.org.uk/ukspec.aspx>

[5] <http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/>

[6] <http://teaching.eng.cam.ac.uk/content/output-standards-matrices>