Engineering Tripos Part IIB, 4A7: Aircraft Aerodynamics and Design, 2020-21

Module Leader

Dr J.P. Jarrett [1]

Lecturers

Dr J.P. Jarrett and Prof W.N. Dawes [2]

Lab Leader

Dr J.P. Jarrett [1]

Timing and Structure

Michaelmas term. 12 lectures + coursework. Assessment: 100% coursework.

Prerequisites

3A1 and 3A3 assumed

Aims

The aims of the course are to:

- develop the basic ideas necessary to understand some advanced concepts in aerodynamics.
- cover the aerodynamic effects that constrain an aircraft design.
- appreciate the challenges of reducing the environmental impact of aviation.

Objectives

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

- have an appreciation of the aerodynamic factors likely to feature in the designs of new aircraft.
- have an understanding of the behaviour of boundary layers over swept wings in compressible flow.
- have sufficient knowledge to be able to predict the different supersonic zones on a wing.
- understand how the basic physics can be integrated into the design of an aircraft.
- understand how to make design trade-offs.
- have a basic appreciation of the impact of aviation on the environment and possible responses.

Content

This course aims to develop the basic ideas necessary to enable the student to understand some advanced concepts in aerodynamics. In particular the course will cover the aerodynamic effects that constrain an aircraft design. The course will highlight those factors determining the configuration of aircraft for different duties relating them to the effect of compressibility at transonic speeds. Coursework will illustrate undelying flow physics, via transonic airfoil design and the integration of these basics via a study of the trade-offs made in producing a transonic wing section design for a given specification. The course will end by reviewing the environmental impact of aviation and show how aircraft design might change to reduce this impact.

Introduction to Transonic Aerodynamics (3L, Dr J.P. Jarrett)

- Overview of transonic design concepts;
- Transonic flow about two-dimensional airfoils;
- Shock-boundary layer interaction;
- Supercritical airfoils with delayed shock-induced drag rise.

Transonic Airfoil Design (4h coursework, Dr J.P. Jarrett)

This coursework section will allow the interactive design of a transonic airfoil profile. The aim is to consolidate the lecture material and illustrate how the various design constraints compete in practice.

Aircraft Aerodynamic Design (3L, Dr J.P. Jarrett)

- Airframe / Intake integration
- Stability of swept wing aircraft
- Practical swept wing design
- Delta and slender ogival wings
- Vertical / short take-off and landing

Aviation and the Environment (6L, Prof W.N. Dawes)

The impact of air transport on the environment; the relationship between technology, operational practice, regulation and economics.

- Basic modelling
- The environment - overview of atmospheric chemistry, fluid dynamics & mixing; the greenhouse effect; radiative forcing.
- Airframe - aircraft range & endurance, the Breguet equation; ML/D payload, fuel and structure weight; choice of fuel. Why do airplanes fly at the altitude they do? Payload and fuel efficiency.
- Engine - simple modelling of a high-bypass ratio turbofan engine. Cycle efficiency and propulsive efficiency, trading production of NOx and CO2.
- What would an airplane look like if optimised to reduce environmental impact?

Reducing the Environmental Impact of Aircraft (Coursework, Prof W.N. Dawes)

The coursework consists of a choice of <u>one</u> from three case studies, based on the simple modelling above to study from the perspective of environmental impact the trade-offs associated with (A) design range;(B) cruise altitude;and (C) engine overall pressure ratio. It is intended that the case studies will be spreadsheet based.

Coursework

Coursework	Format	Due date & marks
Transonic Airfoil Design Computer-based design exercise. <u>Learning objective:</u>	Individual Report Anonymously marked	Thu week 6 [30/60]

Coursework	Format	Due date & marks
• To understand the fundamentals of transonic section design. • To appreciate the necessary off-design performance trade-offs.		
Reducing the Environmental Impact of Aircraft Computer modelling study of aviation and the environment. Learning objective: • To determine the environmental effects of modifying aircraft design and flight conditions. • To understand the trade-offs between aircraft performance and pollutant emissions.	Individual Report Anonymously marked	Wed week 9 [30/60]

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 [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

General Learning Outcomes

Graduates with the exemplifying qualifications, irrespective of registration category or qualification level, must satisfy the following criteria:

Last modified: 25/09/2020 14:56

Source URL (modified on 25-09-20): https://teaching.eng.cam.ac.uk/content/engineering-tripos-part-iib-4a7-aircraft-aerodynamics-and-design-2020-21

Links
[1] mailto:jpj1001@cam.ac.uk
[2] mailto:jpj1001@cam.ac.uk, wnd1000@cam.ac.uk
[3] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching.eng.cam.ac.uk/content/uk-spec