TURBULENCE - 2024/5

Module code: ENGM249

Module Overview

Nearly all flows encountered in engineering practice are turbulent, so it is critical that engineers have an understanding of the complexities of turbulence and the difficulties in modelling it for design purposes. This module therefore builds on earlier modules in aerodynamics, providing an introduction to the fundamental physics of turbulent flows and existing approximate and semi-empirical techniques for modelling turbulence in CFD. The module also provides an overview of experimental techniques for characterizing turbulence, and the importance of experimental validation.

Module provider

Mechanical Engineering Sciences

Module Leader

BIRCH David (Mech Eng Sci)

Number of Credits: 15

ECTS Credits: 7.5

Framework: FHEQ Level 7

Module cap (Maximum number of students): N/A

Overall student workload

Independent Learning Hours: 76

Lecture Hours: 20

Seminar Hours: 5

Laboratory Hours: 18

Guided Learning: 11

Captured Content: 20

Module Availability

Semester 1

Prerequisites / Co-requisites

None

Module content

Indicative content includes:

Turbulence: introduction, laminar flow, transition, definitions; Navier-Stokes equations, Reynolds stresses, turbulence energy; structure of turbulence and turbulent flows; the turbulent boundary layer

Turbulence modelling: the closure problem; one- and two-equation turbulence models; introduction to advanced models, large-eddy simulation (LES) and direct numerical simulation (DNS)

Computational fluid dynamics (CFD): application of turbulence models, physical and computational implications; case studies

Experimental techniques: wind tunnels and anemometry

Assessment pattern

Assessment type	Unit of assessment	Weighting
Coursework	Turbulence Coursework	40
Coursework	CFD Coursework	60

Alternative Assessment

N/A

Assessment Strategy

The assessment strategy is designed to provide students with the opportunity to demonstrate their understanding of the scientific principles, statistical and mathematical methodologies used in the study of turbulence. The CFD coursework element allows students to demonstrate that they can interpret a problem, conduct a computational analysis at the level used in the aerospace industry using a commercial CFD solver, and present a report of the solution clearly and accurately.

Thus, the summative assessment of this module consists of:

(a) Turbulence coursework, assessing learning outcomes 1, 2, 3, 4 and 5;

(b) CFD coursework, assessing learning outcomes 3 and 4.

Formative assessment and feedback are provided in both seminars and during the laboratory sessions.

Module aims

- Provide students with a general understating of turbulence, and the nature and structure of turbulent flows;

- Introduce students to the concepts of turbulence modelling, including common models and their applications;
- introduce students to experimental techniques for investigating turbulent flows;
- Provide students with practical skills implementing turbulence models in a commercial CFD solver.

Learning outcomes

Ref		Attributes Developed	
001	Upon successful completion of this module, you will be able to: Demonstrate a comprehensive understanding of the general features of turbulent flows and modelling methods;	K	M1, M2, M3
002	Describe the origin and significance of Reynolds stresses and associated properties;	KC	M1, M2
003	Demonstrate an understanding of the basis of the 'closure problem' and its resolution through turbulence modelling;	KC	M1, M2, M3
004	Be able to use basic turbulence models in CFD, and be aware of advanced models and their strengths/weaknesses;	KCPT	M2, M3, M4, M12, M13
005	Demonstrate awareness of experimental techniques for investigating turbulent flows	KCP	M5, M13, M15

Attributes Developed

C - Cognitive/analytical

K - Subject knowledge

T - Transferable skills

P - Professional/Practical skills

Methods of Teaching / Learning

The learning and teaching strategy is designed to introduce the basic principles of turbulence through theory with worked examples, and to apply the theory through a case study exercise using a commercial CFD solver.

The learning and teaching methods include

(a) Lectures, in which students will be introduced to the underlying theory and mathematics governing turbulent flows;

(b) Seminars, in which students will engage in discussions and analytical exercises to reinforce the theoretical developments;

(c) Laboratory sessions, in which students will implement a turbulent CFD solution with staff support, using commercial CFD software.

Indicated Lecture Hours (which may also include seminars, tutorials, workshops and other contact time) are approximate and may include in-class tests where one or more of these are an assessment on the module. In-class tests are scheduled/organised separately to taught content and will be published on to student personal timetables, where they apply to taken modules, as soon as they are finalised by central administration. This will usually be after the initial publication of the teaching timetable for the relevant semester.

Reading list

https://readinglists.surrey.ac.uk
Upon accessing the reading list, please search for the module using the module code: ENGM249

Other information

The School of Mechanical Engineering Sciences is committed to developing graduates with strengths in (i) employability, (ii) digital capabilities, (iii) global and cultural capabilities, (iv) sustainability and (v) resourcefulness and resilience. This module is designed to allow students to develop knowledge, skills and capabilities in the following areas:

Employability: Students will develop skills in turbulent CFD simulation using industry-standard software which will be directly transferrable to the engineering workplace;

Digital capabilities: Students will develop skills in numerical simulation, in data extraction and analysis for design decision-making purposes;

Sustainability: Examples and case studies used in the module focus on the importance of improving efficiency in fluids systems;

Resourcefulness and resilience: Students will need to carry out self-guided analysis, requiring independent research and skills-gathering.

Programmes this module appears in

Programme	Semester	Classification	Qualifying conditions
Advanced Mechanical Engineering MSc	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Aerospace Engineering MEng	1	Optional	A weighted aggregate mark of 50% is required to pass the module