# COMPUTATIONAL FLUID DYNAMICS - 2024/5

## Module code: ENG3210

## Module Overview

Computational Fluid Dynamics (CFD) is a pillar of fluid mechanics that uses numerical methods to analyze and solve problems that involve fluid flows. CFD is critical to design and improve the performance of many aspects of modern life. CFD simulations are ubiquitous across all the major engineering endeavors, from gas turbine engines to air and surface vehicles, from blood flow to black holes.

The module will enable students to understand the steps needed to build a digital model of a fluid problem, compute a solution and post process the model to extract meaningful information taking into account possible sources of error . The module will provide hand-on use of computer-based tools to perform simulations of engineering flows of industrial relevance, including pre- and post-processing.

### Module provider

Mechanical Engineering Sciences

### Module Leader

MARQUES Simao (Mech Eng Sci)

### Number of Credits: 15

### ECTS Credits: 7.5

### Framework: FHEQ Level 6

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

## Overall student workload

Independent Learning Hours: 73

Lecture Hours: 22

Tutorial Hours: 22

Guided Learning: 11

Captured Content: 22

## Module Availability

Semester 1

## Prerequisites / Co-requisites

N/A

## Module content

The content of this module includes:

- introduction to the modeling process for fluids engineering
- geometry modeling
- grid generation techniques
- introduction to numerical solution of fluid dynamics problems:
    - conservation equations, Navier-Stokes.
    - discretization methods: finite-volume discretization, compressible and incompressible methods; explicit and implicit methods for temporal discretization.
    - CFL condition and the convection-based Courant number and corresponding diffusion number.
    - Discussion of solution methods, convergence and accuracy/errors of flow solvers.
    - RANS and the need for turbulence modeling.
    - Verification and validation.
    - The role of boundary conditions.
- Post-processing.
- Brief overview of advanced CFD techniques: unsteady problems, parallel processing.

## Assessment pattern

| Assessment type | Unit of assessment | Weighting |
|---|---|---|
| Coursework | CFD Laboratory | 66 |
| Online Scheduled Summative Class Test | CFD Class test (40 min.) | 34 |

## Alternative Assessment

n/a

## Assessment Strategy

The assessment strategy is designed to provide students with the opportunity to demonstrate understanding of theoretical and practical aspects of CFD workflows.

- The CFD class test assesses the students' understanding of theoretical aspects of CFD (Learning Outcome 1,3)
- The coursework tests the students' ability to obtain solutions to flow problems using a computer-based tool, interpret the solutions obtained and awareness of the possible sources of error in the solution (Learning Outcomes 2, 4).

Summative Feedback:

- the CFD class test feedback will be discussed upon completion by the whole class;
- Coursework written feedback will be provided following the laboratory assignments.

Formative Feedback:

- Students will have continuous feedback on their work during the weekly tutorial session, including on their coursework.

## Module aims

- Understand the building blocks of digital models for fluid dynamics
- Develop the ability to solve typical fluid engineering problems.
- Develop an understanding of numerical errors and their impact on solutions.
- Post-process and interpret solutions from numerical models.
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## Learning outcomes

| Ref | | Attributes Developed | |
|---|---|---|---|
| 002 | Select and implement an appropriate numerical method for common practical engineering problems | KCP | C3 |
| 003 | Understand the sources of error in a numerical solution and evaluate the validity of numerical solutions | C | C1,C2 |
| 004 | Solve an engineering flow problem using a computer-based tool | KCP | C1,C2,C3 |
| 001 | Understand the basic mathematical principles underlining CFD simulations | KC | C1 |

### 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 produce learners capable of completing CFD workflows. Students will be provided with the required background and theoretical knowledge underpinning CFD simulations during lectures. This will be followed up by activities that exercise and demonstrate the concepts exposed. Throughout the hand-on sessions, students will receive formative feedback on their work.

This is delivered through lectures and computer laboratory classes. The lectures will provide the theoretical background of the discipline, introduce methodologies to analyze and post-process results. The computer laboratory classes provide the hands-on use of engineering software and expose students to all aspects of a typical CFD workflow. A selected range of computer laboratory results will be formally assessed and will provide the basis of one laboratory report.

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: ENG3210

## Other information

The School of Mechanical Engineering Sciences is committed to developing graduates with strengths in Employability, Digital Capabilities, Global and Cultural Capabilities, Sustainability, and Resourcefulness and Resilience. This module is designed to allow students to develop knowledge, skills, and capabilities in digital skills by using a range industrial grade engineering software (CAD, grid generation, CFD, MatLab); the module will improve the students employability by developing competencies and skills to solve fluid problems; this module focus on the use of tools critical to improve performance and develop more sustainable engineering solutions. The assessment and feedback will require the students to employ a wide range of resources and provide opportunities for students to act on feedback to improve future work.

## Programmes this module appears in

| Programme | Semester | Classification | Qualifying conditions |
|---|---|---|---|
| Aerospace Engineering BEng (Hons) | 1 | Optional | A weighted aggregate mark of 40% is required to pass the module |
| Aerospace Engineering MEng | 1 | Optional | A weighted aggregate mark of 40% is required to pass the module |
| Automotive Engineering BEng (Hons) | 1 | Optional | A weighted aggregate mark of 40% is required to pass the module |
| Automotive Engineering MEng | 1 | Optional | A weighted aggregate mark of 40% is required to pass the module |
| Mechanical Engineering BEng (Hons) | 1 | Optional | A weighted aggregate mark of 40% is required to pass the module |
| Mechanical Engineering MEng | 1 | Optional | A weighted aggregate mark of 40% is required to pass the module |