Module Code	MEU44B13
Module Name	4B13 FLUID MECHANICS 2
ECTS Weighting	5 ECTS
Semester taught	Semester 1
Module Coordinator/s	Craig Meskell
Module Learning Outcomes with reference to the Graduate Attributes and how they are developed in discipline	On successful completion of this module, students should be able to: LO1. Describe various approaches to visualize fluid motion, and formulate relationships between derived variables (*e.g.*, vorticity) and primitive variables (*e.g.*, velocity and pressure) characterising fluid flow LO2. Understand the physical significance of velocity potential and stream functions, and the difference between irrotational and rotational flows LO3. Understand the limitations of various methods to analyse flow around aerofoils LO4. Analyse aerofoils with arbitrary camber, and evaluate the effect of high lift devices on aerofoil performance LO5. Calculate the effect of wing aspect ratio on drag and hence evaluate the impact on aircraft performance LO6. Critically assess the appropriateness of a mesh for computational fluid dynamics and whether numerical and analytical predictions of aerofoil performance are physically reasonable **Graduate Attributes: levels of attainment** To act responsibly - Enhanced To think independently - Enhanced To develop continuously - Enhanced To communicate effectively - Enhanced
Module Content	The module deals with aerodynamics of 2D and 3D wings. The module content is quite mathematical, however real world examples, *e.g.*, from the aerospace and power generation industries, are used to illustrate the technical content. This helps the student to contextualize the details of the module in an engineering light. The module introduces the student to important concepts in flow analysis such as vorticity and circulation. Attached flow around wings and wing sections (*i.e.* aerofoils) is used to demonstrate the significance of the inviscid flow assumption and vorticity. The performance of aerofoils and wings is analysed using various methods. The need for and effect of high-lift devices on aircraft is also dealt with. By the end of this section, the student should realize that without viscosity and hence vorticity, flight would not be possible, but that it also causes problems such as drag and separation. The module concludes with an introduction to aeroelasticity – the consequence of the aerodynamic profile not being rigid.

- ***Classical hydrodynamics***
    - Governing equations for inviscid fluid flow - Laplace and Poisson equations;
    - Development of concepts and equations for stream function, velocity potential, vorticity and circulation;
    - Definition of basic inviscid flows: uniform flow, source/sink flow, point vortex, rigid body rotation, corner flow, doublet flow;
    - Potential flow around a circular cylinder and comparison with real viscous flow;
    - Potential flow around a rotating cylinder and comparison with real viscous flow.
- ***Analysis of flow around aerofoils***
    - Terminology associated with definition of aerofoil geometry and performance;
    - Kutta-Joukowski condition;
    - Joukowski aerofoil analysis;
    - Thin aerofoil theory.
- ***Analysis of flow around finite wings***
    - Helmholtz' vortex theorems;
    - Prandtl's lifting line theory - wing tip vortices and starting vortex;
    - Effect of aspect ratio on wing performance.
- ***Introduction to aeroelasticityAnalysis of flow around finite wings***
    - Static aerodynamic divergence.
    - Classical 1 degree of freedom flutter – starting vortex.
    - Galloping and the impact of effective wind direction.

Teaching and Learning Methods

Lectures: The teaching strategy follows chapters from selected well-established textbooks. Lecture notes and additional supporting material are provided on Blackboard.

Online self-tests aligned with each topic. Performance in these tests is not recorded, and students can repeat them as often as necessary.

Assessment Details Please include the following:

- **Assessment Component**
- **Assessment description**
- **Learning Outcome(s) addressed**
- **% of total**
- **Assessment due date**

Assessment Component	Assessment Description	LO Addressed	% of total	Week due
Written exam (2 hour in person)	End of semester examination	1-5	85	Exam period
Assignment 1	CFD assignment on lift and drag performance of aerofoils – Part 1	3-4,6	3	Approximately week 3
Assignment 2	CFD assignment on lift and drag performance of aerofoils – Part 2	3-4,6	12	Approximately week 9

Reassessment Requirements	Written examination
Contact Hours and Indicative Student Workload Error! Bookmark not defined.	**Contact hours: 25 lectures** **Independent Study (preparation for course and review of materials): 50** **Independent Study (preparation for assessment, incl. completion of assessment): 30**
Recommended Reading List	Kuethe & Chow, Foundations of Aerodynamics G.D. McBain, Theory of Lift: Introductory Computational Aerodynamics in MATLAB/OCTAVE Anderson, Fundamentals of Aerodynamics Versteeg & Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method
Module Pre-requisite	3B2 Fluid Mechanics (or equivalent)
Module Co-requisite	Not applicable
Module Website	See Blackboard
Are other Schools/Departments involved in the delivery of this module? If yes, please provide details.	No
Module Approval Date	
Approved by	
Academic Start Year	
Academic Year of Date	