Prifysgol Wrecsam
Wrexham University

Module specification

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Module Code	ENG6C9
Module Title	Advanced Aerodynamics and CFD
Level	6
Credit value	20
Faculty	FACE
HECoS Code	100115
Cost Code	GAME
Pre-requisite module	N/A

Programmes in which module to be offered

Programme title	Core/Optional/Standalone
BEng (Hons) Aerospace Engineering	Core

Breakdown of module hours

Learning and teaching hours	21 hrs
Placement tutor support hours	0 hrs
Supervised learning hours e.g. practical classes, workshops	21 hrs
Project supervision hours	0 hrs
Active learning and teaching hours total	**42 hrs**
Placement hours	0 hrs
Guided independent study hours	158 hrs
Module duration (Total hours)	**200 hrs**

Module aims

This module integrates advanced theoretical study with applied laboratory investigation. Students critically evaluate techniques, interpret data, and justify design or methodological decisions within a professional context. The combination of theory and practice cultivates independent learning, innovation, and readiness for individual project or dissertation work.

This module aims to develop students' advanced understanding of aerodynamics through the integrated application of computational fluid dynamics (CFD), wind tunnel experimentation, and theoretical analysis, equipping them with industry-relevant skills to analyse and solve complex aerodynamic problems in modern engineering practice.

Module Learning Outcomes

At the end of this module, students will be able to:

1	Apply a systems approach to model and simulate complex aerodynamic flows using CFD techniques, demonstrating knowledge at the forefront of aerodynamics and numerical analysis (AHEP-4 C2).
2	Critically analyse complex aerodynamic problems using first principles, advanced mathematical, statistical, and engineering principles, based on experimental wind tunnel data to reach substantiated and technically justified conclusions (AHEP-4 C12).
3	Critically evaluate aerodynamic performance, including lift, drag and associated coefficients, by comparing experimental measurements with CFD predictions and justifying modelling assumptions, boundary conditions and sources of uncertainty (AHEP-4 C6).

Assessment

Indicative Assessment Tasks:

This section outlines the type of assessment task the student will be expected to complete as part of the module. More details will be made available in the relevant academic year module handbook.

Assessment 1:

Assessment is based on an individual technical report in which students conduct wind tunnel experiments on an aerofoil profile alongside corresponding CFD simulations. The report requires students to analyse and compare experimental and numerical results, apply advanced aerodynamic theory and first principles, and draw substantiated conclusions. This assessment is designed to evaluate achievement of all learning outcomes and explicitly demonstrate alignment with AHEP-4 competencies.

Assessment number	Learning Outcomes to be met	Type of assessment	Duration/Word Count	Weighting (%)	Alternative assessment, if applicable
1	1-3	Written Assignment	3000	100	N/A

Derogations

Credits shall be awarded by an Assessment Board for those modules in which a pass mark 40% has been achieved, with a minimum mark of 30% in each assessment element.

Learning and Teaching Strategies

Learning combines theoretical exploration with applied laboratory investigation to bridge conceptual understanding and professional competence. Students critically analyse data, test approaches, and evaluate outcomes in practical settings. Blended delivery through the Virtual Learning Environment supports flexibility and reflection. Tutorials focus on independent enquiry, innovation, and readiness for project or dissertation work.

Welsh Elements

This module will be delivered through the medium of English; however, students have the option to submit their assessments in the medium of Welsh. While this module is not currently offered fully through Welsh, Welsh language support and guidance are available, and some learning materials or tutorial discussions may incorporate Welsh elements where appropriate. To further promote bilingual learning, all students have the opportunity to take the 20-credit *Welsh for STEM* short course, designed to develop confidence and subject-specific language skills in both English and Welsh.

Indicative Syllabus Outline

Aerodynamic Theory and CFD Fundamentals:
Application of fundamental and advanced aerodynamic principles, including lift, drag, pressure distribution, and aerodynamic coefficients, within CFD frameworks to model aerofoil and three-dimensional flow systems.

CFD Methods, Meshing, and Numerical Modelling:
Formulation and implementation of governing equations for fluid flow using appropriate numerical methods, including development of high-quality meshes, boundary conditions, and assessment of convergence and solution accuracy.

Flow Regimes and Turbulence Modelling:
Analysis of laminar, transitional, and turbulent flow regimes, including selection and evaluation of turbulence models for accurate aerodynamic prediction.

Experimental Aerodynamics and Data Analysis:
Application of wind tunnel testing to investigate aerofoil performance, with interpretation of experimental data using first principles and advanced engineering analysis to reach substantiated conclusions.

CFD Simulation and Result Interpretation:
Application of 2D and 3D CFD simulations to analyse aerodynamic performance, including post-processing and detailed interpretation of flow behaviour and performance metrics.

Validation, Uncertainty, and Performance Evaluation:
Critical comparison of CFD predictions with experimental results, including evaluation of modelling assumptions, boundary conditions, discrepancies, and sources of uncertainty to justify engineering decisions.

Indicative Bibliography

Please note the essential reads and other indicative reading are subject to annual review and update.

Essential Reads:

J. D. Anderson, *Fundamentals of Aerodynamics, 7th ed. New York, NY, USA: McGraw-Hill, 2023*.

Other indicative reading:

NASA Glenn Research Center, "Beginner's guide to aerodynamics," 2023. [Online]. Available: https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/learn-about-aerodynamics/

H. K. Versteeg and W. Malalasekera, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, 2nd ed. Harlow, UK: Pearson, 2007.

P. R. Spalart and S. R. Allmaras, "A one-equation turbulence model for aerodynamic flows," *AIAA J.*, vol. 32, no. 5, pp. 922–930, 1994.

Administrative Information

For office use only	
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