

<b>Module Title:</b>	<b>Aerodynamics</b>	<b>Level:</b>	6	<b>Credit Value:</b>	20
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<b>Module code:</b>	ENG687	<b>Is this a new module?</b>	YES	<b>Code of module being replaced:</b>	ENG619 ENG605
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<b>Cost Centre:</b>	GAME	<b>JACS3 code:</b>	H400
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<b>Trimester(s) in which to be offered:</b>	1, 2	<b>With effect from:</b>	September 17
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<b>School:</b>	Applied Science, Computing & Engineering	<b>Module Leader:</b>	Dr X Huang
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Scheduled learning and teaching hours	60 hrs
Guided independent study	140 hrs
Placement	0 hrs
<b>Module duration (total hours)</b>	<b>200 hrs</b>

<b>Programme(s) in which to be offered</b>	Core	Option
BEng (Hons) Aeronautical & Mechanical Engineering	✓	<input type="checkbox"/>
BEng (Hons) Aircraft Maintenance	✓	<input type="checkbox"/>
BEng (Hons) Automotive Engineering	✓	<input type="checkbox"/>
BEng (Hons) Drone Technology & Operations	✓	<input type="checkbox"/>
BEng (Hons) Aerospace and Modern Optics		✓

<b>Pre-requisites</b>
None

Office use only

Initial approval February 2017

APSC approval of modification

Have any derogations received Academic Board approval?

Version 1

Yes ✓ No

**Module Aims**

1. To develop an understanding of the properties of the atmosphere, the effect of forces on the aerodynamic characteristics of aircraft and vehicles, the mechanics of flight, aircraft performance, design features which provide static and dynamic stability and the forces affecting aircraft stability.
2. To develop an understanding of processes involved practical experience at deriving solutions for engineering tasks.
3. To extend and develop understanding of the aerodynamic characteristics of a 3D wing from 2D aerofoil in both incompressible and compressible flow regimes.

**Intended Learning Outcomes**

Key skills for employability

- KS1 Written, oral and media communication skills
- KS2 Leadership, team working and networking skills
- KS3 Opportunity, creativity and problem solving skills
- KS4 Information technology skills and digital literacy
- KS5 Information management skills
- KS6 Research skills
- KS7 Intercultural and sustainability skills
- KS8 Career management skills
- KS9 Learning to learn (managing personal and professional development, self-management)
- KS10 Numeracy

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

Key Skills

1	Analyse the properties of air and the atmosphere.	KS3
2	Calculate the effect of forces on the aerodynamic characteristics of aircrafts/vehicles.	KS3
3	Apply the mechanics of airflows to aircraft/vehicle performance.	KS3
4	Solve problems involving model design and testing based on similarity.	KS3
5	Analyse boundary layer development on a flat plate, which can be used to approximately estimate boundary layer development on an airfoil	KS3
		KS6
6	Apply the aerodynamic characteristics of wings with various profiles under various flow regimes (subsonic incompressible, subsonic compressible, transonic, supersonic).	KS3
		KS6

**Derogations**

A derogation from regulations has been approved for this programme which means that whilst the pass mark is 40% overall, each element of assessment (where there is more than one assessment) requires a minimum mark of 30%.

**Assessment:**

The learning outcomes will be assessed by means of a 2-hour written examination and 2 pieces of coursework based on lab work. It is an unseen time-constrained examination with a fixed number of questions, typically five, where students are required to answer only four.

Assessment number	Learning Outcomes to be met	Type of assessment	Weighting (%)	Duration (if exam)	Word count (or equivalent if appropriate)
1	1, 2, 3, 4, 5, 6	Examination	60	2 hours	
2	2, 5	Coursework	40	N/A.	2000

**Learning and Teaching Strategies:**

This module will be delivered by a set of structured lectures and will also contain practical laboratory based exercises supported by introductory lectures and demonstrations. Laboratory work and tutorials will be utilised to support lectures. The students will also be encouraged to undertake self-readings of essential and recommended books.

**Syllabus outline:**

**Properties of the atmosphere:**

Properties of atmosphere. Properties of air: Ideal gas law.

**Aeronautical definitions:**

Structures of an airplane. Aerofoil geometry. Angle of attack

**Effect of forces on the aerodynamic characteristics of aircraft and vehicles:**

Forces of importance: thrust, lift and drag. Moments. Centre of Gravity, Centre of Pressure, and Aerodynamic centre. Relationship between these positions.

**Dimensional analysis and similarity:**

Importance of dimensional analysis and model testing in engineering. Dimension and unit. Dimensional homogeneity. Dimensional analysis method. Common non-dimensional groups. Three similarities: geometric, kinematic and dynamic.

**Aerodynamic characteristics:**

Reynolds number, Mach number, coefficients of lift, drag and moment.

**Viscos flow and boundary layers:**

Velocity profile. Boundary layer development on a flat plate. Laminar and turbulent boundary layer. Boundary layer separation. Boundary thickness.

**General external flow characteristics**

Lift and drag generation. Pressure distribution around a cylinder. Variation of pressure distribution with angle of attack of an airfoil. Types of drags: skin drag, form drag, interference drag, induced drag and wave drag.

**Mechanics of flight and vehicle performance:**

Flight: Forces involved in climbing flight, gliding flight. Rate of descent and endurance. Criteria for aircraft control in a horizontal turn. Maximum range/endurance conditions for engine types.

Land vehicles: this section can consider aerodynamic forces at different velocities, turns, effects of aerofoils, efficiency, power.

**Compressible Flow:**

Wave propagation in compressible flow. Mach number relationships. Compressible flow regime analysis: subsonic flow at high Mach number, transonic and supersonic. Wings in compressible flow. Prandtl-Glauert correction factor and critical Mach number. Lift and drag on supersonic moving aerofoils. Lift and drag in the transonic region.

**Bibliography:**

**Essential reading**

Anderson, J.D. (2010) *Fundamentals of Aerodynamics* (5<sup>th</sup> edition). McGraw-Hill Education. ISBN-10: 0073398101, ISBN-13: 978-0073398105

**Other indicative reading**

Houghton, E. L and Carpenter, P. W (2012) *Aerodynamics for Engineering Students* (6<sup>th</sup> edition). Butterworth-Heinemann. ISBN-10: 0080966322, ISBN-13: 978-0080966328

Anderson, J. D. (2011) *Introduction to Flight* (7<sup>th</sup> edition). McGraw-Hill Higher Education. ISBN-10: 0073380245, ISBN-13: 978-0073380247

Dingle, L and Tooley, M (2013) *Aircraft Engineering Principles* (2<sup>nd</sup> edition) Routledge. ISBN-10: 0080970842, ISBN-13: 978-0080970844