MODULE SPECIFICATION PROFORMA

Module Code:	ENG768

Module Title:	Applied Aerodynamics and Flight Mechanics

Level:	7	**Credit Value:**	20

Cost Centre(s):	GAME	JACS3 **code**:	H440

School:	Applied Science, Computing & Engineering	**Module Leader:**	Dr Zheng Chen

Scheduled learning and teaching hours	40 hrs
Guided independent study	160 hrs
Placement	0 hrs
Module duration (total hours)	200 hrs

Programme(s) in which to be offered (not including exit awards)	Core	Option
MSc Engineering (Aeronautical)	✓	☐

Pre-requisites
None

Office use only
Initial approval: 19/06/2018 Version no:1
With effect from: 01/09/2018
Date and details of revision: Version no:

Module Aims
1. Develop a critical understanding of practical aerodynamic flows relevant to aeronautical engineering and other engineering product design; 2. Critically analyse flight mechanics, static and dynamic stability, and utilise modern control approaches for a flight control system design.

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	Critically understand the governing equations for aerodynamics and methodologies for solving them computationally.	KS1	KS3
		KS6	KS10
2	Critically understand and be able to apply theories for predicting lift on finite aspect ratio wings in incompressible flow and fully supersonic flow.	KS3	KS6
3	Critically understand and be able to predict induced drag in incompressible flow and wave drag in compressible flow.	KS3	KS6
4	Derive aerodynamic coefficients and their derivatives, and critically analyse their effects on flight dynamics.	KS1	KS3
		KS6	
5	Analyse and develop the flight dynamic model of a rigid aircraft with respect to body/stability axes; Critically analyse aircraft dynamic performances and stabilities.	KS1	KS3
		KS6	
6	Critically evaluate and effectively use a range of classical and modern control systems algorithms in the design of aircraft stability augmentation systems, attitude control systems and guidance systems.	KS1	KS3
		KS6	KS7
		KS10	

Transferable skills and other attributes
1. Problem solving; 2. Mathematical applications of technology; 3. Application of information technology; 4. Written communication; 5. Analysis by modelling of practical situations.

Derogations
Credits shall be awarded by an assessment board for those Level 7 modules in which an overall mark of at least 50% has been achieved with a minimum mark of 40% in each assessment element.

Assessment:

Indicative Assessment Tasks:

Assessment One: An individually prepared coursework for the critique of the principles and the theory of Aerodynamics, flight mechanics, and the theory, applications and limitations of various control algorithms on flight guidance and control system design. Students will have the opportunity to use equipment such as the Supersonic Wind Tunnel, and software such as ANSYS Fluent and Matlab to aid analysis. Assessment one contributes 50% of the overall module mark.

Assessment Two: A closed-book written examination. Assessment two contributes 50% of the overall module mark.

Assessment number	Learning Outcomes to be met	Type of assessment	Weighting (%)	Duration (if exam)	Word count (or equivalent if appropriate)
1	1, 4, 5	Coursework	50%		2000
2	2, 3, 6	Examination	50%	2 hours	

Learning and Teaching Strategies:
The module will be delivered through detailed presentations combined with interactive sessions to enhance students' learning. The learning experience will be further supported by tutorials and self-study work and case studies of world significance.

Syllabus outline:

- Aerofoil aerodynamic characteristics: properties of the atmosphere. Circulation, vorticity, potential and rotational flow, and lift. Generalised thin aerofoil theory. Pressure distribution and aerodynamic characteristics.

- Finite wing theory: Vortices: starting, trailing, bound and horseshoe. Equivalent systems, Biot Savart law and lifting line method. Lifting surface method.

- Boundary layer: Development of the boundary layer, viscosity, laminar and turbulent flow. Boundary layer separation. Laminar-turbulent transition. Skin friction drag, profile drag. Boundary layer control to prevent separation.

- Flow at high Mach number and compressibility effects: subsonic flow at high Mach number, Glauert correction factor. Supersonic flow, normal shockwave, oblique shockwave, Mach wave, Prandtl-Meyer expansion, shock-expansion technique, Ackeret theory. Supersonic wings

- Flight mechanics: aerodynamic forces and moments on an aircraft, aerodynamic coefficients and their derivatives, longitudinal dynamics, lateral dynamics, the effects of aerodynamic coefficients and their derivatives on flight dynamics;

- Equations of motion of a rigid aircraft: axis systems used in modelling flight dynamics, analysing flight dynamic performance, and designing flight guidance and control systems, stability derivatives and stability analysis;

- Flight control systems: configuration of flight control systems, primary and secondary control surfaces, power control unit and power assistant unit, fly-by-wire, fly-by-light, control configured vehicle, flight director, flight control computer;

- Stability and guidance control: flying qualities and handling qualities, stability augmentation systems, longitudinal and lateral guidance control systems, navigational aids coupling into flight control systems, cross-coupling parameters affecting overall performance, use of modern control approaches for stability and guidance control system design;

- Case studies: problems of integration, examples of failed designs.

Indicative Bibliography:
Essential reading
Houghton, E.L. and Carpenter, P.W. (2016) *Aerodynamics for Engineering Students*, 7th Edition, Butterworth-Heinemann.
Other indicative reading
Cook, M.V. (2012) *Flight Dynamics Principles: A Linear Systems Approach to Aircraft Stability and Control*, 3rd edition, Butterworth-Heineman McCormick, B.W. (1995) *Aerodynamics, Aeronautics and Flight Mechanics*, 2ndEdn. John Wiley & Sons. Anderson, J.D. (1998) *Fundamentals of Aerodynamics*, 3rdEdn. McGraw-Hill. Stengel, R. (2004) *Flight Dynamics*, Princeton University Press Anderson, J.D. (2011) *Fundamentals of Aerodynamics*, McGraw-Hill. McCormick, B.W. (2006) *Aerodynamics, Aeronautics and Flight Mechanics*, John Wiley and Son. Roskam, J. (2003) *Airplane Flight Dynamics and Automatic Flight Controls,* DAR Corporation. Dorf, R.C.; Bishop, R.H.; (2013) *Modern Control Systems (12th Edition)*; Pearson Prentice Hall. Chin, C.S.; (2014) *Computer-Aided Control Systems Design: Practical Applications Using MATLAB and Simulink*; CRC Press Gu, D.W.; Petkov P.H.; (2013) *Robust control design with MATLAB* (Advanced Textbooks in Control & Signal Processing), 2nd edition; Springer-Verlag. The Aeronautical Journal RAeS Journal of Aircraft AIAA