UNIVERSITY OF WARWICK

Proposal Form for New or Revised Modules (MA1 - version 7 - April 2014)

Approval information	
Approval Type	☐ New module ☒ Revised module ☐ Discontinue module
Date of Introduction/Change	October 2017
If new, does this module replace another? If so, enter module code and title:	
If revised/discontinued, please outline the rationale for the changes:	Document re-issue to capture module and course developments.
Confirmation that affected departments have been consulted:	Changes have been made in consultations between the School of Engineering and WMG

Module Summary	
1. Module Code (if known)	ES3D6
2. Module Title	Fundamental Fluid Mechanics for Mechanical Engineers.
3a. Lead department:	School of Engineering
3b. Teaching Split (if known):	100% Engineering
4. Name of module leader	Prof. Peter J. Thomas
5. Level	UG: ☐ Level 4 (Certificate) ☐ Level 5 (Intermediate) ☒ Level 6 (Honours) PG: ☐ Level 7 (Masters) ☐ Level 8 (Doctoral) See Guidance Notes for relationship to years of study
6. Credit value(s) (CATS)	15 CATS
7. Principal Module Aims	The module is part of the suite of core modules for Mechanical Engineering. It builds upon the Fluid Dynamics part of ES2BO Mechanics and Thermofluids module in Year 2 and prepares students for specialist modules in fluid dynamics in Year 4: ES440 Computational Fluid Dynamics and ES441 Advanced Fluid Dynamics.

Module Summary	
	All Mechanical Engineers require a sound understanding of fluid mechanics. Issues involving aspects of fluid mechanics are involved in the vast majority of engineering problems. This module introduces the elementary principles and concepts and the fundamental theoretical and applied tools required for solving typical problems in mechanical engineering. At the end of the course students should have an understanding of how broad physical principles (conservation of mass, momentum, energy) determine fluid behaviour and lead to mathematical descriptions of key features. Students should be able to utilise the results of such descriptions, together with appropriate modelling, to carry out calculations/estimations of such engineering quantities as pressure, forces (*e.g.* friction, drag, lift), power requirements, efficiency.
8. Principal Learning Outcomes (Teaching and learning methods which enable students to achieve this learning outcome/ Assessment method.	By the end of the module the student should be able to: • Identify the importance and role of fluid mechanics within the Mechanical Engineering profession, and consolidate existing knowledge of fluidic systems; • Communicate an understanding of how broad physical principles (consideration of mass, momentum, energy); • Determine fluid behaviour in complex situations, and devise mathematical descriptions to communicate key features; • Distinguish between differing fluid based phenomena and demonstrate ability to abstract solutions; • Devise appropriate modelling and carry out calculations/estimations of such engineering quantities as pressure, forces [e.g. friction, drag, lift, power requirements, efficiency.]; • Apply complex numerical skills to the solution of fluid mechanics problems.
9. Timetabled Teaching Activities (summary)	The module includes 30 hours of lectures, 10 hours of examples classes and 1 hour Example Class (Revision) just prior to exam. **Total 41 hours**
10. Departmental Web-link	http://www2.warwick.ac.uk/fac/sci/eng/eso/modules/year3
11. Other essential notes	Advice and feedback hours are available for answering questions on the lecture material and past examination questions
12. Assessment methods (summary)	100% examined via a 3 hour paper

For use by Strategic Planning and Analytics Office only - Do not fill in this section

Level	JACS3 Code	Teaching Split
		If not provided in 3b above

External Credit Level		Scheme	

Module Context

13. Please list all departments involved in the teaching of this module. If taught by more than one department, please indicate percentage split.

School of Engineering 100%

14. Availability of module

Degree Code	Title	Study Year	C/OC/ A/B/C	Credits
H106	BEng Engineering	3	A	
H107	MEng Engineering (plus variants)	3	A	
H109	MEng Engineering with Intercalated Year	3	A	
H110	MEng Engineering with a Year in Research	3	A	
H310	BEng Mechanical Engineering	3	Core	15
H311	MEng Mechanical Engineering (plus variants)	3	Core	
H312	MEng Mechanical Engineering with Intercalated Year	3	Core	
H313	MEng Engineering with a Year in Research	3	Core	

15. Minimum number of registered students required for module to run

1 (Core module)

16. Pre- and Post-Requisite Modules

Pre-requisite: Fluid Dynamics part of ES2B0 Mechanics and Thermofluids 2nd-year module. Also required is a good background in mathematics.

Module Content and Teaching

17. Teaching and Learning Activities *(totals for module – please see guidance)*

Module duration (weeks)	10 weeks
Lectures	30 lectures
Seminars	Not applicable
Tutorials	Not applicable
Project Supervision	Not applicable
Demonstration	Not applicable
Practical Class/Workshops	Not applicable
Supervised time in studio/workshop	Not applicable
Fieldwork	Not applicable
External visits	Not applicable

Module Content and Teaching	
Work based learning	Not applicable
Placement	Not applicable
Year abroad	Not applicable
Other activity *(please describe): e.g. distance-learning, intensive weekend teaching etc.*	10 hours example classes (5 x 2 hour sessions) 1 hour example class (Revision) just prior to exam Guided Independent Learning 109 hours

18. Assessment Method (Standard)		
Type of assessment	**Length**	**% weighting**
Written Examinations	3 Hours	100%
Practical Examinations	Not applicable	
Assessed essays/coursework	Not applicable	
18a. Final chronological assessment *(please see guidance*)	100% written examination	

19. Methods for providing feedback on assessment.

Model solutions to past papers.
Support through advice and feedback hours.

20. Outline Syllabus

1. Introduction (mostly brief revision from fluid dynamics part of ES2B0 module): Continuum hypothesis, control surface, control volume, Streamlines, Newton's law of viscosity, Non-Newtonian fluids, Reynolds number, hydrostatic pressure.
2. Conservation principles (in integral and differential form): Mass conservation, momentum equation, Reynolds transport theorem, 1-D energy equation, Euler equation, Navier-Stokes equation & its non-dimensionalization.
3. Bernoulli equation: Derivation, limitations, physical interpretation, Flow-measuring devices.
4. Stream function: Continuity equation - existence of stream function to describe flow field; relationship to streamlines.
5. Ideal flow: Assumptions, definition of vorticity, velocity potential. Rotational vs. Irrotational flow, Potential flow theory: mathematical description of incompressible, inviscid, irrotational flow - Laplace equation. Fundamental solution to Laplace equation, linear superposition, modelling of bodies in ideal flow (Rankine bodies). Cylinder in uniform flow, cylinder with circulation in uniform flow, Magnus effect: circulation and lift, Helmholtz vortex theorems, Principle of lifting aerofoils, Kutta-Joukowski- theorem.
6. Internal viscous flows: Laminar and turbulent pipe flows. Application of laminar flow – Darcy's law, Velocity profiles, shear stress, wall friction, pressure gradient. Effect of wall roughness; Moody chart.

7. Boundary-layer flows: Limitations of ideal flow - concept of viscous boundary layer. Momentum-integral equation, displacement and momentum thickness. Laminar and turbulent boundary layers; velocity profiles, skin-friction drag. Modelling of slender-body drag.
8. Transition, Turbulence, Kolmogorov's theory of turbulence and energy spectrum/energy cascade (very brief introduction only), separation and wakes: Mechanisms for boundary-layer transition. Separation and wake drag; aerofoil stall. Drag coefficients for bluff bodies; dynamic similarity. Strategies for drag reduction.
9. Compressible flows: flow regimes (subsonic, transonic, supersonic, ultrasonic flows), Mach number, oblique shock waves and expansion fans, area-velocity relation, Laval nozzle.
10. Rotating flows: Coriolis force, effects of Coriolis force (Taylor-curtains, Taylor-Proudman theorem).
11. Computational methods: Partial differential equations (classification scheme: elliptic, parabolic, hyperpolic). Solution strategies (finite differences, finite volumes, finite elements, method of characteristics), illustrate basic principle of finite-difference method in an example.

21. Illustrative Bibliography

The main recommended textbook option are:

(1) Potter, M.C., Wiggert, D.C., Ramadan, B.H., 2017, Mechanics of Fluids (5th Edition), Cengage Learning, Stamford. ISBN 978-1-305-63761-0.
(2) White, F.M., 2016, Fluid Mechanics (8th Edition), McGraw-Hill, New York. ISBN 9789814720175.
(3) Douglas, J.F., Gasiorek, J.M., Swaffield, J.A., Jack, L.B., 2011, Fluid Mechanics (6th Edition, or latest edition whenever new editions become available), Prentice Hall, Pearson Education Limited, Harlow, UK.

22. Learning outcomes

Successful completion of the module leads to the learning outcomes. The learning outcomes identify the knowledge, skills and attributes developed by the module.

Learning Outcomes should be presented in the format "By the end of the module students should be able to..." using the table at the end of the module approval form:

Resources

23. List any additional requirements and indicate the outcome of any discussions about these.

Not applicable

Approval	
24. Module leader's signature	Professor Peter Thomas
25. Date of approval	Teaching Policy Committee Chair's Action 24 March 2017
26. Name of Approving Committee (include minute reference if applicable)	School of Engineering and WMG Teaching Policy Committee.
27. Chair of Committee's signature	Professor Gillian Cooke
28. Head of Department(s) signature	Professor Nigel Stocks

Examination Information		
A1. Name of examiner (if different from module leader)		
A2. Indicate all available methods of assessment in the table below		
% Examined	**% Assessed by other methods**	**Length of examination paper**
100%		3 hours
A3. Will this module be examined together with any other module (sectioned paper)? If so, please give details below.		
No it will not be examined together with any other module.		
A4. How many papers will the module be examined by?	☒ 1 paper	☐ 2 papers
A5. When would you wish the exam take place (e.g. Jan, April, Summer)?	**The exam should take place in summer.**	
A6. Is reading time required?	☐ Yes	☒ No
A7. Please specify any special exam timetable arrangements.		
Not applicable		
A8. Stationery requirements		
No. of Answer books?	**1**	
Graph paper?	**Yes**	
Calculator?	**Yes**	
Any other special stationery requirements (e.g. Data books, tables etc)?	**Engineering Databook.** **A section with more specialised/advanced formulas, which are not contained in the data book, will be attached at the end of the exam paper.**	
A9. Type of examination paper		
Seen?	☐ Yes	☒ No
Open Book?	☐ Yes	☒ No
Restricted?	☐ Yes	☒ No
If restricted, please provide a list of permitted texts:		

LEARNING OUTCOMES		
(By the end of the module the student should be able to....)	**Which teaching and learning methods enable students to achieve this learning outcome? (reference activities in section 15)**	**Which summative assessment method(s) will measure the achievement of this learning outcome? (reference activities in section 16)**
Identify the importance and role of fluid mechanics within the Mechanical Engineering profession, and consolidate existing knowledge of fluidic systems	Lectures, private study and example classes.	Unseen examination.
Communicate an understanding of how broad physical principles (consideration of mass, momentum, energy)	Lectures, private study, example classes.	Unseen examination.
Determine fluid behaviour in complex situations, and devise mathematical descriptions to communicate key features	Lectures, private study, example classes.	Unseen examination.
Distinguish between differing fluid based phenomena and demonstrate ability to abstract solutions.	Lectures, private study and example work.	Unseen examination.
Devise appropriate modelling and carry out calculations/estimations of such engineering quantities as pressure, forces [*e.g.* friction, drag, lift, power requirements, efficiency.]	Lectures, private study and example work.	Unseen examination.
Apply complex numerical skills to the solution of fluid mechanics problems.	Example classes.	Self-marking against published answers. Unseen examination.