Wrexham Glyndŵr University

MODULE SPECIFICATION

Module Title:	**Thermo-fluids and Propulsion**	**Level**:	5	**Credit Value**:	20

Module code:	ENG538	**Is this a new module?**	no	**Code of module being replaced**:	

Cost Centre:	GAME	**JACS2 code**:	H141

Trimester(s) in which to be offered:	1, 2	**With effect from:**	September 17

School:	Applied Science, Computing & Engineering	**Module Leader:**	Dr. Olaf Niestroj

Scheduled learning and teaching hours	60 hrs
Guided independent study	140 hrs
Placement	0 hrs
Module duration (total hours)	200 hrs

Programme(s) in which to be offered	Core	Option
BEng (Hons) Aeronautical & Mechanical Engineering	✓	

Pre-requisites
None

Office use only	
Initial approval February 17	
APSC approval of modification	Version 1
Have any derogations received Academic Board approval?	Yes ✓ No ☐

Module Aims
To support the development of the student in the following areas: • To develop an in-depth understanding of non-flow and flow processes, liquids, vapours and two phase substances, polytropic processes using gases and vapours, the first and second laws of thermodynamics pressure and flow measurement. • To further develop principles and applications of fluid momentum as applied to aircraft propulsion units, the design and operation of real gas turbine and jet engine cycles and their component parts, gas turbine engine intakes and nozzles, propulsion units and analysis of gas turbine engines

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	Solve problems involving non-flow and steady flow processes	KS1	KS10
2	Define the properties of working fluids and hence analyse two phase systems using tables and represent processes on property diagrams; Apply the first and second laws of thermodynamics and compare the performance of real and ideal cycles	KS3	KS6
		KS10	
3	Apply the laws of fluid mechanics, Bernoulli's equation and the momentum equation to the flow of incompressible fluids	KS3	KS9
		KS5	KS6
4	Derive relationships for the thrust, power and efficiency of aircraft propulsion systems, including axial and radial turbines and compressors.	KS1	KS3
		KS4	KS9
		KS109	

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:

Assessment One: is by means of a coursework with several exercises applying the laws of fluid mechanics and the flow of incompressible fluids. It covers outcome 3.

Assessment Two: is by means of an examination covering all other outcomes. It is an unseen time-constrained examination.

Assessment number	Learning Outcomes to be met	Type of assessment	Weighting (%)	Duration (if exam)	Word count (or equivalent if appropriate)
1	3	Coursework	30		1500
2	1,2,4	Examination	70	2hrs	

Learning and Teaching Strategies:

Detailed printed lecture notes provided for the student will allow the optimisation of lecture time, with good opportunity for self-study and tutorials. The module will also contain practical laboratory based exercises supported by introductory lectures and demonstrations.

This module will be presented to students through a series of lecture materials including videos, demonstrations and structured technical visits to suitable establishments (e.g.: RAF, Cosford). Laboratory investigations and tutorials will be used to support lectures and to provide an opportunity for students to work on problems with individual attention if needed.

Syllabus outline:

Basic Concepts and the First Law: concepts of a thermodynamic system and the Zeroth Law; non-flow and steady flow processes, non-flow energy equation, steady flow energy equation and the continuity equation; identification of compression, expansion, adiabatic, heating, cooling, constant volume processes; boilers, condensers, compressors, turbines, nozzles, throttles.

Properties of Pure Substances and Use of Property Diagrams and Tables: thermodynamic properties the state and phase of a substance; the formation of wet, saturated and superheated vapour at constant pressure, use of thermodynamic property tables and sketching property diagrams (T-s and p-v)

The relationships between the properties of a perfect gas: perfect gases and Joule's law; specific heats of a perfect gas and the relationships between adiabatic index, specific heats and characteristic gas constant; characteristic gas equation, equations for internal energy and enthalpy of a perfect gas.

Description and analysis of polytropic processes: polytropic law; relationships for the work done in various processes; polytropic, adiabatic and isothermal non- flow processes involving gases and vapours; steady flow of gases.

The relationship between ideal and actual power plant cycles: terms associated with thermodynamic cycles, thermal efficiency; the first and second laws applied to thermodynamic cycles; constant volume, diesel, gas turbine, Carnot, Rankine and Stirling cycles; comparison of efficiencies of actual and ideal cycles.

Analysis of heat pump and refrigeration cycles: reversed Carnot and Rankine cycles; use of property diagrams. Refrigerants R12 and ammonia; comparison of ideal and actual cycles.

Principles involved in pressure measurement: principle of operation of a piezometer, U tube, differential manometers, Pitot tubes; relationships necessary to determine absolute and gauge pressures using the above instruments; application to static situations and appreciation of application in conjunction with other devices in dynamic situations.

Laws of mechanics, Bernouilli's equation and the momentum equation to the flow of incompressible fluids: continuity equation and total energy in terms of the various heads; also expressions for flow work and Bernoulli's equation; various flow measuring devices; rate of change of momentum of a fluid between two sections; pressure, kinetic and potential head; orifice plates, Venturi meters and Pitot tubes; force exerted on a stationary or moving flat plate or curved vane by a jet; relates the force exerted by a jet to the power developed by a water turbine.

Propulsive Efficiency and Propellers: Newton’s laws of motion, momentum equation and Froude’s momentum theory; thrust and power developed by aircraft propulsion systems, propulsive efficiency of an aircraft, reasons for using by-pass engines; variation of propulsive efficiency with speed for propeller, jet, turbo-prop, and by-pass engine propulsion; propeller geometry and propeller coefficients, blade element and vortex theory; development of propeller characteristics, propeller matching and propulsion by propeller; fan propulsion, ducted fans, multi-spool engines.

Gas turbine and jet engine cycles: practical cycles, closed and open cycles; shaft power cycles, jet engine, prop-engine cycles.

Centrifugal and axial flow compressors: centrifugal compressors, work done and pressure rise; compressor characteristics and applications; axial flow compressors, stage performance, velocity diagrams, cascade theory, blade design; multistage compressors.

Axial flow gas turbines: introductory theory, blade design and vortex theory, estimation of stage performance, velocity diagrams; turbine cascades and three dimensional flow in turbines, design and operation of multistage turbines; overall turbine performance characteristics, blade cooling and its effects.

Gas turbine engine intakes and nozzles: intake performance, subsonic intake analysis; jet pipe design and operation; nozzle performance characteristics and off-design operation of nozzles.

The overall operation of gas turbine propulsion units: analysis and matching of components; off-design (engine performance) operation of single shaft gas turbines and jet engines.

Bibliography:

Essential reading

Cengel, Y.A. and Turner, R.H. (2012) *Fundamentals of Thermal-Fluid Sciences*, 4th ed., Singapore: McGraw-Hill Higher Education

Douglas, J.F. (2011) *Fluid Mechanics*, 6th ed., New York: Prentice Hall, Harlow

Saravanamutto, H.I.H. et al. (2008) *Gas Turbine Theory*. 6th ed., Harlow: Pearson Education.

Rogers, G.F.C. and Mayhew, Y.R. (1995) *Thermodynamic and Transport Properties of Fluids*. 5th ed., Oxford: Blackwell

Other indicative reading

Crowe, C.T., (2009) *Engineering Fluid Mechanics*, 9th ed., John Wiley and Sons.

Cumpsty, N.A., Heyes, A.L. (2015) *Jet propulsion*: *A Simple Guide to the Aerodynamic and Thermodynamic Design and Performance of Jet Engines 5th ed.*, New York: Cambridge University Press.