PRIFYSGOL glyndŵr UNIVERSITY

MODULE SPECIFICATION FORM

Module Title:	**Thermo-Fluid Mechanics B**	Level:	**6**	Credit Value:	**10**

Module code: (if known)	**ENG676**	Cost Centre:	**GAME**	JACS2 code:	**H141/H311**

Semester(s) in which to be offered:	**2**	With effect from:	**July 2015**

Office use only: To be completed by AQSU:	Date approved: Date revised: Version No:	**July 2015** 1

Existing/New:	**Existing**	Title of module being replaced (if any):	N/A

Originating Academic area:	**Engineering and Applied Physics**	Module Leader:	**C Abeykoon**

Module duration (total hours)	100	**Status:** core/option/elective (identify programme where appropriate):	**Free-standing 10-credit component comprising half of ENG616 (Advanced Thermo-Fluids and Turbomachinery).**
Scheduled learning and teaching hours	36		
Independent study hours	64		
Placement hours	0		

Percentage taught by Subjects other than originating Subject (please name other Subjects):	**0%**

Programme(s) in which to be offered: **Enginering European Programme** (Non Award Bearing)	Pre-requisites per programme (between levels):	**None**

Module Aims:

To further develop the concepts and applications introduced in the Level 5 Thermo-fluid and Propulsion module. The module focuses on the application of dimensional analysis in similarity and model testing, the thorough application of the second law of thermodynamics to more advanced thermodynamic power cycles and the investigation of compressible fluid flow.

Expected Learning Outcomes

Knowledge and Understanding:

At the completion of this module, the student should be able to:

1. Analyse thermodynamically irreversible processes and apply the analysis of more advanced thermodynamic cycles; (KS 3)
2. Analyse compressible fluid flow and develop an understanding of the formation of compression and expansion waves in supersonic streams; (KS 4, 10)

Key skills for employability

1. Written, oral and media communication skills,
2. Leadership, team working and networking skills
3. Opportunity, creativity and problem solving skills
4. Information technology skills and digital literacy
5. Information management skills
6. Research skills
7. Intercultural and sustainability skills
8. Career management skills
9. Learning to learn (managing personal and professional development, self management)
10. Numeracy

Assessment: *Please indicate the type(s) of assessment (eg examination, oral, coursework, project) and the weighting of each (%).*

Assessment is by means of an examination covering all outcomes. It is an unseen time-constrained exam. (This corresponds to one-half (part A) of the examination of ENG616.)

Assessment number (use as appropriate)	Learning Outcomes met	Type of assessment	Weighting	Duration (if exam)	Word count (if coursework)
Assessment One:	1, 2, 3	Examination	100%	2 hr	

Learning and Teaching Strategies:

This module will be presented to students through a series of lecture materials including videos, demonstrations, investigations and structured technical visits to large energy users.

Syllabus outline:

The Second Law and Isentropic Efficiency: Reversible and irreversible processes, the property entropy as a consequence of the second law. Further property diagrams, entropy changes in various processes. T-s and h-s diagrams for gases and vapours. Compressors, turbines, nozzles and diffusers. Isentropic irreversible processes on T-s and h-s diagrams. Entropy changes in various processes where the fluid is a gas or vapour. Use of isentropic efficiency to estimate work transfer to and from the devices listed.

Modified thermodynamic cycles: Criteria for maximum thermal efficiency in various cycles. Modifications necessary to achieve improvements in efficiency and work ratio. Expressions giving the work output and thermal efficiency of various cycles. Use of intercooling, reheat, regeneration, heat exchangers in gas and steam turbine cycles. Actual and ideal cycles.

Gas-vapour mixtures and applications: Dalton’s law, the Gibb’s-Dalton law and Avogadro’s law. Relationships between properties and evaporation of water in a closed space. Terms used in psychrometry and methods of measuring relative humidity. Characteristics and analysis of air conditioning systems and cooling towers-forced and natural draught. Gas/vapour relationships, psychometric chart. Air-conditioning systems and evaporative cooling towers.

Flow of compressible fluids: Stagnation properties derivation of expressions from the S.F.E.E. Relationship between Bernoulli’s equation and S.F.E.E. Movement of a pressure wave in a fluid, equation for the velocity of sound. Mach number, property relationships in terms of Mach number. Isentropic flow of gas through a duct of varying area. Converging and converging-diverging nozzles. Plane normal shock wave, equations for changes of gas properties across a normal shock in a convergent-divergent nozzle. Under and over expansion of a gas through converging-diverging nozzle, critical properties, choked flow.

Compression and expansion waves in a supersonic stream: Mach waves, equation for the Mach angle. Oblique shock wave at a concave corner, velocity components of a gas flow through a shock wave; ’strong ’, ’weak’ shock for given conditions. Detached shock wave, limiting conditions for attached shock. ’Prandtl-Meyer’ expansions, Prandtl-Meyer function. Deflection angle, incident Mach number, resultant shock wave and expansion wave inclination. Compression and expansion over 2-D bodies. Examination of normal, oblique and detached shock waves and the limiting conditions for each case. Normal and oblique shock tables applied to supersonic flow over various bodies. Shock charts to analyse flows.

Bibliography:

Essential reading:

Cengel, Y.A. and Boles, M. (2010) *Thermodynamics: An Engineering Approach,* McGraw-Hill.

Recommended reading:

Rogers and Mayhew (1995) *Thermodynamic and Transport Properties of Fluids*, Blackwell.

Joel, R. (1995) *Basic Engineering Thermodynamics*, Longman.

Massey (2000) *Mechanics of Fluids*, Van Nostrand Reinhold.

Douglas et al (1995) *Fluid Mechanics*, Longman.

Thomas (1993) *Heat Transfer*; Prentice-Hall.