Module Code	MEU44B010
Module Name	Turbomachinery
ECTS Weighting	5 ECTS
Semester taught	Semester 2
Module Coordinator/s	Professor Stephen Spence
Module Learning Outcomes with reference to the Graduate Attributes and how they are developed in discipline	On successful completion of this module, students should be able to: LO1. Analyse compressible flows and calculate relevant parameters including stagnation, static and critical properties and Mach number. LO2. Describe and calculate properties for compressible flow passing through nozzles and through normal shocks. LO3. Draw a Mollier diagram to represent the thermodynamic processes through an axial or radial flow turbomachine or a cascade and calculate all quantities represented on the diagram. LO4. Use velocity vector triangles and 1D analysis to calculate the geometry, efficiency and power for radial and axial turbomachines. LO5. Use slip factor to calculate work input to a compressor impeller. LO6. Discuss the balance between aerodynamic and mechanical considerations in optimising the design of a compressor or turbine. LO7. Calculate flow and blade angles in a turbomachine or cascade blade. LO8. Understand and estimate the losses arising in the stator or rotor blade row of a turbomachine. LO9. Use established empirical loss correlations and design criteria to judge the feasibility of a design and predict the efficiency. LO10. Explain the physical reasons for compressor instability, stall and surge. **Graduate Attributes: levels of attainment** To act responsibly - Enhanced To think independently - Enhanced To develop continuously - Enhanced To communicate effectively - Enhanced
Module Content	Turbomachinery is an essential technology for delivering the power and propulsion needed for society, particularly in rapidly developing economies. This module aims to integrate the fundamental principles of fluid mechanics and thermodynamics in order to analyse compressible flows and high speed turbomachinery. The module will instil students with an awareness of different power and propulsion applications and the importance of high efficiency energy conversion devices to minimise environmental impact, both in a national and global context. The module

	provides an understanding of the unique issues associated with transonic flows and basic tools to analyse these. That understanding underpins a detailed treatment of design calculations for high speed turbomachinery, including aerodynamic performance, instability, losses and structural limitations on performance. The module covers the most important types of turbomachines; centrifugal compressors, radial turbines, axial compressors and axial gas turbines. Students also gain an appreciation of the manufacturer and user perspectives, such as costs, safety, durability, flexibility and noise. The module content is structured into four sections: <u>Compressible Flow</u> - Euler's equation for flow along a streamline. Speed of sound. Mach number. Mach cone. Stagnation & static conditions. Isentropic 1D flow equations. Mass flow relationship. Critical conditions. Converging nozzles. Converging-diverging nozzles. Phenomenon of normal shock. Equations for analysing flow through a normal shock. <u>Introduction to Turbomachinery</u> – Important applications in power and propulsion. Configuration of gas turbines and turbochargers. Classification of turbomachines. Euler's equation for turbomachinery. Inlet and outlet velocity vector triangles. Concepts of efficiency, enthalpy and entropy. Flow & loading coefficients. <u>Radial Turbomachinery</u> – Centrifugal compressor; performance map, preliminary design of impeller and diffuser, Mollier diagram, slip factor, impeller back sweep. Radial turbine; performance map, preliminary design of rotor and nozzle, Mollier diagram, nominal design condition, velocity ratio, mechanical and material considerations. <u>Axial Turbomachinery</u> – Isentropic and polytropic efficiency. Cascade aerofoil geometry. Cascade testing, flow characteristics and performance. Boundary layers and wakes. Cascade lift and drag. Compressor cascades; De Haller number, diffusion factor. Turbine cascades; Soderberg's correlation, Zweifel criterion. Axial turbines & compressors – velocity triangles, thermodynamics, stage design parameters, Mollier diagram, repeating stages, losses & efficiency, preliminary design process, reaction, Smith chart, transonic compressors, stall and surge.
Teaching and Learning Methods	This module uses Blackboard, podium lectures, a class test, and tutorials to help students achieve the required learning outcomes. There are 3 lectures and one tutorial per week. Subject to availability, the module will include one or two guest lectures from senior international industrial engineers or academics. •

Assessment Details **Please include the following:** • **Assessment Component** • **Assessment description** • **Learning Outcome(s) addressed** • **% of total** • **Assessment due date**	(see table below)

Assessment Component	Assessment Description	LO Addressed	% of total	Week due
Class test	Compressible flow	1, 2	20	6
Written examination	End of semester examination	1-10	80	Exam period

Reassessment Requirements	100% written examination
Contact Hours and Indicative Student Workload	**Contact hours: 46** **Independent Study (preparation for course and review of materials): 55** **Independent Study (preparation for class test): 15**
Recommended Reading List	Fluid Mechanics and Thermodynamics of Turbomachinery 7th Edition, Dixon and Hall, Elsevier Science & Technology, ISBN: 978-0-12-415954-9 Gas Turbine Theory 6th Ed, Saravanamuttoo, Rogers, Cohen and Straznicky, ISBN-10: 0132224372 Compressor aerodynamics, Cumpsty, Krieger Publishing Company, ISBN: 9781575242477 Mechanics of Fluids 7th ed., White, published by McGraw-Hill, ISBN-13: 978-0077422417 Thermodynamics: an Engineering Approach, YA Çengel and MA Boles, McGraw Hill
Module Pre-requisite	3B1 Thermodynamics, 3B2 Fluid Mechanics, 4B13 Fluid Mechanics
Module Co-requisite	NA
Module Website	https://www.tcd.ie/Engineering/undergraduate/baiyear4/modules/4B3.pdf
Are other Schools/Departments involved in the delivery of this module? If yes, please provide details.	No
Module Approval Date	
Approved by	
Academic Start Year	

Academic Year of Date