Module Name	Turbomachinery
Module code and mode of delivery	MEU44B10 / MEP55M10 Delivery: Blended Learning through Blackboard Collaborate Ultra, face-to-face teaching and tutorial sessions as appropriate (see below). Subject to availability, the module will include a guest lecture from a senior international industrial engineer or academic.
Module ECTS Weighting	5 ECTS
Semester of delivery	Semester 2
Module Contact Hours	**Contact hours:** 36 **Independent Study (preparation for course and review of materials):** 55 **Independent Study (preparation for class test):** 15 ***Tutorial sheets are an integral part of the course.*** You should try to complete each question immediately after the relevant material has been covered in class. Each lecture will conclude with a list of relevant tutorial questions to work through. The process of attempting the tutorial problems will develop your understanding of the subject and each question has been chosen to provide a different challenge. So that you can optimise your use of the tutorial sessions, you should try to complete as many of the tutorial questions as possible in your own private study time making use of the worked examples provided in class and the recommended textbooks if necessary. The lecturer will discuss the problems with you individually or in small groups during the tutorial class. ***Worked solutions to tutorial problems will not be provided***, since this will not develop the level of competence you need to succeed in the examination. Worked examples are provided with full solutions to help you, but the tutorial questions are intended for you to tackle yourself without a solution to follow. Attempt them first, and then ask for help if you need it.
Module Coordinator	Charles Stuart
Module teaching staff and academic titles	Charles Stuart (Asst. Professor)
Module description—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 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: Compressible Flow - 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. Introduction to Turbomachinery – 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. Centrifugal Compressors – Centrifugal compressor; performance map, preliminary design of impeller and diffuser, Mollier diagram, slip factor, impeller back sweep, inlet guide vanes. Radial Turbines - performance map, preliminary design of rotor and nozzle, Mollier diagram, nominal design condition, velocity ratio, mechanical and material considerations.
Module pre-requisites	**IMPORTANT**: This module assumes an existing understanding of fluid properties, the continuity, energy, momentum,

	Bernoulli and state equations, and also the 1st and 2nd Laws of Thermodynamics. Content covered as part of the following modules is considered to be a pre-requisite for this course: • 3B1 Thermodynamics • 3B2 Fluid Mechanics • 4B13 Fluid Mechanics
Recommended reading list	The following textbooks, while not essential, contain sections that are relevant to the material covered as part of this course course: • Douglas, Gasiorek, Swaffield & Jack, “Fluid Mechanics,” 6th ed., published by Prentice Hall, ISBN-13: 978-0273717720 • Massey, “Mechanics of Fluids,” 7th ed., published by CRC Press, ISBN-13: 978-0748740437 • Oosthuizen & Carscallen, “Introduction to Compressible Fluid Flow,” 2nd ed., published by Taylor & Francis, ISBN-13: 978-1439877913 • White, “Mechanics of Fluids,” 7th ed., published by McGraw-Hill, ISBN-13: 978-0077422417 • Dixon and Hall, “Fluid Mechanics and Thermodynamics of Turbomachinery,” 7th Edition, Elsevier Science & Technology, ISBN: 978-0-12-415954-9. • Saravanamuttoo, Rogers, Cohen and Straznicky, “Gas Turbine Theory”, 6th Ed, ISBN-10: 0132224372.
Module learning outcomes	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. Use fundamental compressible flow theory to calculate flow velocity values obtained from a simple pitot tube in subsonic as well as supersonic flow. LO4. 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. LO5. Use velocity vector triangles and 1D analysis to calculate the geometry, efficiency and power for radial and axial turbomachines. LO6. Use slip factor to calculate work input to a compressor impeller.

<table>
<tr>
<td></td>
<td>LO7. Discuss the balance between aerodynamic and mechanical considerations in optimising the design of a compressor or turbine.
LO8. Calculate flow and blade angles in a turbomachine or cascade blade.
LO9. Understand and estimate the losses arising in the stator or rotor blade row of a turbomachine.
LO10. Use established empirical loss correlations and design criteria to judge the feasibility of a design and predict the efficiency.
Graduate Attributes: levels of attainment
To act responsibly - Enhanced
To think independently - Enhanced
To develop continuously - Enhanced
To communicate effectively - Enhanced</td>
</tr>
<tr>
<td>Module assessment, separate components and their weighting to be mapped into SITS</td>
<td>
<table>
<tr><th>Assessment Component</th><th>Assessment Description</th><th>LO Addressed</th><th>% of total</th><th>Week due</th></tr>
<tr><td>Class test</td><td>Compressible flow</td><td>1-3</td><td>20</td><td>6</td></tr>
<tr><td>Written examination</td><td>End of semester examination</td><td>1-10</td><td>80</td><td>Exam period</td></tr>
</table>

A weighted average of at least <u>40% for MEU44B10</u> and <u>50% for MEP55M10</u> must be achieved across the class test and written examination to pass the module.

Reassessment requirement = 100% written examination</td>
</tr>
</table>