<table>
<tr><td>Course Title</td><td colspan="5">Turbomachinery</td></tr>
<tr><td>Course Code</td><td colspan="5">ME402</td></tr>
<tr><td>Course Type</td><td colspan="5">Elective</td></tr>
<tr><td>Level</td><td colspan="5">BSc (Level 1)</td></tr>
<tr><td>Year / Semester</td><td colspan="5">4th/Spring</td></tr>
<tr><td>Teacher’s Name</td><td colspan="5">Dr. Charalambos Chasos</td></tr>
<tr><td>ECTS</td><td>6</td><td>Lectures / week</td><td>3</td><td>Laboratories/week</td><td>0</td></tr>
<tr><td>Course Purpose</td><td colspan="5">The course purpose is to educate students in the structure and design of turbomachines of various types (axial, mixed flow and radial) and the analysis of the operation. In particular, the course aims to teach students to apply the incompressible flow governing equations (Euler equations), the dynamic similarity laws and the local dimensionless parameters for the analysis of flow and performance in turbomachines. Furthermore, the course aims to teach the students how to derive and/or use characteristic curves of the performance of turbomachines for certain operating conditions. In addition, the course prepares the students to analyse and design the characteristics of turbomachines impellers and blades. The present course is an elective in the BSc. in Mechanical Engineering programme and provides advanced theoretical knowledge and analytical methods for the analysis of performance and the design of turbomachines, which is required for mechanical engineers employed in the energy sector and turbomachinery industry.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">By the completion of the course, the students should be able to:
1. List the different types of turbomachines (axial, radial, mixed flow), their main components and their applications.
2. Assess the performance of the different types of turbomachines (axial, radial, mixed flow) by applying flow governing equations (Euler equations)
3. Calculate compressible and incompressible fluid/rotor energy transfer using Euler turbine and Euler pump equations
4. Read and interpret performance curves for pumps, fans, compressors and turbines.
5. Apply dynamic similarity laws to predict turbomachine performance from scale model performance data.
6. Analyse the performance of turbomachines, and design turbomachines by applying dimensional analysis, velocity triangles and steady flow energy equation for axial and centrifugal rotors and rotor/stator stages.</td></tr>
<tr><td>Prerequisites</td><td colspan="2">ME200, ME202</td><td>Corequisites</td><td colspan="2">None</td></tr>
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Course Content	**Types of turbomachines:** Axial, radial and mixed flow turbomachines. Types of pumps, fans, compressors and turbines (impulse and reaction). Applications of turbomachines. Performance considerations of turbomachines. **Theoretical analysis of turbomachines:** Compressible and incompressible flow governing equations, continuity equation and steady flow energy equation with control volume approach and tangential momentum considerations (Euler pump and Euler turbine equations) with meridional flow approach through turbomachines. Two-dimensional cascades, fluid dynamics effect of a blade row and parameters, cases of frictionless flow and real cascades with fluid friction. **Dimensional analysis:** Global dimensionless performance parameters for turbomachines. Overall hydraulic efficiency of pumps and turbines, effects of turbomachine features on efficiency and reduction of variables with dimensional analysis. Characteristic curves of pumps and fans, dimensionless characteristic curves and turbomachine selection. Dynamic similarity laws for turbomachines and design of turbomachine using scale models. Performance and efficiency curves ("Cordier" diagrams). **Performance analysis of axial compressors and turbines:** Dimensional analysis for a single stage turbine and a single stage compressor with local dimensionless performance parameters (flow and work coefficients), stage velocity triangle and steady flow energy equation. Total-to-total efficiency of single stages, stage reaction, effects of variables on efficiency and reduction of variables with dimensional analysis. Axial stages (rotors and rotor/stator) velocity triangles, 50% reaction stage and arbitrary reaction stage, and dimensionless velocity triangles relationships. Design aspects, selection of stages, lift and drag coefficients and diffusion factors, selection of pitch/chord ratio. Optimum axial turbine and axial compressor stages and performance curves ("Smith" diagrams). **Performance analysis of mixed flow and radial turbomachines:** Local dimensionless performance parameters for mixed-flow pumps and fans. Steady flow energy equation, specific work input in mixed-flow pumps and fans, stagnation enthalpy relative to a rotor and rothalpy. Total-to-total efficiency and reduction of variables with dimensional analysis. Velocity triangles for a mixed-flow fan, and dimensionless velocity triangles relationships. Aspects of design and analysis of mixed-flow cascades with geometrical techniques. Considerations of relative eddy and slip flow in radial and mixed-flow cascades. **Assignment:** Individual assignment performed using the analysis methodologies of the course for the design, calculations and analysis of the impeller and blades of a turbomachine for a certain flow application with given specifications/requirements.

Teaching Methodology	The course is delivered to the students by means of lectures, exercises solution on the whiteboard, conducted with the help of computer presentations, as well as demonstrations of various turbomachines and parts from known manufacturers. Lecture notes and presentations are available through the E-learn site of the course for students to use in combination with the textbooks and references.
Bibliography	**(a) <u>Textbook:</u>** 1. Lewis R. I. “Turbomachinery Performance Analysis”. John Wiley & Sons Inc., 1996. **(b) <u>References:</u>** 1. Wilson D. G. and Korakianitis T. “The Design of High-Efficiency Turbomachinery and Gas Turbines”. Prentice Hall, 1998. 2. Dixon S. L. “Fluid Mechanics and Thermodynamics of Turbomachinery”. Butterworth-Heinemann, 1998. 3. Hans Josef Rath (Editor), C. Egbers. “Advances in Fluid Mechanics and Turbomachinery”. Springer Verlag, 1998. 4. Young D. F., Okiishi T. H., Munson B. R. “Fundamentals of Fluid Mechanics”. John Wiley & Sons, 4th edition, 2002. 5. John Denton. “Developments in Turbomachinery Design”. Mechanical Engineering Pubns Ltd, 1999. 6. Nicholas C. Baines and David Japikse. “Introduction to Turbomachinery”. Concepts ETI, 1997.
Assessment	**<u>(a) Methods:</u>** • Assignment 20% • Mid-term examination 20% • Final Exam 60% **<u>(b) Criteria:</u>** • The assessment criteria are included in the edited document of the assignment. In particular, the clarity of the content and writing, the structure, the quality of diagrams, graphs, tables illustration and data calculation and analysis, the discussion and conclusions are assessed. • The mid-term exam is done during the seventh week of the semester, which assesses the students’ performance on the subject matter taught during the first six weeks of the semester. Two questions ask for turbomachine calculations which are assessed on the correctness, clarity, diagrams, graphs, results and units used. • The final exam includes four questions (theoretical and analytical) and assesses students on the subject matter of the course and their ability to draw diagrams and graphs, carry out calculations for the

	performance, the selection and the design of turbomachines and their components, and compare and discuss the results.
Language	English