Syllabus

Course Description

Course Title	Fluid Machines
Course Code	42177
Course Title Additional	
Scientific-Disciplinary Sector	IIND-06/A
Language	English
Degree Course	Bachelor in Industrial and Mechanical Engineering
Other Degree Courses (Loaned)	
Lecturers	Prof. Massimiliano Renzi, Massimiliano.Renzi@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/32541
Teaching Assistant	
Semester	First semester
Course Year/s	3
CP	8
Teaching Hours	50
Lab Hours	30
Individual Study Hours	120
Planned Office Hours	24
Contents Summary	The course of Fluid Machines is a core teaching ("caratterizzanti") in the context of the degree in Industrial and Mechanical Engineering and specifically it deals with the operative and design aspects of fluid machines that are used for the conversion of energy (production and use). 1. Fundamentals of work exchange and energy conversion in Fluid Machines 2. Design of hydraulic machines: pumps and hydropower machines 3. Compressible fluids behavior: ducts design for gases and vapors; airfoils and aerodynamics principles 4. Design of gas and steam turbines and volumetric compressors.

Course Topics	The course aims to supply a comprehensive overview of the main fundamental concepts and design principles of fluid machines for energy conversion 1. Introduction and basic definitions: definition of fluid machines; basics of aerodynamics of airfoils and hydrofoils for turbo-machines; conservation equations for real flows in fluid machines' systems and their application to thermal and hydraulic machines; velocity triangles and Eulerian work; fluid transformations in turbomachinery vanes; similarity laws applied to fluid machines; 2. Centrifugal, mixed flow and axial pumps: flow rate and head; efficiency; pump impeller design; cavitation; NPSH; coupling with hydraulic circuits; 3. Hydraulic turbines: Pelton, Francis, Kaplan; constructive aspects; specific speed; turbine wheel or impeller design; cavitation; 4. Compressible fluids: behaviour of compressible fluids, sub-sonic and supersonic flows and implications of their use in fluid machines; 5. Gas and steam turbines: nozzles and diffusers; isentropic and polytropic efficiencies; turbine blades; impulse and reaction turbine; one-dimensional analysis of the flow; design process and calculation of stage performance; 6. Reciprocating and rotary gas compressors: working principles and working cycle; basic design solutions and performance. 7. Applications to case studies and experiential learning.
Keywords	Fluid Machines, Energy Conversion, Pumps, Turbines, Compressors.
Recommended Prerequisites	Engineering Thermodynamics, Heat and Mass Transfer and Fluid Mechanics.
Propaedeutic Courses	
Teaching Format	The course consists of classroom lectures in which the topics are presented by the lecturer. Design exercises are also foreseen to supply practical examples of the application of the theoretical topics. Some hours will be dedicated to the development, the design and the realization of components of students' projects included in the experiential learning program. The course also includes exercise sessions and, where possible, practical classes as well as educational field trips with laboratory activities. Course topics will be presented through presentations and slides.

	Exercises will be solved using the digital blackboard. Teaching material will be given to the students in advance of the single lectures; additional material (spreadsheets, etc.) will be provided by the Professor, if necessary.
Mandatory Attendance	Not mandatory, but strongly advisable.
Specific Educational Objectives and Learning Outcomes	The course consists of 50 hours of frontal lectures and 30 hours of exercises. A part of the lectures will also be involved in the Experiential Learning program of the Faculty with a focus on the development of specific practical projects. The lectures introduce the fundamental concepts and the working principles of fluid machines using both compressible and non-compressible fluids. The main mechanical and energy conservation principles and equations will be described and applied to fluid machines. Specific procedures for the design of fluid machines, like pumps, turbomachines, compressors, will be presented. In particular, the following topics will be addressed: constructive aspects, behavior of fluids in fluid machines components, aero- and hydro-profile blades and duct design, work exchange mechanisms and thermo-fluid-dynamic transformations in fluid machines, evaluation of the performance. The exercises consist of developing the design procedures of fluid machines and the introduction of such machines in plants, propulsion systems and circuits with the aim to give the students a deeper comprehension and understanding of the topics. The course aims at supplying specific professional skills and knowledge, and it has the educational objective of supplying the tools for the design and the evaluation of the performance of fluid machines and their adoption in industrial and civil plants. The contents of this course will be useful for all the engineering professional profiles, in the industry or in the public sector, related to the use of fluid machines and power plants in energy conversion process and propulsion systems. Typical jobs can be related to the design, installation and management of pumps, hydro- gas- and steam-turbines, and the application of fluid power machines. These competences are necessary in the companies designing, managing and maintaining fluid machines and power plants, in industrial processes, in propulsion systems, in utilities' companies and in the industries designing components and solutions for the energy conversion.

	Intended Learning Outcomes (ILO) Knowledge and understanding Through the application of the principles of thermo-fluid-dynamics to fluid machines, students should be able: 1. To know and understand the fundamental mechanical components used in the fluid machines and their operative function 2. To know and understand the fluid-dynamics of the fluid machines, the design of the fluid-machines components and the introduction of the fluid machines within the industrial and civil plants and devices Applying knowledge and understanding 3. to apply the fluid-dynamic laws to the design of thermal and hydraulic machines' components 4. to apply the studied fluid-machines to industrial and civil plants and devices 5. to apply the design principles in practical projects developed by the students in the experiential learning platform Making judgements 6. to make autonomous judgements in the choice of the design solutions, of the suitable machines and of the plant solutions in relation to their applications Communication skills 7. to correctly and properly present the concepts acquired in the course both in written and oral form 8. to use the proper technical terms to describe the design solutions of the fluid machines Ability to learn 9. to acquire lifelong learning skills, as well as the required material and information, in the field of fluid machines by applying the methods and the concepts acquired in the course.
Specific Educational Objectives and Learning Outcomes (additional info.)	
Assessment	Examination of the course is conducted via a written exam. The written exam consists of two parts: i) an exercise on the basic design of one of fluid machines presented during the course to assess the ability of the student to apply the topics of the course in practical applications, the comprehension of the theoretical concepts and the ability to make judgments; students will be asked

	to define the main geometrical dimension of the machines, the blades design, the velocity triangles, the performance of the machine and additional evaluations regarding the application of the machine in a real plant; ii) at least two open written questions to assess the knowledge and understanding of the course topics, the theoretical aspects, as well as the ability to transfer these skills to case studies of fluid machines. Specifically, the main thermo-fluid dynamic transformations, the main design parameters and formulations, and the most important sketches and charts describing the performance of the machines will be requested. The student can choose to have an additional optional oral exam to further assess his/her preparation. Summative assessment: 50% written exam, exercises: 1 exercise (1.5 hours); ILOs assessed: 2, 3, 4, 6; 50% written exam, theory: 2 open-ended questions (1 hour); ILOs assessed: 1, 2, 5, 7, 8; Oral (optional): 2 open-question; ILOs assessed: 1, 2, 5, 7, 8.
Evaluation Criteria	Students regularly enrolled at the 3rd year of the Bachelor in Industrial and Mechanical Engineering are eligible for the attendance of the lessons and the exam. Other exceptional cases have to be discussed with the Professor. Written exam - exercise The written exam assesses the ability of the student to apply the topics of the course in a practical dimensioning exercise and the ability to make independent judgments. The following criteria will be taken into account: - Correctness of the design choices: the student is asked to identify the proper machine for a specific application, select the main design criteria and identify the proper procedure to design the machine - Correctness of the dimensioning procedure: the student is asked to define the calculations to design in details the machine ducts, the machine blades and its performance - Correctness of the numerical solution: the student is asked to run calculations on the machine design and performance, and to be able to judge the correctness of the numerical results - Appropriate use of measurement units Written exam – theory (open-end question)

	The written exam on the theory assesses the knowledge and understanding of the course topics, the knowledge of the fluid-dynamic behavior of compressible and incompressible fluids in the components of the fluid machines, as well as the ability to transfer these skills to case studies and to make judgment. The following criteria will be taken into account: - Theoretical knowledge, correctness of formulations, charts and sketches - Ability to provide examples/applications of theoretical concepts - Communication skills and master of the technical language Oral exam (optional) The following criteria will be taken into account: - Theoretical knowledge, correctness of formulations, charts and sketches - Ability to provide examples/applications of the theoretical concepts - Communication skills and master of the technical language The exam will be weighted as follows: written (50%), oral (50%). It will not be possible to pass the exam if the exercise or the questions will not have a sufficient mark singularly.
Required Readings	Slides presented during the lecture (available in the course Teams); additional material supplied by the lecturer (typically available in the course Teams). Subject Librarian: David Gebhardi, David.Gebhardi@unibz.it and Ilaria Miceli, Ilaria.Miceli@unibz.it
Supplementary Readings	• S. Sandrolini, G. Naldi, “Macchine, Vol. 1: Fluidodinamica e termodinamica delle turbomacchine”, Pitagora Editrice • S. Sandrolini, G. Naldi, “Macchine, Vol. 2: Le turbomacchine motrici e operatrici”, Pitagora Editrice • R. Della Volpe, Macchine, Editore Liguori, Napoli • G. Minelli, “Macchine idrauliche”, Pitagora Editrice • R. Della Volpe, Esercizi di macchine, Editore Liguori, Napoli
Further Information	Software used: Spreadsheets or Matlab.
Sustainable Development Goals (SDGs)	Affordable and clean energy, Industry, innovation and infrastructure, Climate action, Responsible consumption and production, Sustainable cities and communities