Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	Fluid Machines Engineering
Course code	45527
Scientific sector	ING-IND/08 "Fluid Machinery"
Degree	Master Energy Engineering
Semester	1
Year	1
Academic year	2021/2022
Credits	9
Modular	No

Total lecturing hours	70
Total lab and exercise hours	20
Attendance	Not mandatory but recommended
Recommended preliminary knowledge	Fluid Machines, Thermodynamics, Mechanics
Connections with other courses	"Hydropower and Wind Power Systems" extends some of the topics of the present course.
Course page	

Specific educational objectives	To master the most important concepts about fluid machines dedicated to energy conversion systems and their integration in the energetic system, to give decision tools and criteria for design, cost analysis, efficiency analysis, and selection with emphasis to community and small scale plants.

Lecturers	Dr. Giuseppe Soraperra
Scientific sector of the lecturer	ING-IND/08
Teaching language	English
Office hours	Appointment by email
Teaching assistant *(if any)*	-
Office hours	-
List of topics covered	The course will cover the following topics: **0. Fluid machines review and classification** - Classification of fluid machines; - Review on different fluid machines. **1. Basic principles** - Forms of energy; - Energy of formation; - Principle of conservation of mass;

	- Principle of conservation of energy; - Work in elementary fluid machines; - Application of the mass and energy conservation principles. **2. Volumetric machines.** - Geometric characterization; - Torque equation; - Volumetric pump: volumetric flow, hydraulic efficiency, ideal, and real functional curves; - Reciprocating compressors: volumetric coefficient, limit work, real work. Applicative examples. **3. Turbomachines.** - Description of the possible architectures: axial turbines, radial turbines, Ljungstom type; - Functioning principle for airfoil-based machines; - Evaluation of compressibility effects; - Work and power: the Euler equation; - Definition of the degree of reaction; - Radial pump: ideal and real characteristic curves and regulation; - Axial turbomachine stages: compressor stages; impulse stage; reactions stage; - Optimization of axial turbine stages; - Losses in turbomachines; - Cavitation: definition of NPSHI and NPSHR and practical examples of calculation. **4. Efficiencies.** - Efficiencies of elementary fluid machines; - Polytrophic efficiency vs isentropic efficiency; - The efficiency chain: internal efficiency, mechanical efficiency, electrical efficiency; - Efficiency for hydropower plants; - Efficiency for wind power plants; - Coupling of power plants with loads and regulation: the example of a small wind turbine; - Definition of thermal efficiency for complex machines; - Examples of efficiencies for power plants: the Rankine cycle, the Brayton-Joule cycle, the combined cycle, and the CHP cycles; - Survey on typical efficiencies for power plants of different sources and technological limits. **5. Technical-economical facts.** - Relevant technical-economical parameters as Capacity Factor and Equivalent Number of Hours for power plants; - Introduction to the load demand; - Reliability and availability of power plants;

	- Cost Of Energy (COE) and Levelized Cost Of Energy (LCOE); - Analysis of investment: the present worth method, the IRR method, the payback period, and the brake-even analysis; - Practical examples of calculation of COE.
Professional applications of the covered topics	The knowledge acquired during the course is essential in companies of the energy sector such as: - energy utilities; - equipment manufacturers; - systems developers; - consultants and certification bodies.
Teaching format	The course uses mainly frontal classes. Exercises on design and laboratory works are organized during the course.

Learning outcomes	The course aims at discussing the main power generating systems, either fossil or renewable fluids fueled. Innovative systems and technologies are presented and discussed, like wind turbines, run-off hydro turbines, and high-temperature gas turbines. Plants are detailed and discussed from the point of view of efficiency. The student will also be able to analyze power generating systems from a technical-economic point of view. <u>Knowledge and understanding</u> 1. Basic knowledge of work, power, and efficiency of fluid machines and power generating systems. <u>Applying knowledge and understanding</u> 2. The student will be able to analyse fluid machines to quantify the functioning parameters, obtain the efficiency and carry out basic design calculations. <u>Making judgements</u> 3. The student will be able to select the proper equipment and compare alternative solutions. <u>Communication skills</u> 4. The student will be able to discuss, set specifications, and form educated questions concerning fluid machines and power generating systems. <u>Ability to learn</u> 5. The student will be able to self-improve his know-how through a critical end selective acquisition of information on the discipline of fluid machines.

Assessment	The evaluation will be based on an oral exam and the development of reports carried out in groups. The reports will regard applicative design cases and/or the post-processing of laboratory experience. The reports shall be submitted one week before the oral exam. The oral exam will cover both the theory and the capability of application of basic principles by discussing the submitted reports.

Formative assessment

Form	Length /duration	ILOs assessed
Reports on design cases and/or post-processing of lab experience.	To be submitted one week before the oral exam.	(2), (3), (5)

Summative assessment

Form	%	Length /duration	ILOs assessed
Oral examination	100	About 20-30 minutes.	All except (5).

Assessment language	English
Evaluation criteria and criteria for awarding marks	Oral exam performance and report quality will be equally weighted for the course final grade.

Required readings	Notes of the course
Supplementary readings	• L. Battisti, Gli impianti motori eolici, Ed. LB 2012 Trento • W.W Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine, Prentice Hall 1988 • R. Fox, Introduction to Fluid Mechanics, John Wiley and Sons 2004 • K.-D. E. Pawlik, Solutions Manual for Guide to Energy Management, The Fairmont Press • S. L. Dixon, Fluid Mechanics, Thermodynamics of Turbomachinery, Pergamon Press 1988 • Layman, Layman's Handbook On How To Develop A Small Hydro Site. • A handbook prepared under contract for the Commission of the European Communities, Directorate-General for Energy by European Small Hydropower Association (ESHA) 1998 • P.P. Walsh, P. Fletcher, Gas Turbine Performance, Blackwell Science Ltd 2004 • R.K. Turton, Principles of Turbomachinery, Chapman e Hall 1995