Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	Environmental Fluid Mechanics / Hydropower Plants
Course code	45504
Scientific sector	ICAR/01 (Module 1) "Hydraulics" ICAR/02 (Module 2) "Hydraulic and Marine Constructions and Hydrology"
Degree	Master Energy Engineering
Semester	1
Year	1
Academic year	2023/2024
Credits	9
Modular	yes

Total lecturing hours	40 + 40+10
Total lab and exercise hours	0 + 8 + 2
Attendance	Not mandatory but recommended
Recommended preliminary knowledge	Basic knowledge of first-level courses of hydrology and hydraulics is required to successfully attend the course. Students with a background in industrial engineering where such topics were not available, or limited, will have to fill the knowledge gap by means of autonomous study following the recommendations and suggestions of the instructors
Connections with other courses	A strict connection with the curse of Fluid Machines Engineering and Electrical System Engineering, for the understanding and design of water turbines, electrical energy production and transport. The course is preparatory to the course Hydro Power System, in which Run of the River Hydro power Plants will be in deep analyzed.
Course page	https://www.unibz.it/en/faculties/engineering/master-energy-engineering/course-offering/

Specific educational objectives	The course aims at providing the basic notions to understand the behavior of hydraulic infrastructures used for hydroelectric energy production, the dynamics of transport processes in rivers, streams and open-channel flows, and to compute mass balances of available water resources.

Module 1	**Environmental Fluid Mechanics**
Lecturer	Prof. Guido Zolezzi
Scientific sector of the lecturer	ICAR/01
Teaching language	English
Office hours	Upon appointment
Teaching assistant *(if any)*	-
Office hours	-
List of topics covered	<u>Hydraulics of open channel flows and transport processes in streams and rivers</u> 1. Introduction Review of basic hydraulic concepts: mass and momentum conservation (integral formulation), steady uniform flow in pipes, Bernoulli theorem. Fundamental equations for open-channel flows: main concepts and assumptions in the derivation of the one-dimensional (cross section average) continuity and momentum equations (Saint Venant equations). Hierarchy of hydraulic models (from 3D local, instantaneous to 1D) 2. One-dimensional open channel flows Flow resistance in turbulent flows; uniform flow model; channel design problem; stage-discharge curves in natural cross-sections. Steady-state water surface profiles in gradually varied flows: subcritical and supercritical flows; boundary conditions, locations and type. Specific energy; hydraulic jump. Gradually varied flows: effect of variable geometry and variable discharge. Unsteady flows: flood waves, celerity of propagation, simplified models (kynematic model, parabolic model). Hysteresis in the stage-discharge rating curve. Hydropeaking waves. Numerical models for the simulation of open channel flows (HEC-RAS software). 3. Fluvial hydraulics and eco-hydraulics Basic concepts of river hydro-morphology. Sediment transport (bed load and suspended load); erosion and deposition processes. Implications for river morphological evolution. Environmental effects of hydropower production on river systems. The national and international regulatory framework. Methods to calculate ecological flows. Hydrological methods and hydraulic-habitat methods.

	Hydropeaking and related effects.
Professional applications of the covered topics	
Teaching format	The theory is presented by means of lectures in class. Examples of exercises supporting the theoretical aspects are proposed by the instructors during teaching hours. Further analyses, which include the solution of various types of exercises and problems, are left to the autonomous study of the students. In order to better understand the practical aspects taught in the course, one or more homework practical exercises will be assigned to the students. The homework will be done in small groups. The discussion of the results of the homework is one of the elements of the exam.

Module 2	**Hydropower Plants**
Lecturers	Prof. Maurizio Righetti and Dr. Giuseppe Pisaturo
Scientific sector of the lecturers	ICAR/02
Teaching language	English
Office hours	Upon appointment
Teaching assistant *(if any)*	-
Office hours	-
List of topics covered	<u>Hydrological modeling for hydropower systems and analysis of the elements of HPP</u> II-1 Introduction (4 hours). Principles of functioning of a Hydro power plant; classification and main components of a HPP. Pumped-storage HPPs. Hydrological curves, duration curves and their use for a reservoir or a RoR HPP design. II-2 Basics of hydrology and hydrological modelling (8 hours) The main components of the hydrological cycle; the water balance (continuity equation); precipitation; floods and droughts; the return time. The uses of water resources. Acquisition of hydro-meteorological data. The main processes of the hydrological / cycle modules that constitute an hydrological model. Models for evapotranspiration, plant interception and infiltration, snow-glacial dissolution, infiltration. Full models: the kinematic model. Continuous hydrological models.

	Construction criteria of a hydrological model at the basin scale. Calibration and validation of models. II-3. Flow measurement (4 hours) Weirs, the method of area-velocity, the dilution method, measurement errors, and its influence on the flow rate scales. II-4. Plant design (34 hours) Hydroelectric plants with reservoir and run of the river plants (RoR), operations management for hydroelectric plants. Analysis of the functional elements constituting a hydroelectric plant: barrages and intakes (dams, sedimentation channels); headraces, channels and adduction tunnels; surge tanks; penstocks; turbines; alternators; regulators; tailrace. Classroom exercises: filtration under dams and dikes; Global stability of dams and dikes; siphoning; drainage of excavations. One exercise among: analysis of water hammer in a pressure pipe, mass oscillation analysis in a surge tank, Reservoir volume and production design.
Professional applications of the covered topics	The topics studied will allow the student to find employment in companies, public and private bodies and professional firms for the design, planning, construction and management of works and plants for hydroelectric production, for the management of environmental and energy resources.
Teaching format	The theory is presented by means of lectures in class. Examples of exercises supporting the theoretical aspects are proposed by the lecturers during teaching hours. Further analyses, which include the solution of various types of exercises and problems, are left to the autonomous study of the students. Observation of key open channel flow processes in the hydraulic laboratory is used to increase concept understanding. A one-day field visit to hydropower plants is usually organized within the course. In order to better understand the practical aspects taught in the course, one or more homework practical exercises will be assigned to the students. The homework will be done in small groups. The discussion of the results of the homework is one of the elements of the exam.

Learning outcomes	**Knowledge and understanding:** 1. Recall the basics of pressurized flow and related energy balance 2. Understand the hydrodynamics and the main hydraulic processes of open-channel flows, including basics of sediment transport 3. Understand the hydrological cycle. 4. Understand the hydraulic design/sizing of the main components of a Hydro power Plant (such as: hydraulic equipment for production, control, outlet works). **Applying Knowledge and understanding:** 5. Compute steady-state profiles of open-channel flows with variable geometry and discharge. 6. Carry out the main hydrological analyses necessary for the design of hydroelectric systems and simulation of their productivity. 7. Carry out the hydraulic design of the main components of a HPP **Making judgments:** 8. Analyze the different compartments of a Reservoir Hydro Power Plant (HPP) and of a Run-of-River HPP. 9. Estimate the hydrological and environmental alterations induced by the operation of hydroelectric power plants. **Communication skills:** 10. Learn specific terminology. 11. Be able to discuss with experts. **Learning skills** 12. Critical analysis and hydraulic design of HPP structures. 13. Group work.
Assessment	Oral exams and exercises/report The student is asked to produce a series of group exercises (homework) reports, on hydraulic problems and/or on the hydraulics of some comparments of an hydro powwer plant. This part of the assessment evaluates 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. The student is also asked to carry out an oral exam for each module of the course. The oral examination includes questions to assess the knowledge and understanding of

	the course topics and questions designed to assess the ability to transfer these skills to case studies of hydro power plants. **Formative assessment** <table><tr><td>Form</td><td>Length/duration</td><td>ILOs assessed</td></tr><tr><td>In class exercises</td><td>15 x 60 min</td><td></td></tr></table> **Summative assessment** <table><tr><td>Form</td><td>%</td><td>Length/duration</td><td>ILOs assessed</td></tr><tr><td>Oral exam</td><td>70%</td><td>2 or 3 open-end questions (45 min)</td><td>1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11</td></tr><tr><td>Exercises presentation</td><td>30%</td><td>Presentation and discussion (15-25 min)</td><td>4, 6, 7, 8, 9, 10, 11, 12</td></tr></table>
Assessment language	English
Evaluation criteria and criteria for awarding marks	The exam comprises two elements: a final oral discussion on the topics dealt with during the course (70%), and an individual presentation and discussion of the homework (30%). The discussion of both elements is contextual and occurs during the oral exam. The homework is developed by groups of maximum 3 students. Each group will write a written report presenting the work done in a clear and concise way. The report has to be sent to the instructors in pdf format by e-mail, at least one week before the date of the exam. Each student is responsible of the whole homework.

Required readings	The student can select any book dealing with the topics of the course. Suggested references: - S. L. Dingman, Physical Hydrology, Prentice Hall, New Jersey, 1994 - F. M. Henderson, Open Channel Flow, MacMillan Series in Civil Engineering, 1966. - H. Chanson, The Hydraulics of Open Channel Flow: An Introduction, Arnold, 1999. - A._J_Peterka, Hydraulic_design_of_stilling_basins - Pavel_Novak, Hydraulic_structures
Supplementary readings	