Syllabus

Course Description

Course Title	Environmental Fluid Mechanics / Hydropower Plants
Course Code	45504
Course Title Additional	
Scientific-Disciplinary Sector	NN
Language	English
Degree Course	Master in Energy Engineering
Other Degree Courses (Loaned)	
Lecturers	Prof. Maurizio Righetti, Maurizio.Righetti@unibz.it https://www.unibz.it/en/faculties/agricultural-environmental-food-sciences/academic-staff/person/33740 dr. Giuseppe Roberto Pisaturo, GiuseppeRoberto.Pisaturo@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/38803 Dott. Guido Zolezzi, https://www.unibz.it/en/faculties/engineering/academic-staff/person/40009
Teaching Assistant	
Semester	First semester
Course Year/s	1
CP	9
Teaching Hours	90
Lab Hours	0
Individual Study Hours	135
Planned Office Hours	
Contents Summary	The course provides a comprehensive introduction to the hydraulics of open-channel flows and hydrological modeling with direct applications to hydropower systems. It is divided into two

	main modules. In the first module, students will review the fundamental principles of open-channel hydraulics, including mass and momentum conservation, and will learn to apply the Saint Venant equations to model both steady and unsteady flow conditions in rivers and channels. Particular attention will be given to flow resistance, gradually varied flows, flood wave propagation, and hydropeaking phenomena. Students will also explore sediment transport and the environmental impacts of hydropower on river ecosystems, with an introduction to ecological flow assessment and eco-hydraulics. The second module¿focuses on the hydrological processes relevant to hydropower design and management. Students will study the hydrological cycle, water balance, and key modeling approaches at the basin scale. Techniques for flow measurement and the analysis of errors will be covered. The course then moves into the design of hydropower plants—including reservoirs, intakes, penstocks, turbines, and related infrastructure—with practical exercises on dam stability, pressure transients, and reservoir sizing. Key learning outcomes: -Understand and model open-channel flow in natural and engineered systems -Analyze flood propagation and hydropeaking using simplified and numerical models -Evaluate sediment transport and river morphological processes -Apply hydrological models to support hydropower planning -Design key components of hydroelectric plants considering both technical and environmental aspects This course integrates theory, numerical tools (e.g., HEC-RAS), and applied exercises to prepare students for real-world challenges in water resources and sustainable energy engineering.
Course Topics	- Module 1:

	Hydraulics of open channel flows and transport processes in streams and rivers 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 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. - Module 2: Hydrological modeling for hydropower systems and analysis of the elements of HPP 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 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.
Keywords	hydropower, hydraulics, environment, rivers, plant
Recommended Prerequisites	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.
Propaedeutic Courses	
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.
Mandatory Attendance	Not mandatory but recommended.
Specific Educational Objectives and Learning Outcomes	Module 1, 2: the course aims at providing 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.
Specific Educational Objectives and Learning Outcomes (additional info.)	
Assessment	Module 2: 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: In class exercises: 15x60 minutes. - Summative assessment: 70% oral exam: 2 or 3 open-end questions (45 min); ILOs assessed: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11; 30% exercises presentation: Presentation and discussion (15-25 min); ILOs assessed: 4, 6, 7, 8, 9, 10, 11, 12.
Evaluation Criteria	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	
Further Information	Connections with other courses: A strict connection with the course 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. 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.
Sustainable Development Goals (SDGs)	Affordable and clean energy, Decent work and economic growth, Climate action, Sustainable cities and communities, Responsible consumption and production, Industry, innovation and

	infrastructure

Course Module

Course Constituent Title	Environmental Fluid Mechanics
Course Code	45504A
Scientific-Disciplinary Sector	ICAR/01
Language	English
Lecturers	Dott. Guido Zolezzi, https://www.unibz.it/en/faculties/engineering/academic-staff/person/40009
Teaching Assistant	
Semester	
CP	4
Responsible Lecturer	
Teaching Hours	40
Lab Hours	0
Individual Study Hours	60
Planned Office Hours	
Contents Summary	Hydraulics of open channel flows and transport processes in streams and rivers 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 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.
Course 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.
Required Readings	- 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.
Supplementary Readings	

Course Module

Course Constituent Title	Hydropower Plants
Course Code	45504B
Scientific-Disciplinary Sector	ICAR/02

Language	English
Lecturers	Prof. Maurizio Righetti, Maurizio.Righetti@unibz.it https://www.unibz.it/en/faculties/agricultural-environmental-food-sciences/academic-staff/person/33740 dr. Giuseppe Roberto Pisaturo, GiuseppeRoberto.Pisaturo@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/38803
Teaching Assistant	
Semester	
CP	5
Responsible Lecturer	
Teaching Hours	50
Lab Hours	0
Individual Study Hours	75
Planned Office Hours	
Contents Summary	Hydrological modeling for hydropower systems and analysis of the elements of HPP 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 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.
Course Topics	
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. 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.
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	