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	dr. Giuseppe Roberto Pisaturo, GiuseppeRoberto.Pisaturo@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/38803
Teaching Assistant	
Semester	First semester
Course Year/s	1
CP	9
Teaching Hours	90
Lab Hours	0
Individual Study Hours	135
Planned Office Hours	27
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 (HECRAS 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 hydraulichabitat 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 hydrometeorological 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 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. Teaching Format 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	Common part: Students have to prepare three short reports (one for Module 1 and 2 for Module 2) that will discuss during oral examination. The three group assignments focus on hydraulic problems and on the hydraulics of selected components of a hydropower plant. This part assesses the student's ability to apply the course topics in a practical context, their understanding of theoretical concepts, and their ability to formulate judgments. The all exam is passed only if each Modules and/or part of module (written exercise; each oral question; assignments) achieves a passing grade. Module 1: The exam consists of: (1) a written exercise on open channel flow; (2) two or three oral questions. The written exercise lasts one hour. Students are allowed to bring a formula sheet of a maximum of two pages prepared individually, as well as dimensionless charts. The oral questions are intended to assess knowledge and understanding of the course topics and the ability to transfer these competencies to case studies of hydropower plants. The exam is passed only if each part (written exercise; each oral question; assignments) achieves a passing grade. The final grade results from an overall integration of the assessments of each part. Module 2: The exam consists of: (1) three or four oral questions. The oral questions are intended to assess knowledge and understanding of the course topics and the ability to transfer these competencies to case studies of hydropower plants. The exam is passed only if each part (each oral question; assignments) achieves a passing grade. The final grade results from an overall integration of the assessments of each part. - 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	CEAR-01/A
Language	English
Lecturers	Dott. Guido Zolezzi, https://www.unibz.it/en/faculties/engineering/academic-staff/person/40009
Teaching Assistant	
Semester	First semester
CP	4
Responsible Lecturer	
Teaching Hours	40
Lab Hours	0
Individual Study Hours	60
Planned Office Hours	12
Contents Summary	Hydraulics of open channel flows and transport processes in streams and rivers 1. Introduction and basics (10 hours) 1.1 Review of some basic hydraulic concepts. 1.2 Hydraulic models, fundamental equations: from Navier Stokes to 1D St Venant equations 1.3 Steady flow in pipes: wall roughness, uniform flow, design. (Not always covered: Mass oscillations in unsteady flow in pipes 2. Open channel flow (20 hours) 2.1 Normal flow; flow resistance; stage-discharge curves in artificial and natural cross-sections.

	2.2 Energy in open channel flows; application of the Bernoulli theorem; critical conditions; Froude number; steep and mild channels 2.3 Gradually varied, steady flow profiles: subcritical and supercritical flows; boundary conditions. Hydraulic jump. Localized phenomena. (not always covered: basics of unsteady flows: flood waves, hydropeaking). 2.4 Numerical models for the simulation of open channel flows (HEC-RAS): introduction to group homework. 3. Environmentally relevant hydraulics (10 hours) 3.1 Sediment characteristics; incipient transport; modes of transport (bed load and suspended load). Morphodynamics: the Exner equation and its links with hydraulic models 3.2 Ecological flows; basic concepts of eco-hydraulics. River habitat modelling, downstream eco-hydro-morphological effects of dam operations on rivers
Course Topics	
Teaching Format	Class lectures for theoretical concepts and equations. Numerical exercises in the class for application of the theory. Further analyses are left to the autonomous study of the students. One / two sessions in the hydraulics laboratory to practically show open channel flow and morphodynsmi processes A one-day field visit to a hydropower plant is organized within the course One group project on 1D river hydraulic modelling is assigned to the students during the lectures and has to be completed as part 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. - H. Chanson, The Hydraulics of Open Channel Flow: An Introduction, Arnold, 1999. - J. Fenton, Open channel hydraulics, 2005
Supplementary Readings	

Course Constituent Title	Hydropower Plants
Course Code	45504B
Scientific-Disciplinary Sector	CEAR-01/B
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	First semester
CP	5
Responsible Lecturer	
Teaching Hours	50
Lab Hours	0
Individual Study Hours	75
Planned Office Hours	15
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 Required Readings - 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	