unibz 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 – ICAR/02
Degree	Master Energy Engineering
Semester	1
Year	1
Academic year	2020/21
Credits	9
Modular	yes

Total lecturing hours	75
Total lab hours	
Total exercise hours	15
Attendance	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
Course page	

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	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	Hydraulics of open channel flows and transport processes in streams and rivers I-1. Introduction (12 hours) Review of basic hydraulic concepts. Fundamental

	equations: derivation of the one-dimensional cross-sectional averaged continuity and momentum equations (Saint Venant equations). Steady flow in pipes: wall roughness, uniform flow, design. 2. Open channel flow (20 hours) Flow resistance in free surface hydrodynamics; uniform flow; stage-discharge curves in natural cross-sections. Steady-state profiles: subcritical and supercritical flows; boundary conditions. Hydraulic jump. Gradually varied flows: effect of variable geometry and variable discharge. Unsteady flows: flood waves, celerity of propagation, simplified models. Numerical models for the simulation of open channel flows. Ecohydraulics and physical river habitat 3. Transport processes in stream and rivers (8 hours) Basic concepts. Concentration of a scalar tracer. One-dimensional advection-diffusion equation; turbulent diffusion; dispersion. Mass and heat transport in rivers. Sediment transport (bed load and suspended load); erosion and deposition processes. Implications on morphological evolution. Environmental effects of hydropower production
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
Lecturer	Maurizio Righetti and Giuseppe Pisaturo
Scientific sector of the lecturer	ICAR/02
Teaching language	English
Office hours	Upon appointment
Teaching assistant *(if any)*	
Office hours	

List of topics covered	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. Water resources and their global distribution; the uses of water resources. Acquisition of hydro-meteorological data. Criteria and protocols for the creation of a hydrological model. The main processes of the hydrological / cycle modules that constitute an hydrological model. Models for evapotranspiration, plant interception and infiltration, nivo-glacial dissolution, infiltration. Full models: the kinematic model, the Instant Unit hydrograph. 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 withdrawal (dams, sedimentation channels); channels and adduction tunnels; water towers; penstocks; turbines; alternators; regulators; drains. Classroom exercises: filtration under dams and dikes; Global stability of dams and dikes; siphoning; drainage of excavations. Analysis of water hammer in a pressure pipe, mass oscillation analysis in a surge shaft.
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. 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. Understand the hydrodynamics and the main transport processes of open-channel flows. 2. Understand the hydrological cycle. 3. 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:** 4. Compute steady-state profiles of open-channel flows with variable geometry and discharge. 5. Carry out the main hydrological analyses necessary for the design of hydroelectric systems and simulation of their productivity. 6. Carry out the hydraulic design of the main components of a HPP **Making judgments:** 7. Analyze the different compartments of a Reservoir Hydro Power Plant (HPP) and of a Run-of-River HPP. 8. Estimate the hydrological and environmental alterations induced by the operation of hydroelectric power plants. **Communication skills:** 9. Learn specific terminology. 10. Be able to discuss with experts. **Learning skills** 11. Critical analysis and hydraulic design of HPP structures. 12. 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

Form	Length/duration	ILOs assessed
In class exercises	15 x 60 min	

Summative assessment

Form	%	Length/duration	ILOs assessed
Oral exam	70%	2 or 3 open-end questions (45 min)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Exercises presentation	30%	Presentation and discussion (15-25 min)	4, 6, 7, 8, 9, 10, 11, 12

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 - S.A. Socolofsky & G.H. Jirka, Special Topics in Mixing and Transport Processes in the Environment, Coastal and Ocean Engineering Division, Texas A&M University, 5th Edition, 2005.
Supplementary readings	