



National University of Engineering (UNI)

School of Civil Engineering

Syllabus 2027-I

1. COURSE

CE3H6. Irrigation and hydropower (Mandatory)

2. GENERAL INFORMATION

2.1 Course	: CE3H6. Irrigation and hydropower
2.2 Semester	: 10 th Semester.
2.3 Credits	: 4
2.4 Hours	: 2 HT; 4 HP;
2.5 Duration of the period	: 16 weeks
2.6 Type of course	: Mandatory
2.7 Learning modality	: Face to face
2.8 Prerequisites	: CE3H4. Water Resources. (8 th Sem)

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Irrigation and Hydropower addresses the comprehensive design of irrigation projects and small-scale hydropower schemes: from the context of Peruvian agriculture and the soil-water-plant relationship, the estimation of evapotranspiration and agricultural water demand, to the hydraulic sizing of dams and reservoirs, the design of intake structures (diversion weirs, desanders) and conveyance structures (canals), the agronomic and hydraulic design of gravity and pressurized irrigation systems (including drip irrigation), and agricultural drainage. The course also covers the fundamentals of run-of-river small hydropower schemes, including penstock design and turbine selection, and concludes with the evaluation of irrigation and hydropower projects from environmental, social, and economic perspectives.

5. GOALS

- Estimate agricultural water demand based on the soil-water-plant relationship and crop evapotranspiration.
- Size dams, reservoirs, and intake and conveyance structures for an irrigation project.
- Design gravity and pressurized irrigation systems, including the agronomic and hydraulic design of drip irrigation.
- Design an agricultural drainage system to control waterlogging and soil salinity.
- Design the layout of a small-scale hydropower scheme and select an appropriate turbine for given head and flow conditions.
- Evaluate irrigation and hydropower projects considering environmental, social, and economic criteria.

6. COMPETENCES

ABET-1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. (Usage)

ABET-2) An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. (Usage)

7. TOPICS

Unit 1: Agriculture in Peru and Description of an Irrigation Project (6 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
- Context and current status of irrigated agriculture in Peru. - Components and general description of an irrigation project.	- Describe the context of irrigated agriculture in Peru and its main challenges [Familiarizarse]. - Identify the main components of an irrigation project [Familiarizarse].
Readings : [Chambouleyron2005]	

Unit 2: Agricultural Water Demand (12 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
- Soil-water-plant relationships and soil water availability - Estimation of reference and crop evapotranspiration - Crop water requirement and crop coefficients - Water supply-and-demand balance for an irrigation project - Irrigation scheduling and cropping calendars - Irrigation efficiency at the field, conveyance, and system level	- Explain the soil-water-plant relationship and its effect on water availability for crops [Familiarity] - Calculate reference and crop evapotranspiration using standard methods [Usage] - Estimate a crop's water requirement throughout its growth cycle [Assessment] - Develop the water supply-and-demand balance for an irrigation project [Usage] - Design an irrigation schedule accounting for the cropping calendar [Assessment] - Evaluate the irrigation efficiency of a system and propose improvements [Usage]
Readings : [Allen1998], [Chambouleyron2005]	

Unit 3: Design of Hydraulic Structures (12 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Dam types and selection criteria • Spillway hydraulics and design • Weir and gate flow equations • Energy dissipation and stilling basin design • Culvert hydraulics and design • Dam safety analysis and risk assessment • Outlet works and control structures • Fish passage facilities and environmental hydraulics • Cavitation analysis and prevention • Physical hydraulic modeling and scale effects	• Classify dam types and select appropriate configurations for site conditions [Familiarity] • Design spillways for flood discharge capacity [Assessment] • Calculate discharge over weirs and through gates [Usage] • Proportion energy dissipation structures and stilling basins [Assessment] • Analyze culvert hydraulics for inlet and outlet control [Usage] • Perform dam safety evaluations and hazard classification [Assessment] • Design outlet works including intake structures and conduits [Usage] • Incorporate fish passage requirements in hydraulic structure design [Assessment] • Evaluate cavitation potential and design preventive measures [Usage] • Interpret physical model results and apply scale corrections [Assessment]
Readings : [Novak2007]	

Unit 4: Open Channel Flow and River Mechanics (9 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Channel flow classification and hydraulic elements • Energy and momentum principles in open channels • Uniform flow and Manning's equation • Critical flow and specific energy concepts • Gradually varied flow profiles • Hydraulic jump and rapidly varied flow • Channel design for stable conveyance • Sediment transport in open channels • River morphology and channel stability • Scour analysis and protection measures	• Classify open channel flow regimes and calculate hydraulic elements [Familiarity] • Apply energy and momentum equations to solve channel flow problems [Assessment] • Calculate normal depth and discharge using Manning's equation [Usage] • Determine critical depth and analyze specific energy relationships [Assessment] • Compute gradually varied flow profiles using standard methods [Usage] • Analyze hydraulic jumps and calculate energy dissipation [Assessment] • Design stable channels with appropriate cross-sections and linings [Usage] • Estimate sediment transport rates in alluvial channels [Assessment] • Evaluate river channel stability and bank erosion potential [Familiarity] • Predict scour depths at hydraulic structures and design protection [Assessment]
Readings : [Chow1959]	

Unit 5: Irrigation Systems Design (33 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Types of irrigation intake works • Headworks design • Desander design • Other structures of the irrigation conveyance and distribution system • Design of gravity irrigation systems • Design of pressurized (technified) irrigation systems • Agronomic design of drip irrigation • Hydraulic design of drip irrigation: laterals, distribution lines, and emitters	• Select the appropriate intake work type for the conditions of an irrigation project [Usage] • Design a headworks structure and its associated desander [Assessment] • Design a gravity irrigation system for a given field [Usage] • Compare pressurized irrigation alternatives against gravity irrigation [Assessment] • Perform the agronomic design of a drip irrigation system [Usage] • Hydraulically design the lateral and distribution lines of a drip irrigation system [Assessment]
Readings : [Chambouleyron2005], [Karmeli1975]	

Unit 6: Economic, Financial and Social Evaluation of Water Resources Projects (9 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Economic evaluation indicators: Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit-Cost ratio • Selecting among project alternatives by comparing economic indicators • Sensitivity analysis to variations in costs, benefits, and discount rate • Funding sources and financial structuring of water projects • User payment capacity and tariff schemes • Cost allocation among beneficiaries in multipurpose projects • Social evaluation of projects: exchange theory and shadow prices • Distributional impacts and equity in project social evaluation	• Calculate NPV, IRR, and Benefit-Cost ratio for a water resources project [Usage] • Select among project alternatives based on compared economic indicators [Assessment] • Perform a sensitivity analysis of project profitability to changes in key variables [Usage] • Evaluate funding sources and tariff schemes based on user payment capacity [Assessment] • Allocate costs among beneficiaries in a multipurpose project [Usage] • Apply social evaluation principles to estimate a project's net benefit to society [Assessment]
Readings : [Blank2017]	

Unit 7: Agricultural and Subsurface Drainage (9 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Waterlogging and salinity: causes and the need for agricultural drainage • Design of subsurface (tile/pipe) drainage systems: drain spacing and depth • Design of surface and open-ditch drainage systems for irrigated fields • Salinity control through drainage and the leaching requirement • Drainage water collection, disposal, and reuse	• Explain the causes of waterlogging and soil salinity in irrigated land [Familiarity] • Design a subsurface drainage system, determining drain spacing and depth [Usage] • Size a surface drainage network for an irrigated field [Assessment] • Calculate the leaching requirement needed to control soil salinity [Usage] • Propose a drainage water collection and disposal scheme for an irrigation project [Assessment]
Readings : [Ritzema1994]	

Unit 8: Small-Scale Hydropower Engineering (15 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
- Hydropower potential estimation from head and flow-duration curves - Run-of-river small hydropower scheme layout: intake, forebay, penstock, powerhouse, and tailrace - Penstock design: diameter selection, head losses, and water-hammer considerations - Turbine type selection (Pelton, Francis, Kaplan, cross-flow) based on head and flow - Grid connection, electromechanical equipment fundamentals, and off-grid rural electrification schemes	- Explain the concept of hydropower potential and the use of flow-duration curves [Familiarity] - Estimate the hydropower potential of a river reach or irrigation canal drop structure [Usage] - Design the layout of a run-of-river small hydropower scheme [Assessment] - Select an appropriate turbine type for given head and flow conditions [Usage] - Design a penstock accounting for head losses and water-hammer effects [Assessment]
Readings : [Penche2010]	

Unit 9: Environmental Impact Assessment and Sustainability Metrics (3 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
- EIA process: screening, scoping, impact analysis, mitigation, and public participation - Impact prediction methods for air, water, soil, noise, and ecological systems - Mitigation hierarchy and design of environmental management plans - Legal and institutional frameworks for EIA - Sustainability concepts and the triple bottom line (environment, economy, society) - Cumulative impact assessment and strategic environmental assessment (SEA) - Social impact assessment and stakeholder engagement methods - Sustainability metrics and indicator frameworks (e.g., SDGs, Envision) - Decision-support tools and multi-criteria analysis for sustainable design	- Outline the key stages of a standardized Environmental Impact Assessment (EIA) process [Familiarity] - Predict primary environmental impacts of a proposed infrastructure project on local air and water quality [Usage] - Develop mitigation measures for identified significant environmental impacts [Assessment] - Explain the legal requirements and purpose of EIA in the project approval process [Familiarity] - Apply the triple bottom line framework to evaluate a simple engineering project [Assessment] - Conduct a scoping exercise to define the boundaries and key issues for a cumulative impact assessment [Assessment] - Design a stakeholder engagement plan for a controversial development project [Usage] - Select appropriate sustainability metrics to track the performance of a green infrastructure project [Assessment] - Use a simple multi-criteria decision analysis (MCDA) tool to compare alternative project designs [Usage]
Readings : [Glasson2019]	

8. WORKPLAN

8.1 Methodology

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

8.2 Theory Sessions

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

8.3 Practical Sessions

The practical sessions are held in class where a series of exercises and/or practical concepts are developed through problem solving, problem solving, specific exercises and/or in application contexts.

9. EVALUATION SYSTEM

***** EVALUATION MISSING *****

10. BASIC BIBLIOGRAPHY