University of Isfahan

Course outline
Water Engineering and Hydraulic Structures
Graduate Program

Department of Civil Engineering
Faculty of Civil Engineering and Transportation
University of Isfahan

September 2024

1. Definition and goal

The Water Engineering and Hydraulic Structures graduate program provides a specialized segment within the field of civil engineering. It emphasizes the theoretical foundations, design methodologies and implementation strategies pertaining to hydraulic structures. The courses are structured to train students with the skills necessary to design and supervise the execution of specialized projects related to water resources and hydraulic structures.

2. Duration of Program and the structure

The average duration of Master and PhD program are 2 and 4 years, respectively. Every semester lasts 16 complete weeks of education. Each theoretical course takes 16 hours, each laboratory course might take 32 or 48 hours, and each workshop takes 48 hours.

3. Credits

The total credit requirements for this program are 30 credits for the Master's degree and 36 credits for the PhD degree, as detailed in Tables 1 and 2. The titles of the courses are provided in Tables 3 and 4.

Table 1. Course credits of Water Engineering and Hydraulic Structures graduate program (MSc Program)

No.	Type of courses	Credits
1	Core courses	13
2	Elective courses	12
3	Thesis	5
Total		30

Table 2. Course credits of Water Structures and Hydraulic Engineering graduate program (PhD Program)

No.	Type of courses	Credits
1	Core & Elective courses	18
2	Dissertation	18
Total		36

Table 3. Core courses for Water Engineering and Hydraulics Structures graduate program

Course No.	Course Title	Credits	Hours per week		Pre-requisites
			Theoretical	Practical	
3016327	ADVANCED HYDRAULICS	3	3	-	-
3016530	HYDRAULIC DESIGN OF STRUCTURES	3	3	-	-
3016098	EARTH AND ROCKFILL DAMS	3	3	-	-
3016331	HYDRODYNAMICS	3	3	-	-
3016473	RESEARCH METHOD	1	1	-	-
TOTAL		13	13	-	-

Table 4. Elective courses for Water Engineering and Hydraulic Structures graduate program

Course No.	Course Title	Credits	Hours per week		Pre-requisites
			Theoretical	Practical	
3016216	FINITE ELEMENT METHOD	3	3	-	-
3016385	ADVANCED GROUNDWATER	3	3	-	-
3016330	WATER RESOURCE SYSTEM ANALYSIS	3	3	-	-
3016219	ADVANCED ENGINEERING MATHEMATICS	3	3	-	-
3016410	FRACTURE MECHANICS	3	3	-	-
3016434	ROCK MECHANICS	3	3		

- 12 credits should be passed from this table.

ADVANCED HYDRAULICS

BASIC INFORMATION

Place in Curriculum and semester: Core, S1
Number of credits: 3

COURSE PREREQUISITES:

Fluid Mechanics, Open Channel Hydraulics

COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Ahmad Shanehsazzadeh
Office location: Building no. 2, Faculty of Civil Engineering and Transportation, University of Isfahan, Azadi Sq., Isfahan, Iran
Phone Number: +98 (31) 37935328
Homepage: http://eng.ui.ac.ir/~a.shanehsazzadeh
Email Address: a.shanehsazzadeh@eng.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	1 h

COURSE OBJECTIVES

Flow in open channel is part of fluid mechanics and the knowledge is applied in many civil engineering practices including design of hydraulic structures, river engineering, culverts, coastal and ocean engineering,

By the end of the course students are expected to:

- ✓ Understand the definition, physics and behavior of flow in open channels
- ✓ Apply the fluid mechanics basic laws in the open channels
- ✓ Solve the problems of steady and unsteady flows in open channels
- ✓ Calculate the water surface profile of gradually varied flow and flood routing
- ✓ Get familiar with the physics of various phenomena in open channels and the method of solutions
- ✓ Know the principles of numerical modeling the open channel flow and work with the related software.

REQUIRED STUDENT RESOURCES

Textbooks and References:

1. Open Channel Flow, Henderson.
2. Open Channel Hydraulics, Ven Te Chow
3. Open-Channel Hydraulics, Richard H. French

Web links:

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COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Introduction
2	Review the concepts, definitions and basic principles
3	Application of fluid mechanics principles in open channel flow

Week	Topic
4	Application of Specific energy and specific force
5	Steady flow- uniform and gradually varied flow
6	Spatially varied flow-inflow
7	Spatially varied flow-outflow
8	Unsteady flow- introduction
9	Unsteady flow- Saint Venant equations
10	Computation of Saint Venant equations
11	Rapidly unsteady flow, surges and waves
12	Rapidly unsteady flow-dam break
13	Sediment transport- modes of transport
14	Estimate of sediment rate
15	Student research presentations: water hummer, transitions, scouring, spillways, stilling basins, wave theories
16	Open channel flow software (HEC-RAS)- student project

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignment	10% of final grade
Project	25% of final grade
Mid-Term Exam	25% of final grade
Final Exam	40% of final grade
	100%

ATTENDANCE STATEMENT

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STUDENTS WITH DISABILITIES ACT FOR STUDENTS WITH SPECIAL NEEDS STATEMENT

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APPROVED ACADEMIC HONESTY STATEMENT

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SYLLABI ON WEB PAGES

Last update: September 2024.

HYDRAULIC DESIGN OF STRUCTURES

BASIC INFORMATION

Place in Curriculum and semester: Core, S2
Number of credits: 3

COURSE PREREQUISITES:

-

COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Ramtin Moeini
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
Phone Number:+98 (31) 37935293
Email Address: r.moeini@eng.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	1 h

COURSE OBJECTIVES

This course is designed to familiarize students with advanced theories and fundamental principles of open channel hydraulics, as well as analytical methods for addressing challenges associated with hydraulic structures.

REQUIRED STUDENT RESOURCES

Textbooks and References:

1. Novak P., Mofat A.I.B, Nalluri C. and Narayanan R. 2007, Hydraulic Structures , Taylor and Francis
2. USBR, 1973, Design of Small Dams
3. Peterka, A. J., 2005, Hydraulic Design of Stilling Basins and Energy Dissipators, USBR
4. Vischer D. L. and Hager W.H., 1998, Dam Hydraulics, Wiley
5. Sheng-Hong. C, 2015, Hydraulic Structures

Web links:

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COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Overview of Hydraulic Structures: Dams, Weirs, and Bridges
2	Factors Affecting the Selection of Dam Locations and Characteristics (hydrological, hydraulic, geological, geotechnical, structural)
3	Types of loads and loadings (water, under pressure, soil, structural, static, dynamic, earthquake, oscillations, drift, loads during construction, operational loads, stability control of landslides & overturning)
4	Dam components
5	Hydraulic design of gates (surface, pressurized, pressure fluctuations)
6	Hydraulic design of open spillways (weir edge, chute, step)
7	Hydraulic design of closed spillways (morning glory, siphon, lateral)
8	Cavitation (high-velocity pressure fluctuations, cavitation, aeration)

Week	Topic
9	Hydraulic design of small dams and weirs (body and spillway)
10	Hydraulic design of energy dissipation structures (stilling basin, plunge pools)
11	Seepage and seepage reduction methods (waterproofing the dam body, foundation, and abutment, dam wall)

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignment	10% of final grade
Project	25% of final grade
Mid-Term Exam	25% of final grade
Final Exam	40% of final grade
	100%

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SYLLABI ON WEB PAGES

Last update: September 2024.

EARTH AND ROCKFILL DAMS

BASIC INFORMATION

Place in Curriculum and semester: Core, S1
Number of credits: 3

COURSE PREREQUISITES:

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COURSE CO-REQUISITES:

-

TEACHERS:

The person in charge: Dr. Mahmoud Hashemi
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran.
Phone Number: +98 (31) 37935086
Homepage: http://eng.ui.ac.ir/~m.hashemi
Email Address: m.hashemi@eng.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 hrs	By appointment	-	By appointment

COURSE OBJECTIVES

This course intends to introduce the stages of studies, calculation methods and design principles, methods of construction, maintenance and understanding of the functions of earth and rockfill dams.
The course may be divided in 4 parts: dam parameters selection, slope stability analysis, seepage estimation, construction issues including filter, drainage etc.
In each chapter, the lectures begin with a brief historical & basic ideas and evolution of the method followed by introducing the framework of the problem & solution. To apply the theoretical methods, practical examples are examined then the various methods are compared and evaluated.
A set of consecutive related (chain) homeworks are given to students finally leading to a separate fully practical project. The ability of analyzing and merge the results with design methodologies are evaluated through an interview for the submitted project. The midterm and final exams are also present to examine the basic written design abilities.

REQUIRED STUDENT RESOURCES

Textbooks and References:

1. B. M. Das, K. Sobhan, “Principles of Geotechnical Engineering”, 8th edition, Cengage Learning, 2014
2. B. M. Das, “Advanced Soil Mechanics”, 3rd edition, Taylor & Francis, 2008
3. S. L. Kramer, “Earth and Rockfill Dams”, 3rd Edition, Prentice Hall, 1996.
4. S.K. Sarma, “Stability of Embankments and slopes”, Springer; 1st Edition, 2008.
5. S.K. Sarma, “Embankment Dams”, McGraw-Hill Professional; 1st Edition, 2001.
6. J.L. Sherard, R.J. Woodward and S.F. Gizienski, “Earth and Earth Rock Dams: Engineering Problems of Design and Construction”, 1st Edition , John Wiley & Sons Inc, 1963.
7. A.L. Goldin, “Design of Earth Dams (Geotechnika)”, Taylor & Francis; 1st Edition, 1992.

8. C. Kutzner, “Earth & Rockfill Dams”, Taylor & Francis; 1st Edition, 1997.

Web links:

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COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	General comments and history of different types of dams from the past until now and the importance of earth dams - an overview of the importance of the dam as a development project and its objectives
2	Types of dams, adaptation of dam type to site conditions, various options for earth and rockfill dams.
3	Different phases of earth and rockfill dam project studies, how to choose a suitable site, studies planning
4	Examining different sections in earth and rockfill dams by providing examples of built dams, determining the criteria for choosing dam sections with their details.
5	Classification of slope stability methods
6	Limit equilibrium methods including Fellenius (Swedish), Taylor, friction circle, Bishop and Bishop-Morgenstern
7	Examples of limit equilibrium methods - stability study of earth and rockfill dams
8	Review of seepage flow in soil, Darcy's law, soil permeability coefficient - vertical and horizontal equivalent permeability - laboratory and field permeability
9	Mathematical equation of seepage flow in soil - seepage flow network and rules for drawing it - calculation of seepage flow through soil
10	Methods of calculating seepage from earth dams - methods of drawing the phreatic line of seepage
11	Examples of seepage calculation methods
12	Filter and drain design methods
13	Examples of filter and drain design
14	Insitu and laboratory studies related to damsite and foundations (engineering geology, geophysics, geotechnics, drilling, tracing) - methods of improving alluvial, soil and rock foundations
15	Dam construction methods including construction management, required machineries, construction details, probable problems, experimental fills
16	Principles and rules governing the compaction of soils - the role of energy consumption in compaction, the theoretical curve of compaction, how to control the soil compaction operations

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignment	15% of final grade
Mid-Term Exam	25% of final grade
Final Exam	25% of final grade
Project	35% of final grade
	100%

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SYLLABI ON WEB PAGES

Last update: September 2024

HYDRODYNAMICS

BASIC INFORMATION

Course prefix and semester: Core, S1 or S2
Number of credits: 3

COURSE PREREQUISITES:

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COURSE CO-REQUISITES:

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TEACHERS:

Person in charge: Dr. Ahmad Shanehsazzadeh
Office location: Building no. 2, Faculty of Civil Engineering and Transportation, University of Isfahan, Azadi Sq., Isfahan, Iran
Phone Number: +98 (31) 37935328
Homepage: http://eng.ui.ac.ir/~a.shanehsazzadeh
Email Address: a.shanehsazzadeh@eng.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	1 h	-	-

COURSE OBJECTIVES

Students are expected to be familiar with the advanced fluids and two- and three-dimensional flows, including the Navier-Stokes equations, ideal flows, and basic boundary layer principles.

REQUIRED STUDENT RESOURCES

Textbooks and References:

1. Kundu, P.K. and I.M. Cohen (2004). Fluid Mechanics, Academic Press/Elsevier
2. Acheson, D.J. (1990). Elementary Fluid Dynamics, Oxford Press.
3. Liggett, J.A. (1994), Fluid Mechanics, McGraw Hill
4. Paterson, A. R.(1983). A First Course in Fluid Dynamics, Cambridge
5. Schlichting, H. (1975). Boundary-Layer Theory. (11 ed.) McGraw-Hill.
6. Sherman, F.S. (1990). Viscous flow. McGraw Hill.
7. Trittton, D.J.(1977) Physical Fluid Dynamics. Van Nostrand Reinhold (U.K.).
8. Van Dyke, M. (1982). An Album of Fluid Motion. Parabolic Press.
9. Guyon. E, Hulin. J.P, Petit .L, Mitescu. C.D. (2019)., Physical Hydrodynamics

Web links:

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COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1---2	Review of fluid mechanics topics: fluid kinematics and dynamics, including (viscosity, basic equation of fluid statics, compressibility, steady flow and unsteady flow, classification of flows from the perspective of velocity, integral flow equations, velocity and acceleration fields, types of motion and their causes in fluids (translational, rotational motions, and linear and shear deformations), etc.
3	Assessing methods of fluid flow, Euler and Lagrangian views, the concept of control volume, the general relationship expressing the relationship between the two views above. Derivation

Week	Topic
	of velocity field functions and obtaining the acceleration field and types of velocity vectors and acceleration vectors, the concept of tensor and introduction to the stress tensor.
4	Differential equations governing flow and the relationship between Euler's and Lagrangian perspectives and obtaining the continuity, and the momentum relations.
5	Definition of ideal flows and ideal fluid flow equations (extraction of continuity and motion equations, different forms of equations in different coordinate systems)
6	Ideal fluid flow (Eulerian relation, stream function, potential function, Bernoulli relation, application of analytical functions, two-dimensional potential flows, flow network)
7	Applications of ideal fluid flow (basic ideal flows including linear or simple ideal flow, fountain and well flow, vortex flow, and binary flow. And combining multiple simple flows, expression of ideal flows in porous media, overflow flow)
8	Concepts and functions of streamlines, potential lines, and streak lines in various steady and unsteady flow states.
9-10	Equivalent transformations and combinations of ideal basic flows to obtain applied flows (transformation of parallel flow into flow in a physical plane, flow at different angles, flow in a gap, flow around a cylinder, circular transition, flow around an ellipse, flow around a spindle-shaped body, flow around an airfoil, resultant force in a two-dimensional airfoil)
11-12	Viscose flow, proving of the Navier-Stokes equations based on the momentum forces, body forces, pressure change forces and viscous forces that are introduced as stress vectors on the element surface. (In different Cartesian, cylindrical and spherical coordinates). Solving practical examples in this relation such as flow in channels and flow in pipes in steady and unsteady states as well as uniform and non-uniform. Obtaining velocity profiles in simple laminar flows, viscous fluid flow and physical properties of the Navier-Stokes equation.
13	Definition of turbulent flows in fluids including definition of turbulence and its effect on velocity and acceleration fields, average velocity and oscillatory velocity, modification of Navier-Stokes equations in turbulent flows. Expression of the concept and equations of shear velocity. Division of flow layers and expression of Prandtl's laws. Roughness in turbulent flows and equations of turbulent velocity profile in fluid motion layers. Solution of practical examples in this regard. Estimation of shear stress, estimation of turbulence viscosity. Concept and definitions of rotation, vortices and circulation.
14	Boundary layer includes the concept of boundary layer, boundary layer thickness and velocity, Prandell's relation, simplification of continuity and Navier-Stokes equations in thin boundary layer, concepts and equations of displacement thickness and momentum thickness, velocity profile in boundary layer and similar and dissimilar velocity profiles in non-uniform flows, von Karman momentum integral equation at zero and non-zero pressure gradient, friction coefficients and exact solution of laminar boundary layer for zero pressure gradient, Blasius' exact method and reference to approximate solutions and the effect of pressure gradient.
15-16	Introduction to computational Fluid Mechanics (CFD)

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignment	10% of final grade
Mid-Term Exam	30% of final grade
Final Exam	60% of final grade
	100%

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SYLLABI ON WEB PAGES

Last update: September 2024.

RESEARCH METHODS

BASIC INFORMATION

Course prefix and semester: Core, S1
Number of credits: 2

COURSE PREREQUISITES:

-

COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Mohammadali Alijanian
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran.
Phone Number: +98 (31) 3793 5317
Email Address: m.alijanian@eng.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
2 h	-	-	-

COURSE OBJECTIVES

Students are expected to:

- ✓ become familiar with the scientific searching and indexing.
- ✓ become familiar with the methods of presentation and scientific speech.
- ✓ become familiar with the principles of writing research proposals and thesis.

REQUIRED STUDENT RESOURCES

Textbooks and References:

www.clarivate.com
www.scimagojr.com

Web links:

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Computer Software:

-

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic	Reading /Assignment
1	Definitions	-
2	Introducing research steps	HW1
3	Types of publications and research outcomes	-
4	Types of references and indexing	-
5	Indices for evaluation of research	-
6	Keys to searching and literature review	-
7	Keys to develop an introduction	HW2
8	Types of material and methods (in Engineering)	HW3
9	Keys to prepare scientific results	HW4
10	Keys to develop discussion, abstract or conclusions	HW5
11	Keys to prepare a presentation	HW6

Week	Topic	Reading /Assignment
12	Reviewing process and keys to prepare responses	-
13	Seminar by students	-
14	Seminar by students	-
15	Seminar by students	-
16	Presenting proposals	-

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignment	30 of final grade
Seminar	40% of final grade
Research proposal	30% of final grade
	100%

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SYLLABI ON WEB PAGES

Last update: September 2024

FINITE ELEMENT METHOD

BASIC INFORMATION

Course prefix and semester: Core, S1 or S2
Number of credits: 3

COURSE PREREQUISITES:

- Static analysis of structures
- Theory of elasticity
- Mathematics

COURSE PREREQUISITES AND CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Mahdi Zandi
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
Phone Number: +98 (31) 3793 5305
Homepage: http://eng.ui.ac.ir/~m.zandi
Email Address: s.m.zandi@eng.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	1 h

COURSE OBJECTIVES

1. Understand the Fundamentals of FEA
2. Learn the Mathematical Basis of FEA
4. Apply Boundary Conditions and Loads
5. Solve and Analyze FEA Problems
6. Develop Skills in FEA Software
7. Apply FEA to Real-World Engineering Problems
8. Prepare for Industry or Research

REQUIRED STUDENT RESOURCES

Textbooks and references:

1- O.C. Zienkiewicz and R. L. Taylor, “The Finite Element Method”, 7th edition, Butterworth-Heinemann; 2013.
2- O.C. Zienkiewicz and R. L. Taylor, “The Finite Element Method for Solid and Structural Mechanics”, 7th edition, Butterworth-Heinemann; 2013.
3- K.H. Huebner and D.L. Dewhirst, “The Finite Element Method for Engineers”, 4th edition, Wiley-Interscience; 2001.
4- I. M. Smith and D.V. Griffiths, “Programming the Finite Element Method”, 4th edition, Wiley; 2004.

Web links:

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Computer Software:

-SAP2000

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Introduction to the FEM

Week	Topic
2	Mathematical preliminaries
3	Different methods for function approximation
4	Approximate solution of differential equations
5	Weak form formulation of problems
6	2D & 3D elasticity formulation
7	Variational and energy methods
8	Shape functions, continuity, connectivity, …
9	Mapping and Jacobian
10	1D, 2D and 3D shape functions
11	Error in finite element method
12	Numerical integration
13	Domain and boundary integration
14	Plates and shells
15	Axisymmetric problems
16	FEM programing

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	10% of final grade
Project	30% of final grade
Mid-Term Exam	30% of final grade
Final Exam	30% of final grade
	100%

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SYLLABI ON WEB PAGES

Last update: September 2024.

ADVANCED GROUNDWATER

BASIC INFORMATION

Place in Curriculum and semester: Core, S2
Number of credits: 3

COURSE PREREQUISITES:

-

COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Mahmoud Hashemi
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
Phone Number: +98 (31) 37935086
Homepage: http://eng.ui.ac.ir/~m.hashemi
Email Address: m.hashemi@eng.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	1 h	-	1 h

COURSE OBJECTIVES

The course is aimed to make student familiar with the types of aquifers, basic concepts of groundwater flow, groundwater hydraulics in steady and unsteady conditions near the wells, analysis, modelling, attenuation and remediation of groundwater pollution.

Students are expected to learn:

- ✓ General and basic concepts: history, types of porous media (unconsolidated, jointed, karst), types of aquifers (unconfined, confined, leaky, perched) and their characteristics, history of exploiting groundwater with emphasis on Iranian qanat system
- ✓ Introduction on the modelling: continuum approach in porous media, hydrologic cycle, groundwater budget equation, groundwater data and how to measure, record and report it
- ✓ Concepts of groundwater flow: concepts of porosity, hydraulic conductivity, storage, permeability, heterogeneity and anisotropy in aquifers
- ✓ General groundwater flow: Darcy law and its application in one-dimensional groundwater flow problems, Dupuit-Forchheimer assumptions and their application in unconfined aquifer flow
- ✓ Analysis of groundwater flow: General groundwater equation in unconfined and confined aquifers, application of groundwater flow equation in steady one-dimensional groundwater flow problems, application of groundwater flow equation in unsteady one-dimensional groundwater flow problems, potential theory and flow nets, two-dimensional steady groundwater flow
- ✓ Hydraulics of groundwater flow in unconfined aquifer well: hydraulics of groundwater steady flow in aquifer well, hydraulics of groundwater unsteady flow in aquifer well, pumping-out test, flow near boundaries, image well method
- ✓ Hydraulics of groundwater flow in confined aquifer well: hydraulics of groundwater steady flow in aquifer well, hydraulics of groundwater unsteady flow in aquifer well, Theis equation, Cooper-Jacob method, recovery method, hydraulics of groundwater unsteady flow in leaky aquifer well, multiple well systems, partially penetrating wells

- ✓ Groundwater pollution: natural quality of groundwater, salinity of groundwater and its sources, physical, chemical and biological characteristics of groundwater, municipal, industrial and agricultural irrigation sources of groundwater pollution, solved and dissolved pollutants of groundwater, light non-aqueous phase liquids LNAPLs and non-aqueous phase liquids DNAPLs, methods for attenuation and remediation of groundwater pollution
- ✓ Analysis of groundwater pollution: advection-dispersion equation, groundwater pollutants, analytical solution for advection-dispersion equation
- ✓ Remediation of groundwater pollution: monitoring quality and quantity of groundwater, methods for remediation of aquifers with emphasis on conventional pump and treatment method
- ✓ Saline water intrusion: types of water salinity problems in aquifers, island and coastal aquifers, Ghyben-Herzberg relation for estimation of fresh-saline waters interface, effect of well in form of fresh-saline waters interface (Strack relation), upconing of fresh-saline waters interface due to well pumpage, equation of fresh-saline waters interface in oceanic island aquifers, control of saline water intrusion
- ✓ Numerical modelling of groundwater flow: various numerical models for solution of flow and solute transport equations, finite-difference method for solution of flow in steady and unsteady conditions, finite-difference method for solution of solute transport equation, introduction on MODFLOW and MT3DMS softwares, their related packages and applications

REQUIRED STUDENT RESOURCES

Textbooks:

1. Todd, D.K., Mays, L.W., Groundwater Hydrology, John Wiley & Sons, Inc. 2005. London, 273 p.

References:

1. Charbeneau, R.J., Groundwater Hydraulics and Pollutant Transport, Prentice-Hall, 2006.
2. Fetter, C.W., Applied Hydrogeology, Prentice-Hall, 2001.
3. Bedient, P.B., Rifai, H.S., Newell, C.J., Ground water contamination: transport and remediation, Prentice Hall 1994/1999.
4. Bear, J., Hydraulics of Groundwater, McGraw-Hill, New York, 1979.

Web links for Required Computer Softwares:

MODFLOW 6 v.6.2.2: USGS Modular Hydrologic Model

https://www.usgs.gov/software/modflow-6-usgs-modular-hydrologic-model

MT3D-USGS: Groundwater Solute Transport Simulator for MODFLOW

https://www.usgs.gov/software/mt3d-usgs-groundwater-solute-transport-simulator-modflow

The Groundwater Toolbox: A Graphical and Mapping Interface for Analysis of Hydrologic Data

https://www.usgs.gov/software/groundwater-toolbox-graphical-and-mapping-interface-analysis-hydrologic-data

PEST++, a Software Suite for Parameter Estimation, Uncertainty Analysis, Management Optimization and Sensitivity Analysis

https://pesthomepage.org/

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	General and basic concepts: history, types of porous media (unconsolidated, jointed, karst), types of aquifers (unconfined, confined, leaky, perched) and their characteristics, history of exploiting groundwater with emphasis on Iranian qanat system
2	Introduction on the modelling: continuum approach in porous media, hydrologic cycle, groundwater budget equation, groundwater data and how to measure, record and report it

Week	Topic
3	Concepts of groundwater flow: concepts of porosity, hydraulic conductivity, storage, permeability, heterogeneity and anisotropy in aquifers
4	General groundwater flow: Darcy law and its application in one-dimensional groundwater flow problems, Dupuit-Forchheimer assumptions and their application in unconfined aquifer flow
5	Analysis of groundwater flow: General groundwater equation in unconfined and confined aquifers, application of groundwater flow equation in steady one-dimensional groundwater flow problems, application of groundwater flow equation in unsteady one-dimensional groundwater flow problems, potential theory and flow nets, two-dimensional steady groundwater flow
6	Hydraulics of groundwater flow in unconfined aquifer well: hydraulics of groundwater steady flow in aquifer well, hydraulics of groundwater unsteady flow in aquifer well, pumping-out test, flow near boundaries, image well method
7	Hydraulics of groundwater flow in confined aquifer well: hydraulics of groundwater steady flow in aquifer well, hydraulics of groundwater unsteady flow in aquifer well,
8	Hydraulics of groundwater flow in confined aquifer well: Theis equation, Cooper-Jacob method, recovery method, hydraulics of groundwater unsteady flow in leaky aquifer well, multiple well systems, partially penetrating wells
9	Groundwater pollution: natural quality of groundwater, salinity of groundwater and its sources, physical, chemical and biological characteristics of groundwater, municipal, industrial and agricultural irrigation sources of groundwater pollution,
10	Groundwater pollution: solved and dissolved pollutants of groundwater, light non-aqueous phase liquids LNAPLs and non-aqueous phase liquids DNAPLs, methods for attenuation and remediation of groundwater pollution
11	Analysis of groundwater pollution: advection-dispersion equation, groundwater pollutants, analytical solution for advection-dispersion equation
12	Remediation of groundwater pollution: monitoring quality and quantity of groundwater, methods for remediation of aquifers with emphasis on conventional pump and treatment method
13	Saline water intrusion: types of water salinity problems in aquifers, island and coastal aquifers, Ghyben-Herzberg relation for estimation of fresh-saline waters interface, effect of well in form of fresh-saline waters interface (Strack relation)
14	Saline water intrusion: upconing of fresh-saline waters interface due to well pompage, equation of fresh-saline waters interface in oceanic island aquifers, control of saline water intrusion
15	Numerical modelling of groundwater flow: various numerical models for solution of flow and solute transport equations, finite-difference method for solution of flow in steady and unsteady conditions
16	Numerical modelling of groundwater flow: finite-difference method for solution of solute transport equation, introduction on MODFLOW and MT3DMS softwares, their related packages and applications

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignment	50% of final grade
Mid-Term Exam	20% of final grade
Final Exam	30% of final grade
	100%

ATTENDANCE STATEMENT

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SYLLABI ON WEB PAGES

Last update: September 2024.

WATER RESOURCE SYSTEM ANALYSIS

BASIC INFORMATION

Course prefix and semester: Core, S2
Number of credits: 3

COURSE PREREQUISITES:

-

COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Ramtin Moeini
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
Phone Number:+98 (31) 37935293
Email Address: r.moeini@eng.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	1 h

COURSE OBJECTIVES

Students are expected to:

- ✓ become familiar with the methods of modeling, analysis and evaluation of various issues in the field of water resources engineering and management

REQUIRED STUDENT RESOURCES

Textbooks and References:

1. D. P. Loucks, J.R. Stedinger, D.A. Haith, Water resource systems planning and analysis, Englewood Cliffs, N.J. : Prentice-Hall, First edition, 1981.
2. W. Hall, J. Darcup, Water resource system engineering, McGraw-Hill, NewYork, 1970.
3. L.W. Mays, Y.K. Tung, Hydro systems engineering and management, McGraw-Hill, NewYork, 1972.
4. C. Revelle, Optimizing reservoir resources: including a new model for reservoir reliability, John Wiley & Sons, NewYork, 1st edition, 1999.
5. J. Arora, Introduction to optimum Design, McGraw-Hill, 2004.
6. G. Hadley, Linear programming, Addison Wesley publishing company Inc., 1994.
7. N. Buros, Scientific allocation of water resources: water resources development and utilization-a rational approach, American Elsevier Publishing Company, 52 Vanderbilt Avenue, New York, 1971.
8. Dreyfus S.E., Averill, M.L., The art and theory of dynamic programming, Academic Press, 1977.
9. A.O. Esogbue, Dynamic programming for optimal water resources systems analysis, Prentice Hall Advanced Reference Series: Engineering, Englewood Cliffs, N.J. : Prentice-Hall, 1989.
10. C. Revelle, Optimizing reservoir resource: Including a New Model for Reservoir Reliability, John Wiley & Sons, INC. NewYork etc., 1999.

Web links:

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Computer Software:

Matlab, LINDO, LINGO, GAMS, MODSIM, WEAP, MIKE-BASIAN, HEC-ResPRM

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Presenting the syllables and policy regarding class absence, Generality (basic concepts of water resources planning, system concept and its components)
2	Generality (Systematic approach, Integrated water resources management (IWRM), index definition (such as sustainability)
3	System modeling (water resource system modeling challenges and advances, different methods of modeling, simulation and optimization methods)
4	Modeling steps, real examples of water resource management models (including surface and underground resource, qualitative and qualitative models)
5	Classical optimization (principles of optimization and optimality conditions, linear programming (LP) method, Linear optimization models)
6	Graphical method, simplex method, Big-M and II-phase methods, Dual model, sensitivity analysis
7	Network models: Basis and importance of network models, Shortest path model, Maximum flow model, Minimum spanning tree model, Critical path method
8	Nonlinear optimization and nonlinear programming (NLP) method (Lagrange method, Kuhn-Tucker condition, Necessary condition, constrained optimization problem)
9	Mixed integer linear and nonlinear programming methods, binary (Zero-one) problem
10	Dynamic programming (DP) method: basis of DP method and its theory, methodology of solving classical problem, forward and backward methods
11	Dynamic Programming (DP) method: inverted and non inverted forms, traveling salesman problem (TSP), water allocation problem, reservoir operation problem
12	Water storage volume determination of dam reservoir (Dead storage, active storage, surplus (flood) storage)
13	Active storage determination (simple methods, mass curves, Ripple, sequential peak method, simulation and optimization)
14	Water resource modeling (different water resource definition, single and multi objective models, single and multi purpose models)
15	Reservoir rule curves determination (standard operation policy (SOP), simulation, optimization)
16	Primary familiarized related software such as LINGO, LINDO, GAMS, MODSIM, WEAP, MIKE-BASIAN, HEC-ResPRM

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignment	10% of final grade
Project	20% of final grade
Mid-Term Exam	30% of final grade
Final Exam	40% of final grade
	100%

ATTENDANCE STATEMENT

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SYLLABI ON WEB PAGES

Last update: September 2024

ADVANCED ENGINEERING MATHEMATICS

BASIC INFORMATION

Course prefix and semester: Core, S2 or S3
Number of credits: 3

COURSE PREREQUISITES AND CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Mahmoud Hashemi
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran.
Phone Number: +98 (31) 37935086
Homepage: http://eng.ui.ac.ir/~m.hashemi
Email Address: m.hashemi@eng.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	1 h

COURSE OBJECTIVES

- The preparation of this course has been inspired by the following objectives:
- Advanced topics in engineering and applied mathematics
- Topics in differential equations, complex numbers theory, tensors and functional analysis

REQUIRED STUDENT RESOURCES

Textbooks and references:

1- P. V. O'Neil, “Advanced Engineering Mathematics”, 7th edition, Cengage-Engineering; 2011.
2- D. G. Zill and W. S. Wright, “Advanced Engineering Mathematics”, 4th edition, Jones & Bartlett Pub; 2009.
3- M. Greenberg, “Advanced Engineering Mathematics”, 2nd edition, Prentice Hall; 1998.
4- E. Kreyszig, “Advanced Engineering Mathematics”, 10th edition, Wiley, New York, 2011.
5- Hildebrand, FB. Methods of Applied Mathematics, Dover Publications, 1992.

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	course introduction, objectives, references, assignments; preliminary definitions; Fourier series; Euler’s formula
2	Fourier series convergence theorem; periodic functions of arbitrary period; Fourier series for even and odd functions; half-range expansion; solution of differential equations with Fourier series
3	approximation with trigonometric polynomials; Gibb’s phenomenon; Sturm-Liouville problems; orthogonality of functions; Fourier-Bessel and Fourier-Legendre series
4	Fourier integral; Fourier sine and cosine integral; Fourier transform; Fourier sine and cosine transforms; Fourier transform of derivatives of a function
5	complex Fourier integral; complex Fourier transform; introduction to partial differential equations; definitions for linear, non-linear, homogenous, inhomogeneous differential equations
6	wave equation; separation of variables method; D'Alembert’s method; heat transfer equation; Dirichlet and Neumann problems; solution of heat transfer problems with Fourier series
7	solution of heat transfer problems with Fourier integral; solution of membrane problem (2D wave equation); 2D Fourier series

Week	Topic
8	mid-term exam; complex numbers in Cartesian and polar coordinates; basic algebra on complex numbers; integer powers of a complex number; integer roots of a complex number
9	limits and derivatives of complex functions; analytic function; Cauchy-Riemann equations; exponential function; trigonometric functions; logarithm and general power
10	an introduction to complex integration; indefinite integration; Cauchy integral theorem; derivatives of analytic functions
11	series and sequences; convergence tests; power series; convergence of power series; functions given by power series
12	Taylor series; Maclaurin series; Taylor series convergence; functions given by Taylor series; uniform convergence
13	residue theorem; residue integration method; residue integration of real integrals; residue integration of improper integrals
14	conformal mapping; properties of conformal mappings in harmonic equations; using conformal mapping in solution of partial differential equations
15	an introduction to tensor calculus; properties of tensors; indicial notation; Cartesian tensors; tensor operations
16	an introduction to functional analysis; Euler-Lagrange equation; application of functional analysis in numerical methods such as Rayligh-Ritz

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	10% of final grade
Mid-Term Exam	40% of final grade
Final Exam	50% of final grade
	100%

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SYLLABI ON WEB PAGES

Last update: September 2024.

FRACTURE MECHANICS

BASIC INFORMATION

Course prefix and semester: Elective, S2 or S3
Number of credits: 3

COURSE PREREQUISITES:

Strength of Materials, Theory of Elasticity

TEACHERS:

Person in charge: Dr. Hamed Haftbaradaran
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
Phone Number: +98 (31) 37935616
Homepage: https://eng.ui.ac.ir/~h.haftbaradaran
Email Address: h.haftbaradaran@eng.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	1 h

COURSE OBJECTIVES

Students are expected to:

- ✓ be able to describe the general principles governing structural fracture subject to mechanical loading
- ✓ be able to apply the fundamental principles of fracture mechanics to predict crack growth
- ✓ become familiar with various fracture mechanics models

REQUIRED STUDENT RESOURCES

Textbooks and references:

1. Gdoutos E. E. Fracture Mechanics: An introduction, 2nd ed. Springer, 2005.
2. T. L. Anderson, Fracture Mechanics: Fundamentals and Applications, 3rd ed., Taylor & Francis, 2005.

Web links:

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Computer Software:

ABAQUS

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Elementary concepts, stress concentration around an elliptic hole, Inglis problem, energy considerations
2	Elasticity solution for a wedge, Williams problem, square root stress singularity
3	K-filed solutions for displacement and stresses, mode I and II cracks
4	Potential energy, Free energy, Surface energy, Griffith fracture criterion, Fracture energy
5	Potential energy calculations subject to fixed-loading or fixed-grips conditions
6	Surface energy, implications in liquids and solids
7	Giffith's experiments, size effects, theoretical strength vs. experimentally measured strength
8	Griffith fracture criterion applied to elastic solids, G-K Irwin's relationship
9	Applications of Griffith criterion: double-cantilever beam, and other examples
10	Application of Griffith criterion for fracture energy calculations
11	Small-scale yielding, Irwin-Orowan correction to the Griffith conditions, fracture process zone

12	Size of the plastic zone ahead of a crack tip, Strip yield model, Cohesive zone models, Equivalence of the Griffith criterion and cohesive models
13	Mode III fracture problem, Anti-plane elasticity problems, Laplace eqauion and its solutions using complex potentials, K-field solution in terms of complex potentials
14	Solution of some anti-plane problems in fracture mechanics using complex methods
15	J-integral and applications
16	Empirical Paris law for fatigue and life prediction

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignment	10% of final grade
Project	10% of final grade
Mid-Term Exam	30% of final grade
Final Exam	50% of final grade
	100%

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