M.Sc. GRADUATE PROGRAM

Graduate students must take 15-18 credits from compulsory courses, 6-9 credits from elective courses, 2 credit from seminar and 6 credits from thesis, overall 32 credits to receive M.Sc. degree.

Curriculum for the Degree of Master of Science in Civil Engineering, Major *Water Resources Engineering and Management*

COURSE CODE	COURSE TITLE	CREDITS
Semester I		
1610500	Engineering Mathematics	3
1614576	Advanced Hydrology	3
1614582	Water Resources Systems Analysis I	3
1614614	Hydroinformatics	3
Semester II		
Elective Courses from		
1614578	Numerical Methods in Water Engineering	3
1614597	Advanced Groundwater	3
1614628	Hydrologic Models	3
1614630	Flood and Draught Management	3
1614704	Water Resources Quality Models	3
Semester III		
9010503	Seminar	2
9010606	M.Sc. Project	6
Semester IV		
9010606	M.Sc. Project (Continue)	0

Ph.D. GRADUATE PROGRAM

The complete Ph.D. program consists of 15 units of coursework, 21 units of thesis and the students must pass the written and oral comprehensive exam after completion of their course works.

Curriculum for the Degree of Doctor of Philosophy in Civil Engineering, Major *Civil Engineering,* Minor *Water Resources Engineering and Management*

The complete Ph.D. program consists of 15 units of coursework and 21 units of thesis.

A - Courses: (15 Units)		
1614706	Water Resources systems Analysis II	3
1614708	Advanced Water and Wastewater Networks Design	3
1614712	Advanced Hydrogeology	3
1614714	Groundwater Protection and Management	3
1614716	Special Topics	3
At least 5 of these courses should be taken		
B - The Ph.D. students	must pass the written and oral comprehensive exam after completion of their coursework.	
C – Thesis (21 Units)		
9014724	Thesis	6
9014724	Thesis	6
9014724	Thesis	6
9014724	Thesis	3

COURSE DESCRIPTIONS

1610500 Engineering Mathematics
3 Cr.
Review on Basic Mathematics, Special Functions, Calculus of Variations, Difference Equations, Vectors and Matrices, Fourier Analysis, Partial Differential Equations, Complex Analysis.

Instructor: Dr. Mohammad Reza Chamani, Dr. Milad Aminzadeh

1614576 Advanced Hydrology
3 Cr.
To introduce further advanced topics of engineering hydrology to complement the undergraduate course. To analyze the conceptual and digital models for the simulation of the hydrologic processes in watersheds and for runoff prediction. More emphasis is given to application of the methods introduced in analyzing the hydrological processes. **Course Outline**: Review of Hydrology , Deterministic Lumped Unsteady Flow Models (Chap. 7), General system model, Response functions of linear systems, Unit hydrograph, Runoff hydrograph computation, Hydrologic Routing (Chap. 8), Lumped system, Reservoir routing methods, River routing, Hydrologic Design (Chap. 14 & 15): Design Storms, Design Flows, HEC-HMS (software), Application of Data-Driven Models in Hydrologic Processes (Handouts), Rainfall-Runoff process, Rainfall forecasting/disaggregating, Groundwater, Application of GIS in Hydrology .

Instructor: Prof. Hamid Reza Safavi

1614578 Numerical Methods in Water Engineering
3 Cr.
Introduction and Overview of Class, **Distributed Surface Flow Routin**g: Basic Equations and Classification of Models, Kinematic, Diffusion and Full Dynamic Eqs., Analytical and Numerical (FD) Solutions, **Physics of GW Flow, Finite Difference Method**, Steady State Flow (Laplace and Poisson's Eq.), Transient Flow, Solution Methods, **Finite Elements Method:** 1-D and 2-D Problems, Steady State Flow, Transient Flow, **Advanced Topics – Machine Learning Methods**, **Application of numerical methods in water engineering**: Surface Water Flow (open channel), Pipe Flow, Groundwater Flow.

Instructor: Dr. Keyvan Asghari, Dr. Mohammad Navid Moghim, Dr. Milad Aminzadeh

1614582 Water Resources Systems Analysis I
3 Cr.
Introduction: Water resources planning, The system concept and characteristics, Issues in hydrosystems engineering, Design vs. analysis, Conventional vs. optimization methods, Reservoir system operation, **Economics for Hydrosystems:** Engineering economic analysis, Evaluation of time streams of benefits and costs, **Simulation:** Water balance simulation of a reservoir, Reservoir/River system configuration and operation, **Deterministic Optimization:** Plan formulation, Objective functions and constraint equations, Lagrange multiplier, Linear Programming (LP), Forms of LP, Solution algorithms for LP, Simplex method, Artificial variable methods, Sensitivity analysis, Simulation/Optimization methods, Dynamic Programming (DP), Concepts, Recursive equations, Applications, Integer Programming (IP), Mixed-integer linear programming, Chance constraint models, **Search Methods:** Genetic algorithms (Evolutionary method), Artificial Neural Networks (Simulation method)

Instructor: Dr. Keyvan Asghari, Prof. Hamid Reza Safavi, Dr. Mohammad Hossein Golmohammadi

1614597 Advanced Groundwater
3 Cr.
Introduction to Groundwater flow. Properties of aquifers: porosity, hydraulic conductivity, specific yield, specific storage, transmissivity. Basic assumptions, Darcy's law, Solution of flow equations, Un-steady flow in aquifers (confined and unconfined). Regional groundwater flow, Transient flow in regional groundwater systems, Groundwater flow to wells. Soil moisture and groundwater recharge, Theory of unsaturated flow. Interaction of groundwater and surface water (lakes, wetland and rivers). Groundwater flow modeling techniques, simulation of two and three-dimensional groundwater systems. Numerical methods in groundwater flows (finite differences), different initial and boundary conditions, stability of scheme. MODFLOW- 2000 Description, Space and time discretization, External source and stress, Solver packages, Case study. Management of groundwater, Concepts of basin management. Conjunctive use of surface water and groundwater, optimal control groundwater management models.

Instructor: Prof. Hamid Reza Safavi, Dr. Mohammad Hossein Golmohammadi

1614614 Hydroinformatics
3 Cr.

Instructor: Dr. Azadeh Ahmadi

1614628 Hydrologic Models
3 Cr.

General and basic concepts, describing the model, process modeling, hydrological modeling history, hydrological models classification, catchment models, physical models, white box models, conceptual models, gray box models, data-driven models, black box models, Rainfall-runoff modeling, modeling of rainfall and losses, watershed characteristics, surface flow modeling, base flow modeling, Hydrological data evaluation, data selection and classification, model evaluation criteria, results consistent with the observed output, Nash-Sutcliffe criterion, evaluation of hydrologic models, simple calibration, automatic calibration using optimization model, model verification, sensitivity analysis of model parameters, Uncertainty analysis (sources of uncertainty, variety of hydrologic uncertainties, inherent, model parameter uncertainty, uncertainty analysis using approximate analytical methods and Monte Carlo, Introducing artificial neural networks and its application in modeling, development of neural networks for rainfall-runoff modeling, MATLAB application in neural network model preparation, Considerations of catchment models development, The introduction of catchment models such as HEC-HMS, SWMM, TR-20, TANK, HBV, Modeling a case study in a river basin and work with introduced models.

Instructor: Dr. Azadeh Ahmadi

1614630 Flood and Drought Management
3 Cr.

An introduction to the importance of flood and drought effects in water resources management, early definitions of flood and drought, categorization of direct and indirect damages caused by flood and droughtt, integrated approaches to extreme hydrological events and the need for comprehensive management in flood and drought risk management, drought conditions adaptability, overview on hydraulic and hydrology of flood plain, modeling of extreme rainfall events and their effects on runoff and groundwater recharge, extraction of rainfall hyetographs, extraction of flood hydrographs, flood zoning in the rivers, and the description of national and international standards in this field, an explanation of structural and non-structural methods in the field of flood control, management of reservoirs in flood conditions, computational methods for determination of the bed and boundaries of rivers, monitoring of the rules and standards for the determination of the bed and boundaries of surface water resources, designing methods for controlling of flood by means of risk analysis, analysis of uncertainty in the design of various methods, structural and non-structural methods for flood control, causes of drought, effective parameters and drought indicators, regional and drought zonation, frequency analysis and prediction of duration, extent and duration of droughts, management of surface water resource and groundwater resources in drought conditions, water resources management of supply and demand during drought conditions, adaptation to water scarcity and drought management.

Instructor: Prof. Hamid Reza Safavi

1614704 Water Resources Quality Models
3 Cr.

Instructor: Dr. Azadeh Ahmadi

1614706 Water Resources systems Analysis II
3 Cr.
The course will focus on the quantitative approach for identifying and evaluating alternative possible decisions and their physical, economic, environmental, and social impacts of water resources systems. Modeling methods include various deterministic and probabilistic optimization and simulation models, decision analysis, evolutionary search algorithms and multiobjective planning and management models.

Instructor: Dr. Keyvan Asghari

1614708 Advanced Water and Wastewater Networks Design
3 Cr.

Introduction to water supply systems and sewer systems in urban areas, Basics for designing water network systems, water supply resources, transmission lines, treatment plants, and tanks, Hydraulic principles and technical constraints in the design of urban water distribution networks, Optimization of water supply networks using new search algorithms, Hydraulic basics of wastewater and urban runoff collection systems, Optimization of sewer systems and urban runoff collection systems using new search algorithms, Governing equations of unsteady flows in pumping systems and numerical solution methods, Water hammer and its control methods in pumping systems, Optimization of pumping systems in unsteady flow condition.

Instructor: Prof. Hamid Reza Safavi

1614712 Advanced Hydrogeology
3 Cr.
Basic assumptions: Darcy's law, Solution of flow equations, Unsteady flow in aquifers (confined and unconfined), Unsaturated flow in porous media and soil moisture profile, Regional groundwater flow: Steady and transient flow in regional groundwater systems, Interaction of groundwater and surface water (lakes, wetland and rivers), Groundwater flow modeling: techniques, simulation of two and three-dimensional groundwater systems, Groundwater modeling in the complex hydrosystem, Numerical methods in groundwater flows (finite differences), different initial and boundary conditions, Stability of schemes, Management of groundwater: Concepts of basin management, Conjunctive use of surface water and groundwater: Optimal control groundwater management models, Case study.

Instructor: Prof. Hamid Reza Safavi

1614714 Groundwater Protection and Management
3 Cr.
Introduction and investigation of the importance of groundwater management in the hydrology cycle with emphasis on arid and semi-arid regions, Quantitative and qualitative crises of groundwater resources in the country and the need to restore and balance, Interaction equations of surface and groundwater resources, Groundwater regulatory frameworks, laws and standards, Groundwater management and conservation, quantitative determination, groundwater artificial recharge, Groundwater quality protection, Groundwater vulnerability, Contaminated groundwater restoration, Methods and evaluation of aquifer restoration operations, Application of new algorithms in simulation and optimization of groundwater resource, groundwater system modeling and management softwares.

Instructor: Prof. Hamid Reza Safavi