

DELHI TECHNOLOGICAL UNIVERSITY
SCHEME OF TEACHING AND EVALUATION
MASTER OF TECHNOLOGY IN HYDRAULICS & WATER RESOURCES ENGINEERING (HWE)

The following alphanumeric coding scheme has been adopted

Core Courses XXXYMN

Elective Courses XXXYCMN

XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1st year, 6 for M. Tech. 2nd year),

C – credit of the course (4/3/2),

MN – Subject code (Odd number for odd semester and even number for even semester courses)

Semester-I														
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	HWE501	Computational Hydraulics	Core	4	3	0	2	15	25	20	40	-	17
	2	HWE503	Advanced fluid Mechanics	Core	4	3	0	2	15	25	20	40	-	
Group B	3	HWE5401/5403/..	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	HWE5301/5303/..	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	HWE5201/5203/../ UEC5201/5203/.	Elective 3/University Elective I	Elective	2	2	0	0	20	-	30	50	-	
Semester-II														
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	HWE502	Water Resources Systems Planning and management	Core	4	3	0	2	15	25	20	40	-	17
	2	HWE504	Advanced open channel Hydraulics	Core	4	3	0	2	15	25	20	40	-	
Group D	3	HWE5402/5404/..	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	HWE5302/5304/..	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	HWE5202/5204/../ UEC5202/5204/.	Elective 6/University Elective II	Elective	2	2	0	0	20	-	30	50	-	
Semester-III														
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Track 1														12
Group E	1	HWE651	Research Project	Core	12	0	0	12	0	-	0	100	0	

Track 2														
1	HWE601	Major Project I	Core	3	0	0	6	0	-	0	100	0		
2	HWE6401/6403/...	Elective 7	Elective	4	3	0	2	15	25	20	40	-		
3	HWE6301/6303/...	Elective 8	Elective	3	3	0	0	20	-	30	50	-		
4	HWE6201/6203/...	Elective 9	Elective	2	2	0	0	20	-	30	50	-		
Semester-IV														
S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits	
Group F	Track 1													12
	1	HWE652	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
1	HWE602	Major Project II	Core	12						40	60			

List of Elective Courses

LIST OF ELECTIVES :													
S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
Elective 1	1	HWE5401	Advanced Hydrology	Elective	4	3	0	2	15	25	20	40	-
	2	HWE5403	Environmental Hydraulics		4	3	0	2	15	25	20	40	-
	3	HWE5405	Coastal Engineering		4	3	0	2	15	25	20	40	-
	4	HWE5407	Systems Engineering		4	3	0	2	15	25	20	40	-
S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
Elective 2	1	HWE5301	Water Power Engineering	Elective	3	3	0	0	20	0	30	50	-
	2	HWE5303	Geotechnical Earthquake Engineering		3	3	0	0	20	0	30	50	-
	3	HWE5305	Sediment Transport		3	3	0	0	20	0	30	50	-
	4	HWE5307	Water and Soil Conservation Engineering		3	3	0	0	20	0	30	50	-
S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
Elective 3	1	HWE5201	Seminar	Elective	2	0	0	2	-	100	-	-	-
	2	HWE5203	Environmental System Modelling		2	2	0	0	20	0	30	50	0

	3	HWE5205	Engineering Risk Analysis		2	2	0	0	20	0	30	50	0
	4	HWE5207	Urban Water Infrastructure		2	2	0	0	20	0	30	50	0
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	HWE5402	Design of Flood Control and River Training Works	Elective	4	3	0	2	15	25	20	40	-
	2	HWE5404	Irrigation and Drainage Engineering		4	3	0	2	15	25	20	40	-
	3	HWE5406	Hydrometeorology		4	3	0	2	15	25	20	40	-
	4	HWE5408	Hydro-informatics and Simulations		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	HWE5302	MINOR PROJECT	Elective	3	0	0	-	-	40	-	-	60
	2	HWE5304	Applications of GIS and Remote Sensing in Water Resources Engineering		3	3	0	0	20	-	30	50	-
	3	HWE5306	Soil Structure Interaction		3	3	0	0	20	-	30	50	-
	4	HWE5308	Disaster Mitigation and Management		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	HWE5202	Ground Water Hydrology	Elective	2	2	0	0	20	0	30	50	-
	2	HWE5204	Transients in Pipes		2	2	0	0	20	0	30	50	-
	3	HWE5206	Offshore Geotechnical Engineering		2	2	0	0	20	0	30	50	-
	4	HWE5208	Waste to Energy		2	2	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	HWE6401	Design of Hydraulic Structures	Elective	4	3	0	2	15	25	20	40	-
	2	HWE6403	Environmental Impact Assessment		4	3	0	2	15	25	20	40	-
	3	HWE6405	Water pollution control and stream Sanitation		4	3	0	2	15	25	20	40	-
	4	HWE6407	Stability Analysis of Slopes		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	HWE6301	Water Resources Economics	Elective	3	3	0	0	20	-	30	50	-
	2	HWE6303	An Introduction to Sustainable development		3	3	0	0	20	-	30	50	-

SEMESTER I

Courses

HWE501 Computational Hydraulics

Introduction to Computational Fluid Dynamics and Principles of Conservation: Continuity Equation, Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations, Classification of Partial Differential Equations and Physical Behaviour. Approximate Solutions of Differential Equations: Error Minimization Principles, Variational Principles and Weighted Residual Approach, Fundamentals of Discretization: Finite Element Method, Finite Difference and Finite Volume Method, Finite Volume Method: Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems, Boundary Condition Implementation and Discretization of Unsteady State Problems, Important Consequences of Discretization of Time Dependent Diffusion Type Problems.

Stability Analysis: Consistency, Stability and Convergence, LAX Equivalence theorem, Grid independent and time independent study, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): FTCS (Forward time central space) scheme, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): CTCS scheme (Leap frog scheme), Dufort-Frankel scheme, Stability analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes. Finite Volume Discretization of 2-D Unsteady State Diffusion Type Problems, Solution of Systems of Linear Algebraic Equations: Elimination Methods, Iterative Methods, Gradient Search Methods. Discretization of Convection-Diffusion Equations: A Finite Volume Approach, Discretization of Navier Stokes Equations: Stream Function Vorticity approach and Primitive variable approach, SIMPLE Algorithm, SIMPLER Algorithm, Unstructured Grid Formulation, Introduction to Turbulence Modelling.

Suggested Books:

1. Anderson, Computational Fluid Mechanics and Heat Transfer, McGraw Hill, 1984.
2. T. J. Chung, Finite Element Analysis in Fluid Dynamics, McGraw Hill, 1978.
3. Anderson, & Weessner, Applied Groundwater Modelling , Academic Press, 1992.
4. H. M. Chaudhary, Applied Hydraulic Transient, McGraw Hill, 1976.
5. Streeter and Wylie, Fluid Transients, McGraw Hill, 1976.

HWE503 Advanced Fluid Mechanics

Kinematics of Flow: Equation of continuity in Cartesian, polar and cylindrical coordinates, Standard 2D Flow Patterns: Source, sink, doublet and their combinations, construction of flows by superposition, D'Alembert's paradox. Modelling and dimensional analysis: Introduction, Dimensional Homogeneity Methods of Dimensional analysis, Model Analysis like types of similarity, Types of forces acting on moving fluids, Dimensionless numbers, Classification of models and Model laws.

Laminar Flow: Derivation of Navier-Stokes equations – exact solutions for flow between parallel plates, Couette flow, flow near a suddenly accelerated plate and an oscillating plate. Boundary Layers: introduction, types of boundary layer Drag force on Flat plate due to boundary layer analysis of turbulent boundary layer, separation in boundary layer under adverse pressure gradient and methods of preventing of the separation

of boundary layer. Fundamentals of compressible flows: Introduction, Thermodynamics Relations. Basic equations of compressible flow, velocity of sound or pressure wave in a fluid, Mach number.

Suggested Books:

1. F.M. White, Fluid Mechanics, McGraw-Hill, 1979.
2. H. Schlichting, Boundary Layer Theory, McGraw-Hill, 1979.
3. R.J. Garde, Turbulent Flow, Wiley Eastern Limited, 1994.
4. S. B. Pope, Turbulent Flows, Cambridge University Press, 2000.
5. H. Rouse, Advanced Mechanics of Fluids, John Wiley and Sons, 1959.

HWE5401 Advanced Hydrology

Introduction: Hydrologic system and hydrologic budget, fundamental laws of hydrology; atmospheric water vapour. Hydrologic Inputs: Precipitation and its forms, snowfall and rainfall; measurement techniques and space-time characteristics. Hydrologic Abstractions: Infiltration, depression storage, evapotranspiration; measurement techniques, space time characteristics and their modelling. Stream flow: Measurement techniques, space-time characteristics, rating curves System Approach: Unit Hydrograph IUH, GIUH. Mathematical Modelling: Linear and Nonlinear models, Physically based models. Hydrological routing, Flood forecasting. Advanced Method of Frequency Analysis: Outliers, Time series analysis. Impact of climate change and Land use/Land cover on basin response.

Suggested Books:

1. V.T. Chow, D.R. Maidment and W.L. Mays, Applied Hydrology, McGraw Hill, 1988.
2. C.S.P. Ojha, R. Berndtsson and P. Bhunya, Engineering Hydrology, Oxford University Press, 2008.
3. M. Wanielista, R. Kersten and R. Eaglin, Hydrology, John Wiley, 1997.

HWE5403 Environmental Hydraulics

Introduction and scope, review of basic principles of engineering fluid mechanics, continuity, momentum, and energy equations, steady flow through pipes- hydraulic gradient and total energy line, basics of open channel flow; Ground water, well hydraulics, well design and constructions, Parallel, compound and equivalent pipes, head losses in pipes, design of pressurized Conduits. Various forms of mixing in the environment, modeling of the mixing process: advection dispersion equation, Various forms of advection dispersion eq. and its solution. Special cases of mixing, density stratified flow, tide, etc. Mass transfer in gas-liquid and liquid -liquid system with special emphasis on aeration

Suggested Books:

1. J.A. Roberson, J.J. Cassidy, M.H. Chaudhry, Hydraulic Engineering, 2nd Edition, Wiley, 1998.
2. A. Chadwick, J. Morfett, M. Borthwick, Hydraulics in Civil and Environmental Engineering, 5th Edition, CRC Press, 2004.
3. C. C. Lee, S.D. Lin, Handbook of Environmental Engineering Calculations, McGraw Hill, 2007.
4. J.L. Schnoor, Environmental Modeling: Fate of Chemicals in Water, Air and Soil, John Wiley & Sons, New York, 1996.

HWE5405 Coastal Engineering

Definition-wave classification-linear theory of waves-assumptions and derivations of relationship of wave characteristics-pressure within a progressive wave, wave energy, energy flux-wave. Decay-Transformation of Waves-Fundamental aspects of Stokes theory. Reflection, Refraction, Diffraction of Wave-Breaking of waves-types, criterion and importance of breaking- wave force on structure-vertical, sloping, curved and stepped barrier-force due to non-breaking, breaking and broken Waves-Force on piles. Need for forecasting- SMB and PNJ methods of wave forecasting. Origin and classification of tides Karwin's equilibrium, theory of tides-effects on structure-seiches and tsunamis. Types of sediment and movement-types of beaches and beach profile. Long Shore drift and its engineering significance. Causes of coastal erosion and methods of protection.

Suggested Books:

1. R. M. Sorensen, Basic Coastal Engineering, Chapman & Hall, New York, 1997.
2. A. Wantanabe, M. Isobe, & N. Kraus, International Handbook Of Coastal Engineering and Management, Academic, 1999.
3. R. L. Wiegel, Oceanographical Engineering, Prentice-Hall, 1964.
4. R. Silvester, Coastal Engineering, Elsevier, 1974.

HWE5407 Systems Engineering

Definitions and components of a system, system control, systems modelling and model development. System synthesis, economic analysis. Conflicts and role of optimization in Systems resolution. Unconstrained optimization –analytical and numerical. Constrained optimization analytical and numerical. Integer programming. Geometric programming. Linear programming. Dynamic programming. Stochastic programming.

Suggested Books:

R.J. Aguilera, Systems Analysis and Design, Prentice Hall, 1973.
P. J. Ossenbruggen, Systems Analysis for Civil Engineering, John Wiley, 1984.
R. De Neufville, Systems Analysis for Engineer, McGraw Hill, 1971.
S.S. Rao, Engineering Optimization – Theory and Practice, New Age International Ltd, 1999.

HWE5301 Water Power Engineering

Introduction: Development of water power, Estimation of Hydropower potential, Comparison of Hydro, thermal and nuclear power, Flow duration curve, firm power, secondary power, Load and Load duration curves, Load factor, etc. Types of Hydropower Plants: Classification of hydropower plants, Run-of-river plants, Valley dam plants, High head diversion plants, Diversion Canal plants, Pumped storage plants, Tidal power plants. Water Conveyance System: Power canals, Alignment, Design of power canals, Flumes, Covered conduits and tunnels, Drainage and ventilation in tunnels. Penstocks: - Alignment, types of penstocks, economic diameter of penstocks, Anchor blocks. Fore bay, Intakes, Balancing Reservoir, Escape, Surge Shafts/ Inclined Shafts. General Layout of power house and arrangement of hydropower units. Underground Power Stations.

Dams: Selection of site, preliminary investigations, Final investigations, Types of dams: - Rigid dams, Gravity dams, Arch and buttress dams, Basic principles of design and details of construction. Earthen dams, rock fill dams, Design considerations. Spillways: Types, spillway gates, Design of stilling basins. Types of Turbines and their utility: Hydraulic Turbines, Classification Based on Head, Discharge, Turbines, Differences between Impulse and Reaction Turbines, choice of Type of Turbine-Specific Speed. Component Parts & Working Principles of a Pelton Turbine and Francis Turbine.

Suggested Books:

1. D.P. Loucks , J.R. Stedinger, and D.A. Haith , Water Resources Systems Planning and Analysis, 1st Ed., Prentice Hall, 1981.
2. C.S. ReVelle , E.E. Whitlatch Jr and J.R. Wright, Civil and Environmental Systems Engineering, Pearson Prentice Hall, 2004.
3. L.D. James and R.R. Lee, Economics of Water Resources Planning, McGraw-Hill, 1971
4. A. A. Smith, E. Hinton and R.W. Lewis, Civil Engineering Systems Analysis and Design, John Wiley and Sons, 1983.

HWE5303 Geotechnical Earthquake Engineering

Introduction to engineering seismology, seismic risks and hazards, causes and strength of earthquakes, social and economic consequences, Theory of dynamic and seismic response, the nature and attenuation of earthquake magnitude, Ground motion, determination of site characteristics, local geology and soil condition, Determination of design earthquake, response spectra and accelero-grams Site response to earthquake site investigation and soil test; dynamic behaviour of soils, liquefaction and cyclic mobility, analysis of pore pressure development In-situ test for liquefaction, Analysis and design of slopes, embankments, seismic response of soil structure system, foundation, Earth retaining structures for seismic loading, case histories, mitigation techniques.

Suggested Books:

1. Steven Kramer, Geotechnical Earthquake Engineering, Pearson, 1996.
2. F. Naeim, The Seismic Design Handbook, Kluwer Academic Publication, 2ndEdition, 2001.
3. J.M Ferrito, Seismic design criteria for soil liquefaction, Tech. Report of Naval Facilities service centre, Port Hueneme, 1997.

HWE5305 Sediment Transport

Introduction of sediment transport, sediment problems, properties of sediments, incipient motion of uniform and non-uniform sediments. Bed forms and channel resistance. Bed load and suspended load transport for uniform and non-uniform bed material, total load equations, sediment sampling. Stable channel design and sediment control. Bed level variations, local scour, degradation, aggradation and reservoir sedimentation. Physical and mathematical models. Design of guide bunds and other river training banks.

Suggested Books:

1. R.J. Garde, River Morphology, New International Publishers, 2006.
2. P.Y. Julien , Erosion and Sedimentation, Cambridge University Press, 1998.
3. P.P.H. Jansen , Principals of River Engineering, VSSD Publications, 1994.
4. R.J. Garde and K.G.R. Raju , Mechanics of Sediment Transportation and Alluvial Stream Problems, Wiley Eastern Limited, 2006.

HWE5307 Water and Soil Conservation Engineering

Water conservation: Rain water harvesting techniques, water shed development, ground water recharging, check dams, reservoirs and aquifers, Control of infiltration, seepage and evaporation, control of effluent and waste water disposal, control of agricultural runoff and siltation. Plan utilisation of water resources, flood plains zone management, reuse and recycling of treated waste water, effluent irrigation. Soil Conservation: Introduction to soil erosion, mechanisms and its causes and control, sheet erosion, rill erosion, gully erosion, control of erosion by bunding, terracing, contour trenching, gully stabilizing, check dams, drop spillways, chute spillways. Grass land management and forest management, reclamation of saline and usher soils, remediation of contaminated soils.

Suggested Books:

1. Soil survey manual - All India soil & land use survey organization.
2. Soil taxonomy, basic system of soil classification for making & interpreting soil survey, Agriculture Handbook No. 36, Nbss & Lup Publication New Delhi.
3. Soil & water conservation engineering by Schwab, Fravert Edminster & Barnes John Wiley and Sons Publication.
4. Soil conservation in India I.C.A.R. New Delhi, Ramarao, M.S.V. - 1962.

HWE5201 Self-Study Open Area Seminar**HWE5203 Environmental System Modelling**

Introduction to natural and manmade systems, managerial requirements. Application of package programmes such as dBASE, GIS in data base management, Operational aspects and environmental auditing. Determinate and structure modelling applications: Models of waste collection systems and treatment systems, models of water quality and contamination, models of solid waste collections.

Suggested Books:

1. R.V. Thomann and J.A. Mueller, Principles of Surface Water Quality Modelling and Control, Harper and Row, 1987.
2. Chapra, C. Steven, Surface Water Quality Modelling, Mc Graw Hill, 1997.
3. Hammer, J. Mark, Water and Wastewater Technology, John Wiley, 1977.
4. H.S. Peavy, R.R. Donald and G. Tchobanoglous, Environmental Engineering, Mc Graw Hill, 1986.

HWE5205 Engineering Risk Analysis

Application of probability theory and statistics in planning, analysis and design of civil engineering systems. Development of probabilistic models for risk and reliability evaluation, occurrence models, extreme value distributions. Analysis of uncertainties, introduction to Bayesian statistical decision theory and its application in engineering. Decision making. Risk evaluation and management of engineering systems.

Suggested Books:

1. A. Hoyland, and M. Rausand, System Reliability Theory. Hoboken, NJ: Wiley-Interscience, 1994.
2. H. Tehler, A general framework for risk assessment, Department of Fire Safety Engineering and Systems Safety, Lund University, Sweden, 2013.

3. G. Apostolakis, How Useful is Quantitative Risk Assessment, 2004.
4. Institute of Chemical Engineers, Guidelines for Chemical Process Quantitative Risk Analysis, New York, 2000.

HWE5207 Urban Water Infrastructure

Urban water cycle, Urban water infrastructures - water supply, storm water drainage, sanitation, sewerage and wastewater conveyance infrastructures. Water supply and sewerage network hydraulics, SCADA systems, Sustainable urban designs, Methodologies for assessing sustainability of urban water infrastructures, Emerging sustainable materials and design procedures for water supply and sewerage pipelines. Hydraulic performance and structural strength, chemical resistance and resilience characteristics of emerging materials based water and sewer pipelines, Rehabilitation and augmentation technologies for water supply and sewerage networks, Analytic hierarchy process and optimization techniques for arriving at the best appropriate rehabilitation/ augmentation technology. Urban water management, Rain water harvesting, Managed aquifer recharge, Constructed/engineered wetlands, Sprinkler and drip irrigation, Water use efficiencies, Effect of water management practices on urban water infrastructure. Hydrology and groundwater regime, Surface and subsurface mapping of water supply and sewerage networks, Structural safety and mitigating plans against natural and human caused threats.

Suggested Books:

1. N.S. Grigg, Water, Wastewater, and Storm water Infrastructure Management, Second Edition, CRC Press, 2012.
2. T.R. Lazaro, Urban Hydrology, CRC Press, 1990.
3. WEF and ASCE, Existing Sewer Evaluation and Rehabilitation, McGraw-Hill, 2009.
4. A.K. Keshari, Rainwater Harvesting. Water Digest, 2006.
5. S.W. Smith, Landscape Irrigation: Design and Management, 1st Edition, Wiley, 1996.
6. T.L. Saaty, Decision Making for Leaders, 3rd Revised Edition, RWS Publications, 2012.
7. L.W. Mays, Hydraulic Design Handbook, McGraw-Hill, 1999.

SEMESTER II

HWE502 Water Resources Systems Planning & Management

Introduction: Water resources planning process, multi-objective planning. Evaluation of Water Plans: Basic concepts of engineering economics, welfare economics, economic comparison of alternatives. Water Plan Optimization: Plan formulation, objective functions and constraint, analytical optimization, numerical optimization, linear programming, dynamic programming, simulation, planning under uncertainty. Deterministic River Basin Modelling: Stream flow modelling, estimation of reservoir storage requirements – dead storage, active storage for water supply/ irrigation / power generation, flood storage. Optimal allocation. Conjunctive Use/Groundwater Management Models: LP based conjunctive use modelling, aquifer response models, link - simulation, embedded, matrix response based models, soft modelling. Water Quality Management Models: Basic water quality modelling, objectives of management, control alternatives, optimal plans.

Suggested Books:

1. W.A. Hall and J.A. Dracup, Water Resources Systems Engineering, McGraw Hill Book Company, 1970.

2. D.P. Loucks, Water Resource Systems Planning and Analysis, Prentice Hall, 1981.
3. Maass et al., Design of Water-Resource Systems, Harvard University Press, 1962.
4. S. Vedula and P.P. Mujumdar, Water Resources Systems, Tata McGraw Hill, 2005.

HWE504 Advanced Open Channel Hydraulics

Open Channel Flow: Kinds of open channel flow, channel geometry, types and regimes of flow, Velocity distribution in open channel, wide open channel, specific energy, critical flow and its computation. Energy in non-prismatic channel, momentum in open channel flow, specific force. Qualification of uniform flow, velocity measurement, Manning's and Chezy's formula, determination of roughness coefficients. Determination of normal depth and velocity, most economical sections, non-erodible channels. Flow in a channel section with composite roughness, flow in close conduit with open channel flow. **Varied Flow:** Dynamic equations of gradually varied flow, assumptions and characteristics of flow profiles, classification of flow profile, draw down and back water curves profile determination, graphical integration, direct step and standard step method, numerical methods, flow through transitions **Varied Flow:** Dynamic equation of spatially varied flow. Analysis of spatially varied flow profile, computation of spatially varied flow using numerical integration. **Unsteady Flows:** St. Venant's equations and their solution using method of characteristics and finite difference schemes; dam break problem, hydraulic flood routing. **Channel Transitions:** Sub-critical and supercritical.

Suggested Books:

1. V.T. Chow, Open Channel Hydraulics, McGraw Hill, 1959.
2. M.H. Choudhary, Open-Channel Flows, Prentice-Hall, 1994.
3. K.G. Ranga Raju, Flow Through Open Channels, Tata McGraw Hill, 2003.
4. H. Chanson, The Hydraulics of Open Channel Flow: An Introduction, Elsevier, 2004.

HWE5402 Design of Flood Control and River Training Works

Basic causes of flood: Flood prone areas in India and their problems, case history of some important river basins of India. Engineering and administrative methods of flood plain regulation. Economic aspects of flood control schemes, cost benefit analysis. Flood forecasting, flood warning and flood fighting. Morphological study of river behaviour. Theories of river meandering and river regimes. Necessity, principles and methods of river training. Case history of river training works in India and abroad. Design of Levees, Groynes, Cut-offs and Guide bunds etc. River training works for different hydraulic structures.

Suggested Books:

1. R.J. Garde, River Morphology, New International Publishers, 2006.
2. P.Y. Julien, Erosion and Sedimentation, Cambridge University Press, 1998.
3. P.P.H. Jansen, Principals of River Engineering, VSSD Publications, 1994.
4. R.J. Garde and K.G. Ranga Raju "Mechanics of Sediment Transportation and Alluvial Stream Problems" Wiley Eastern Limited, 2006.

HWE5404 Irrigation and Drainage Engineering

Water Resources of India - Irrigation- Need, Advantages and Disadvantages, History of Irrigation development in India- National Water Policy- Inadequacy of Irrigation Management- Criteria for good Irrigation management. Introduction: Water resources planning process, multi-objective planning. Soil physical properties influencing Soil-water Relationship-Forms and occurrence of Soil Water Classification of Soil Water- Soil Water Constants- Energy concept of Soil Water-Forces acting on Soil Water- Soil Water Potential concept- Soil Water retention- Soil Moisture

Measurement. Water requirement of crops- Evapotranspiration and Consumptive use- Methods of estimating Evapotranspiration- Effective Rainfall- Irrigation Requirement-Duty of Water- Irrigation Efficiencies Irrigation Scheduling- Irrigation measurement. Canal network and canal design- Surface irrigation methods- Types- Border irrigation, Furrow irrigation and Strip irrigation- Specifications, Hydraulics and Design. Problems of water logging- salinity and alkalinity, land drainage problem- design of surface and sub-surface drainage system, reclamation Water Quality Management Models: Basic water quality modelling,

Suggested Books:

1. W.R. Walker and G.V. Skogerboe, Surface Irrigation Theory and Practice, Prentice Hall, 1987.
2. Drainage Principles and Applications, International Institute for Land Reclamation and Improvement, Wageningen, 1973.
3. A.M. Michael, Irrigation: Theory and Practice, Vikas Publishing House, 1978.
4. G.L. Asawa, Irrigation Engineering, New Age International Publishers, 1996.

HWE5406 Hydrometeorology

Atmosphere: General Circulation, Composition and Structure of Atmosphere, Role of Meteorology in Hydrology. Precipitation Process – Adiabatic Process Stability and Instability of Atmosphere, Atmosphere thermodynamics. **Clouds** – Classification, Formation and Characteristics Climate, Preparation of Climatological norms and Climate Classification Weather Charts: Preparation, Analysis and Interpretation. Weather Forecast Monsoon – Monsoon Circulation, Monsoon Troughs, Monsoon Depression and Tropical Cyclones Hydro-meteorological Instrumentation and Observations. Use of Radar and Satellites in Hydrology. Storm Analysis: Storm Selection, Storm Maximization Probable Maximum Precipitation, Meteorological Homogeneity, Storm Transposition Computer applications in the design of hydraulic structures.

Suggested Books:

1. P.S. Eagleson, Dynamic Hydrology, European Geophys Union, 2003.
2. S.L. Dingman, Physical Hydrology, Prentice Hall, 2002.
3. V. Lakshmi, J. Albertson and J. Schaake, Land Surface Hydrology Meteorology and Climate - Observations and Modeling. Amer. Geophys. Union, 2001.
4. C. J. Wiesner, Hydrometeorology, Chapman & Hall, 1970.

HWE5408 Hydro-informatics and Simulations

Introduction, Concept of hydro-informatics scope of internet and web based modelling in water resources engineering. Introduction to multi criterion decision support system – Components for modelling software. Introduction to Simulation, Different simulation techniques – Applications of simulation techniques in hydraulics. Introduction to Artificial Neural Networks, Networks and its Training-Back propagation algorithm, Conjugate gradient algorithm, Cascade correlation algorithm, Applications of ANN in WRE. Genetic Algorithm (G.A.) Concept, Basic principle of GA, Working principle of GA. Coding, Fitness function, GA. Operations, Reproduction, Cross over Mutation, Applications of GA in Water Resources Engineering.

Suggested Books:

1. P. Kumar, Hydro informatics: Data Integrative Approaches in Computation, Analysis, and Modeling, CRC Press, 2005.
2. R. Grayson and G. Blöschl, ed., Spatial Patterns in Catchment Hydrology: Observations and Modelling, Cambridge University Press, 2000.
3. S.K. Tomer, Python in Hydrology, Grean Tea Press, Indian Institute of Science, 2012.

HWE5302 MINOR PROJECT

HWE5304 Applications of GIS and Remote Sensing in Water Resources Engineering

Introduction, Geographical concepts and Terminology, Difference between Image Processing system and GIS, Utility of GIS. Various GIS packages and their salient features, Essentials components of GIS, Data acquisition through scanners and digitizers. Raster and Vector Data: Introduction, Descriptions: Raster and Vector data, Raster Versus Vector, Raster to Vector conversion, Remote Sensing Data in GIS, Topology and Spatial Relationships. Data storage verification and editing Data preprocessing, Georeferencing, Data compression and reduction techniques, Run length encoding, Interpolation of data, Database Construction, GIS and the GPS, Data Output Database structure, Hierarchical data, Network systems, Relational database, Database management, Data manipulation and analysis. Spatial and mathematical operations in GIS, Overlay, Query based, Measurement and statistical modelling, Buffers, Spatial Analysis, Statistical Reporting and Graphing. Programming languages in GIS, Virtual GIS, Web GIS, Application of GIS to various natural resources mapping and monitoring and engineering problems.

Suggested Books:

1. P.A. Burrough and R.A. Mc Donnel, Principles of Geographic Information System, Oxford University Press, 2000.
2. Chrisman, R. Nicholas, Exploring Geographic Information Systems, John Wiley, 2002 .
3. Demers, N. Michael, Fundamentals of Geographic Information System, 2nd Ed. Wiley, 2008.
4. S.K. Ghosh and A.M. Chandra, Remote Sensing and GIS, Narosa Publishing House, 2008.
5. C.P. Lo and A.K.W. Young, Concepts and Techniques of Geographical Information System, Prentice Hall India, 2002.

HWE5306 Soil Structure Interaction

General soil-structure interaction problems: Contact pressures and soil-structure interaction for shallow foundations. Concept of sub-grade modulus, effects/parameters influencing subgrade modulus. Analysis of foundations of finite rigidity, Beams on elastic foundation concept, introduction to the solution of beam problems. Analytical Methods of Analysis of Finite Beams on Winkler Foundation: Introduction, analysis of finite and infinite beam on wrinkle foundation, method of super position, method of initial parameters and its application to analysis of regular beams, analysis of continuous beams and frames on wrinkle foundation, analysis of frames on wrinkle foundation, analysis of rigid piles with horizontal and vertical loads. Analysis of Beams on Elastic Half Space: Introduction, analysis of Rigid Beams, short beam analysis, long beam Analysis, Analysis of Frame on Elastic Half Space. Dynamic Soil Structure Interaction: Direct and Sub-structure method of Analysis, Equation of Motion for flexible and rigid base, kinematic interaction, inertial interaction and effect of embedment, Temporal and special variation of external loads including seismic loads, continuous models, discrete models and finite element models. Wave Propagation for SSI: Waves in Semi-Infinite Medium, one two and three dimensional wave propagation, dynamic stiffness matrix for out of plane and in plane motion.

Free Field Response of Site: Control point and control motion for seismic analysis, dispersion and attenuation of waves, half space, single layer on half space, modelling of boundaries, elementary, local, consistent and transmitting boundaries. Engineering Application of Soil-Structure Interaction: Low rise residential building, multi-storey building, bridges and dams, soil-pile structure interaction.

Suggested Books:

1. S K Garg, Soil Mechanics and Foundation Engineering, Khanna Publications, 2003.
2. C Venkataramaiah, Geotechnical Engineering, New Age International Publishers.
3. E. Tsudik, Analysis of Structures on Elastic Foundations, J. Ross Publishing, 2012.
4. J. P. Wolf, Dynamic soil-structure interaction, Prentice Hall int, 1985.

HWE5308 Disaster Mitigation and Management

Introduction to various hazard, vulnerability and risk, hazard estimation, hazard mapping, effect of site conditions on structures, event monitoring, processing and integration of data. Damages: Grade of damages, direct and indirect damages, damage to structures, lessons learnt. Management and mitigation of earthquake: earthquake risk and vulnerability in India, traditional housing construction in rural and urban areas, critical areas of concern in earthquake management, past and present initiative in India, disaster management plan, approaches to seismic risk mitigation, seismic strengthening and retrofitting methods, awareness and preparedness, capacity building. Management and mitigation of tsunamis: Tsunami Risk Assessment and Vulnerability Analysis, Coastal Zone Management, Tsunami Preparedness, Structural Mitigation Measures, Regulation and Enforcement of Techno-Legal Regime. Management and mitigation of cyclones: Understanding cyclone and wind hazard in India, vulnerability and risk assessment, early warning systems, structural mitigation measures, management of coastal zones, disaster risk management and capacity development Management and mitigation of flood (including urban flooding): The Flood Hazard, Flash Floods, urban flooding, structural measures for flood management, design and management of urban drainage system, urban flood disaster risk management, early warning system and communication, capacity development. Management and mitigation of landslide: Introduction to landslide hazard, Landslide Vulnerability and Risk in India, Hazard Zonation Mapping, Geological and Geotechnical Investigations, Landslide Risk Treatment, Landslide Monitoring and Forecasting, Capacity building. Disaster Management Act : Disaster management policy; Techno legal aspect: Techno-Legal and Techno-Financial work; Model Town and country planning legislation land use zoning regulation, development control regulations and building bye-laws registration, qualification and duties of professionals, disaster response policy.

Suggested Books:

1. D. K. Chester, EA Bryant, Natural hazards, Cambridge University Press, 1991.
2. P. Blaikie, T. Cannon, I. Davis & B. Wisner, At risk: natural hazards, people's vulnerability and disasters. Routledge, 2003.
3. National Disaster Management Agency Documents, www. <http://ndma.gov.in>
4. FEMA Documents, <http://www.fema.gov>
5. A. Coburn and R. Spence Earthquake protection, Wiley, 2002.
6. L.Reiter, Earthquake hazard analysis: issues and insights, Columbia University Press, 1991.
7. D. J. Dowrick, Earthquake risk reduction, Wiley, 2003.
8. K. Aki & P. G. Richards, Quantitative Seismology: Theory and Methods, University Science Books, U.S., 1997.
9. D. Mileti, Disasters by Design: A Reassessment of Natural Hazards in the United States, Joseph Henry Press, 1999.

HWE5202 Groundwater Hydrology

Introduction: Definition of groundwater, role of groundwater in hydrological cycle, groundwater bearing formations, classification of aquifers, flow and storage characteristics of aquifers, Darcy's law, anisotropy and heterogeneity. Wells and Well Hydraulics: Different types of wells, construction of wells, steady and unsteady state solutions for confined, unconfined and leaky aquifers, effect of boundaries, Multiple Well Systems, Partially Penetrating Wells, Well for special Conditions, Characteristics Well Losses, Specific Capacity Surface investigation of Ground water: Geologic methods, Remote sensing, geophysical exploration, Electric resistivity Method, Seismic Refraction Method, Gravity and Magnetic Methods, Water Witching. Concept of Artificial Recharge of Ground water, recharge methods, research on water spreading, Wastewater recharge for reuse, Recharge Mounds. Artificial Recharge on long Island, New York, Include Recharge, artificial Recharge for Energy purposes. Groundwater Flow Modelling: Porous media models, Analog models, Electric Analog Models and Digital computer models.

Suggested Books:

1. D.K. Todd, Groundwater Hydrology, John Wiley, 1959.
2. J. Bear, Hydraulics of Groundwater, McGraw, 1979.
3. H. Bouwer, Groundwater Hydrology, McGraw Hill, 1978.
4. W.C. Walton, Groundwater Resources Evaluation, McGraw Hill, 1970.
5. Freeze and Cherry, Groundwater, Prentice Hall, 1979.

HWE5204 Transients in Pipes

Introduction, Causes of transients; Governing Equations; explanations of equation with real life example, Method of characteristics; Transients in pumping schemes and hydroelectric schemes. Transient bubble flow, Transient control.

Suggested Books:

1. G.Z. Watters, Analysis and control of unsteady flow in pipelines, 2nd Ed., Butter Worth Publishers, 1984.
2. Q. Syed, R.M. Edward and M.Z. Guang, Water Works Engineering: Planning, Design and Operation, PHI Learning, 2011.
3. Viessman Jr, J.M. Hammer, E.M Perez and P.A Chadik, Water Supply and Pollution Control, PHI Learning, 2009.
4. M.H. Choudhary, Applied Hydraulic Transients, 2nd Ed., Van Nostrand Reinhold, 1987.

HWE5206 Offshore Geotechnical Engineering

DESIGN OF OFFSHORE PLATFORMS: Introduction, fixed and floating platforms, case studies and general features, elements of hydrodynamics and wave theory, fluid structure interaction, steel concrete and hybrid platforms Consolidation and shear strength characteristics of marine sediments. Design Criteria: Environmental loading, wind, wave and current loads after installation, stability during towing Foundations: Site investigations, piled foundation, foundations for sgravity structures, pile-supported structures. Behaviour under dynamic loading, static and dynamic analysis of platforms and components. Dynamic response in deterministic and indeterministic environment, codes of practice, analysis of fixed platform and semisubmersible related topics.

Suggested Books:

1. S. Gourvenec and D. White, *Frontiers in Offshore Geotechnics II*, CRC Press, 2005.
2. V. Meyer, *Frontiers in Offshore Geotechnics II*, CRC Press, .
3. A S Balasubramaniam, *Geotechnical Aspects of Coastal and Offshore Structures: Proceedings of the Symposium, Bangkok*, CRC Press.

HWE5208 Waste to Energy

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors. Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications. Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation. Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors. Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion -Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production. Urban waste to energy conversion - Biomass energy programme in India.

Suggested Books:

1. A.V. Desai, *Non Conventional Energy*, Wiley Eastern Ltd., 1990.
2. K.C. Khandelwal and S.S. Mahdi, *Biogas Technology - A Practical Hand Book - Vol. I & II*, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. D.S. Challal, *Food Feed and Fuel from Biomass*, IBH Publishing Co. Pvt. Ltd., 1991.
4. C.Y. WereKo-Brobby and E.B. Hagan, *Biomass Conversion and Technology*, John Wiley & Sons, 1996.

SEMESTER III

HWE651 Research Project

HWE601 Major Project-1

HWE6401 Design of Hydraulic Structures

Project planning of hydraulic structure, site investigation, selection of hydraulic structures (w.r.t foundation), Different types of dam. Design and Construction of Gravity Dams. Design and Construction of Earthen Dams and Rockfill Dams. Design & analysis of weirs and barrages. Design and Analysis of different types of spillway and energy dissipaters.

Suggested Books:

1. P. Novák, A.I.B. Moffat, C. Nalluri, and R. Narayanan, *Hydraulic structures*, CRC Press, 2006.

2. W.P. Creager, J.D.W. Justin and J. Hinds, , Engineering for dams, Willey, 1929.
3. W.P. Creager, J.D. Justin and J. Hinds, Engineering for Dams: Earth Rock-fill Steel and Timber Dams, John Wiley & Sons, 1945.
4. R.K. Linsley and J.B. Franzini, Water Resources Engineering, McGraw-Hill Publications, New York, 1991.
5. S. Leliavsky, Design textbooks in civil engineering, Chapman and Hall, 1981.
6. B. Singh, Fundamentals of Irrigation Engineering, Nem Chand & Bros,1979 .
7. R.S. Varshney, S.C. Gupta & R.L. Gupta, Theory & Design of Irrigation Structures: Nem Chand & Bros, 2007.
8. S.K. Garg, Irrigation engineering and hydraulic structures, Khanna publishers, 1976.

HWE6403 Environmental Impact Assessment

Objectives of environmental impact assessment, methodology for EIA, Baseline study, scoping, checklist scaled and weighted matrices networks overlays index methods, Prediction and Assessment of impacts on air, water, land, demography and Biological Environment. Impact analysis of Hydro power/ Thermal power project, different case studies, environmental Impact Analysis-Laws and Status in India. Elements of environmental auditing-material and fuel balance. Conversion efficiency of manufacturing processes. Identification of process operation imbalances resulting in resources loss and their impact on environment.

Suggested Books:

1. L.W. Canter, Environmental Impact Assessment, McGraw Hill Pub. Co., 1997.
2. D.P. Lawrence, Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley & Sons, 2003.
3. B.B. Hosetti and A. Kumar, , Environmental Impact Assessment & Management, Daya Publishing House, 1998.
4. P. Wathern, Environmental Impact Assessment- Theory and Practice, Routledge Publishers, London, 2004.

HWE6405 Water Pollution Control and Stream Sanitation

Water quality and stream quality standards Organic self-purification-quantitative definition-re-oxygenation-oxygen balance and stream dissolved oxygen profile-oxygen sag curve-Streeter Phelp's equation-Critical deficit problems. Microbial self-purification-pathogenic microorganisms of sewage origin-indices of contamination-enumeration-per-capita contribution-seasonal variations-death rate survival in the stream environment. Classification of streams-natural self-purification process-disposal of wastewater Rational stream sanitation practices-dual objectives of stream sanitation practices-the science and art of applied stream sanitation-stream survey-types of stream survey-execution of stream surveys. Purification in estuaries-evaluation of self-purification in estuaries-tides and currents distribution of waste loads by tidal translation-sea water intrusion-waste assimilation capacity of estuaries-bacterial contamination-stable wastes. Case studies/simulation studies water quality modelling using qual2E/ WASP.

Suggested Books:

1. V.M. Eulers, and E.W. Steel, Municipal and Rural Sanitation, 6th Ed., McGraw Hill Book Company, 1965.
2. J.E. Park, and K. Park, Text Book of Preventive and Social Medicine, Banarsidas Bhanot, 1972.
3. F.B. Wright, Rural Water Supply and Sanitation, E. Robert Krieger Publishing Company, Huntington, New York, 1977.
4. P. Juuti, S.K. Tapio, and H. Vuorinen, Environmental History of Water: Global Views on Community Water Supply and Sanitation, Iwa Publishing, 2007.

HWE6407 Stability Analysis of Slopes

Introduction: Natural and manmade slopes, types of slope movements & landslides, nature of soil & rock. Progressive failure of slopes; Limit Equilibrium Methods: Infinite and finite height slopes, Planar failure surface; Slip surface of arbitrary shape. Natural slope analysis considering initial stresses; Swedish method, Bishop's simplified method, other methods, stability chart, Various conditions of analysis, factor of safety, code provisions. Some special aspects of slope analysis, i.e Earthquakes, Creep, Anisotropy; Probabilistic approach in slope analysis. Centrifuge Model testing. Reinforced slopes, embankment on soft soils.

Suggested Books:

1. H.R. Cedergren, Seepage Drainage and Flow Nets, 3rd Edition, John Wiley & Sons, Inc., New York, 1989.
2. J.M. Duncan and S.G. Wright, Soil Strength and Slope Stability, John Wiley & Sons, Inc., New Jersey, 2005.
3. Gopal, Ranjan and Rao, Basic Mechanics And Foundation Engineering, Khanna publication, 2010.

HWE6301 Water Resource Economics

Principles of engineering economics: discounting techniques, un-certainty, planning horizon. Selection of optimal alternatives. Application of linear, non-linear and dynamic programmings in water resources. Optimal sequencing and scheduling of resources. Planning of water resources projects, cost- benefit analysis for irrigation. Application of linear, non-linear and dynamic programming's water power generation and flood control projects. Engineering and administrative methods of flood plain regulation. Economic aspects of flood control schemes, cost benefit analysis. Flood forecasting, flood warning and flood fighting. Suggested Books:

1. R.C. Griffin, Water Resource Economics, MIT Press, 2006.
2. E. Kuiper, Water Resources Project Economics, Butterworth Pub. Co, London, 1971.
3. D.G. James, and R.R. Lee, Economics of Water Resources Planning, McGraw Hill Publishing Co, N.York, 1979.
4. L.D. James, and R.R. Lee, Economics of Water Resources Planning, McGraw-Hill, 1971.
5. S. Merrett, Introduction to Economics of Water Resources: An International Perspective, Routledge Publishers, UK, 1997.

HWE6303 An Introduction to Sustainable development

Introduction: Definition of sustainable development, Importance and History of sustainable development Sustainable development systems & PURA, Eco friendly sustainable development, Community driven sustainable development system, Enterprise creation leading to empowerment. Evolution of Sustainable Development, The sustainable development goals, pathways to sustainable development. Challenges of sustainable development, Global Environmental and Energy Issues Sustainable Development Indicators, Environmental assessment, Environmental Management: Trends & policies. Introduction to Economic growth, Brief History of economic development, Human Development Indicators. Global environmental threats caused by economic development, economics of sustainability, Education for all, Health for all, food for all, Food security Resilient cities, Climate change, saving Biodiversity and protecting eco system services.

Suggested Books:

1. APJ Abdul Kalam & S.P Singh, Target 3 Billion Innovative Solution towards Sustainable Development, Penguin India, 2011.

2. H. Sharma, T. Sobti, An introduction to Sustainable Development Goals, 2018.
3. P.P. Rogers, K.F. Jalal, J. Boyd, An introduction to Sustainable Development, Routledge, 2007.
4. J.D. Sachs, The age of sustainable Development, Columbia University Press, 2017.

HWE6305 Ground Improvement Techniques

Introduction: situations where ground improvement becomes necessary. Mechanical modification: dynamic compaction, impact loading, compaction by blasting, vibro-compaction; pre-compression, stone columns; Hydraulic modification: dewatering systems, preloading and vertical drains, electro-kinetic dewatering Chemical modification; modification by admixtures, stabilization using industrial wastes, grouting. Thermal modification: ground freezing and thawing. Soil reinforcement: Reinforced earth, basic mechanism, type of reinforcements, selection of stabilisation/improvement of ground using Geotextiles, Geogrid, geomembranes, geocells, geonets, and soil nails. Application of soil reinforcement: shallow foundations on reinforced earth, design of reinforced earth retaining walls, reinforced earth embankments structures, wall with reinforced backfill, analysis and design of shallow foundations on reinforced earth, road designs with geosynthetics

Suggested Books:

1. M.R. Hausmann, Engineering Principles of Ground Modification, McGraw-Hill International Editions, 1990.
2. R. Yonekura, Terashi, M. and Shibazaki, M. (Eds.), Grouting and Deep Mixing, A.A. Balkema, 1966.
3. M.P. Moseley, Ground Improvement, Blackie Academic & Professional, 1993.
4. P.P. Xanthakos, L.W. Abramson, and D.A. Bruce, Ground Control and Improvement, John Wiley & Sons, 1994.
5. R.M. Koerner, Designing with Geosynthetics, Prentice Hall Inc, 1998.

HWE6307 Probability and Statistical Methods in Engineering

Preliminary data analysis: Graphical representation of data (stem and leaf plot, box plot, Q-Q Plots), frequency distribution, measure of central tendency-grouped and ungrouped data, measure of dispersion, measure of asymmetry, measure of peakedness, covariance, correlation coefficient. Random events: Sample space and events, Interpretation of probability, Probability axioms, Elementary theorems, conditional probability, Bayes' theorem. Random Variables: Definition of random variables - discrete and continuous; Probability definitions - PMF, PDF, CDF; Moments and expectations. Concept of risk and reliability Probability Distributions: Discrete distributions - binomial distribution, Poisson's distribution; Continuous distributions – uniform distribution exponential distribution, gamma distribution, Weibull, Normal and lognormal distributions. Extreme value distributions, Multivariate distribution-Bivariate Normal distribution, other bivariate distribution, Transformations to Normal distribution. Model Estimation and Testing: Properties of estimators, sampling distributions-Chi square distribution, t-distribution, F distribution, Parameter estimation-Point estimation, confidence interval estimation, Hypothesis testing-Tests of hypotheses on the mean and variance, Goodness-of-fit tests, fitting theoretical distributions to observed frequency distributions and Tests of goodness-of-fit (chi-square test, Kolmogorov-Smirnov test). Curve fitting: method of least squares, simple linear regression, coefficient of correlation and the sample correlation, multiple linear regression. Principal component analysis. Case study of Monte Carlo simulation.

Suggested Books:

1. A. Haldar and S. Mahadevan, Probability reliability and statistical methods in engineering design, John Wiley and Sons, 1999.
2. J.R. Benjamin and C.A. Cornell, Probability statistics and decisions for civil engineers, John Wiley, 2014.
3. A Papoulis, Probability random variables and stochastic processes, 3rd Edition, McGraw-Hill, 2002.
4. N.T. Kottogoda and R. Rosso, Probability Statistics Reliability for Civil and Environmental Engineer, McGraw-Hill College, 1997.

5. R.A Jonson, Miller and Freund's Probability and Statistics for Engineers, Pearson Education,2011.
6. S.M. Ross, Introduction to Probability and Statistics for Engineering and Scientist, Academic Press, 2009.

HWE6201 Subsurface Investigations

Introduction & broad classification of subsurface methods. **Direct Methods:** Excavation & Pitting, Well Drilling Techniques, Drill Stem Testing, Geological Well Logs. **Indirect Methods:** Geophysical Well Logging, Electrical Well logging methods Normal & Lateral Resistivity, Logs, Self-Potential Logs, Induction & Micro focused logs; electrical logging practices. Evaluation of aquifer parameters Radiation logging (Natural gamma, neutron & gamma gamma logging) - Acoustic Logs Caliper logs & Dip-meter surveys, & their applications in groundwater prospecting.

Suggested Books:

1. R.E. Hunt, Geotechnical Engineering Investigation Manual, Second Edition, Mc Graw Hill, 2005.
2. B.M. Das, Principles of Geotechnical Engineering, Seventh Edition, Cengage Learning Inc, 2010.
3. P. Purushothama Raj, Soil Mechanics & Foundation Engineering, Pearson Education India, 2008.

HWE6203 Introduction to AI Techniques

Expert Systems (ES): Basic concepts of ES, definition and components of ES. Reasoning mechanisms e.g. forward reasoning and backward reasoning, concept of causable variable, knowledge representation methods and development of the rule based knowledge base, dealing with uncertainty, linear and nonlinear behaviour of variables, statistical concepts and their applications to engineering and sciences; Artificial Neural Networks (ANNs): background and history of ANNs, definitions and basic concepts of ANNs, biological and artificial neural networks, feed-forward and feed-back networks, supervised and unsupervised learning methods—standard back-propagation (BP), concept of learning, learning rate and momentum concepts, self-organizing networks, etc., development of ANN models for specific problems and selected case studies. Introduction to Genetic Algorithms (GAs): fundamentals and preliminary concepts of evolution and GA, preliminaries of optimization, genetic operators-selection, crossover, and mutation, binary and real-coded GAs, selected case studies involving GA applications to engineering.

Suggested Books:

1. Russell & Norvig, Artificial Intelligence: A Modern Approach, 3rd edition, Pearson, 2009.
2. Qiangfu Zhao and Tatsuo Higuchi, Artificial Intelligence: From fundamentals to intelligent searches, Kyoritsu, 2017.

HWE6205 Geotechnical Practice for Waste Management System and Ground modifications

Introduction to waste containment, Soil system and soil-water pollution interaction, Structural components of clayey soils for landfill liner, Soil organic matter-soil minerals interaction Site investigation at polluted sites (Geophysical techniques, Hydrological investigations etc.). Landfill liner system, Classification of liners and potential problems for clay barrier system, Leachate & gas collection and removal system, Leachate production and clay-leachate compatibility. Soil attenuation by biochemical, physical & chemical processes, Final covering system, Design of top & drainage layers, Monitoring in the saturated and unsaturated zone, Construction quality control and quality assessment, Challenges associated with landfill design & construction in tropical region. Mechanical modification: Introduction, principles of soil densification, properties of compacted soil and compaction control specifications for quality controls. Hydraulic modification: Introduction, objectives,

techniques, Dewatering methods, soil and water relationship, Types of aquifer, Design of Dewatering systems, filtration, drainage and seepage, control, preloading and vertical drains, electro kinetic dewatering and stabilization. Ground Modifications: Physical and chemical Modification: Modification by admixtures, grouting, and thermal modification. Modification by inclusions and confinement: Soil reinforcement, ground anchorage, and rock bolting soil nailing, crib walls, and gabions.

Suggested Books:

1. D.P. Coduto, Geotechnical Engineering, Pearson Education Asia, 2002.
2. M.R. Hausmann, Engineering Principles of Ground Modification, McGraw-Hill International Editions, 1990.
3. P.P. Xanthakos, L.W. Abramson and D.A Bruce, Ground Control and Improvement, John Wiley & Sons, 1994.
4. M.H. Choudhary, Applied Hydraulic Transients, 2nd Ed., Van Nostrand Reinhold, 1987.

SEMESTER IV

HWE652 Research Project

HWE602 Major Project-2