Post Graduate Program Syllabus

M.Tech. (Water Resources Engineering)

AUGUST 2021

DEPARTMENT OF CIVIL ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR,

J.L.N. MARG, MALVIYA NAGAR, JAIPUR, RAJASTHAN,

INDIA

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Institute Vision:

To create a centre for imparting technical education of international standards and conduct research at the cutting edge of technology to meet the current and future challenges of technological development.

Institute Mission:

To create technical manpower for meeting the current and future demands of industry: To recognize education and research in close interaction with industry with emphasis on the development of leadership qualities in the young men and women entering the portals of the Institute with sensitivity to social development and eye for opportunities for growth in the international perspective.

DEPARTMENT OF CIVIL ENGINEERING

Vision:

To serve the nation by providing high quality engineering education that enables students to get a profession that can improve the civil infrastructure and social welfare.

Mission:

To create an environment conducive for excellent teaching, learning and research in order to produce leading entrepreneurs and innovators in the field of civil engineering for sustainable development.

Malaviya National Institute of Technology Jaipur
Department of Civil Engineering

Master of Technology - Water Resources Engineering

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

PEO1	To prepare students to get employment and/or to pursue higher education and research in the water resources engineering discipline and allied engineering disciplines.
PEO2	To provide students a strong knowledge in mathematical, scientific and engineering fundamentals required to formulate, analyze and solve problems related to water resources management.
PEO3	To prepare the students to acquire the skills in order to solve problems related to analytical, design and management of water resources and related systems.
PEO4	To inculcate ethical practices in students and to establish an understanding of professionalism, water resources sustainability, their responsibilities to society and to the nation.
PEO5	To provide students with an academic environment that makes them aware of excellence in the field of water resources engineering and to enable them to understand the significance of life-long learning in global practices.

PROGRAM OUTCOMES (PO)

A student who has met the objectives of the program will possess:

PO1	An ability to independently carry out research /investigation and development work to solve practical problems of water resources engineering.
PO2	An ability to write and present a substantial technical report/document for a water resource project.
PO3	Students should be able to demonstrate a degree of mastery in the area of water resources engineering. The mastery should be at a level higher than the requirements in the bachelor civil engineering program.
PO4	Students shall be able to plan, design, commission, maintain, and operate (including its cost estimation) water resources projects of all types and scales involving multidisciplinary aspects including environmental sustainability, safety and social aspects.
PO5	Students shall be able to use the latest technology and software tools to solve complex systems/activities.

Malaviya National Institute of Technology Jaipur
Department of Civil Engineering

ACADEMIC CURRICULUM
Master of Technology - Water Resources Engineering

Semester. I

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21CET581	Design of Water Resources Structures	Program Core	Theory	3	3	0	0
2	21CET582	Groundwater Hydrology	Program Core	Theory	3	3	0	0
3	21CET583	Physical and Stochastic Hydrology	Program Core	Theory	3	3	0	0
4	CEP xxx	Elective 1 (Lab Course)	Program Elective	Practical	1	0	0	2
5	CET xxx	Elective 2	Program Elective	Theory	3	3	0	0
6	CET xxx	Elective 3	Program Elective	Theory	2	2	0	0
7	CET xxx	Elective 4	Program Elective	Theory	3	3	0	0
				Total Semester Credits	**18**			

Semester. II

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21CET584 /21CET506	Geo-informatics and its Applications	Program Core	Theory	3	3	0	0
2	21CET585	Introduction to CFD	Program Core	Theory	3	3	0	0
3	21CET586	Watershed Development and Management	Program Core	Theory	3	3	0	0
4	21CEPxxx	Elective 5 (Lab Course)	Program Elective	Practical	1	0	0	2
5	21CETxxx	Elective 6	Program Elective	Theory	3	3	0	0
6	21CETxxx	Elective 7	Program Elective	Theory	2	2	0	0
7	-	Elective 8	Open Elective	Theory	3	3	0	0
				Total Semester Credits	**18**			

Semester. III

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21CES682	Seminar/ Minor Research Project	Program Core	Seminar	4	0	0	8
2	21CED681	Dissertation	Program Core	Dissertation	8	0	0	16
				Total Semester Credits	**12**			

Semester. IV

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21CED683	Dissertation	Program Core	Dissertation	12	0	0	24
				Total Semester Credits	**12**			
				Total Program Credits	**60**			

List of Courses

Semester/ Core/Elective	Course Code (As per ERP)	Course Name	Abbreviation
First Semester Core Courses	21CET581	Design of Water Resources Structures	DWRS
	21CET582	Groundwater Hydrology	GH
	21CET583	Physical and Stochastic Hydrology	P&SH
Second Semester Core Courses	21CET584/21CET506	Geo-informatics and its Applications	GI&A
	21CET585	Introduction to CFD	ICFD
	21CET586	Watershed Development and Management	WD&M
Third Semester Core Courses	21CES682	Seminar/ Minor Research Project	Seminar/MRP
	21CED681	Dissertation	Diss.
Fourth Semester Core Courses	21CED683	Dissertation	Diss.
Program Elective Courses	21CET842/21CET505	Climate Variability and Adaptation	CV&A
	21CET843	Contaminant Hydrogeology	CHG
	21CEP844/21CEP507	Geo-informatics Laboratory	GILab
	21CET845/21CET805	Hydro-meteorological Disasters, Adaptation and Mitigation	HAD&M
	21CEP846/21CEP503	Spatial Data Analysis Laboratory	SDALab
	21CET847/21CET504	Spatial Data Collection and Analysis	SDCA
	21CET848	Urban Water Management	UWM
	21CET849	Water Resources Field Methods	WRFM
	21CET850	Water Resources System	WRS
	21CET851	Water Resources System Modelling	WRSM

Department/Centre : Department of Civil Engineering

Course Code : 21CET582

Course Name : Groundwater Hydrology

Credits : 3 **L -** 3 **T -** 0 **P -** 0

Course Type : Core

Prerequisites : none; [preferred – Basic Hydrology]

Course Outcomes

CO1: An ability to apply knowledge of mathematics, science, and engineering to groundwater flow problems.

CO2: An ability to identify, formulate, and solve groundwater engineering problems.

CO3: An ability to communicate effectively, understand economic, environmental, social, and sustainability issues

CO4: An ability to use the modern engineering tools for engineering practice.

Course Contents

Fundamentals of Groundwater Flow: Occurrence of Ground Water, Vertical Distribution of G.W. Darcy's Law, Permeability, Porosity, Anisotropic Aquifers, Differential equations of G.W. flow.

Potential Flow: Flownets, Boundary conditions, Flow-net construction for confined & unconfined flow systems.

Mechanics of Well Flow: Steady & unsteady flow in confined & unconfined aquifers, Leaky aquifers, Partial penetration of wells, Multiple well systems, Boundary effects & method of images. Characteristics Well Loses.

Ground water Modelling: Sand Tank, Heleshaw, Electrical analogous models, Finite Element/Difference models, Analytical models, Basics of conformal mapping, Schwarz-Christoffel transformation, Zhukovsky's function and velocity hodograph.

Ground Water Development and Management: Design of wells, construction of wells, Well Development, Artificial recharge, Conjunctive use, Salinity of G.W., Ground water pollution, Infiltration galleries.

Rainwater Harvesting (Recharge to Aquifers), Groundwater mapping and assessment.

Recommended Readings

1. Text/Reference book
   a. De Weist "Geohydrology" Wiley
   b. Harr, M.E. "Groundwater and Seepage" Dover Publications Inc., New York
   c. Pinder, G.F., and Celia, M.A. "Subsurface Hydrology" Wiley-Interscience
   d. Polubarinova-Kochina, P. Ya. "Theory of Ground Water Movement" Princeton University Press
   e. Todd, D.K. "Groundwater Hydrology" Wiley India

Department/Centre : Department of Civil Engineering

Course Code : 21CET583

Course Name : Physical and Stochastic Hydrology

Credits : 3 **L -** 3 **T -** 0 **P -** 0

Course Type : Core

Prerequisites : none; [preferred – Basic Hydrology]

Course Outcomes

CO1: Evaluation of climatic parameters affecting various components of hydrological cycle.

CO2: Assessment of surface runoff and water yield from respective areas.

CO3: Evaluation of statistical parameters for agro-hydro meteorological analysis.

CO4: Analysis of hydrological extremes.

Course Contents

The Hydrological Cycle: Global Water and Energy Budgets, Philosophy of Mathematical Models of Watershed Hydrology.

Precipitation: Climate impacts of irrigation, Climate change and water resource sustainability, Human-water-climate interactions, formation and processes, Data availability, Spatio-temporal scale issues

Evapotranspiration: general processes, components of ET, surface turbulent fluxes; roughness for heat and momentum transfer; bulk coefficient with respect to vapor; moisture stress factor, water vs. energy control on ET.

Rainfall-runoff modeling: Topographic control on runoff generation; Analytical and Numerical solutions; simplification and application in large-scale hydrological modeling, unit hydrograph theory.

Hydrologic Analysis: watershed concepts, rainfall-runoff, hydrograph analysis, unit hydrograph theory, linear and kinematic wave model, overland flow models, lumped flow, distributed flow, dynamic wave routing, Muskingum method, Saint-Venant Equations.

Hydrologic Statistics: statistical parameter estimation, probability distribution, goodness of fit, concepts of probability weighted moments & L–moments, frequency analysis, Markov process, Markov chain, reliability analysis, Hydrologic Simulation Models; major hydrologic models, single and multiple regression analysis.

Classification of time series, characteristics of hydrologic time series, statistical principles and techniques for hydrologic time series modelling, time-series modelling of annual and periodic hydrologic time series (including AR, MA, ARMA, ARIMA models), multivariate modeling of hydrologic time series, practical considerations in time series modeling applications.

Recommended Readings

1. Text/Reference book-
   a. Bras, R. L., and Rodriguez-Iturbe, 1994, "Random Functions and Hydrology", Dover Publications, New York.
   b. Chow, V. T., D. R. Maidment, and L. W. Mays; "Applied Hydrology", McGraw Hill International Editions.
   c. Haan, C. T., 2002, "Statistical Methods in Hydrology", 2nd ed., Blackwell Publishing, Ames, IA.
   d. Haan C.T. “Stochastic Hydrology”
   e. Hoskings, J. R. M. and J. R. Wallis, 1997, "Regional Frequency Analysis, An Approach Based on L-Moments", Cambridge University Press, New York.
   f. Maidment, D.R., “Handbook of Hydrology”, Mc Graw Hill Inc
   g. Reddy, P. Jaya Rami. “Stochastic Hydrology” Laxmi Publications Pvt Limited
   h. Viessman Jr., W., and G. L. Lewis, "Introduction to Hydrology", 4th ed., Harper-Collins, New York, 1996.

Department/Centre : Department of Civil Engineering

Course Code : 21CET581

Course Name : Design of Water Resources Structures

Credits : 3 **L -** 3 **T -** 0 **P -** 0

Course Type : Core

Prerequisites : none; [preferred – none]

Course Outcomes

CO1: Ability to know about Water Resources structures

CO2: Ability to know about different elements of storage structure and able to design the sections of gravity and earthen dams

CO3: Ability to design different elements of Irrigation regulating structure

CO4: Ability to know about operation, management and limitations of Irrigation structure and to develop irrigation water distribution system.

Course Contents

Dams: Different kinds of dams and the choice criteria, Environmental considerations

Gravity Dams: various forces acting and their analysis and representation, stability requirements, two-dimensional analysis, distribution of normal and shear stress, principal stresses, joints and their treatment.

Foundation treatment: grouting, drainage wells, drainage galleries, types of galleries, design concepts of galleries, stress concentration.

Embankment dams: homogeneous and zoned earthen embankments, foundation requirements, typical cross-sections.

Stability analysis of earthen dams: slip circle method, wedge method, seepage through and beneath dams, Casagrande's base parabola and determination of top flow line, calculation of seepage rate, flow net during steady seepage and during sudden drawdowns, pore pressures and their significance, design of filters and rock toes, slope protection, Foundation problems of various soil strata of earthen dams and their remedies.

Rockfill dams and earth rock dams: construction techniques of embankment dams. modes of failure.

Spillways: Different types of spillways and their design criteria, design of crest profile, reinforcement, selection criteria for downstream arrangement, trajectories and bucket arrangements, buckets; design of stilling basins, Spillway aerators.

Gates: Various types of gates and their merits and demerits; design requirements of radial, vertical, low head gates and automatic gates. Design of vertical lift and sector gates, flow induced vibrations and down-pull forces. Gate seals. Design of outlet sluices through dams.

Canals: Basic concepts of various canal design theories and their limitations. Design of weirs and canal structures on permeable foundations, Khosla's theory and applications. Design of canal falls

and regulators, cross drainage works, canal outlets and river training works. Design of silt excluders, silt extractors. Layout and design of watercourses. Canal lining.

Recommended Readings

1. Text/ Reference book-
   a. Asawa, G.L. “Irrigation Engineering” John Wiley & Sons Australia, Limited
   b. Creager, W.P., Justin, J. De. W, and Hinds, J. “Design of Dams” J. Wiley & Sons, Incorporated
   c. Modi, P.N. “Irrigation & Water Power Engineering”
   d. Sherard “Design of Earthen Dams”

Department/Centre : Department of Civil Engineering

Course Code : 21CET584 /21CET506

Course Name : Geo-informatics and its Applications

Credits : 3 **L -** 3 **T -** 0 **P -** 0

Course Type : Core

Prerequisites : Spatial Data Collection and Analysis (Theory), Spatial Data Analysis Laboratory (Practical); [preferred – none]

Course Outcomes

CO1: Ability to understand geo-spatial data/ information collection and handling through geographical information systems

CO2: Learning spatial data integration and ability to select a particular method of geo-spatial data analysis

CO3: Analysis of geo-spatial data and design of analysis strategies for different engineering problems

Course Contents

Geographical Information System: Components of GIS; Feature types, Spatial data models (raster & vector) - their advantages and disadvantages; Spatial data creation and management-methods, topology creation, editing and manipulation, attaching attribute data,

Spatial analysis: single and multiple layer spatial analysis, Spatial querying; arithmetic and logical operations, 3D analysis, Spatial data visualization –map design and layout for thematic layers and display of tables and graphs using GIS software,

Application of GIS in Natural Resources Assessment and inventory, change detection.

Applications of GIS for assessment of disasters, preparation of vulnerability maps for different type of disasters, prioritization analysis for mitigation of different type of disasters.

Recommended Readings

1. Text/ Reference book-
   a. Burrough, P. (1998) “Principles of geographical information system.” Oxford: Oxford University Press.
   b. Chou, Yue-Hong (1997), “Exploring spatial analysis in geographical information systems.” OnWord Press, USA
   c. Jones, Christopher (2002), “Geographical information systems and computer cartography” Longman, London.

Department/Centre : Department of Civil Engineering

Course Code : 21CET586

Course Name : Watershed Development and Management

Credits : 3 **L -** 3 **T -** 0 **P -** 0

Course Type : Core

Prerequisites : none; [preferred – none]

COURSE OUTCOMES

CO1: Components for watershed modelling and their evaluation.

CO2: Understanding and estimation of soil erosion, and conservation techniques.

CO3: Evaluation of hydrological processes in wetland and upland areas.

CO4: Assessment of wetland drainage in from agriculture watersheds.

Course Contents

Concept of watershed, introduction to watershed management, different stakeholders and their relative importance, watershed management policies and decision making, Watershed Management Practices in Arid and Semiarid Regions, short term and long term strategic planning, types and Sources of pollution, environmental guidelines for water quality, Perspective on recycle and reuse.

Morphometry, Soil erosion, Sediment Yield and Sedimentation

Course Introduction: Wetland definitions and the role of water in wetland structure and function, Introduction to wetland water budgets and hydro-period

Components of the water budget: inflows, outflows, and storage, Precipitation and runoff, Evapotranspiration;

Surface water flows: structures and channels, Groundwater-surface water exchange in wetlands, Surface water flows II and wetland hydrology case studies, Flow and Mixing in Wetlands

Wetland water quality Information: nutrients, organic/inorganic contaminants, sediments and colloids, Wetland transport models I: Plug Flow, CSTRs and CSTRs in Series; Intro to Method of Moments.

Wetland transport case studies and Field Trip

Wetland hydrologic assessment: physical and biological processes, Anthropogenic and climate change impacts on wetland hydrology, Modeling wetland hydrology, hydraulics, and hydrodynamics, Introduction to wetland treatment systems design

Rain water management. Planning and operation of irrigation systems. Conjunctive use of water. Participatory Irrigation Management and Integrated Water Resources Management (IWRM), Water management policy during droughts. Predicting effect of water shortage on crops.

Introduction to water footprint of Crops and its applications. Blue, green and grey water foot print.

Recommended Readings

1. Text/ Reference book-
   a. Haan, C.T. “Hydrology of Small Watersheds”
   b. Hillel, Daniel A. “Advances in Irrigation” Elsevier Science
   c. Singh, Rajbir “Watershed Hydrology”
   d. Singh, V.P. “Watershed Hydrology”
   e. Schwaab, Frevert. “Soil and Water Conservation”
   f. Suresh, R. “Land and Water Management Principles”

Department/Centre : Department of Civil Engineering

Course Code : 21CET585

Course Name : Introduction to CFD

Credits : 3 **L -** 3 **T -** 0 **P -** 0

Course Type : Core

Prerequisites : none; [preferred – Basic Fluid Mechanics]

Course Outcomes

CO1: To develop understanding of basic concepts used in CFD from mathematics and fluid mechanics

CO2: To build skill and knowledge of Finite Difference and Finite Volume Methods for implementation in CFD methods

CO3: To Identify and implement numerical techniques for space and time integration of the governing equations.

CO4: To be able to apply the concepts of CFD for problem solving

Course Contents

Introduction, Fluid flow, Governing equations, Classifications of PDE, Elliptic, Parabolic and Hyperbolic equations, Navier-Stokes (NS) and Energy equations,

Explicit and implicit methods, Higher order schemes, Finite difference (FDM) and Finite volume (FVM) methods, Finite difference formulation, Various aspects of finite difference equation, Error and stability analysis, Modified equations;

Solutions of simultaneous equations, Iterative and direct methods, TDMA, ADI, Incompressible flow, Solution of incompressible NS equation, Higher order discretization, Finite volume formulations, Flux splitting and upwinding, Grid generation, Uncertainty of numerical results, Sources of uncertainties, Independence studies on grid, time-step, domain and initial condition.

Recommended Readings

1. Text/ Reference book-
   a. Anderson J. D., “Computational Fluid Dynamics: The Basics with Applications”, McGraw Hill.
   b. Chaudhry M. H., “Open Channel Flow”, Prentice-Hall.
   c. Chung T. J., “Computational Fluid Dynamics”, Cambridge University Press, 2003.
   d. Muralidhar K. and Sundararajan T., “Computational Fluid Flow and Heat Transfer”, Narosa Publisher, 2011.

Department/Centre : Department of Civil Engineering

Course Code : 21CET847 /21CET504

Course Name : Spatial Data Collection and Analysis

Credits : 3 **L -** 3 **T -** 0 **P -** 0

Course Type : Elective

Prerequisites : none; [preferred – none]

Course Outcomes

CO1: Ability to understand geo-spatial data collection techniques i.e., remote sensing, satellite-based positioning and laser based spatial data collection

CO2: Learning selection of appropriate geo-spatial data requirement and collection technique for different applications

CO3: Able to extract required information from the geo-spatial data through different image processing techniques, processes and methods

CO4: Analyzing geo-spatial data and finding solution of different geographic problems

Course Contents

Basics of map reading, types and sources of map, cartographic representation of data, map coordinate system, projections and their types, and guidelines for preparing a base map, thematic mapping.

Aerial photographs, Mosaic, Image interpretation - Elements and methods, Stereo-model.

Physics of remote sensing: Electro-magnetic spectrum and spectral signatures, Types of remote sensing, Platforms and sensors; active and passive sensors; aerial photographs, satellite images, radars; sensor characteristics, Resolution- spatial, spectral, radiometric and temporal, Image interpretation - Elements and methods, Image correction–geometric, Digital image enhancement techniques (stretching, filtering), Classification: supervised and unsupervised, Application of remote sensing techniques in resource and environment mapping, monitoring case studies.

Introduction to Microwave remote sensing

Global Positioning Systems (GPS): Introduction to the GPS functions, Field operation of GPS and data collection using GPS, Basic concepts and components of GIS, Introduction of laser based spatial data collection techniques.

Recommended Readings

1. Text/ Reference book-
   a. Jensen, J. R., “Introductory digital image processing: a remote sensing perspective.” Prentice Hall
   b. Lillesand, T.M., and Keifer, R.W. “Remote Sensing and DIP.” John Wiley & Sons, Inc.
   c. Lillian, Thomas M (2003), “Remote sensing and image interpretation.” John Wiley & Sons. New York
   d. Rao, G. S. “Global Navigation Satellite Systems (GNSS)” Tata McGraw hill Publications

Department/Centre : Department of Civil Engineering

Course Code : 21CEP846 /21CEP503

Course Name : Spatial Data Analysis Laboratory

Credits : 1 **L -** 0 **T -** 0 **P -** 2

Course Type : Elective

Prerequisites : Spatial Data Collection and Analysis (Theory);
[preferred – none]

Course Outcomes

CO1: Learning geo-spatial data selection and ordering

CO2: Able to process the geo-spatial data through different processing software and extraction of different information

CO3: Able to apply and use geo-spatial data and information for solution of -different geographical problems

Course Contents

1. Demonstration of different type of remote sensing data products.
2. Collection of radiometric data from different surfaces using digital spectral radiometer or available data and preparation of spectral reflectance curve – Two exercises
3. Learning how to identify correct remote sensing data product and their referencing schemes
4. Visual interpretation of remote sensing imageries to extract different information.
5. Demonstration of scanning of TOI Toposheets and other maps on A0 size scanner.
6. Demonstration of Remote Sensing software (ERDAS Imagine).
7. Pre-processing of remote sensing data using ERDAS Imagine software.
8. Learning image enhancement and feature extraction techniques using digital image processing techniques.
9. Unsupervised classification of remote sensing images.
10. Use GPS for collection data/surveying – two exercises

Recommended Readings

1. Text/ Reference book-
   a. Jensen, J. R., “Introductory digital image processing: a remote sensing perspective.” Prentice Hall
   b. Lillesand and Keifer. “Remote Sensing and DIP.” John Wiley & Sons, Inc.
   c. Lillian, Thomas M (2003), “Remote sensing and image interpretation.” John Wiley & Sons. New York

Department/Centre : Department of Civil Engineering

Course Code : 21CET842 /21CET505

Course Name : Climate Variability and Adaptation

Credits : 3 **L -** 3 **T -** 0 **P -** 0

Course Type : Elective

Prerequisites : none; [preferred – none]

Course Outcomes

CO1: To study the evolution of climate science

CO2: To develop the understanding of agreements and protocols of climate change

CO3: To understand the mitigation measures for climate change

CO4: To understand the adaptation and risk adaptation for climate change

Course Contents

Climate Change Policy Framework: Climate change as a problem, Impacts of climate change, Climate variability and natural resources, United Nations Framework Convention on Climate Change (UNFCCC), Background to the Convention and its aims, Kyoto Protocol and the Flexibility Mechanisms, Emission trading.

Mitigation: Mitigation and policy evaluation, Strategies and technology options, Climate change case studies.

Adaptation: Adaptation and policy evaluation, Strategies and technology options, Case studies of adaptation, Evaluation of the effectiveness of approaches in managing climate change risk, Effectiveness of policy approaches in reducing climate change and variability risk.

Recommended Readings

1. Text/ Reference book-
   a. Boylr, G., Everest, B. and Ramage, J. (eds), 2003, “Energy Systems and Sustainability: Power for a Sustainable Future”, Oxford.
   b. Hovi, J., Stokke O. and Ulfstein, G., (eds) 2005, “Implementing the Climate Regime: International Compliance”, Earthscan.
   c. Yamin, F. (ed), 2005., “Climate Change and Carbon Markets: A Handbook of Emission Reduction Mechanisms”, Earthscan.
2. Online resources
   a. Climate Change 2007, “Mitigation of Climate Change, Summary for Policymakers”, IPCC. Available at: http://www.ipcc.ch/SPM040507.pdf.
   b. Climate Change 2007, “Impacts, Adaptation and Vulnerability, Summary for Policymakers”, IPCC. Available at: http://www.ipcc.ch/SPM13apr07.pdf.
   c. Climate Change, “The Physical Science Basis”, IPCC. Available at: http://ipccwg1.ucar.edu/wg1/wg1-report.html.

Department/Centre : Department of Civil Engineering

Course Code : 21CET845 /21CET805

Course Name : Hydro-meteorological Disasters, Adaptation and Mitigation

Credits : 3 **L -** 3 **T -** 0 **P -** 0

Course Type : Elective

Prerequisites : none; [preferred – none]

Course Outcomes

CO1: To understand the hydrological and meteorological phenomenon responsible for hydrometeorological disasters

CO2: To identify the hydrometeorological hazards and their likely impacts on society and environment

CO3: To gain the knowledge and understanding about possible adaptation and mitigation measures for hydro-meteorological hazards

Course Contents

Hydrologic cycle, Relationship between hydrology, meteorology and climatology, Hydrometeorology, Importance of study of hydrometeorology, Hydrometeorological extreme events, Characteristics of extreme events, Climate change impacts on hydrometeorology.

Hydrometeorological hazards and disasters, Flood, Drought, Storms and Heat & Cold Waves, Causes, effects and their impacts, Hydrometeorological hazard monitoring and forecasting, Early warning systems, Risk assessment and Socioeconomic responses, Resilience of communities to hydrometeorological hazards, Adaptation and Mitigation measures and considerations, Hydrometeorological hazard studies, their mapping and impact assessment.

Recommended Readings

1. Text/ Reference book-
   a. Chow, Ven-Te, Maidment, David R., and Mays, Larry W. “Applied Hydrology”, McGraw Hill Publications.
   b. Iglesias, Ana, Assimacopoulos, Dionysis, and Lanen, Henny A.J. Van. “Hydrometeorological Extreme Events”, Wiley.
   c. Pandey, Vinay Kumar and Mishra, Ajai. “Climate Change and Hydro-Meteorological Disaster”, Lambert Academic Publishing.
   d. Quevauviller, Philippe. “Hydrometeorological Hazards”, John Wiley & Sons Inc.
   e. Shroder, John F., Paron, Paolo, and Baldassarre, Giuliano Di. “Hydro-Meteorological Hazards, Risks and Disasters”, Elsevier.

Department/Centre : Department of Civil Engineering

Course Code : 21CEP844 /21CEP507

Course Name : Geo-informatics Laboratory

Credits : 1 **L -** 0 **T -** 0 **P -** 2

Course Type : Elective

Prerequisites : Spatial Data Collection and Analysis (Theory),
Spatial Data Analysis Laboratory (Practical),
Geo-informatics and its Applications (Theory);
[preferred – none]

Course Outcomes

CO1: Learning spatial data handling software and creation of spatial databases

CO2: Ability to select a suitable geographical data and method integration and analysis

CO3: Able to analyze geographic problems, design methodology to solve through geographical information system

CO4: Able to use GIS for different engineering problems

Course Contents

1. Demonstration of GIS Software.
2. Georeferencing of Scanned images and Reference datasets – Two exercises
3. Creation of GIS Database (Digitization of point, line and polygon features)
4. GIS database modification and editing (for point, line and polygon features)
5. Attribute data handling in GIS
6. GIS data retrieval (selection based on attributes and location)
7. GIS Operations (Arithmetic, Boolean, Logical operators)
8. Classification and measurements in GIS
9. Overlay analysis in GIS
10. Neighborhood analysis in GIS (Buffer analysis, Interpolation, topographic functions)
11. Connectivity functions
12. Digital Elevation model and its application
13. Optimum site selection in GIS

Recommended Readings

1. Text/ Reference book-
   a. Burrough, P. (1998) “Principles of geographical information system.” Oxford: Oxford University Press.
   b. Chou, Yue-Hong (1997), “Exploring spatial analysis in geographical information systems.” OnWord Press, USA
   c. Jones, Christopher (2002), “Geographical information systems and computer cartography” Longman, London.

Department/Centre : Department of Civil Engineering

Course Code : 21CET848

Course Name : Urban Water Management

Credits : 3 **L -** 3 **T -** 0 **P -** 0

Course Type : Elective

Prerequisites : none; [preferred – none]

Course Outcomes

CO1: Ability to know about urban hydrological cycle

CO2: Ability to know about different elements of drainage system

CO3: Ability to design different elements of drainage system

CO4: Ability to know about operation and management of urban drainage system and to develop storm water management models

CO5: Ability to know about Planning and operation of irrigation systems and Water management policy during droughts.

Course Contents

Introduction to drainage problems in different climates: Urbanisation, its effects and consequences for drainage-interaction between urban and peri-urban areas

Planning concepts and system planning: Objectives of urban drainage and planning criteria, drainage and system layout. Planning tools and data requirement, drainage master plan, examples for drainage structures.

Review of Hydrologic and hydraulic principles: Urban hydrologic cycle, hydrologic principles, rainfall analysis and design storm, hydraulic principles, hydrodynamic principles.

Calculation methods and mathematical tools: Rational method and SCS method, time area diagram, hydrologic models, hydrodynamic models, modelling options, constant concentration, spreadsheets, regression rating curve approaches, urban runoff and water quality models.

Design of drainage system elements: Hydraulic fundamentals, infiltration and on-site detention of stormwater, design of sewerage and drainage channels, design of appurtenances, road drainage, design of pumping stations.

Control of stormwater pollution: Pollution build-up and washoff process with reference to urban drainage systems. Source control in commercial and industrial complexes, storage options - dry and wet ponds, biological treatment of wastewater, chemical treatment of stormwater, erosion control measures. Best Management practices.

Operation and maintenance of urban drainage systems: Maintenance requirement for different structures, maintenance planning, cleaning of sewers and drains, inventory of damages, repair options.

Roof-top Rainwater harvesting

Recommended Readings

1. Text/ Reference book-
   a. Hall, M.J. “Urban Hydrology” Taylor & Francis
   b. Viessman, W. Jr., Harbaugh, T. E., and Knapp, J. W. “Introduction to Hydrology” Intext Educational, New York

Department/Centre : Department of Civil Engineering

Course Code : 21CET851

Course Name : Water Resources System Modelling

Credits : 2 **L -** 2 **T -** 0 **P -** 0

Course Type : Elective

Prerequisites : none; [preferred – none]

Course Outcomes

CO1: Ability to formulate and solve problems related to water resources systems by writing their own programs (codes)

CO2: Ability to perform statistical analysis on big-datasets.

CO3: Ability to employ basic models/tools in the field of water resources available in public domain.

CO4: Ability to implement the soft-computing techniques in the field of water resources engineering

Course Contents

Introduction to Programming (in MATLAB): Basic mathematical operations, loops, conditional statements, functions (inbuilt, user defined), arrays, file handling (input and/or output to various formats)

Applications through MATLAB: Basic statistical analysis, Interpolation (in 1D, 2D, 3D spaces), Contours, Development of Regression based models and analysis, Principal Component Analysis.

Applications to Hydraulics, Hydrology and Water Resources: Water surface profiles (varied flow), Trend analysis, Time series modeling, Hydro-meteorological data download and analysis, Design of canals.

Introductions to modelling applications related to Hydrology and Water Resources Engineering, Hands on training with models related to: Surface water flow, groundwater flow.

Case-studies, data preparation, processing and result reporting for field problems.

Introduction to Soft-computing techniques and there applications in water resources engineering.

Recommended Readings

1. Text/ Reference book-
   a. Araghinejad, Shahab (2014) “Data-Driven Modeling: Using MATLAB® in Water Resources and Environmental Engineering”, Water Science and Technology Library, Springer
   b. Pratap, Rudra (2005) “Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers” Oxford University Press.
   c. Tayfur, G. (2012) “Soft Computing in Water Resources Engineering: Artificial Neural Networks, Fuzzy Logic and Genetic Algorithms”, WIT Press.

Department/Centre : Department of Civil Engineering

Course Code : 21CET843

Course Name : Contaminant Hydrogeology

Credits : 3 **L -** 3 **T -** 0 **P -** 0

Course Type : Elective

Prerequisites : Groundwater Hydrology (Theory); [preferred – none]

Course Outcomes

CO1: An ability to apply knowledge of mathematics, science, and engineering to groundwater contaminant flow problems.

CO2: An ability to identify, formulate, and solve and determine groundwater contaminant plume, migration of pollutants and engineering problems thereof.

CO3: An ability to communicate effectively, understand economic, environmental, social, and sustainability issues

CO4: An ability to use the modern engineering tools necessary for engineering practice.

Course Contents

Introduction: Hydrologic cycle, Movement & occurrence of groundwater, properties of groundwater, general flow equations, Dupuit's equation.

Sources & type of groundwater contamination, Contaminant transport mechanisms: Advection, Diffusion & dispersion, Mass transport equations, one & two-dimensional modeling.

Sorption & other chemical reactions: factors affecting sorption, Sorption isotherms, Sorption effect on fate & transport of pollutants, Estimation of sorption.

Biodegradation reactions & kinetics: biological transformations, microbial dynamics, kinetics of biodegradation.

Non-aqueous-phase liquids: Types of NAPLs, general processes, NAPL transport computational methods

Groundwater remediation and design: Remedial alternatives, source control, hydraulic controls, bioremediation, soil vapor extraction systems, remediating NAPL sites, emerging technologies

Groundwater quality mapping, Groundwater quality index, Vulnerability mapping

Recommended Readings

1. Text/ Reference book-
   a. Fetter, C.W. "Contaminant Hydrogeology", Prentice Hall; 2nd edition
   b. Harr, M.E. "Groundwater and Seepage" McGraw Hill
   c. Palmer, Christopher M. "Principles of Contaminant Hydrogeology" 2nd Ed.:, Lewis Publisher
   d. Philip B. Bedient, Hanadi S. Rifai, Charles J. Newell. "Ground Water Contamination: Transport and Remediation" Prentice Hall; 2 edition
   e. Todd, David K., and Mays, Larry M. "Groundwater Hydrology", 3rd Ed.: and, Wiley-India Ed.

Department/Centre : Department of Civil Engineering

Course Code : 21CET850

Course Name : Water Resources System

Credits : 2 **L -** 2 **T -** 0 **P -** 0

Course Type : Elective

Prerequisites : none; [preferred – none]

Course Outcomes

CO1: An ability to apply knowledge of mathematics, science, and engineering to any water resources system.

CO2: An ability to identify, formulate, and solve water resources problems.

CO3: An ability to apply her/his knowledge for practical implementation of water resources system related solutions in field

CO4: An ability to communicate effectively, understand economic, environmental, social, and sustainability issues

Course Contents

Water resources systems: components of the system, objectives of water resources development, development, planning, and design, construction and operation of water resources systems; System demands, geographic and geological aspects; Hydrological implications, economic, social, political and legal consideration in system development; Benefits and costs; Economic objectives: mathematical and econometric principles in optimal system design, numerical and digital computer methods in hydraulic and water resources engineering.

Recommended Readings

1. Text/ Reference book-
   a. Stedinger, Haith and Loucks. “Water Resources Planning and Development”
   b. Biswas, Asit K. “Water Resources Systems” Harvest House
   c. Hall and Dracup. “Water Resources Systems”
   d. Chaturvedi, M.C. “Water Resources Planning and Development”

Department/Centre : Department of Civil Engineering

Course Code : 21CET849

Course Name : Water Resources Field Methods

Credits : 2 **L -** 2 **T -** 0 **P -** 0

Course Type : Elective

Prerequisites : none; [preferred – none]

Course Outcomes

CO1: Ability to assess the requirement of water resources field data

CO2: Ability to capture surface water/ ground water/ hydro-meteorological data/information using appropriate instrumentation.

CO3: Ability to capture physiographic features of a catchment using appropriate tools and techniques.

CO4: Analyzing extent of uncertainties and its quantification related to water resources field data

Course Contents

Introduction, Experimental Design, Program Planning: Introduction, Measurement vs Calculation vs Estimation; Hypothesis Testing and Experimental Design; Uncertainty and Error Analysis.

Groundwater Measurements and Methods: Groundwater Hydraulics and Principles; Well Construction; Hydraulic Tests and Measurements; Thermal Property Testing; Groundwater-quality Sampling.

Surface-Water and Meteorologic Measurements and Methods: Open-Channel Hydraulics; Measurement Principles; Hydro-acoustics; Meteorologic Measurements; Tracer Studies.

Sediment and Water Quality Measurements and Methods: Sediment Principles; Water-quality Principles; Measurement Principles; Sample Collection; Sample Preparation