DEPARTMENT OF CIVIL ENGINEERING

ANNA UNIVERSITY, CHENNAI

OUR VISION:

Department of Civil Engineering, Anna University, shall strive hard to develop and impart technical knowledge and professional skills required for Civil Engineering practice through excellence in teaching, research and consultancy to address sustainable infrastructure development needs at local, national and International levels.

OUR MISSION:

Department of Civil Engineering, Anna University shall contribute to technological and social development by

1. Providing a firm scientific and technological base in Civil Engineering to achieve self-reliance.
2. Providing quality education through innovation in teaching practices at par with global standards.
3. Nurturing leadership and entrepreneurship qualities with ethical values.
4. Developing and disseminating latest knowledge and technologies in emerging areas of Civil Engineering.
5. Sharing intellectual resources and infrastructure facilities through collaborative partnership.
6. Ensuring supporting conditions for enhancing the employability skills.

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS - 2019
CHOICE BASED CREDIT SYSTEM
M.E. HYDROLOGY AND WATER RESOURCES ENGINEERING

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

Graduates of the Programme M E Hydrology and Water Resources Engineering will

PEO1	Gain knowledge and skills in Water Resources engineering which will enable them to have a career and professional accomplishment in the public or private sector organizations
PEO2	Become consultants in Water Resources Engineering and solve complex real life issues related to analysis, design and maintenance of structures under various environmental conditions.
PEO3	Contribute to the enhancement of knowledge in Water Resources Engineering by performing quality research in institutions of international repute or in Research organizations or Academia.
PEO4	Practice their profession with good communication, leadership, ethics and social responsibility and formulate solutions that are technically sound, economically feasible, and socially acceptable.
PEO5	Graduates will function in multi-disciplinary teams and adapt to evolving technologies through life-long learning and innovation

2. PROGRAMME OUTCOMES (POs):

After going through the four years of study, our Water Resources Engineering Graduates will exhibit ability to:

PO#	Graduate Attribute	Programme Outcome
PO1	Engineering knowledge	Apply the knowledge of mathematics, science and engineering fundamentals to the formulation and conceptualization of Hydrology Water Resources Engineering theory and model.
PO2	Problem analysis	Identify, formulate and solve engineering problems.
PO3	Design/development of solutions	Design structures, Water Resources elements or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.
PO4	Conduct investigations of complex problems	Conduct experiments and collect, analyze and interpret the data.
PO5	Modern tool usage	Create, select and apply appropriate techniques and modern engineering tools including analysis, modeling and design software, with due understanding of the limitations.
PO6	The Engineer and society	Conduct themselves to uphold the professional and social obligations.
PO7	Environment and sustainability	Design the structure with environment consciousness and sustainable development.
PO8	Ethics	Understand and commit to professional ethics and responsibilities of Water Resources Engineers and to contribute to the society for sustainable development.
PO9	Individual and team work	Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings and demonstrating a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis.

PO10	Communication	Communicate effectively with the engineering community and with society at large, and write reports and make effective presentations.
PO11	Project management and finance	demonstrate a knowledge and understanding of management and business practices, such as risk and change management, and understand their limitations
PO12	Life-long learning	Develop ability to engage in independent and life-long learning to improve competence by critical examination of the outcomes of one's actions and learning from corrective and preventive measures.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs):

Graduates of the program M.E. Water Resources Engineering will be able to

PSO1	Knowledge of Water Resources Engineering discipline	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges.
PSO2	Critical analysis of Water Resources Engineering issues and innovation	Analyse hydrological data to model water quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.
PSO3	Conceptualization and evaluation of Engineering solutions to Water Resources Design issues	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering.

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A. PEO / PO Mapping:

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES (HWRE)														
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
I	H	M	L	M	M	M	M	M	M	H	L	M	H	M	L
II	H	L	M	L	H	M	H	H	M	H	L	M	H	H	L
III	H	H	L	M	H	M	H	H	M	H	M	M	H	H	M
IV	H	H	L	M	H	M	H	H	H	H	M	M	H	H	M
V	H	H	M	H	H	M	H	H	H	H	H	H	H	H	M

Mapping of Course Outcome and Programme Outcome			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
YEAR I	SEMESTER I	Advanced Numerical Methods															
		Surface Water Hydrology	M	M	M	M	M	M		M	M	M		H	M	H	M
		Groundwater Hydrology	H	H	H	M	H	H	M	H	M	H	H	H	H	H	M
		Program Elective I															
		Program Elective II															
		Research Methodology and IPR															
		Audit Course – I															
		Technical Seminar															
	SEMESTER II	Hydrologic Analysis and Design	M	M	M	L	M	M		M	L	M	L	H	M	M	M
		Open Channel Hydraulics	H	H	H	H	H	H	M	H	M	M	H	H	H	H	M
		Systems Analysis in Water Resources	H	H	H	H	H	H	M	H	M	M	H	H	H	H	M
		Remote Sensing and GIS for Water Resources	H	H	H	M	H	M	H	M	M	M	M	H	H	H	H
		Program Elective III															
		Program Elective IV															
		Hydraulics Laboratory	H	H	H	H	H	H	M	H	M	M	H	H	H	H	M
		Satellite Image Processing and GIS Laboratory	H	H	H	M	H	M	H	M	M	M	M	H	M	M	H
YEAR II	SEMESTER III	Dam hydraulics and safety Engineering	H	H	H	H	H	H	M	H	M	M	L	H	H	H	M
		Surface Water Quality Modelling	M	H	M	M	M	M	M	M	M	M	M	H	M	H	H
		Program Elective V															
		Open Elective															
		Audit Course –II															
		Practical Training	H	H	H	H	H	H	M	H	M	M	H	H	H	H	M
		Dissertation I	H	H	H	M	H	M	H	M	M	M	M	H	M	H	H
	SEM IV	Dissertation II	H	H	H	M	H	M	H	M	M	M	M	H	M	H	H

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M. E. HYDROLOGY AND WATER RESOURCES ENGINEERING

REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM
CURRICULA AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA5154	Advanced Numerical Methods	FC	3	1	0	4	4
2.	HW5101	Surface Water Hydrology	PCC	3	0	0	3	3
3.	HW5102	Groundwater Hydrology	PCC	3	0	0	3	3
4.		Program Elective I	PEC	3	0	0	3	3
5.		Program Elective II	PEC	3	0	0	3	3
6.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
7.		Audit Course I*	AC	2	0	0	2	0
PRACTICALS								
8.	HW5111	Technical Seminar	EEC	0	0	2	2	1
			TOTAL	**19**	**1**	**2**	**22**	**19**

* Audit Course is optional

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	HW5201	Hydrologic Analysis and Design	PCC	3	0	0	3	3
2.	HW5202	Open Channel Hydraulics	PCC	3	0	0	3	3
3.	HW5203	Systems Analysis in Water Resources	PCC	3	0	0	3	3
4.	HW5251	Remote Sensing and GIS for Water Resources	PCC	3	0	0	3	3
5.		Program Elective III	PEC	3	0	0	3	3
6.		Program Elective IV	PEC	3	0	0	3	3
PRACTICALS								
7.	HW5211	Hydraulics Laboratory	PCC	0	0	2	2	1
8.	HW5261	Satellite Image Processing and GIS Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**0**	**6**	**24**	**21**

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	HW5301	Dam hydraulics and safety Engineering	PCC	3	0	0	3	3
2.	HW5302	Surface Water Quality Modelling	PCC	3	0	2	5	4
3.		Program Elective V	PEC	3	0	0	3	3
4.		Open Elective	OEC	3	0	0	3	3
5.		Audit Course II*	AC	2	0	0	2	0
PRACTICALS								
6.	HW5311	Practical Training**	EEC	0	0	0	0	2
7.	HW5312	Dissertation I	EEC	0	0	12	12	6
			TOTAL	**14**	**0**	**14**	**28**	**21**

* Audit Course is optional

**Practical Training will be undergone (minimum 4 weeks) during the summer break and will be evaluated in third semester.

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	HW5411	Dissertation II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR AWARD OF THE DEGREE: 73

FOUNDATION COURSES (FC)

S. No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	MA5154	Advanced Numerical Methods	3	1	0	4	1

PROGRAM CORE COURSES (PCC)

S. No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	HW5101	Surface Water Hydrology	3	0	0	3	1
2.	HW5102	Groundwater Hydrology	3	0	0	3	1
3.	HW5201	Hydrologic Analysis and Design	3	0	0	3	2
4.	HW5202	Open Channel Hydraulics	3	0	0	3	2
5.	HW5203	Systems Analysis in Water Resources	3	0	0	3	2

6.	HW5251	Remote Sensing and GIS for Water Resources	3	0	0	3	2
7.	HW5211	Hydraulics Laboratory	0	0	2	1	2
8.	HW5261	Satellite Image Processing and GIS Laboratory	0	0	4	2	2
9.	HW5301	Dam hydraulics and safety Engineering	3	0	0	3	3
10.	HW5302	Surface Water Quality Modelling	3	0	2	4	3
					TOTAL CREDITS	**28**	

PROGRAM ELECTIVE COURSES [PEC]

S. No.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	HW5001	Advanced Fluid Mechanics	3	0	0	3
2.	HW5002	Computational Intelligence for Hydrosystems	3	0	0	3
3.	HW5003	River Engineering	3	0	0	3
4.	HW5004	Environmental Hydraulics	3	0	0	3
5.	HW5005	Sediment Transportation	3	0	0	3
6.	HW5006	Flood Modelling and Drought Management	3	0	0	3
7.	HW5007	Groundwater Modelling and Management	3	0	0	3
8.	HW5008	Radar Meteorology	3	0	0	3
9.	HW5009	Water Supply and buried pipelines	3	0	0	3
10.	HW5010	Water Power and Dam Engineering	3	0	0	3
11.	HW5011	Water and Ecosystems	3	0	0	3
12.	HW5012	Urban Water Resources Management	3	0	0	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	RM5151	Research Methodology and IPR	2	0	0	2	1
					TOTAL CREDITS	**2**	

OPEN ELECTIVE COURSES [OEC]

*(Out of 6 Courses one Course must be selected)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OE5091	Business Data Analytics	3	0	0	3	3
2.	OE5092	Industrial Safety	3	0	0	3	3
3.	OE5093	Operations Research	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	3	0	0	3	3
5.	OE5095	Composite Materials	3	0	0	3	3
6.	OE5096	Waste to Energy	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/3
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	
TOTAL CREDITS						0	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1	HW5111	Technical Seminar	0	0	2	1	1
2	HW5311	Practical Training	0	0	0	2	3
3	HW5312	Dissertation I	0	0	12	6	3
4	HW5411	Dissertation II	0	0	24	12	4
TOTAL CREDITS						**21**	

SUMMARY

	Name of the Programme: M.E HYDROLOGY AND WATER RESOURCES ENGINEERING					
	SUBJECT AREA	**CREDITS PER SEMESTER**				**CREDITS TOTAL**
		I	**II**	**III**	**IV**	
1.	FC	4	0	0	0	4
2.	PCC	10	15	3	0	28
3.	PEC	3	6	6	0	15
4.	RMC	2	0	0	0	2
5.	OEC	0	0	3	0	3
6.	EEC	1	0	8	12	21
7.	Non Credit/ Audit Course			0	0	0
8.	**TOTAL CREDIT**	**20**	**21**	**20**	**12**	**73**

MA5154 **ADVANCED NUMERICAL METHODS** **L T P C**
3 1 0 4

OBJECTIVES:

- To impart knowledge in understanding the advantages of various solution procedures of solving the system of linear and nonlinear equations.
- To give a clear picture about the solution methods for solving the BVPs and the system of IVPs.
- To acquire knowledge in solving time dependent one and two dimensional parabolic PDEs by using various methodologies.
- To strengthen the knowledge of finite difference methods for solving elliptic equations.
- To get exposed to the ideas of solving PDEs by finite element method.

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev – Leverrier Method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, collocation method, orthogonal collocation method, Galerkin finite element method.

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION 12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, Lax - Wendroff explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme-Stability of above schemes.

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 12

Partial differential equations – Finite element method - collocation method, orthogonal collocation method, Galerkin finite element method.

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, students will be able to

- Get familiarized with the methods which are required for solving system of linear, nonlinear equations and eigenvalue problems.
- Solve the BVPs and the system of IVPs by appropriate methods discussed.
- Solve time dependent parabolic PDEs by using various methodologies up to dimension two.
- Solve elliptic equations by finite difference methods.
- Use the ideas of solving PDEs by finite element method.

REFERENCES:

1. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", Cengage Learning, India Edition, New Delhi, 2010.
2. Gupta S.K., "Numerical Methods for Engineers", New Age Publishers, 3rd Edition, New Delhi, 2015.

3. Jain M. K., Iyengar S. R. K., Jain R.K., “Computational Methods for Partial Differential Equations”, New Age Publishers, 2nd Edition, New Delhi, 2016.
4. Morton K.W. and Mayers D.F., “Numerical solution of partial differential equations”, Cambridge University press, Cambridge, 2005.
5. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.
6. Saumyen Guha and Rajesh Srivastava, “Numerical methods for Engineering and Science”, Oxford Higher Education, New Delhi, 2010.

HW5101 SURFACE WATER HYDROLOGY L T P C
3 0 0 3

OBJECTIVE:

- To impart the knowledge on Precipitation, Abstraction and Runoff processes of hydrologic cycle, their estimation and field measurements and Water harvesting methods.

UNIT I HYDROMETEOROLOGY 9

Hydrologic cycle – Global water budget – Practical applications – Hydrometeorology – Constituents of atmosphere – Vertical structure of the atmosphere – Climate and Weather – Meteorological Observations - Formation of precipitation – Types and forms of precipitation .

UNIT II PRECIPITATION 8

Measurement of rainfall – Rain gauges – Radar Measurement of rainfall - Rainfall Hyetograph – Intensity Duration and Frequency analysis – Consistency – Missing data – Rain gauge network – Average depth of rainfall analysis – Spatial analysis using GIS – Annual rainfall of India and Tamilnadu

UNIT III ABSTRACTIONS 8

Water losses - Initial losses – Interception and depression storage – Evaporation – Evaporimeters – Estimation of Evaporation - Evapotranspiration – Field Measurement – Empirical Equations - Infiltration – Infiltrometers – Infiltration Equations - Infiltration Indices

UNIT IV CATCHMENT RUNOFF AND YIELD 12

Concept of catchment – Linear, Areal and Relief Aspects – Detailed study of Runoff process – Factors affecting Runoff – Hydrograph – Unit Hydrograph – Synthetic Hydrograph – Runoff estimation - Strange and SCS methods – SWAT and HEC-HMS model

UNIT IV STREAMFLOW MEASUREMENT 8

Stage and Velocity Measurement – Gauges – Current meter - Discharge measurement – Area Velocity method - Area Slope method – Discharge Measuring Structures - Stage Discharge Relationship - Dilution Technique – Water Conservation – Rain water and Runoff Harvesting in Rural and Urban Areas.

TOTAL: 45 PERIODS

OUTCOMES:

CO1	Describe the hydrologic cycle and devices for hydro meteorological Measurements
CO2	Explain different rain gauges and Perform various kind of Rainfall Analysis
CO3	Estimate various losses such as evaporation, Evapotranpiration and Infiltration.
CO4	Discuss the various methods of runoff estimation and derive hydrographs
CO5	Demonstrate the various methods of Stream flow measurement and water harvesting Techniques.

REFERENCES:

1. Chow V.T., Maidment D.R., Mays L.W., Applied Hydrology, McGraw Hill Publications, New York, 1995.
2. Subramanya K., Hydrology,Tata McGraw Hill Co., New Delhi, 1994.

3. Patra.K.C, Hydrology and Water Resources Engineering, Narosa Publications, 2008, Second Edition, New Delhi.
4. Jeya Rami Reddy.P, Hydrology, Laxmi Publications, New Delhi, 2004

CO – PO MAPPING OF SURFACE WATER HYDROLOGY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	M	M	M	M	M
PO2	Problem analysis	L	H	M	H	M	M
PO3	Design / development of solutions	L	L	M	L	M	M
PO4	Investigation		L	M	M	M	M
PO5	Modern Tool Usage	M	M	M	M	M	M
PO6	Individual and Team work	L	H	M	M	M	M
PO7	Communication						
PO8	Engineer and Society	M	M	M	M	H	M
PO9	Ethics	M	M	M	L	H	M
PO10	Environment and Sustainability	M	L	M	M	H	M
PO11	Project Management and Finance		L				
PO12	Life Long Learning	H	M	H	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges.	H	M	M	H	M	M
PSO2	Analyse hydrological data to model water quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	L	H	M	M	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering.	L	M	M	H	M	M

HW5102 GROUNDWATER HYDROLOGY L T P C
3 0 0 3

OBJECTIVES:

- The objective of this course is enable the student to understand the basic aquifer parameters, groundwater resources for different hydro-geological boundary conditions, empirical knowledge of the residence and movement of groundwater aspects.

UNIT I GROUNDWATER BASICS 8

Introduction to Groundwater – Hydro meteorology – Groundwater in Hydrologic Cycle – Occurrence of groundwater – zone of Aeration and Saturation – Hydrogeology –— Types of aquifers soil sample analysis - Water bearing materials – Aquifer parameters and its determination.

UNIT II GROUNDWATER HYDRAULICS 10

Groundwater Movement - Darcy‟s law and its limitations - Stream lines and flow net analysis – Potential flow theory – Discharge and draw down for various condition of groundwater flow - Principles of groundwater flow and its equation – Dupuit – Forchheimer assumptions – Influent and Effluent streams - Evaluation of well loss parameters – Partial penetration of wells – Interference of wells

UNIT III PUMPING TEST ANALYSIS 10

Determining aquifer parameters for unconfined, leaky and non-leaky aquifers – steady and transient conditions - Slug test – Locating hydro geological boundaries – Image well theory – Determination of well characteristics and specific capacity of wells – Well characteristics of large diameter wells.

UNIT IV WELL DESIGN AND CONSTRUCTION 8

Well design criteria – Construction of wells – Well drilling methods – Filter design – Artificial and natural packing – Well casings and screens – Production test – Maintenance of production wells – Pumping Equipment – protection of wells and Rehabilitation – Horizontal wells - Collector wells and Infiltration galleries

UNIT V SPECIAL TOPICS 9

Methods of artificial groundwater recharge – Groundwater Basin Management and conjunctive use - Groundwater assessment and balancing – Seawater intrusion in coastal aquifers – Land Subsidence – Groundwater flow in Hard Rock System: conceptual models – structure and hydrodynamic properties of hard rock aquifers.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to:

CO1	Define the groundwater system, types of aquifers and aquifer parameters
CO2	Apply the knowledge of groundwater basics to study the groundwater movement and its potential for confined and unconfined aquifers.
CO3	Explain the details of steady and unsteady flow characteristics in well hydraulics
CO4	Adopt design concept for various wells in different hydrogelogical formations and to construct the wells for different purposes
CO5	Apply the creative and advance techniques in groundwater model development for management of groundwater resources.

REFERENCES:

1. Todd D.K., Groundwater Hydrology, John Wiley & Sons, Inc, New York, 1976.
2. Bear J., Hydraulics of Groundwater, McGraw-Hill, New York, 1979.
3. Bouwer H., Groundwater Hydrology, McGraw-Hill, New York, 1978.
4. Driscoll, Groundwater and Wells, Johnson Filtration Systems, Inc., 1986.
5. Ojha, C.S.P, Berndtsson, R and Bhunya, P., Engineering Hydrology, Oxford University Press,New Delhi, 2008.
6. Rastogi A.K. , Numerical Groundwater Hydrology, 2011

CO – PO GROUNDWATER HYDROLOGY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	H	M	H
PO2	Problem analysis	M	H	H	H	M	H
PO3	Design / development of solutions	M	H	H	H	M	H
PO4	Investigation	M	H	H	M	H	M
PO5	Modern Tool Usage			M	H	H	H

PO6	Individual and Team work	M	H	M	H	H	H
PO7	Communication					M	M
PO8	Engineer and Society	M	H	M	H	H	H
PO9	Ethics					M	M
PO10	Environment and Sustainability					H	H
PO11	Project Management and Finance		M	H	M	H	H
PO12	Life Long Learning	H	M	H	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	M	M	H	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	M	H	H	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	M	M	M	H	M

RM5151 RESEARCH METHODOLOGY AND IPR LT P C
2 0 0 2

OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics

UNIT III TECHNICALWRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology.Patent information and databases.Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

REFERENCES:

1. Asimov, "Introduction to Design", Prentice Hall, 1962.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

HW5201 HYDROLOGIC ANALYSIS AND DESIGN L T P C
3 0 0 3

OBJECTIVE:

- To impart the knowledge on hydrological modeling approaches, hydrologic statistics, hydrologic time series and simulation models.
- To teach the hydrologic design concepts and Design Flows estimation

UNIT I DETERMINISTIC HYDROLOGIC SIMULATION 9

Hydrologic cycle – System concept – Hydrologic system Model – Classification of Hydrologic Models – Statistical, Stochastic and Deterministic Approaches – Types of Deterministic Model – Black Box, Conceptual and Physically based models - Models of IUH, Nash and Chow-Kulandaiswamy Models – Modelling Procedure, Calibration and Validation, Modelling Errors - HEC HMS, SWAT and MIKE SHE Models.

UNIT II HYDROLOGIC TIME SERIES ANALYSIS 10

Stochastic Process – Classification – Stationary and Non-Stationary Process – Time series – Classification – Component of Time series – Method of Investigation – Auto Correlation Analysis – Moving Average Process – Auto Regressive Process - Auto Regressive Moving Average Process - Auto Regressive Integrated Moving Average Process – Thomas Fiering Model – Box Jenkins Model – Model formulation – Parameter Estimation – Calibration and Validation – Application to hydrologic Forecasting.

UNIT III STATISTICAL HYDROLOGY 9

Random Variable - Statistical characteristics of Hydrological Data – Discrete and Continuous Probability distribution Functions - Frequency and Return Period of Hydrologic Variables Correlation Analysis – Developing Prediction Equation by Simple and Multiple Linear Regression – Reliability of the Model.

UNIT IV HYDROLOGIC DESIGN 8

Hydrologic Design Scale – Estimating Limiting Value – Hydrologic Design level – Design storms for Minor and Major structures - Hydrologic Design Data - Hydraulic structure Design methods – Hydrologic Design Standard and Criteria - Hydrologic Risk, Reliability and Safety Factor - Computation of Design Storm - IDF Relationship - Estimation of PMP.

UNIT V DESIGN FLOWS 9

Estimation of Design Flows - Rational Method - Urban Storm Drainage Design – SWMM Model - Hydrologic Design of Dam Spillway, Culverts, Highway and Railway Bridges - Flood Control Reservoir Design – Water Supply Reservoir Design – Real Time Flood Forecasting.

TOTAL: 45 PERIODS

OUTCOMES:

CO1	Describe the classification of hydrologic models and the deterministic modeling approach of Hydrologic Simulation
CO2	Evaluate the statistical characteristics, Carryout frequency analysis and develop prediction equation between hydrologic variables using regression.
CO3	Apply the time series models for hydrologic forecasting
CO4	Compute the design storm by knowing the design concepts and methods
CO5	Estimate the design flows for minor, medium and major hydraulic structures.

REFERENCES:

1. Chow V. T., David Maidment, and Larry Mays, Applied Hydrology, McGraw Hill Publications, New York, 1995.
2. Singh, V. P. Hydrologic Systems, Prentice-Hall Englewood Cliffs, NJ 1989.
3. Jayarami Reddy P., Stochastic Hydrology, Laxmi Publications, New Delhi 1995.
4. Viessman W Jr and Lewis.G.L., Introduction to Hydrology (5ed) Pearson Education, Inc. 2008.
5. Haan C.T., Statistical Methods in Hydrology Iowa State Press 2002.

CO – PO MAPPING OF HYDROLOGIC ANALYSIS AND DESIGN

PO/PSO		Course Outcome					Overall Correlation of COs to POs and PSOs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	M	M	M	M	M	M
PO2	Problem analysis	L	H	M	M	M	M
PO3	Design / development of solutions	M	M	M	M	M	M
PO4	Investigation	L	M	M	L	L	L
PO5	Modern Tool Usage	M	M	M	L	M	M
PO6	Individual and Team work	M	M	M	M	M	M
PO7	Communication						
PO8	Engineer and Society	M	M	M	M	M	M
PO9	Ethics	L	L	L	L	M	L
PO10	Environment and Sustainability	M	L	L	M	M	M
PO11	Project Management and Finance	L	L	L	M	M	L
PO12	Life Long Learning	H	H	H	H	H	H

PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges.	H	M	M	M	M	M
PSO2	Analyse hydrological data to model water quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	M	M	M	M	M	M
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering.	M	M	M	M	M	M

HW5202 OPEN CHANNEL HYDRAULICS

L	T	P	C
3	0	0	3

OBJECTIVES:

- Application of principles of fluid mechanics to the solution of problems encountered in both natural and constructed water systems.
- Use of model studies and computers in solving a host of problems in hydraulic engineering.

UNIT I BASIC PRINCIPLES **8**

Basic concepts of uniform flow – characteristics of open channel flows - computations. Specific energy – transitions – weirs - specific force concepts – hydraulic jump – stilling basins. Applications

UNIT II FLOW MEASUREMENTS AND HYDRAULIC MODELING **8**

Sharp-Crested weirs, broad-crested weirs, critical depth flumes. Recent advancement in open channel flow measurements. Physical modeling in hydraulics. Dimensional analysis. Modeling closed flows and free surface flows. Distorted models. Design of physical models.

UNIT III UNIFORM FLOW **9**

Control volume analysis – Reynolds transport theorem analysis for open channels – momentum analysis – Chezy and Manning formulae – turbulence and flow resistance – channels with composite roughness – uniform flow computations

UNIT IV VARIED FLOWS **10**

Governing equations – classification of water surface profiles – sketching water surface profiles – computation of varied flow profiles – direct step method – standard step method – simultaneous solution procedure – . Spatially varied flows and rapidly varied flows – applications.

UNIT V UNSTEADY FLOWS **10**

Definitions – surges – classifications – Dam break problems - St. Venant equations – Boussinesq equations – solution methods – method of characteristics - Introduction to HEC-RAS.

TOTAL: 45 PERIODS

OUTCOMES

- On completion of the course, the student is expected to be able to:

CO1	Illustrate the concepts of open channel flows vis-à-vis closed conduct flow and design channel transitions and stilling basins.
CO2	Calculate the discharge for open channel appurtenances like weir and flumes. Formulate the non-dimensional variables using dimensional analysis.

CO3	Compute uniform flows using iterative and or Newton Raphson technique. Calculate the flow resistance using fluid mechanics concepts of turbulent flows.
CO4	Demonstrate the use of governing equations to classify gradually varied flow profiles and compute the same using numerical methods.
CO5	Formulate the one-dimensional unsteady flow equations and solve using method of characteristics. Appraise the use of software like HEC-RAS .

REFERENCES:

1. Sturm T.W., Open Channel Hydraulics – Tata-McGraw Hill 2nd edition, New Delhi 2011. ISBN:978-1-25-900225-0
2. Wurbs R.A., and James W.P. Water Resources Engineering. Prentice Hall of India, Eastern Economic Edition. ISBN: 81-203-2151-0, New Delhi, 2007.
3. Subramanya K., Flow in Open Channels (2nd ed.) Tata McGraw Hill, ISBN 00-746- 2446-6, New Delhi 2003.
4. Chaudhry M. H., Open Channel Flow. Prentice Hall of India, Eastern Economic Edition, ISBN: 81-203-0863-8, New Delhi. 1994.
5. Chow Ven-te Open Channel Hydraulics McGraw Hill, New York NY 1959.
6. French, R. H., Open Channel Hydraulics McGraw Hill, New York NY 1985.
7. Srivastava R. Flow through Open Channels Oxford University Press New Delhi, 2008

CO – PO Mapping - OPEN CHANNEL HYDRAULICS

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	H	H	H
PO2	Problem analysis		M	H	H	H	H
PO3	Design / development of solutions			M	H	H	H
PO4	Investigation					H	H
PO5	Modern Tool Usage			M	H	H	H
PO6	Individual and Team work		H	M	H	H	H
PO7	Communication	M					M
PO8	Engineer and Society		H	M	H	H	H
PO9	Ethics					M	M
PO10	Environment and Sustainability				M		M
PO11	Project Management and Finance		M	H	M	H	H
PO12	Life Long Learning	H	M	M	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	M	M	L	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	L	H	H	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	L	M	M	H	M

HW5203 SYSTEMS ANALYSIS IN WATER RESOURCES L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge and skills relevant to application of systems concept to water resources planning and management. Optimization technique for modeling water resources systems and advanced optimization techniques to cover the socio-technical aspects will be taught

UNIT I SYSTEM CONCEPTS 7

Definition, classification, and characteristics of systems - Scope and steps in systems engineering - Need for systems approach to water resources and irrigation.

UNIT II LINEAR PROGRAMMING 9

Introduction to operations research - Linear programming, problem formulation, graphical solution, solution by simplex method - Sensitivity analysis, application to design and operation of reservoir, single and multipurpose development plans - Case studies.

UNIT III DYNAMIC PROGRAMMING 9

Bellman's optimality criteria, problem formulation and solutions - Application to design and operation of reservoirs, Single and multipurpose reservoir development plans - Case studies.

UNIT IV SIMULATION 9

Basic principles and concepts - Random variant and random process - Monte Carlo techniques - Model development - Inputs and outputs - Single and multipurpose reservoir simulation models - Case studies.

UNIT V ADVANCED OPTIMIZATION TECHNIQUES 11

Integer and parametric linear programming - Goal programming models with applications - Discrete differential dynamic programming and incremental dynamic programming - Linear decision rule models with application - Stochastic dynamic programming models.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to:

CO1	Define the system concept and steps in systems approach for the water resources engineering
CO2	Apply the knowledge of optimisation techniques such as Linear programming and simplex method for reservoir operation.
CO3	Explain single and multipurpose reservoir optimisation using dynamic programming
CO4	Develop the simulation model based on deterministic and stochastic simulation for reservoir operating policy
CO5	Apply the creative and advance optimisation techniques like goal programming, heuristic algorithm in the field of water planning and management.

REFERENCES:

1. Vedula, S., and Majumdar, P.P. Water Resources Systems – Modeling Techniques and Analysis Tata McGraw Hill, New Delhi, Fifth reprint, 2010.
2. Gupta, P.K., and Man Mohan, "Problems in Operations Research", (Methods and Solutions), Sultan Chand and Sons, New Delhi, 1995.
3. Chaturvedi, M.C., "Water Resources Systems Planning and Management", Tata McGraw Hill, New Delhi, 1997.
4. Taha, H.A., "Operations Research", McMillan Publication Co., New York, 1995.
5. Hiller, F.S., and Liebermann, G.J., "Operations Research", CBS Publications and Distributions, New Delhi, 1992.

CO – PO SYSTEMS ANALYSIS IN WATER RESOURCES

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	H	H	H
PO2	Problem analysis		M	H	H	H	H
PO3	Design / development of solutions			M	H	H	H
PO4	Investigation					H	H
PO5	Modern Tool Usage			M	H	H	H
PO6	Individual and Team work		H	M	H	H	H
PO7	Communication	M					M
PO8	Engineer and Society		H	M	H	H	H
PO9	Ethics					M	M
PO10	Environment and Sustainability				M		M
PO11	Project Management and Finance		M	H	M	H	H
PO12	Life Long Learning	H	M	M	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	M	M	L	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	L	H	H	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	L	M	M	H	M

HW5251 REMOTE SENSING AND GIS FOR WATER RESOURCES L T P C
3 0 0 3

OBJECTIVE

- To impart knowledge and skills of remote sensing and geographical information system for data interpretation, analysis, classification of images for formulation of methodology using remote sensing and GIS tools for various applications in water resources engineering

UNIT I BASICS OF REMOTE SENSING 9

Physics of remote sensing, Types of Remote sensing, electromagnetic radiation (EMR), Interaction of EMR with atmosphere, earth surface, soil, water and vegetation; Swath, Nadir, resolutions, image referencing system; Monitoring atmosphere, land and water resources - Indian Space Programme, Sensor characteristics LANDSAT, SPOT, ERS, IKONOS, IRS and others.

UNIT II INTERPRETATION AND ANALYSIS 9

Remote sensing data products – Visual image interpretation – interpretation keys; data formats of digital image - Digital image processing – Image preprocessing – Image enhancement – Image transformation – image classification – accuracy assessment - Data merging.

UNIT III GEOGRAPHIC INFORMATION SYSTEM 9

Definition – Basic components of GIS – Map projections and co-ordinate system – Spatial data structure: raster, vector – Spatial Relationship – Topology – Geodatabase models: hierarchical, network, relational, object oriented models – Data Encoding methods – encoding raster data, vector data and attribute data, linking spatial and attribute data- Integrated GIS database -common sources of error – Data quality: Macro, Micro and Usage level components - Meta data - Spatial data transfer standards.

UNIT IV GEOSPATIAL ANALYSIS 9

Thematic mapping – Geospatial Measurements, query analysis, buffering, overlay operations, network analysis, DEM, DSM, DTM, Interpolation - Geovisualisation - Object oriented GIS – Modern trends of GIS – WebGIS, 3DGIS, Real-time GIS.

UNIT V WATER RESOURCES APPLICATIONS 9

Water resources models – Rainfall runoff modelling – Groundwater modeling – Water quality modeling - Flood inundation mapping and modelling – Drought monitoring – Cropping pattern change analysis - Site selection for artificial recharge - Reservoir sedimentation - Case study in microwave remote sensing.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	describe the basics of remote sensing and distinguish the sensors and satellites characteristics
CO2	choose the appropriate data products and techniques for image analysis
CO3	Illustrate the basics of map preparation in GIS
CO4	Demonstrate the geospatial data analysis techniques
CO5	Formulate the methodology using remote sensing and GIS tools for various applications in water resources engineering

REFERENCES:

1. Lillesand, T.M. and Kiefer, R.W., Remote Sensing and Image Interpretation, III Edition. John Wiley and Sons, New York. 1993.
2. Burrough P.A. and McDonnell R.A., Principles of Geographical Information Systems, Oxford University Press. New York. 1998.
3. Ian Heywood Sarah, Cornelius and Steve Carver, An Introduction to Geographical Information Systems. Pearson Education. New Delhi, 2002.
4. Basudeb Bhatta, Remote Sensing and GIS, II Edition, Oxford University Press, New Delhi, 2011
5. George Joseph and C. Jeganathan: Fundamentals of Remote Sensing, Third Edition, Universities Press Pvt. Ltd., Hyderabad, India, 2018
6. Centre for Water Resources, Change in Cropping Pattern in Drought Prone Chittar Sub-basin, Project Report, Anna University, Chennai, 2002.

CO – PO Mapping: REMOTE SENSING AND GIS FOR WATER RESOURCES

PO/PSO		Course Outcome					Overall Correlation of COs to Pos
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	L	M	M	H	H	H
PO2	Problem analysis		H	M	H	H	H
PO3	Design / development of solutions				M	H	H
PO4	Investigation		M	M	M	M	M
PO5	Modern Tool Usage	L	M	H	H	H	H

PO6	Individual and Team work	L	M	M	M	H	M
PO7	Communication			H	M	H	H
PO8	Engineer and Society	M	M	M	M	H	M
PO9	Ethics				M	M	M
PO10	Environment and Sustainability	L	L	M	M	M	M
PO11	Project Management and Finance				M	M	M
PO12	Life Long Learning	M	M	H	H	H	H
PSO1	Knowledge of Hydrology and water resources, Irrigation water management discipline				H	H	H
PSO2	Critical analysis of Hydrology and water resources, Irrigation water management problems and innovation				H	H	H
PSO3	Conceptualization and evaluation of Hydrology and water resources, Irrigation water management Issues			H	H	H	H

HW5211 HYDRAULICS LABORATORY

L	T	P	C
0	0	2	1

OBJECTIVE:

- To expose the students to experimental learning of fluid phenomena both in air and water.

LIST OF EXPERIMENTS (Any ten of the following experiments)

1. Wave length, profile and group velocity as a function of wave period, water depth and wave height.
2. Wave forces on cylinders and piers.
3. Drag and lift characteristics of aerofoils.
4. Drag characteristics of cylinders.
5. Boundary layer measurements.
6. Measurement of velocities in wave flume.
7. Hydraulic jump studies.
8. Discharge measurements using venturi-flume.
9. Hele – Shaw model.
10. Velocity profiles in free jets.
11. Flow through porous media. Flow net plotting.

TOTAL: 30 PERIODS

OUTCOMES

- On completion of the course, the student is expected to be able to:

CO1	Conduct experiments in wave flume to determine the wave characteristics and wave energy
CO2	Determine the drag and lift of aerofoils and cylinders
CO3	Evaluate the energy loss in hydraulic jumps and jet flows.
CO4	Distinguish between laminar and turbulent boundary layers
CO5	Compare the flow nets obtained through graphical plotting and Hele-Shaw model.

REFERENCES:

1. Novak, Pavel, Vincent Guinot, Alan Jeffrey, and Dominic E. Reeve. "Hydraulic modelling–an Introduction." *Spon Press, London* (2010).

2. Hughes, Steven A. *Physical models and laboratory techniques in coastal engineering*. Vol. 7. World Scientific, 1993.
3. Rathakrishnan, Ethirajan. *Instrumentation, measurements, and experiments in fluids*. CRC Press, 2007.

CO – PO Mapping - HYDRAULICS LABORATORY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	**CO2**	**CO3**	**CO4**	**CO5**	
PO1	Knowledge of Engineering Sciences	H	H	H	H	H	H
PO2	Problem analysis		M	H	H	H	H
PO3	Design / development of solutions			M	H	H	H
PO4	Investigation					H	H
PO5	Modern Tool Usage			M	H	H	H
PO6	Individual and Team work		H	M	H	H	H
PO7	Communication	M					M
PO8	Engineer and Society		H	M	H	H	H
PO9	Ethics					M	M
PO10	Environment and Sustainability				M		M
PO11	Project Management and Finance		M	H	M	H	H
PO12	Life Long Learning	H	M	M	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	M	M	L	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	L	H	H	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	L	M	M	H	M

HW5261 SATELLITE IMAGE PROCESSING AND GIS LABORATORY L T P C
0 0 4 2

OBJECTIVE

- The hands on experiments in the image processing, GIS platforms and GPS will make the students to appreciate their importance in hydrology and water resource.

LIST OF EXPERIMENTS

Image processing

1. Satellite data products : commercial and open source
2. Land use land cover classification
    1. Unsupervised
    2. Supervised
    3. Accuracy assessment

3. Vegetation indices for vegetative cover analysis
4. Reservoir volume estimation using temporal satellite imageries

Geographical Information System

5. Georeferencing of toposheet and creating vector layers, attribute tables and layout preparation
6. GPS Survey, data transformation into GIS, analysis of data and creation of maps using Google earth maps.
7. Use of D8 pointer algorithm for deriving flow direction, flow accumulation and watershed delineation.
8. Interpolation of point data to create Spatial Maps.
    1. Theisson polygon method
    2. Natural Neibourhood method
    3. Triangular irregular network
    4. Kriging method
9. Derivation of integrated map using weighted overlay techniques (any one).
    1. Identifying suitable artificial recharge areas
    2. Identification of ground water potential zones
    3. Estimation of sedimentation yield using RUSLE method
10. Join and Relate tables, File conversion from .kml to .shp
11. Open source GIS – Demo

TOTAL: 60 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Demonstrate the methodology used for satellite image processing for applications in water resource engineering
CO2	Illustrate the basics of map preparation in GIS through geo referencing, digitisation and attribute creation
CO3	Demonstrate the use of GIS for watershed delineation and creation of basic entities for application of various water resources problems
CO4	Demonstrate the geospatial data analysis techniques
CO5	Formulate the methodology using remote sensing and GIS tools for various applications in water resources engineering

REFERENCES

1. Lillesand, T.M. and Kiefer, R.W., Remote Sensing and Image Interpretation, III Edition. John Wiley and Sons, New York. 1993.
2. Burrough P.A. and McDonnell R.A., Principles of Geographical Information Systems, Oxford University Press. New York. 1998.

CO – PO Mapping: SATELLITE IMAGE PROCESSING AND GIS LABORATORY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	L	M	M	H	H	H
PO2	Problem analysis		H	M	H	H	H
PO3	Design / development of solutions				M	H	H
PO4	Investigation		M	M	M	M	M
PO5	Modern Tool Usage	L	M	H	H	H	H
PO6	Individual and Team work	L	M	M	M	H	M
PO7	Communication			H	M	H	H
PO8	Engineer and Society	M	M	M	M	H	M
PO9	Ethics				M	M	M

PO10	Environment and Sustainability	L	L	M	M	M	M
PO11	Project Management and Finance				M	M	M
PO12	Life Long Learning	M	M	H	H	H	H
PSO1	Knowledge of Hydrology and water resources, Irrigation water management discipline	M	M	M	H	H	M
PSO2	Critical analysis of Hydrology and water resources, Irrigation water management problems and innovation	M	M	M	H	H	M
PSO3	Conceptualization and evaluation of Hydrology and water resources, Irrigation water management Issues	M	M	H	H	H	H

HW5301 DAM HYDRAULICS AND SAFETY ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To understand the hydraulic principles that govern the design practices.

UNIT I INTRODUCTION 9

Introduction: Description of dam hydraulics – design discharges of bottom outlet, spillway, intake structure and diversion tunnel or channels. Dam safety principles.

UNIT II DIVERSION STRUCTURES 9

Diversion structures – Introduction to diversion tunnel – River diversion culverts – outlet structures – cascade spillway – stilling basins.

UNIT III OUTLETS AND INTAKE STRUCTURES 9

Bottom outlets – hydraulics of high head gates – air entrainment and cavitation – types of intake structures.

UNIT IV HYDRAULIC MODELING 9

Hydraulic modeling of spillways and energy dissipators – dimensionless numbers – distorted models – scale effects – dynamic flow measurements – analysis and interpretation of results. Structural models.

UNIT V DAM SAFETY 9

Dam safety – risk and reliability – instrumentation surveillance – dam safety legislation – reservoir hazard and risk assessment. Emergency action plans.

TOTAL: 45 PERIODS

OUTCOMES

- On completion of the course, the student is expected to be able to:

CO1	Enumerate the different components of dam which are designed mainly on hydraulic principles
CO2	Design the diversion structures and stilling basins
CO3	Explain the phenomenon of air entrainment and cavitation in various structures of the dam appurtenances
CO4	Employ the concepts of dimensional analysis and model studies to design scale models of different appurtenances of the dam
CO5	Assess the safety of the dam through risk and reliability concepts and describe emergency action plans.

REFERENCES:

1. Vischer D.L., and Hager W.H. *Dam Hydraulics.* John Wiley and Sons. 1998.
2. Khatsuria, Rajnikant M. *Hydraulics of spillways and energy dissipators*. CRC Press, 2004.
3. Novak, P., Moffat, A.I.B., Nalluri, C. and Narayanan, R., 2014. *Hydraulic structures*. CRC Press.

CO – PO DAM HYDRAULICS AND SAFETY ENGINEERING

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	H	H	H
PO2	Problem analysis	M	M	H	H	H	H
PO3	Design / development of solutions			H	H	H	H
PO4	Investigation		H	H	H	H	H
PO5	Modern Tool Usage			M	H	H	H
PO6	Individual and Team work		H	M	H	H	H
PO7	Communication						M
PO8	Engineer and Society		H	M	H	H	H
PO9	Ethics					H	M
PO10	Environment and Sustainability					H	M
PO11	Project Management and Finance						
PO12	Life Long Learning	H	M	M	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	M	M	L	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	L	H	H	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	L	M	M	H	M

HW5302 SURFACE WATER QUALITY MODELLING L T P C
3 0 2 4

OBJECTIVE

- To impart knowledge on water quality problems, mathematical interpretation in the water quality environments such as rivers, streams, lakes, sediments and to develop the skills on numerical modeling for water quality along with hands-on practice for water quality analysis.

UNIT I WATER QUALITY AND MATHEMATICAL INTERPRETATION 9

Water quality problems – interpretation – What to model? – Common way of modeling – Features of mathematical model, data – Advection transport – dispersion transport- external contributions – in water transformations – non-conservative pollutants – hydrodynamic aspects.

UNIT II RIVERS AND STREAMS 9

River hydrology – types – low frequency analysis, dispersion, mixing, flow estimation, morphometry- travel time, depth, velocities – Mass balance – conservative and non-conservative substances, dispersion coefficient, pollutants in rivers

UNIT III LAKES, IMPOUNDMENTS, SEDIMENTS 9

Lake Morphometry – physical and hydrologic characteristics- Water balance – steady state, temperature and stratification- lakes as mixed systems – lakes in series – Finite segment steady state lake model Sediment transport – suspended solids – bottom sediments- simple solids budgets - resuspension

UNIT IV EUTROPHICATION AND TEMPERATURE 9

Basic mechanism –nutrients – N/p ratio - phosphorus loading concept – sediment –water interaction, heat budgets, thermal stratification, finite segment models – eutrophication control techniques Significance of water temperature - sources and sinks – heat balance – temperature models – reduction of excess heat inputs

UNIT V NUMERICAL MODELING 9

Fundamentals of Finite difference method – finite element method – finite volume method – 2D FEM – Model calibration and verification - water quality measurements and uncertainty – reliability.

UNIT VI WATER QUALITY LAB 15

Demo of water quality field kit, Field measurements, Water sample collection and transport, introduction to analytical laboratory, Good Laboratory Practices and Quality Control, Hydro chemical methods, Measurement of turbidity, solids, pH and EC, major ions, nutrients, Demo of BOD and COD estimations, Calculation of SAR, Hardness, Alkalinity

TOTAL: (45 + 15) : 60 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Comprehend the water quality problems and to interpret mathematically to develop models
CO2	Demonstrate the methodology in developing water quality models in the environment rivers and streams
CO3	Demonstrate the methodology in developing water quality models in the environment lakes, impoundments and sediments
CO4	Illustrate the mechanism of nutrient loading, its control and heat budget for temperature models
CO5	Comprehend the differences among the numerical modelling methods in water quality modelling and also hands-on practice for water quality analysis

REFERENCES

1. Thomann, RV and Mueller JA, *Principles of surface water quality modeling and control*, Harper & Row, Publishers, New York, 1987
2. Steven C. Chapra, *Surface Water Quality Modeling*, McGraw-Hill International Editions, 1997
3. Marcello Benedini and George Tsakiris, *Water Quality Modelling for Rivers and Streams*, Springer Dordrecht Heidelberg New York London, 2013
4. Chin, David A. *Water-quality Engineering in natural systems : fate and transport processes in the water environment,* A John Wiley & Sons, Inc., Publication, Hoboken, New Jersey, 2013
5. Zhen-Gang Ji, *Hydrodynamics and Water Quality: Modeling Rivers, Lakes, And Estuaries*, A John Wiley & Sons, Inc., Publication, 2008

CO – PO Mapping: SURFACE WATER QUALITY MODELING

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	M	M	M	H	H	M
PO2	Problem analysis		H	M	H	H	H
PO3	Design / development of solutions			M	M	H	M
PO4	Investigation	M	M	M	M	H	M
PO5	Modern Tool Usage	L	L	M	M	M	M
PO6	Individual and Team work	L	L	L	M	M	M
PO7	Communication			M	M	H	M
PO8	Engineer and Society	M	M	M	M	H	M
PO9	Ethics				M	M	M
PO10	Environment and Sustainability	L	L	M	M	M	M
PO11	Project Management and Finance				M	M	M
PO12	Life Long Learning	M	M	H	H	H	H
PSO1	Knowledge of Hydrology and water resources, Irrigation water management discipline		M	M	M	H	M
PSO2	Critical analysis of Hydrology and water resources, Irrigation water management problems and innovation	L	M	M	H	H	H
PSO3	Conceptualization and evaluation of Hydrology and water resources, Irrigation water management Issues	L	M	M	H	H	H

HW5001 ADVANCED FLUID MECHANICS L T P C
3 0 0 3

OBJECTIVES:

- To introduce students to concepts of fluid mechanics from both theoretical and applications perspective.

UNIT I INTRODUCTION & BACKGROUND 9

Continuum hypothesis, fluid properties, basic thermodynamic relations, perfect gas, scalars and vectors, cartesian tensors, Gauss' theorem, Stokes theorem. Lagrangian and Eulerian description, material derivative and stream function.

UNIT II CONSERVATION LAWS AND DIMENSIONAL ANALYSIS 9

Control volume concepts, Reynolds transport theorem, conservation of mass, momentum and energy, Navier-Stokes equation, non-dimensional parameters determined from differential equations, Buckingham's Pi theorem, similitude and model testing.

UNIT III IDEAL FLUID FLOW 9

Stream function and velocity potential, Laplace equation, application of complex variables, flow at a wall angle, source, sink, doublet, flow past Rankine half-body, flow past a circular cylinder with circulation, source near a wall, method of images, conformal mapping and applications.

UNIT IV REAL FLUID FLOW 9

Laminar flow, analogy between heat and vorticity diffusion, steady flow between parallel plates, steady flow between concentric cylinders, impulsively started plate, high and low Reynold's number flows, creeping flow around a sphere, Hele-Shaw flow. Boundary layers, Blasius solution, von-Karman momentum integral equation, boundary layer separation and control.

UNIT V INSTABILITY AND TURBULENCE 9

Method of normal modes, thermal instability, Kelvin-Helmholtz instability, Orr-Sommerfeld equation, inviscid instability of parallel flows, turbulence, averages, correlations and spectra, averaged equation of motion, kinetic energy budget of mean flow, kinetic energy budget of turbulent flow, turbulence production and cascade, wall shear flows, eddy viscosity and mixing length hypothesis, turbulence closure.

TOTAL: 45 PERIODS

OUTCOMES

- On completion of the course, the student is expected to be able to:

CO1	Distinguish between the fluid properties and apply basic mathematical concepts of vectors and tensors to fluid kinematics.
CO2	Formulate the integral equations for conservation laws from control volume perspective.
CO3	Solve problems of ideal fluids by applying concepts of complex variables and combination of simple flow problems.
CO4	Reduce the complexity of the governing equation of flow for simplified boundaries and obtain closed for solutions. Illustrate the solution of boundary laver flows for integral formulation.
CO5	Illustrate the application of instability theory for onset of turbulence and discuss the concepts of turbulence and problem of turbulence closure.

REFERENCES:

1. Kundu P.K. and Cohen I.M. Fluid Mechanics 2/e Academic Press, Elsevier Science India 2002.
2. Schlichting H. and Gersten K. Boundary Layer Theory, 8th ed. Springer-Verlag 2004, ISBN 81-8128-121-7
3. Yuan S.W. Foundations of Fluid Mechanics (SI unit edition) Prentice Hall of India 1970
4. Vallentine H.R. Applied Hydrodynamics Butterworths London 1959
5. White F.M. Viscous Fluid Flow, 3rd edition McGraw Hill, New York, ISBN:007124493X
6. Tennekes H. and Lumley J.L. A First Course in Turbulence MIT Press 1972 ISBN 0 262 20019

CO – PO ADVANCED FLUID MECHANICS

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	H	H	H
PO2	Problem analysis	H	H	H	H	H	H
PO3	Design / development of solutions			M	H	H	H
PO4	Investigation		H	H		H	H
PO5	Modern Tool Usage				H	H	H
PO6	Individual and Team work	H	H	H	H	H	H
PO7	Communication						M

PO8	Engineer and Society			M	H	H	H
PO9	Ethics						
PO10	Environment and Sustainability				M	H	M
PO11	Project Management and Finance						
PO12	Life Long Learning	H	H	H	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	H	H	H	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	L	L	L	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	L	L	M	H	M

HW5002 COMPUTATIONAL INTELLIGENCE FOR HYDRO SYSTEMS L T P C
3 0 0 3

OBJECTIVES:

- To develop skills of the students in software usage for simulation and water resources management
- To enable the students to understand application of the latest information technology to water resources engineering

UNIT I INTERFACE MODELLING DESIGN CONCEPT 10

Computer methods in water resources - Computing techniques - Design of digital models - data design, architectural design, interface design, component-level design.- Visual programming - Graphical user interface - Interactive model concepts.

UNIT II ARTIFICIAL INTELLIGENCE 10

Heuristic search - Principle of Artificial Neural Network (ANN) - Application of ANN Model to Hydrology and Crop Water Requirement model. Fuzzy Logic concepts and Applications – Genetic Algorithms-Heuristic Optimization techniques.

UNIT III DIGITAL DATA MANAGEMENT 10

Data base structure - Data acquisition - Data warehouse - Data retrieval-Data format Attribute - RDBMS - Data analysis - Network data sharing - Statistical Analysis (SYSTAT) - Regression - factor analysis - histogram - scatter diagram - Goodness of fit.

UNIT IV SIMULATION SOFTWARE IN WATER RESOURCES 8

Surface water models (HMS) - Storm Water Management Models (SWMM) –culvert hydraulic design(HY) – River Analysis system models (HEC-RAS)-Ground Water Flow models – Groundwater transport models.

UNIT V SIMULATION MODELS IN IRRIGATION WATER MANAGEMENT 7

Soil water assessment simulation models (SWAT) - Basin simulation models (MITSIM, VASIM) Real time operation models - Water Resources Information System, Management Information System. Decision support system for Irrigation management.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to:

CO1	Define the concept of digital model design concept of interface and create visual programming modules
CO2	Apply the knowledge of Artificial inelegance techniques to water resources application and optimising the resources using Fuzzy and heuristic algorithms.
CO3	Create the data base management system and applied to statistical data analysis of participatory rural appraisal information
CO4	Develop the simulation model for hydrological system such as surface water and groundwater modelling
CO5	Apply the simulation model in the field of irrigation water management such as SWAT, Real time modelling and MIS

REFERENCES:

1. Aliev R. A, and Aliev Rashad Soft Computing and its Applications World Scientific Publications Co. Pte. Ltd. Singapore, 2001.
2. Janusz Kacprzyk Applied Decision with Soft Computing Springer, 2003
3. Carlos A. Coello Coello, David A Van Veldhuizen, Gary B Lamont, Evolutionary Algorthms for Solving Multi-objective problems, Springer, 2002.
4. Tayfur Gökmen Soft computing in water resources engineering, WIT Press, Great Britain,UK,20124.
5. John E. Gribbin, Introduction to hydraulics and hydrology with applications for Storm water Management. DELMAR, Thomson Learning, USA,2002.
6. Remson I, Hornberger G.M. and Moiz F.J., Numerical methods in Sub- Surface Hydrology. Wiley Inter Science, 1985
7. Kazda, I., Finite element Techniques in ground water flow studies (with Applications in Hydraulic and Geotechnical Engineering), Elsevier, 1990.
8. Abbott M.B, and Minns A.W. Computational hydraulics Ashgate, London,UK,2007.
9. Loucks Daniel P., Jery R Stedinger and Douglas, A. Haith, Water Resources systems Planning and Analysis. Prentice Hall Inc., Englewood Clifts, New Jersey, 1981.

CO – PO COMPUTATIONAL INTELLIGENCE FOR HYDRO SYSTEMS

PO/PSO		Course Outcome					Overall Correlation of COs to Pos
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	H	H	H
PO2	Problem analysis		M	H	H	H	H
PO3	Design / development of solutions			M	H	H	H
PO4	Investigation					H	H
PO5	Modern Tool Usage			M	H	H	H
PO6	Individual and Team work		H	M	H	H	H
PO7	Communication	M					M
PO8	Engineer and Society		H	M	H	H	H
PO9	Ethics					M	M
PO10	Environment and Sustainability				M		M

PO11	Project Management and Finance		M	H	M	H	H
PO12	Life Long Learning	H	M	M	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	M	M	L	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	L	H	H	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	L	M	M	H	M

HW5003 **RIVER ENGINEERING** **L T P C**
3 0 0 3

OBJECTIVES:

- To understand theoretical concepts of water and sediment movements in rivers
- To inculcate the benefits of fluvial system to the society

UNIT I RIVER FUNCTIONS **8**

Primary function of a river – River uses and measures – Water and Sediment loads of river – Rivers in India, Himalaya and Peninsular.

UNIT II RIVER HYDRAULICS **10**

Physical Properties and Equations – Steady flow in rivers – uniform and non-uniform – Turbulence and velocity profiles – resistance coefficients – Boundary conditions and back waters – Transitions – Rating Curve – Unsteady flow in rivers : Propagative of surface waves – Characteristics, flood waves – kinematic and diffusion analogy – velocity of propagation of flood waves – Flood wave –Maximum

UNIT III RIVER MECHANICS **9**

River Equilibrium : Stability of Channel – regime relations – river bend equilibrium – hydraulic geometry of downstream - Bars and meandering - River dynamics – degradation and aggradations of river bed – Confluences and branches – River Data base.

UNIT IV RIVER SURVEYS AND MODEL **9**

Mapping – Stage and Discharge Measurements – Sediments – Bed and suspended load Physical hydraulic Similitude – Rigid and mobile bed – Mathematical – Finite one dimensional – multi – dimensional – Water Quality and ecological model

UNIT V RIVER MANAGEMENT 9

River training works and river regulation works – Flood plain management – waves and tides in Estuaries - Interlinking of rivers – River Stabilization

TOTAL: 45 PERIODS

OUTCOMES

- On completion of the course, the student is expected to be able to:

CO1	Define the system concept and steps in systems approach for the water resources engineering
CO2	Apply the knowledge of optimisation techniques such as Linear programming and simplex method for reservoir operation.
CO3	Explain single and multipurpose reservoir optimisation using dynamic programming
CO4	Develop the simulation model based on deterministic and stochastic simulation for reservoir operating policy
CO5	Understand and apply the creative and advance optimisation techniques like goal programming, heuristic algorithm in the field of water planning and management.

REFERENCES:

1 Julien, Pierre Y. *River mechanics*. Cambridge University Press, 2018.
2. Garde, R. J. *River morphology*. New Age International, 2006.
3. K.L Rao , India's Water Wealth – Orient Longman Ltd., 1979.

CO – PO RIVER ENGINEERING

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	H	H	H
PO2	Problem analysis		M	H	H	H	H
PO3	Design / development of solutions			M	H	H	H
PO4	Investigation					H	H
PO5	Modern Tool Usage			M	H	H	H
PO6	Individual and Team work		H	M	H	H	H
PO7	Communication	M					M
PO8	Engineer and Society		H	M	H	H	H
PO9	Ethics					M	M
PO10	Environment and Sustainability				M		M
PO11	Project Management and Finance		M	H	M	H	H
PO12	Life Long Learning	H	M	M	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	M	M	L	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	L	H	H	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	L	M	M	H	M

HW5004 **ENVIRONMENTAL HYDRAULICS** **L T P C**
3 0 0 3

OBJECTIVES:

- To apply the knowledge of fluid mechanics to analyze and predict mixing in natural bodies of water.
- To study the hydrodynamic aspects of water quality management in natural bodies of water.

UNIT I INTRODUCTION TO ENVIRONMENTAL TRANSPORT PROCESSES 9

Concentration and units of measure – Conservation laws – Systems and Control Volume approach – Differential element approach – Sources, Sinks and box-models – Mixing. Advection-Diffusion equation. Analytical and numerical solution to Advection-Diffusion equation.

UNIT II GROUNDWATER FLOW AND QUALITY MODELING 9

Dupuit's approximation – Basic contaminant transport equation – Application of boundary layer approximations – Saltwater intrusion into aquifers – Non-aqueous phase liquid (NAPL) in groundwater – numerical modeling.

UNIT III TRANSPORT PROCESSES IN RIVERS 9

Mixing in Rivers – Continuous point discharges – Two rivers mixing – Dispersion in rivers.

UNIT IV TRANSPORT PROCESSES IN LAKES AND RESERVOIRS 9

Reservoir classification – External energy sources – Surface layer – mixing in the hypolimnion – inflows and outflows.

UNIT V TRANSPORT PROCESSES IN THE ESTUARIES 9

Classification – Forces – wind, tides, rivers – Trapping and pumping – Estuarine Circulation.

TOTAL: 45 PERIODS

OUTCOMES

- On completion of the course, the student is expected to be able to:

CO1	Conceptualize the conservation laws for environmental transport processes
CO2	Develop the diffusion dispersion equation for the groundwater processes and formulate the problem for numerical solution
CO3	Formulate and solve the process of mixing in rivers.
CO4	Compare and contrast the transport processes in lakes and reservoirs
CO5	Explain the causes of mixing in estuaries due to wind, tide and rivers. Describe the natural phenomena of mixing.

REFERENCES:

1. Fischer, H.B., List, E.G., Koh, R.C.Y., Imberger, J and Brooks, N.H. Mixing in Inland and Coastal Waters Academic Press, New York, 1979.
2. Clark, M.M., Transport Modeling for Environmental Engineers and Scientists John Wiley and Sons, New York. 1996.
3. Martin J.L. and McCutcheon S.C. Hydrodynamics and Transport for Water Quality Modeling CRC Press, Inc. ISBN:0-87371-612-4, 1999.
4. Chapra, S.C. Surface Water Quality Modeling McGraw Hill Book Co. Singapore, 1997.
5. Thomann M., R.V. and Mueller, J.A. Principles of Surface Water Quality Modeling and Control Harper and Row, New York, 1987.
6. Csanady, G.T., Turbulent Diffusion in the Environment D.Reidel Publishing Co. Holland, 1973.
7. Rubin H. and Atkinson J. Environmental Fluid Mechanics Marcel Dekker, Inc. New York. 2001

CO – PO ENVIRONMENTAL HYDRAULICS

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	H	H	H
PO2	Problem analysis		M	H	H	H	H
PO3	Design / development of solutions			M	H	H	H
PO4	Investigation					H	H
PO5	Modern Tool Usage			M	H	H	H
PO6	Individual and Team work		H	M	H	H	H
PO7	Communication	M					M
PO8	Engineer and Society		H	M	H	H	H
PO9	Ethics					M	M
PO10	Environment and Sustainability				M		M
PO11	Project Management and Finance		M	H	M	H	H
PO12	Life Long Learning	H	M	M	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	M	M	L	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	L	H	H	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	L	M	M	H	M

HW5005 SEDIMENT TRANSPORTATION

L	T	P	C
3	0	0	3

OBJECTIVE:

- Describe the properties of sediments and to use concepts of fluid mechanics to solve problems associated with sediment motion in rivers and channels.

UNIT I SEDIMENT PROPERTIES **8**

Nature of sediment problems - Properties of sediments – individual and bulk properties of sediments. Incipient motion of sediments – critical tractive stress of cohesionless and cohesive material.

UNIT II BEDFORMS **8**

Bedforms – descriptions of regimes of flow – importance and predictions of regimes of flow – complexities of regimes in natural streams – resistance to flow – velocity distribution and resistance in turbulent flow over rough boundaries.

UNIT III TRANSPORT MECHANISM 11

Bed load transport and saltation – bed load equations – dimensional considerations – semi-theoretical equations – suspended load – mechanism of suspension – diffusion equation – simple relations of suspended load transport – total load – microscopic and macroscopic approaches – sediment yield from catchment – sediment sampling.

UNIT IV CHANNEL DESIGN 9

Design of stable channels – variables in channel design and conditions for design – stable channels carrying clear water in coarse non-cohesive material – stable channels design in alluvial material - Regime channels.

UNIT V RESERVOIR SEDIMENTATION 9

Reservoir sedimentation - incoming sediment load – reservoir hydraulics – trap efficiency and aggradation – dry specific weight of sediment deposits – life expectancy of reservoirs – density currents – reservoir sedimentation surveys – control measures.

TOTAL: 45 PERIODS.

OUTCOMES

- On completion of the course, the student is expected to be able to:

CO1	Define the system concept and steps in systems approach for the water resources engineering
CO2	Apply the knowledge of optimisation techniques such as Linear programming and simplex method for reservoir operation.
CO3	Explain single and multipurpose reservoir optimisation using dynamic programming
CO4	Develop the simulation model based on deterministic and stochastic simulation for reservoir operating policy
CO5	Understand and apply the creative and advance optimisation techniques like goal programming, heuristic algorithm in the field of water planning and management.

REFERENCES:

1. Garde R J and Ranga Raju K G *Mechanics of Sediment Transportation and Alluvial Stream Problems* Wiley Eastern (Second Edition) ISBN – 0852263066
2. Yalin, M. S., and A. M. F. da Silva. *Fluvial Processes. IAHR, Delft, The Netherlands* (2001).
3. Julien, Pierre Y. *Erosion and sedimentation*. Cambridge University Press, 2010.

CO – PO SEDIMENT TRANSPORTATION

PO/PSO		**Course Outcome**					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	H	H	H
PO2	Problem analysis		M	H	H	H	H
PO3	Design / development of solutions			M	H	H	H
PO4	Investigation					H	H
PO5	Modern Tool Usage			M	H	H	H
PO6	Individual and Team work		H	M	H	H	H
PO7	Communication	M					M
PO8	Engineer and Society		H	M	H	H	H
PO9	Ethics					M	M
PO10	Environment and Sustainability				M		M
PO11	Project Management and Finance		M	H	M	H	H
PO12	Life Long Learning	H	M	M	H	H	H

PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	M	M	L	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	L	H	H	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	L	M	M	H	M

HW5006 FLOOD MODELLING AND DROUGHT MANAGEMENT **L T P C**
3 0 0 3

OBJECTIVES:

- To impart the students about hydrologic extremes of floods and droughts, estimation of severity and extent of damages using models and the mitigation measures to combat them.

UNIT I FLOOD ESTIMATION **9**

Hydrologic extremes – Flood – Types of Flood – Effects of Flood – Design Flood - SPF/MPF Estimation of design flood – Physical Indicators - Envelope curves - Empirical methods – Rational method - Statistical methods – Frequency analysis – Unit hydrograph method.

UNIT II FLOOD MODELLING AND MANAGEMENT **9**

Hydrologic and Hydraulic Routing – Reservoir and Channel Routing - Flood Inundation Modelling – HEC HMS and HEC RAS software - Flood control methods – Structural and non structural measures - Flood Plain Zoning – Flood forecasting – Flood Mitigation - Remote Sensing and GIS for Flood modelling and management.

UNIT III DROUGHT AND IMPACTS **9**

Definition – Definitions based on rainfall, stream flow, vegetation and comprehensive aspects - Characterisation of Drought/water shortage/aridity/desertification - Types of Drought – NCA classification – Impacts of Drought – Environmental, Social and Economical aspects

UNIT IV DROUGHT ASSESSMENT **9**

Drought Severity Assessment – Meteorological Hydrological and Agricultural methods – Drought Indices – GIS based Drought Information system – Drought Vulnerability Assessment and Mapping Using GIS.

UNIT V DROUGHT MONITORING AND MANAGEMENT **9**

DPAP Programme - Drought Monitoring – Application of Remote sensing – Drought Mitigation – Proactive and Reactive Approach – Supply and Demand Oriented Measures – Long term and Short term Measures – Water Scarcity Management in Urban, Industrial and Agricultural sectors

TOTAL: 45 PERIODS

OUTCOMES

CO1	Perform design flood estimation using different methods.
CO2	Explain different flow routing methods and suggest suitable flood control measures.
CO3	Describe different types of drought and their impacts.
CO4	Comprehend different indices and methods used for drought assessment.
CO5	Discuss the various approach of Drought mitigation and water scarcity management

REFERENCES:

1. Chow V.T., Maidment D.R., Mays L.W., Applied Hydrology, McGraw Hill Publications, New York, 1995.
2. Vijay P.Singh., Elementary Hydrology, Prentice Hall of India, New Delhi, 1994.
3. Yevjevich V., Drought Research Needs, Water Resources Publications, Colorado State University, USA, 1977.
4. Rangapathy V., Karmegam M., and Sakthivadivel R., Monograph in Flood Routing Methods as Applied to Indian Rivers, Anna University Publications.

CO – PO MAPPING OF FLOOD MODELLING AND DROUGHT MANAGEMENT

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	M	M	M	M	M	M
PO2	Problem analysis	M	M	L	M	L	M
PO3	Design / development of solutions	M	M	L	L	H	M
PO4	Investigation	L	M	M	M	M	M
PO5	Modern Tool Usage	L	M	M	M	M	M
PO6	Individual and Team work	H	M	L	M	M	M
PO7	Communication						
PO8	Engineer and Society	M	M	M	L	H	M
PO9	Ethics	L	L				L
PO10	Environment and Sustainability	M	M	H	L	H	M
PO11	Project Management and Finance	L	M	M	M	M	M
PO12	Life Long Learning	M	M	H	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges.	L	M	L	M	L	L
PSO2	Analyse hydrological data to model water quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	H	M	L	M	L	M
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering.	M	M	M	H	M	M

HW5007 GROUNDWATER MODELLING AND MANAGEMENT L T P C
3 0 0 3

OBJECTIVE:

- The objective of this course is enable the student to understand the inputs, system parameters, policy, variables and outputs of a groundwater management models to estimate the groundwater quantity, qualities.

UNIT I GROUNDWATER PROSPECTING 9

Investigation and evaluation – Geophysical methods- Electrical Resistivity methods – Interpretation of data – Seismic method – Subsurface investigation – Test drilling – Resistivity logging – Application of remote sensing techniques.

UNIT II GROUNDWATER FLOW MODEL 9

Physical models – Analog models – Mathematical modeling – Unsaturated flow models Numerical modeling of groundwater flow – Finite difference equations and solutions – Successive over

Relaxation, Alternating direction implicit procedure – Crank Nicolson equation – Iterative methods - Direct methods - Inverse problem – Finite element method

UNIT III CONTAMINANT TRANSPORT MODEL 9

Contaminant transport theory – Advection, dispersion equation – Longitudinal and transverse dispersivity – Hydrodynamic dispersion – Analytical models – Numerical simulation of solute transport – Solution methods - Sorption model – Density driven flow - Heat transport.

UNIT IV MODEL APPLICATIONS 9

Data requirements – Conceptual model design : Conceptualization of aquifer system – Parameters, Input-output stresses, Initial and Boundary conditions - Model design and execution: Grid design, Setting boundaries, Time discretization and Transient simulation – Model calibration : steady state and unsteady state – sensitivity analysis – Model validation and prediction – Uncertainty in the model prediction

UNIT V GROUNDWATER MANAGEMENT MODELS 9

Optimal groundwater development – Indian GEC norms – Conjunctive use models Modeling multilayer groundwater flow system -Modeling contaminant migration – Modeling fracture flow system – Artificial recharge feasibility through modeling – Simulation of movements of solutes in unsaturated zone – Stochastic modeling of groundwater flow - Groundwater contamination, restoration and management

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to:

CO1	Explain the geophysical methods for subsurface investigation and application of remote sensing techniques
CO2	Develop the groundwater flow model to study the groundwater movement and its potential using numerical methods.
CO3	Explain the concepts of contaminant transport theory, numerical simulation of solute transport, solution methods for density driven flow and heat transport.
CO4	Conceptualize aquifer system and execute the flow simulation model for prediction
CO5	Apply the advance techniques in groundwater model for better management of groundwater resources.

REFERENCES:

1. Anderson M.P., and Woessner W.W., Applied Groundwater Modelling: Simulation of flow and advective transport, Academic Press, Inc., 1992
2. Fetter C.W., Contaminant Hydrogeology, Prentice Hall, 1999
3. Rushton K.R., Groundwater Hydrology : Conceptual and Computational Models, Wiley, 2003
4. Elango L. and Jayakumar, R. Modelling in Hydrology, Allied Publishers Ltd., 2001
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6. Robert Willis and William W.G.Yenth, Groundwater System Planning and Management, Prentice Hall, Englewood Cliffs, New Jersey, 1987.
7. Groundwater Hydraulics and Pollutant Transport, Randall J.Charbeneau, Prentice Hall, 2000
8. Rastogi K. , Numerical Groundwater Hydrology, 2011

CO – PO GROUNDWATER MODELLING AND MANAGEMENT

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	M	M	M	H	M	M
PO2	Problem analysis	M	H	H	H	M	H
PO3	Design / development of solutions	M	H	H	H	M	H

PO4	Investigation	M	H	H	M	H	M
PO5	Modern Tool Usage	H	M	M	H	H	H
PO6	Individual and Team work	M	H	M	H	M	M
PO7	Communication	M				M	M
PO8	Engineer and Society	M	H	M	H	H	H
PO9	Ethics					M	M
PO10	Environment and Sustainability					H	H
PO11	Project Management and Finance		M	H	M	H	H
PO12	Life Long Learning	H	M	H	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	M	M	H	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	M	H	H	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	M	M	M	H	M

HW5008 RADAR METEOROLOGY L T P C
3 0 0 3

OBJECTIVE

- To impart knowledge on radar principles for quantitative precipitation estimation using Ground radar and space borne radar for hydrologic modeling.

UNIT I RADAR PRINCIPLES 9

Electromagnetic waves (EM): Electric field (EF), Magnetic field (MF), relating EF and MF, Maxwell's equations; Interaction of EM waves: refraction, reflection, scattering, absorption, Polarization of waves; Radar components: radar beam, pulse, signal processing;

UNIT II RADAR RAY PROPOGATION, REFLECTIVITY FACTOR AND RADIAL VELOCITY 9

Ray propagation in idealized atmosphere: factors influencing ray paths, range and height of pulse; Radar equation: solitary target and distributed target, weather radar equation, radar reflectivity factor, validity of Rayleigh's approximation; Radial velocity: Doppler effect, measurement, Doppler spectra

UNIT III PRECIPITATION ESTIMATION WITH RADAR 9

Measurement of precipitation rate, total precipitation, drop size distribution; instruments, terminal velocities, Radar reflectivity (Z) and Rainfall rate (R), Z-R relationships; Polarimetric Radar Quantitative Precipitation Estimation: Hydrometeor Classification, Polarimetric Radar-Based QPE, Microphysical Retrievals, Precipitation Typology, Precipitation Estimation

UNIT IV ADVANCED RADAR TECHNOLOGIES FOR QUANTITATIVE PRECIPITATION ESTIMATION 9

Mobile and Gap-Filling Radars, Space borne Radars: TRMM and GPM, Phased-Array Radar; Surface water radar: Stream flow radar, SAR, Altimetry; Subsurface water: L-band, c band and Ground penetrating radar

UNIT V RADAR QPE FOR HYDROLOGIC MODELING 9

Model Classes, Model Parameters, Model State Variables and Data Assimilation, Hydrological Model Evaluation, Hydrological Evaluation of Radar QPE; Flash Flood Forecasting: Lumped flash flood guidance and gridded flash flood guidance. Flash Flood Potential Index, threshold frequency approach

TOTAL : 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Describe the principles of radar, its components and the interaction of waves with atmosphere and objects
CO2	Comprehend the radar ray propagation and the parameters that can be measured using radar waves
CO3	Illustrate the methodology for estimation of precipitation using radar principles
CO4	Demonstrate the advanced techniques for precipitation estimation using mobile and space borne radars
CO5	Formulate and choose the appropriate model classes and parameters for hydrologic modelling using QP estimated through radar

REFERENCES

1. Robert M. Rauber and Stephen W. Nesbitt, 2018, *Radar Meteorology: A first course*, Wiley Blackwell, UK
2. Bringi V. N and Chandrasekar. V, 2004, *Polarimetric Doppler Weather Radar: Principles and applications*, Cambridge University Press.
3. Richard J Doviak and Dusan S Zrnic, 2016, *Doppler Radar and, Weather observations*, Dover Publications Inc., New york.
4. Yang Hong, Jonathan J. Gourley, 2015, *Radar Hydrology : Principles, Models, and Applications*, CRC Press, Taylor & Francis Group, USA
5. Peter Meischner, 2004, *Weather Radar: Principles and Advanced applications*, Springer-Verlag Berlin Heidelberg Publications

CO – PO Mapping: RADAR METEOROLOGY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	L	M	M	H	H	H
PO2	Problem analysis		H	M	H	H	H
PO3	Design / development of solutions			M	M	H	H
PO4	Investigation		M	M	M	M	M
PO5	Modern Tool Usage	L	M	H	H	H	H
PO6	Individual and Team work	L	M	M	M	H	M
PO7	Communication			H	M	H	H
PO8	Engineer and Society	M	M	M	M	H	M
PO9	Ethics				M	M	M
PO10	Environment and Sustainability	L	L	M	M	M	M
PO11	Project Management and Finance				M	M	M
PO12	Life Long Learning	M	M	H	H	H	H
PSO1	Knowledge of Hydrology and water resources, Irrigation water management discipline			M	H	H	H
PSO2	Critical analysis of Hydrology and water resources, Irrigation water management problems and innovation		M	M	H	H	H
PSO3	Conceptualization and evaluation of Hydrology and water resources, Irrigation water management Issues		M	H	H	H	H

HW5009 WATER SUPPLY AND BURIED PIPELINES L T P C
3 0 0 3

OBJECTIVE

- To educate the students in detailed design concepts related to water transmission mains, water distribution system and buried pipes with emphasis on computer application.

UNIT I WATER SUPPLY SYSTEMS 9

Water requirement – sources of water – water demand – reservoir storage – nodal hydraulic gradient level values - water supply consideration, Types of water supply systems- piping system- distribution network- Network models – design – optimization in practice

UNIT II HYDRAULIC PRINCIPLES AND NETWORK PARAMETERS 10

Energy and hydraulic gradient lines – head loss in links – equivalent pipes – series – parallel pipes – path head loss and loop head loss – analysis of water distribution network- static node, dynamic node – network performance – flow analysis - Layout – in situ lining - pipes material – appurtenances – minimization of water losses – leak detection.

UNIT III STORM WATER DISTRIBUTION AND BURIED PIPES 9

Planning – runoff estimation – rainfall data analysis – storm water drain design Introduction to Buried pipes – external loads – gravity flow design, pressurized flow- rigid and flexible pipes – installation – trenchless technology

UNIT IV RELIABILITY ASSESSMENT AND DESIGN 8

Uncertainty and reliability – affecting events- assessment – reliability parameters- configurations. Design methodology - strengthening and expansion

UNIT V FLUID TRANSIENTS 9

Basic equations of unsteady flows through closed conduits. Method of characteristics. Transients caused by centrifugal pumps and hydroelectric power plants.

TOTAL: 45 PERIODS

OUTCOMES:

CO1	Define the water supply and demand and water distribution network creation for the effective water supply system.
CO2	Apply the knowledge of hydraulics in the field of pipe line system. Analyse the branch and loop network flow and head loss for various pipe material and configuration.
CO3	Explain storm water drain buried pipeline system. Design the underground storm water drainage system with hydraulic appurtenances
CO4	Analyse the reliability of the water supply distribution system and prepare the detailed methodology for risk management and strengthening the system.
CO5	Apply and design the unsteady flow pipe line network in order to with stand the surge/transient developed due to power failure of centrifugal pump and also due to hydro electric power plant.

REFERENCES:

1. Bhave P. R, Optimal design of water distribution networks, Narosa publishing House, New Delhi, 2003.
2. Bajwa. G. S, Practical handbook on Public Health Engineering, Deep publishers, Shimla 2003
3. Manual on water supply and treatment, CPHEEO, Ministry of Urban Development, GOI, New Delhi, 1999
4. B.A. Hauser, practical hydraulics Hand Book, Lewis Publishers, New York, 1991
5. Moser A. P, Buried pipe Design, 3rd Edition, American Water Works Association
6. Robert van Bentum and Lan K. Smout, Buried Pipe lines for surface Irrigation, The Water, Engineering and Development Centre, Intermediate Technology Publications,UK,1994
7. Wurbs R.A., and James W.P. Water Resources Engineering. Prentice Hall of India, Eastern Economic Edition. ISBN: 81-203-2151-0, NewDelhi, 2007

CO- PO WATER SUPPLY AND BURIED PIPELINES

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	L	M	M	H	H	H
PO2	Problem analysis		M	M	H	H	H
PO3	Design / development of solutions			M	H	H	H
PO4	Investigation					H	H
PO5	Modern Tool Usage			M	H	H	H
PO6	Individual and Team work		H	M	H	H	H
PO7	Communication	M	M				M
PO8	Engineer and Society		H	M	H	H	H
PO9	Ethics					M	M
PO10	Environment and Sustainability				M		M
PO11	Project Management and Finance		M	H	M	H	H
PO12	Life Long Learning	L	M	M	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	H	H	H	H	H	H
PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	L	L	M	H	H	M
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	M	M	H	H	M

HW5010 WATER POWER AND DAM ENGINEERING L T P C
3 0 0 3

OBJECTIVE:

- The student is exposed to the design aspects of hydro-power plants, various components of hydropower plants and their layout.
- Different types of dams design taking into account the suitability of the site and the different type loads that are likely to be encountered.

UNIT I HYDROELECTRIC POWER DEVELOPMENT 9

Introduction – Types of power development – Classification. Planning – Environmental Considerations - Data requirement for assessment of hydropower. Components of hydropower.

UNIT II DESIGN OF HYDROPOWER INSTALLATION 9

Components – Intake structure – water conductor systems – tunnels – surge tanks – penstocks – valves – anchor blocks.

UNIT III TYPES OF POWER HOUSE 8

Underground – semi-underground. Turbines and their foundations – structural and geotechnical aspects of power house design.

UNIT IV EMBANKMENT DAM ENGINEERING 9

Introduction. Nature and classification of engineering soils. Principles of design. Materials and construction. Internal seepage. Stability and stress. Settlement and deformation. Rock fill and rock fill embankments.

UNIT V CONCRETE DAM ENGINEERING 10

Loading: Concepts and criteria. Gravity dam analysis. Buttress dam analysis. Arch dam analysis. Design features and construction. Concrete for dams. Roller Compacted Concrete (RCC) Dams. Dam safety and instrumentation. Foundation measurements. Analysis of strain data.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to:

CO1	Explain the basic knowledge of planning and designing hydropower plants
CO2	Design the components hydro power such as intake structure, water conductor systems, tunnels, surge tanks, penstocks, valves and anchor blocks.
CO3	Describe the geotechnical aspects of power house design for underground and semi-underground structures
CO4	Explain the design principles of rock fill and rock fill embankment dams
CO5	Describe the concept of loading criteria and instrumentation requires for dame safety of concrete dam

REFERENCES:

1. Novak, P., Moffat, A.I.B., Nalluri, C. and Narayanan, R. Hydraulic Structures Unwin Hyman Ltd., London 1989.
2. Dandekar, M.M. and Sharma, K.N. Water Power Engineering Vikas Publishing House, New Delhi 1994.
3. USBR Design of Small Dams Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi 1974.
4. Sharma, H.D. Concrete Dams Metropolitan New Delhi 1981
5. Varshney, R.S. Concrete Dams Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi 1982.
6. Varshney, R.S. Hydro Power Structures – Nem Chand Bros. Roorkee 1973 Guthrie, Brown J. (ed) Hydro Electric Engineering Practice Blackie and Son, Glasgow 1970.

CO – PO WATER POWER AND DAM ENGINEERING

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	M	M	M	H	M	M
PO2	Problem analysis	M	H	H	H	M	H
PO3	Design / development of solutions	M	H	H	H	M	H
PO4	Investigation	M	H	H	M	H	M
PO5	Modern Tool Usage	H	M	M	H	H	H
PO6	Individual and Team work	M	H	M	H	M	M
PO7	Communication	M				M	M
PO8	Engineer and Society	M	H	M	H	H	H
PO9	Ethics					M	M
PO10	Environment and Sustainability					H	H
PO11	Project Management and Finance		M	H	M	H	H
PO12	Life Long Learning	H	M	H	H	H	H
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges	M	M	H	H	H	H

PSO2	Analyse hydrological data to model water quantity and quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.	M	H	H	H	H	H
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering	L	M	M	M	H	M

HW5011 WATER AND ECOSYSTEMS L T P C
3 0 0 3

OBJECTIVE:

- To introduce the principles of natural ecosystems, the social dimensions and approaches to water, the benefits to the society and the need for conservation of aquatic ecosystems.

UNIT I ECOLOGICAL PRINCIPLES 8

Levels of organization - Concept of Ecosystems – Ecosystem structure and function – Ecosystem development - Freshwater ecosystems – Agro ecosystems.

UNIT II AQUATIC ECOSYSTEMS 8

Ecosystem processes – Agricultural vs Ecosystem productivities – Riparian processes and interactions – Eco hydrology – Impacts of human intervention – Water-food-ecosystem linkages.

UNIT III ECOSYSTEM SERVICES 9

Water for irrigation – Livelihoods – Industrial / developmental needs – domestic and drinking water sector – Green, Blue and Grey water concepts – Economic instruments – Virtual water and trade.

UNIT IV ACCESS AND EQUITY 10

Water access and equity – Urban-Rural and Gender dimensions - Adjusting to water scarcity – Water allocation principles - Upstream-downstream perspectives – Institutions and democracy – Stakeholder involvement.

UNIT V ECOSYSTEM MANAGEMENT 10

Ecosystem assessments – Environmental flows – Future freshwater challenges - Eco tourism -– Social and political issues of water use - Sustainable Ecosystems - Environmental governance.

TOTAL: 45 PERIODS

OUTCOME:

- On completion of the course, the student is expected to be able to

CO1	Explain the various ecological principles and interactions between water and ecosystem.
CO2	Describe the different ecosystem processes governing the Water-food-ecosystem linkages
CO3	Comprehend the ecosystem services required for different sectors
CO4	Explain the water access and equity in a constrained environment
CO5	Illustrate the various ecosystem management strategies for sustainable ecosystem management.

REFERENCES:

1. Malin Falkenmark and Johan Rockstrom, Balancing water for Humans and Nature, Earthscan, VA, USA, 2005.
2. Caroline M Figueres, Cecilia Tortajada and Johan Rockstrom (ed), Rethinking Water Management, EarthScan, VA, USA, 2005.
3. Eugene P Odum, Basic Ecology, Holt-Saunders International Edition, Philadelphia, US, 1983.

4. Gooch, G. D., A. Rieu-Clarke and P. Stalnacke (eds), Integrating Water Resources Management: Interdisciplinary methodologies and strategies in Practice, IWA Publishing, London, UK, 2012.
5. Jorgensen, S., J. G. Tundisi, J. M. Tundisi, Handbook of inland aquatic ecosystem management, CRC Prerss, FL, USA, 2013
6. Sithamparanathan, J., Rangasamy, A. and Arunachalam, N., Ecosystem principles and sustainable agriculture, Scitech Publishers, Chennai, 1999.

CO – PO MAPPING OF WATER AND ECOSYSTEMS

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	M	M	M	L	M	M
PO2	Problem analysis	L	L	M	L	M	L
PO3	Design / development of solutions	M	M	M	M	M	M
PO4	Investigation	L	L	M	M	M	M
PO5	Modern Tool Usage	M	M	M	L	M	M
PO6	Individual and Team work	L	M	M	M	M	M
PO7	Communication	M	M	M	M	M	M
PO8	Engineer and Society	M	M	H	H	H	H
PO9	Ethics	H	H	H	H	H	H
PO10	Environment and Sustainability	M	M	M	M	M	M
PO11	Project Management and Finance	L	M	M	L	M	M
PO12	Life Long Learning	M	M	M	M	H	M
PSO1	Explain the concepts of water management, field research methodology, gender, legal and environmental aspects in the context of Integrated Water Resources Management.	M	M	M	M	M	M
PSO2	Formulate, analyze and comprehend the differences in social and economical variability in South Asian context with their peers and strive to work towards sustainability.	M	M	M	M	M	M
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering.	L	M	M	M	M	M

HW5012 URBAN WATER RESOURCES MANAGEMENT L T P C

3 0 0 3

OBJECTIVES:

- To impart knowledge and skills relevant to water management in the context of urbanization and relate engineering principles to water supply, storm water and wastewater management, along with related regulations and best management practices from around the world.

UNIT I URBAN ECOSYSTEM 9

Cities as Ecological system – hybrid ecosystem – Resilience in urban ecosystem. Human components of Ecosystem – Urban pattern and Ecosystem function. Population and Community dynamics, functions of Urban Ecosystem.

UNIT II URBAN HYDROLOGY 9

The urban hydrological cycle – Function – Human induced changes in urban watershed – Hydrological calculation – Runoff – Infiltration – hydrograph.

UNIT III URBAN STORM WATER MANAGEMENT 9

Design of Drainage System – Roadway Drainage Analysis – Types of inlet – inlet design – Design of storm drain, Hydraulic design of culverts, Erosion control. Storm water management regulations - structural storm management systems – Newer trends in storm water management (Green infrastructure) – installation – operation and maintenance.

UNIT IV WATER CONSERVATION AND REUSE 9

Trends in supply and demand – indoor conservation – outdoor conservation – water reuse – Rainwater harvesting – public education.

UNIT V WATER GOVERNANCE AND GOOD PRACTICES 9

Challenges in water sector - Institutional setting, Supply Management, Demand Management, Waste water management – Private sector participation, urban service delivery, customer satisfaction, financial resource management – case studies of best practices in cities across the world.

TOTAL : 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Explain various functional elements of urban ecosystem.
CO2	Calculate urban runoff, compute supply and demand of water, draw hydrograph
CO3	Compare advantages of Newer techniques of green infrastructure and illustrate benefits
CO4	Assess the Operation and Maintenance needs of urban water systems
CO5	Propose best management practices for Indian context

REFERENCES:

1. Anand Chiplunkar, K Seetharam and Cheon Kheong (ed) (2012), "Good Practices in urban water management" ADB, National University Singapore.
2. Marina Alberti (2008), "Advances in Urban Ecology", SpringeR
3. Hormoz Pazwash (2016), "Urban storm water management", CRC Press.

CO – PO URBAN WATER RESOURCES MANAGEMENT

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	M	M	H
PO2	Problem analysis	M	H	H	M	L	H
PO3	Design / development of solutions	L	H	M	M	L	M
PO4	Investigation				H	H	H
PO5	Modern Tool Usage			M			M
PO6	Individual and Team work				M	M	M
PO7	Communication	M			M	M	M
PO8	Engineer and Society	H	H	H	H	H	H
PO9	Ethics	L	L			M	L
PO10	Environment and Sustainability	H	H	H	H	H	H
PO11	Project Management and Finance				M	M	M
PO12	Life Long Learning				M	M	M
PSO1	Defend the concepts in fluid mechanics, surface and groundwater hydrology, river hydraulics, research methodology, legal frame works and relate them to current challenges.		H	H	H	H	H

PSO2	Analyse hydrological data to model water quality, water supply distribution for optimizing water resources system and risk analysis for real world problems.				M	M	M
PSO3	Produce and publish professional reports, peer-reviewed journal, on contemporary and state of art research in water resources engineering			M		M	M

OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop – RDBMS versus Hadoop – Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop – Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

REFERENCES:

1. Vignesh Prajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, Umesha Nayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. Anand Rajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

Business Data Analytics

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

OE5092 INDUSTRIAL SAFETY LT P C
3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook,Eighth Edition,2008

OE5093 OPERATIONS RESEARCH LT P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method,Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENT OF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING *CONCEPTS* 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

OUTCOMES

CO1 – Understand the costing concepts and their role in decision making
CO2– Understand the project management concepts and their various aspects in selection
CO3– Interpret costing concepts with project execution
CO4– Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 COMPOSITE MATERIALS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5				✓	✓		✓					

REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, West Germany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 WASTE TO ENERGY L T P C
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITII BIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III BIOMASS GASIFICATION 9

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.

UNIT IV BIOMASS COMBUSTION 9

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.

UNITV BIO ENERGY 9

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.

TOTAL: 45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

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

AUDIT COURSES (AC)

AX5091 ENGLISH FOR RESEARCH PAPER WRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

AX5092 **DISASTER MANAGEMENT** **L T P C**
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 6

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster

CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

CO5: Ability to develop the strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS 6

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES 6

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS 6

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE 6

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. "Abhyaspustakam" – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094 **VALUE EDUCATION** **L T P C**
2 0 0 0

OBJECTIVES
Students will be able to
- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I
Values and self-development–Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements

UNIT II
Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

UNIT III
Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.
Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV
Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

TOTAL: 30 PERIODS

OUTCOMES
Students will be able to
- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the overall personality.

Suggested reading
1. Chakroborty, S.K.“Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

AX5095 **CONSTITUTION OF INDIA** **L T P C**
2 0 0 0

OBJECTIVES
Students will be able to:
- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals’ constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION
History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION
Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION

District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

Suggested reading

1. The Constitution of India,1950(Bare Act),Government Publication.
2. Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution,1st Edition, 2015.
3. M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

AX5096 PEDAGOGY STUDIES L T P C
2 0 0 0

OBJECTIVES

Students will be able to

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions **-** Overview of methodology and Searching.

UNIT II THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT IV PROFESSIONAL DEVELOPMENT

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to understand:

- What pedagogical practices are being used by teachers informal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Suggested reading

1. Ackers J, HardmanF (2001) Classroom interaction in Kenyan primary schools, Compare, 31(2): 245-261.
2. Agrawal M (2004)Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36(3):361-379.
3. Akyeampong K (2003) Teacher training in Ghana-does it count? Multi-site teacher education research project (MUSTER) country report 1.London:DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M(2003) Read India: Amass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf

AX5097 STRESS MANAGEMENT BY YOGA L T P C
2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do‘s and Don’t’s in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTED READING

1. ‘Yogic Asanas for Group Tarining-Part-I”:Janardan Swami Yoga bhyasi Mandal, Nagpur
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

UNIT I

Neetisatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses-29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont’s) - Verses-71,73,75,78 (do’s)

UNIT II

Approach to day to day work and duties - Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 - Personality of role model - shrimad bhagwad geeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and mankind to peace and prosperity
- Study of Neet is hatakam will help in developing versatile personality of students.

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari’s Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.