DETAIL

COURSE CURRICULUM

FOR

POSTGRADUATE PROGRAMME

M.TECH

IN

CIVIL ENGINEERING

Specialization in

Hydro-Informatics Engineering

NATIONAL INSTITUTE OF TECHNOLOGY AGARTALA

TRIPURA (WEST), INDIA

PIN-799046

Preface

Civil Engineering Department of NIT Agartala, awards the degree of Master of Technology (M.Tech) in seven different specializations viz, Environmental Engineering, Geotechnical Engineering, Hydro-Informatics Engineering, Structural Engineering, Seismic Science and Engineering, Transportation Engineering and Water Resources Engineering.

The course structures of all post graduate degree programmes are carrying a total of 80 credits and 2000 marks. Semester wise distribution of course and credits are as follows: First semester: 25 credits and 800 marks for five theory subjects (comprises basic core, core, and elective subjects), two laboratory subjects and seminar; Second semester: 25 credits and 800 marks for four theory subject (comprises basic core, core, and elective subjects), two laboratory subjects, comprehensive viva-voce and project preliminaries; Third semester: 10 credits and 100 marks; and Fourth semester:20 credits and 300 marks. Third and fourth semester of PG courses will be fully devoted to project works. Minimum requirement of number of class hours for each theory course is 40 hours per semester.

There will be continuous assessment of the performance of students throughout the semester. Each theory subject in a semester is evaluated for 100 marks, with the following weightages. Sub-component weightage: Continuous evaluation: 30 Marks (Attendance: 5 Marks, Quiz: 5 Marks, Class test: 10 Marks, Assignment: 10 Marks); Mid-semester Examination: 20 Marks; and End-semester Examination: 50 Marks

The course curriculum of all Post-graduate programmes are designed considering the following three Programme outcomes as formulated by National Board of Accreditation (NBA)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: An ability to identify, formulate and solve Hydro-Informatics Engineering related problems using advanced soft computing techniques.

PO5: An ability to understand the impact of Hydro-informatics Engineering solutions in a global, regional and local context which can convert into sustainable and contemporary solutions.

PO6: Ability to demonstrate the knowledge of Hydro-informatics Engineering and Management techniques along with clear principles for application in multidisciplinary domains.

Expert opinions are being taken in regular basis in order to improve the quality of teaching learning process and to attain the programme outcomes efficiently.

In the Final year of M.Tech programmes (Third and Fourth Semesters) students may also opt for industrial research. If any student desire to pursue his/her research in reputed industries, he/she may be allowed to do so, provided:

a. The selected industry is a permanent member of NASSCOM, FICCI and other such industry bodies.
b. The selected industry needs is approved by the DPPC of the concerned Department.
c. The student selects one supervisor from industry and another supervisor from the Institute.

d. If any student opts for such industrial research he/she will not receive any scholarship from the institute in this tenure, even if he/she wants to return back. In such cases the student will be allowed to complete his/her project in the institute but without any scholarship.

Syllabus of M.Tech Hydro-Informatics Engineering

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	First Semester			
1	**Basic Core** **PCE61B01**: Artificial Intelligence and Data Science in Water Resource Development	4	4	100
2	**Core Subject-I** **PCE61C01**: Principle of Water Resources Engineering	4	4	100
3	**Elective Paper-I (Any one)** **PCE61E01**:One course from Elective Group	4	4	100
4	**Elective Paper-II(Any one)** **PCE61E02**: Another course from Elective Group (Excluding the course already selected as Elective I)	4	4	100
5	**Elective Paper-III(Any one)** **PCE61E03**: Another course from Elective Group (Excluding the course already selected as Elective I and Elective II)	4	4	100
6	**PCE61P01**: Application Software Laboratory	2	3	100
7	**PCE61P02**: Minor Project-I	2	3	100
8	**PCE61P03**: Seminar	1	2	100
	Total	**25**	**28**	**800**
	Second Semester			
1	**Basic Core** **PCE62B01**: Design of Water Resources System	4	4	100
2	**Core Subject-I** **PCE62C01**: Advanced Hydrology	4	4	100
3	**Core Subject-II** **PCE62C02**: Advance Hydropower Engineering	4	4	100
4	**Elective Paper-IV(Any one)** **PCE61E04:**One course from Elective Group (excluding the course already selected as Elective I, II and III)	4	4	100
5	**PCE62P04**: Water Quality, Hydrology and Hydraulic Instruments Laboratory	2	3	100
6	**PCE62P05:** Minor Project-II	2	3	100
7	**PCE62P06**: Project Preliminary	3	6	100
8	**PCE62P07**: Comprehensive Viva-voce	2	0	100
	Total	**25**	**28**	**800**
	Third Semester			
1	**PCE63P01**: Project & Thesis - I	**20**	**-----**	**100**
	Fourth Semester			
2	**PCE64P02**: Project & Thesis - II	**40**	**-----**	**300**
			Total Marks	**2000**

Elective Subjects

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	Water			
1	Energy Management in Water Industry	4	4	100
2	Climate Change and Water Resources	4	4	100
3	Water Quality Modeling And Management	4	4	100
4	Application of Geo-Informatics in Water Resource Management			
5	Systems Analysis in Water Resources	4	4	100
6	Underwater Remote Sensing and Life Cycle Assessment	4	4	100
7	GIS Applications in Monitoring and Management of Ground Water	4	4	100
	Electrical and Energy Engineering			
8	Power Plant Engineering	4	4	100
9	Renewable Energy System	4	4	100
10	Advance Hydropower Engineering	4	4	100
11	Hydrology and Hydraulic Instruments	4	4	100
	Agriculture/ Soft Computing/ Others			
12	Internet of things applications in Agriculture	4	4	100
13	Optimization Technique	4	4	100
14	Smart-Instrumentation in Water Resources Applications	4	4	100
15	Image Processing	4	4	100
16	Hydraulic Structure Engineering	4	4	100
17	River Engineering	4	4	100
18	Smart Monitoring and Management of Pipe Network	4	4	100
19	Free Surface Flow	4	4	100
20	Computational Fluid Dynamics	4	4	100

6th September, 2021

First Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	First Semester			
1	**Basic Core** **PCE61B01**: Artificial Intelligence and Data Science in Water Resource Development	4	4	100
2	**Core Subject-I** **PCE61C01**: Principle of Water Resources Engineering	4	4	100
3	**Elective Paper-I (Any one)** **PCE61E01**:One course from Elective Group	4	4	100
4	**Elective Paper-II(Any one)** **PCE61E02**: Another course from Elective Group (Excluding the course already selected as Elective I)	4	4	100
5	**Elective Paper-III(Any one)** **PCE61E03**: Another course from Elective Group (Excluding the course already selected as Elective I and Elective II)	4	4	100
6	**PCE61P01**: Application Software Laboratory	2	3	100
7	**PCE61P02**: Minor Project-I	2	3	100
8	**PCE61P03**: Seminar	1	2	100
	Total	**25**	**28**	**800**

Basic Core

ARTIFICIAL INTELLIGENCE AND DATA SCIENCE IN WATER RESOURCE DEVELOPMENT (PCE61B01)
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Course Objective

1. To obtain fundamental understanding and application of multi criteria decision making.
2. To be able to interpret the application procedure of artificial neural networks and complex topology.
3. To obtain an understanding of distribution function and other statistical concepts.
4. To understand the phenomenon of different conventional optimization techniques.
5. To obtain an understanding of nature based optimization techniques.
6. To understand the concept of Hydrological models.

Course Content

Unit- 1

Introduction, Classification of MCDM Techniques, Basic Working Principle, Compensatory Techniques: Analytical Hierarchy Process, Analytical Networking Process, Weighted Sum Method, Weighted Product Method) MACBETH, Outranking Techniques: ELECTRE, PROMETHEE.

Unit -2

Introduction, Classification of Neural Networks, Training Algorithms, Quick Propagation, Conjugate Gradient Descent, Levenberg Marquadart, Quasi Newton, Newtons Method, Topology Optimization, Genetic Algorithm, Trial and Error, Polynomial Neural Network.

Unit -3

Outlier Detection, Auto Correlation, Cross Correlation, Auto and Cross Regression Model, Test of Homogenity: Runs Test, Moving Average, Distribution Function, Error Metrics and Fitness functions.

Unit – 4

Introduction to Optimization Technique, Region of Feasibility, Difference between Simulation, Prediction and Optimization, Classification of Optimization Techniques, Linear Programming, Dynamic Programming, Differential Evolution Techniques.

Unit – 5

Introduction to nature based optimization techniques, meta-heuristic and heuristic techniques, Particle Swarm Optimization, Ant Colony Optimization, Fire Fly Algorithm.

Unit – 6

Hydrological Models, development steps, time dependent and space dependent models, deterministic and stochastic hydrologic model, Introduction to MATLAB.

References:

1. Multicriteria Decision Aid: Methods and software. A. Ishizaka, P. Nemery.
2. Multicriteria Analysis: Applications to Water and Environment Managemen,M. Zarghami, F. Szidarovszky.
3. Engineering Optimization: Theory and Practice,Singiresu S. Rao.
4. A First Course in Optimization Theory,Rangarajan K. Sundaram.
5. Modeling Hydrologic Change: Statistical Methods,Richard H. McCuen.
6. Hydrologic Time Series Analysis: Theory and Practice,Deepesh Machiwal Madan Kumar Jha.

Course Outcome

1. Students will be able to apply MCDM techniques in different real life and time decision making problems.
2. Students will be able to develop an idea and know the procedure of developing neural network based models for simulation and predictive objectives.
3. Students will be able to analyze and synthesize different statistical derivations essential for numerical hydrology.
4. Students will be able to minimize real life problems and optimize designs for maximum benefit or any new or old hydrologic structures.
5. Students will be able to apply nature based optimization techniques to identify optimal solutions under difficult constraints.
6. Students will be able to apply the different concepts and MATLAB programming language to analyze the efficacy of hydrologic models

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE61B01.1	Students will be able to apply MCDM techniques in different real life and time decision making problems.
PCE61B01.2	Students will be able to develop an idea and know the procedure of developing neural network based models for simulation and predictive objectives.
PCE61B01.3	Students will be able to analyze and synthesize different statistical derivations essential for numerical hydrology.
PCE61B01.4	Students will be able to minimize real life problems and optimize designs for maximum benefit or any new or old hydrologic structures.
PCE61B01.5	Students will be able to apply nature based optimization techniques to identify optimal solutions under difficult constraints.
PCE61B01.6	Students will be able to apply the different concepts and MATLAB programming language to analyze the efficacy of hydrologic models

Table-2: Correlation between COs & POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE61B01.1	3	3	3	3	3	3
PCE61B01.2	3	3	3	3	3	3
PCE61B01.3	3	2	3	3	3	3
PCE61B01.4	3	3	3	3	3	1
PCE61B01.5	3	3	3	3	3	3
PCE61B01.6	3	3	3	3	3	3
Total	18	17	18	18	18	16
Average	3	2.83	3	3	3	2.7
Equivalent Avg. Attainment	3	3	3	3	3	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE61B01.1	3	3
PCE61B01.2	3	3
PCE61B01.3	3	3
PCE61B01.4	3	3
PCE61B01.5	3	3
PCE61B01.6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	3	3

Core Subject-I

PRINCIPLE OF WATER RESOURCES ENGINEERING (PCE61C01)
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To understand the global perspective of Hydrology and water resources.
2. To understand the different natural phenomenon and their measurement techniques.
3. To understand the techniques of forecasting flood.
4. To gather the knowledge about Groundwater Hydrology.

Course Content:

Unit- 1

Water resources – Global Perspective, Fields of Water Resources Engineering, Hydrological Cycle, Precipitation and its Measurement, Raingauge Networking, Precipitation Data Processing & Analysis, Probable Maximum Precipitation (PMP).

Unit -2

Abstractions from Precipitation- Hydrological Data and their Measurements such as Evaporimeter, Transpiration, Evapotranspiration, Interception, Depression Storage, Infiltration.

Unit – 3

Stream Flow Measurement- Measurement of stage and velocity, Area-Velocity method, Stage-Discharge relationship, Ration Curve, Hygrometry station.

Unit – 4

Runoff and Hydrograph – Flow duration Curve, Flow Mass Curve, concept of Hydrograph, UH, S-curve, IUH.

Unit – 5

Flood and flood routing- Determination of flood magnitude, Flood frequency analysis, storage routing & channel routing.

Unit – 6

Flood flows – Estimation and Control Measures, Flood Forecasting Techniques, Risk, Reliability and Safety Factor, Hydrologic Surface Water and Storage Reservoir, Conveyance of Surface Water through River Intakes and Dam Outlet.

Unit – 7

Groundwater Hydrology – well hydraulics, drainage and reclamation of water logged lands, water quality, desalination of brackish water, cost benefit considerations in water resources planning.

References:

1. Water Resources Engineering, Larry W. Mays.
2. Water Resources Engineering, Linsley and Franzin.
3. Principles of Water Resources Planning, Alvin, S. Goodman.
4. Engineering Hydrology, R.S. Varshaney.
5. Hand Book of Applied Hydrology, (Ed) Ven T. Chow.
6. Remote Sensing in Hydrology, E.T. Engman& R.J. Gurney
7. Engineering Hydrology,K. Subramanya.
8. Water Resources Engineering, Linseley.
9. Flow in open channels, K. Subramanya.
10. Elementary Hydrology,V. P. Singh.

Course Outcome:

1. Students will be able to identify the types of losses due to the precipitation and its impact on runoff.
2. Students will be able to describe the Stream Flow Measurement techniques.
3. Students will be able to derive the amount of runoff or discharge for any given catchment which is very necessary in terms of hydrology and water resources.
4. Students will be able to find the Flood value under meteorological condition.
5. Students will be able to understand the concepts of flood routing and its application.
6. Students will be able to analyze the Flood control measurement with various flood forecasting techniques.
7. Students will be able to describe and analyze the Groundwater Hydrology.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE61C01.1	Students will be able to identify the types of losses due to the precipitation and its impact on runoff.
PCE61C01.2	Students will be able to describe the Stream Flow Measurement techniques.
PCE61C01.3	Students will be able to derive the amount of runoff or discharge for any given catchment which is very necessary in terms of hydrology and water resources.
PCE61C01.4	Students will be able to find the Flood value under meteorological condition.
PCE61C01.5	Students will be able to understand the concepts of flood routing and its application.
PCE61C01.6	Students will be able to analyze the Flood control measurement with various flood forecasting techniques.
PCE61C01.7	Students will be able to describe and analyze the Groundwater Hydrology.

Table-2: Correlation between COs & POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE61C01.1	3	2	3	3	3	3
PCE61C01.2	3	2	3	3	3	3
PCE61C01.3	3	3	3	3	3	3
PCE61C01.4	3	2	3	3	3	1
PCE61C01.5	3	2	3	3	3	3
PCE61C01.6	3	3	3	3	3	3
PCE61C01.7	3	3	3	3	3	1
Total	21	17	21	18	18	14
Average	3	2.83	3	3	3	2.3
Equivalent Avg. Attainment	3	3	3	3	3	2

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE61C01.1	3	2
PCE61C01.2	3	3
PCE61C01.3	3	3
PCE61C01.4	3	3
PCE61C01.5	3	3
PCE61C01.6	3	3
PCE61C01.7	3	2
Total	21	19
Average	3	2.71
Equivalent Avg. Attainment	3	3

LABORATORY

APPLICATION SOFTWARE LABORATORY (PCE61P01)
Total Credit: 02
Contact Periods: 03 (0L+0T+3P)

Courses Objective:

1. To learn the application of different software in Hydro-informatics engineering.
2. To learn how to operate the software.
3. To learn where to apply the software.
4. To able to analyze the different water related issues using soft computing techniques.

Course Content:

Unit- 1

Watershed Development- Google Earth and G.I.S. Tool

Unit -2

Image processing-FreeView Image processing software

Unit -3

Hydrological modeling- HEC -HMS Software

Unit -4

Simulation model- Alyuda Neurointelligence (based on Artificial Neural Network), Group Method of Data Handling (GMDH).

Unit -5

Mapping -Surfer 3D mapping software.

Unit -6

Statistical Software- MaxStat Lite software.

Unit-7

Pipe Flow- CADRE Flow software.

Course Outcome:

1. Students will be able to apply the Google Earth and G.I.S tool.
2. Students will be able to derive the information using image processing software.
3. Students will be able simulate the hydrological response of watershed using hydrological modeling using the HEC-HMS software.
4. Students will be able to develop various model based on real life problem using Alyuda Neurointelligence and Group Method of Data Handling.
5. Students will be able to convert the data into outstanding color, surface, weir frame, vector, image, shaded relief and post maps using Surfer 3D mapping software.

6. Students will be able to develop an autoregressive model that is representation of a type of random process, as such, it is used to describe certain time-varying process in nature, economics etc.
7. Analysis of Hydraulic and pipe flow system-CADRE Flow software.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE61P01.1	Students will be able to apply the Google Earth and G.I.S tool.
PCE61P01.2	Students will be able to derive the information using image processing software.
PCE61P01.3	Students will be able simulate the hydrological response of watershed using hydrological modeling using the HEC-HMS software.
PCE61P01.4	Students will be able to develop various model based on real life problem using Alyuda Neurointelligence and Group Method of Data Handling.
PCE61P01.5	Students will be able to convert the data into outstanding colour, surface, weir frame, vector, image, shaded relief and post maps using Surfer 3D mapping software.
PCE61P01.6	Students will be able to develop an autoregressive model that is representation of a type of random process, as such, it is used to describe certain time-varying process in nature, economics etc.
PCE61P01.7	Analysis of Hydraulic and pipe flow system-CADRE Flow software.

Table-2 Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE61P01.1	3	3	3	3	3	3
PCE61P01.2	3	3	3	3	3	3
PCE61P01.3	3	3	3	3	3	3
PCE61P01.4	3	3	3	3	3	1
PCE61P01.5	3	3	3	3	3	3
PCE61P01.6	3	3	3	3	3	3
PCE61P01.7	3	3	3	3	3	3
Total	21	21	21	21	21	19
Average	3	3	3	3.0	3.0	2.7
Equivalent Average Attainment	3	3	3	3	3	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE61P01.1	3	3
PCE61P01.2	3	3
PCE61P01.3	3	3
PCE61P01.4	3	3
PCE61P01.5	3	3
PCE61P01.6	3	3
PCE61P01.7	3	3
Total	21	21
Average	3	3
Equivalent Average Attainment	3	3

MINOR PROJECT-I (PCE61P02)
Total Credit: 01
Contact Periods: 02 (0L+0T+2P)

Each student will be given a Project problem as per their interest and related to the specialization. They will work on the literature survey, scope of work, development of equipments/software etc. and submit a report. The student's will present a seminar related to this project work at the end of the semester. In this semester, the weightage will be given for theoretical and applied concepts.

SEMINAR (PCE21P03)
Total Credit: 01
Contact Periods: 02 (0L+0T+2P)

Each Student shall prepare a Report and present a Seminar on topic related to the branch of specialization under the guidance of a Faculty member. Grades will be awarded on the basis of contents of the paper and the presentation.

Second Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	Second Semester			
1	**Basic Core** **PCE62B01**: Design of Water Resources System	4	4	100
2	**Core Subject-I** **PCE62C01**: Advanced Hydrology	4	4	100
3	**Core Subject-II** **PCE62C02**: Advance Hydropower Engineering	4	4	100
4	**Elective Paper-IV**(**Any one**) PCE61E04:One course from Elective Group (excluding the course already selected as Elective I, II and II)	4	4	100
5	**PCE62P04**: Water Quality, Hydrology and Hydraulic Instruments Laboratory	2	3	100
6	**PCE62P05:** Minor Project-II	2	3	100
7	**PCE62P06**: Project Preliminary	3	6	100
8	**PCE62P07**: Comprehensive Viva-voce	2	0	100
	Total	**25**	**28**	**800**

Basic Core

DESIGN OF WATER RESOURCES SYSTEM (PCE62B01)
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Course Objective:

1. To understand the basic areas water resources planning and development.
2. To understand the design criteria of storm water control structure.
3. To understand the design of energy dissipater and water harvesting structure.
4. To understand the design of water treatment plant.
5. To understand the design of irrigation structure.

Course Content:

Unit- 1

Overview- Development and feasibilities of water resources, planning alternatives.

Unit -2

Storm water management: Design of storm sewers and detention, Highway drainage and culverts.
Design of Energy dissipater: Spillway Design, probability risk and uncertainty analysis.

Unit – 3

Design of Water Treatment Plant - Pipeline Distribution Network, Design of Water Intake Stations, Design of Aerator, Design of Settling Tank, Design of Sedimentation Tank, Design of Slow Sand Filter and Rapid Sand Filter, Chlorination and Softening.

Unit – 4

Design of Water Harvesting Structures - Types of Water Harvesting Structures, Design of Rain Water Harvesting Structure.

Unit-5

Design of Irrigation Systems- Canal Operation and Automation, Irrigation Water Demands, Canal Architecture, Canal Control Structures, Low-Pressure Pipelines, Canal Lining, Canal Hydraulic Design

References:

Sl. No.	Name of Book	Author
1	Water Resources System Engineering	Hall and Dracup
2	Water Resources System	Asit Kumar Biswas

3	River Basin Planning (Theory & Practice)	Suranjit K. Saha and Christopher J. Barrow
5	Developments in Water Science	S. K. Jain and V. P. Singh
6	Water Resources Engineering	Larry W. Mays

Course Outcome:

1. Students will be able to do the feasibility analysis of different hydraulic structure.
2. Students will be able to analyse and design storm water control structure.
3. Students will be able to analyse and design of energy dissipater and water harvesting structure.
4. Students will be able to analyse and design of water treatment plant.
5. Students will be able to do analyse and design irrigation structure.

Table 1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE62B01.1	Students will be able to do the feasibility analysis of different hydraulic structure.
PCE62B01.2	Students will be able to analyse and design storm water control structure.
PCE62B01.3	Students will be able to analyse and design of energy dissipater and water harvesting structure.
PCE62B01.4	Students will be able to analyse and design of water treatment plant.
PCE62B01.5	Students will be able to do analyse and design irrigation structure.

Table-2: Correlation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62B01.1	3	2	3	3	3	3
PCE62B01.2	3	3	3	3	3	3
PCE62B01.3	3	3	3	3	3	3
PCE62B01.4	3	3	3	3	3	1
PCE62B01.5	3	3	3	3	3	3
Total	15	14	15	15	15	13
Average	3	2.8	2	3	3	2.6
Equivalent Avg. Attainment	3	3	3	3	3	3

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62B01.1	3	3
PCE62B01.2	3	3
PCE62B01.3	3	3
PCE62B01.4	3	3
PCE62B01.5	3	3
Total	15	15
Average	3	3
Equivalent Avg. Attainment	3	3

Core Subject-I

ADVANCED HYDROLOGY (PCE62C01)
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To obtain fundamental understanding the phenomenon and types of Hydrograph.
2. To understand different analysis and procedure of routing and frequency analysis.
3. To obtain an understanding of runoff and fluvial geomorphology.
4. To understand the phenomenon of snow hydrology.
5. To understand the concept of Hydrological models.

Course Content:

Unit- 1
Hydrograph-Distribution graph for runoff generation, complex storm hydrograph, Synthetic UH generation techniques, IUH generation techniques and UH generation from IUH.

Unit -2
Routing Analysis- Lumped Flow Routing, Distributed Flow Routing, Dynamic Wave Routing
Frequency Analysis- Extreme value distribution, Probability Plotting, Reliability of analysis.

Unit -3
Runoff-SCS runoff curve number method
Fluvial Geomorphology- Stream Morphology, Stream morphology processes and Environmental Triggers.

Unit – 4
Snow Hydrology- Snow Formation and Accumulation, Melting of Snowpack, Snowmelt Indices, Effect of Snowpack Condition on Runoff, Snowmelt Hydrograph Synthesis.

Unit – 5

Hydrological Models- types of catchment model components and construction, analysis of time series data – generation of synthetic hydrologic data models for hydrologic abstraction processes.

References:

Sl. No.	Name of Book	Author
1	Urban Hydrology	T. L. Lazaro
2	Applied Hydrology:	R. K. Linsley Jr.
3	Environmental Hydrology	Andy D. Ward and Stanley W. Trimble
4	Applied Hydrology	Ven Te Chow

5	Hydrology and Water Resources Engineering	S. K. Garg
6	Hydrology and Water Resources Engineering	K. C. Patra
7	Applied Hydrology	K. N. Mutreja
8	Facets of Hydrology	J. C. Rodda
9	Hydrology & Hydraulic Systems	R. S. Gupta
10	Introduction to Hydrology	R. L. Brass
11	Engineering & Hydrology	Principles & Practices: V. M Ponce

Course Outcome:

1. Students will be able to describe and derivation of Hydrograph and able to apply this for any hydraulic structure analysis.
2. Students will be able to derive the frequency analysis and able to apply the routing in any channel.
3. Students will be able to identify the types of soil using SCS-CN method, which is important to analysis of runoff.
4. Students will be able to discuss about the fluvial geomorphology.
5. Students will be able to discuss about the snow hydrology and its impact on runoff.
6. Students will be able to do the hydrological modelling to find the discharge or runoff for a given catchment area.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE62C01.1	Students will be able to describe and derivation of Hydrograph and able to apply this for any hydraulic structure analysis.
PCE62C01.2	Students will be able to derive the frequency analysis and able to apply the routing in any channel.
PCE62C01.3	Students will be able to identify the types of soil using SCS-CN method, which is important to analysis of runoff.
PCE62C01.4	Students will be able to discuss about the fluvial geomorphology.
PCE62C01.5	Students will be able to discuss about the snow hydrology and its impact on runoff.
PCE62C01.6	Students will be able to do the hydrological modeling to find the discharge or runoff for a given catchment area.

Table-2 : Co-relation Between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO2	PO4	PO5	PO6
PCE62C01.1	3	3	3	3	3	3
PCE62C01.2	3	2	3	3	3	3
PCE62C01.3	3	2	3	3	3	3
PCE62C01.4	3	2	3	3	3	1
PCE62C01.5	3	2	3	3	3	3
PCE62C01.6	3	3	3	3	3	3
Total	18	14	18	18	18	16
Average	3	2.33	3	3	3	2.7
Equivalent Avg. Attainment	3	2	3	3	3	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62C01.1	3	3
PCE62C01.2	3	3
PCE62C01.3	3	3
PCE62C01.4	3	3
PCE62C01.5	3	3
PCE62C01.6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	3	3

LABORATORY

WATER QUALITY, HYDROLOGY AND HYDRAULICS LABORATORY (PCE62P04)
Total Credit: 02
Contact Periods: 03 (0L+0T+3P)

Courses objective:

1. To understand the relation between the various hydrological and meteorological parameters and their impact of water resources and hydrology.
2. To learn to measure the different meteorological parameters
3. To learn to use and application of Instrument used to measure the various parameters.
4. To learn to handling the instruments used to determine the meteorological and hydrological parameters.
5. To learn the operation of different instruments use in fluvial hydraulics.
6. To learn how to use and operate the instruments in laboratory and field.
   To learn the applicability of the various instruments in real life problem

Course content:

Unit-1

Determination of φ index- Double Ring type Infiltrometer, Single Ring Infiltrometer.

Unit- 2

Determination of rate of evaporation- PAN Evaporimeters.

Unit-3
Determination of different Water Quality parameter

Unit-4

Meteorological Parameter determination- Weather Station Instrument.

Unit -5

Velocity measurement- Micro ADV (Lab measurement)

Unit -6

Velocity & Discharge measurement - River Surveyor M9

Unit -7

Particle size distribution analysis-Sieve Analysis

Course outcome:

1. Students will be able to determine the φ index using double ring type Infiltrometer and single ring Infiltrometer.
2. Students will be able to determine the Evaporation rate using Pan Evaporimeter.
3. Students will be able to determine different Water Quality parameter
4. Students will be able to use Weather Station Instrument.
5. Students will be able to derive the velocity in laboratory using Micro ADV.

6. Students will be able to measure the discharge using River Surveyor M9 in any flowing water body.
7. Students will be able to find the soil particle size using sieve analysis.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE62P04.1	Students will be able to determine the φ index using double ring type Infiltrometer and single ring Infiltrometer.
PCE62P04.2	Students will be able to determine the Evaporation rate using Pan Evaporimeter.
PCE62P04.3	Students will be able to determine different Water Quality parameter
PCE62P04.4	Students will be able to use Weather Station Instrument
PCE62P04.5	Students will be able to derive the velocity in laboratory using Micro ADV.
PCE62P04.6	Students will be able to measure the discharge using River Surveyor M9 in any flowing water body.
PCE62P04.7	Students will be able to find the soil particle size using sieve analysis.

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62P04.1	3	3	3	3	3	3
PCE62P04.2	3	3	3	3	3	3
PCE62P04.3	3	3	3	3	3	3
PCE62P04.4	3	3	3	3	3	2
PCE62P04.5	3	3	3	3	3	2
PCE62P04.6	3	3	3	3	3	2
PCE62P04.7	3	3	3	3	3	2
Total	21	21	21	21	21	14
Average	3	3	3	3	3	2
Equivalent Average Attainment	3	3	3	3	3	2

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62P04.1	3	2
PCE62P04.2	3	3
PCE62P04.3	3	3

PCE62P04.4	3	3
Total	12	11
Average	3	2.8
Equivalent Average Attainment	3	3

MINOR PROJECT-I (PCE62P05)

Total Credit: 01
Contact Periods: 02 (0L+0T+2P)

Each student will be given a Project problem as per their interest and related to the specialization. They will work on the literature survey, scope of work, development of equipments/software etc. and submit a report. The student's will give a presentation related to this project work at the end of the semester. In this semester the weightage will be given for design and socio-economical aspects.

PROJECT PRELIMINARY (PCE62P06)

Total Credit: 03
Contact Periods: 06 (0L+0T+6P)

Each student will be given a Thesis/Project problem at the beginning of Second Semester as per their interest and related to the specialization under the supervision of a Faculty Member. They will work on the literature survey, scope of work, development of equipments/software etc. and submit a report/dissertation. The student's will present the progress of their work in the third semester which will be evaluated by a Board of Examiners consisting of the Supervisor and External Examiner.

COMPREHENSIVE VIVA-VOCE (PCE62P07)
Total Credit: 02

Viva-voce will be conducted for all the students at the end of the Second Semester in the department by the board of examiners constituted by the Hydro-Informatics Engineering Section of Civil Engineering Department.

ELECTIVE SUBJECTS

WATER

ENERGY MANAGEMENT IN WATER INDUSTRY

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To introduce the students to achieve and maintain optimum energy procurement and utilization, throughout the organization.
2. The students will learn how to minimize energy costs / waste without affecting production & quality
3. To minimize environmental effects.

Course Content:

Unit-1

Introduction
Present Scenario of Water Resources, Present Scenario of Energy Resources, Climate Change, Climate Change Effect on Water Resources, Impact of Climate Change on Energy Resources, Water-Energy Nexus.

Unit-2

Measuring Energy Consumptions
Energy Units, Energy Sources, Energy Audits, Energy Efficiency, Electrical Energy Measurement, Thermal Energy Measurements, Mechanical and Utility System Measurements.

Unit-3

Thermal and Mechanical Energy Utility Systems
Boilers- Types, Combustion in Boilers, Performance Evaluation, Analysis of Losses, Feed Water Treatment, Blow Down
FBC Boilers: Introduction, Mechanism of Fludized Bed Combustion, Types of FBC Boilers, Retrofitting FBC System to Conventional Boilers.

Unit-4

Energy Monitoring, Targeting Review and Evaluation Definition, Monitoring and Targeting, Elements of Monitoring and Targeting, Data and Information Analysis, Techniques of Energy Consumption, Production, Cumulative Sum of Difference (CUSUM), Review and Evaluation.

Unit-5

Optimal Trade-Off Between the Energy-Economy of a Hydropower Plant for Better Management of the Renewable Energy Resources: Introduction, Detail Methodology,

Application of Optimization Techniques (OT) for Identification of Optimal Trade-Off, Results and Discussions.

Unit-6

Impact Analysis of Water, Energy, and Climatic Variables on performance of Surface Water Treatment Plants: Introduction, Objectives, Methods Used, Methodology, Applications and Case Study.

Unit-7

Energy Policy
Need for Energy Policy for Industries, Formulation of Policy by any Industrial Unit, Implementation in Industries, National and State Level Policies, Global Energy Issues, Energy Pricing & Impact of Global Variations, Energy Security and Energy Vision.

References:

Sl. No.	Name of Book	Author
1	Energy Management	W.R. Murphy, G. Mckay
2	Energy Management Handbook	W.C Turner
3	Industrial Energy Conservation, Manuals	MIT Press,Mass,1982
4	Industrial Energy Management and Utilization	L.C. Witte
5	Handbook of Energy Efficiency	CRC Press
6	Water and Energy Management in India	Springer
7	Industrial Energy Conservations	D.A. Reay
8	Energy Management of Water Utilities	Laura Dufresne

Course Outcome:

1. Students will be able to understand the strategy of adjusting and optimizing energy.
2. Students will be able to know systems and procedures to reduce energy requirements per unit of output.
3. Students will be able to learn the benefits of lowering and eliminating energy use through energy efficiency improvements.
4. Students will be able to learn energy efficiency advantages over renewable energy.
5. Students will be able to understand approaches for achieving energy efficiency and renewable energy gains.
6. Students will be able to understand that energy and water have mutual goals and can help each other reach them.

Table-1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE61E03.1	Students will be able to understand the strategy of adjusting and

	optimizing energy.
PCE61E03.2	Students will be able to know systems and procedures to reduce energy requirements per unit of output.
PCE61E03.3	Students will be able to learn the benefits of lowering and eliminating energy use through energy efficiency improvements
PCE61E03.4	Students will be able to learn energy efficiency advantages over renewable energy.
PCE61E03.5	Students will be able to understand approaches for achieving energy efficiency and renewable energy gains.
PCE61E03.6	Students will be able to understand that energy and water have mutual goals and can help each other reach them.

Table-2: Correlation between COs & POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE61E03.1	3	2	3	2	2	2
PCE61E03.2	3	2	3	2	2	2
PCE61E03.3	3	2	3	2	2	2
PCE61E03.4	3	2	3	2	2	2
PCE61E03.5	3	2	3	2	2	2
PCE61E03.6	3	2	3	2	2	2
Total	18	12	18	12	12	12
Average	3	2	3	2	2	2
Equivalent Avg. Attainment	3	2	3	2	2	2

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE61E03.1	3	2
PCE61E03.2	3	2
PCE61E03.3	3	2
PCE61E03.4	3	3
PCE61E03.5	3	3
PCE61E03.6	3	3
Total	18	15
Average	3	2.5
Equivalent Avg. Attainment	3	3

CLIMATE CHANGE AND WATER RESOURCES
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To understand the concept of climate system
2. To comprehend the fundamental impacts of climate change and its effect on natural resources and socio-economic status of mankind.
3. To analyze the extreme event and its impact and occurrence probability.
4. To be acquainted with the different climate models and how to downscale and use the predicted data extracted from these simulation frameworks.
5. To be familiar with the different assessment methodologies for analysis of climate change impacts.
6. To be acquainted with different mitigation strategies to stop and reverse the climate change impacts.

Course Content:

Unit-1

THE CLIMATE SYSTEM
Introduction, weather and climate: Impact of climate on environment, earth, its atmospheric, cycle and its relationship with climate; Basic concepts of atmospheric dynamics, ocean dynamics, cloud physics, radiative heat transfer and climate, Drivers of Climate change, Characteristics of climate system components, Greenhouse effect, Carbon cycle, Wind systems, Trade Winds and the Hadley Cell, Ozone hole in the stratosphere, El Nino, La Nina ENSO, Teleconnections.

Unit-2

CLIMATE CHANGE AND IT'S IMPACTS
Past, Present, and future climate changes., monsoon circulation, paleo-climatic approaches to the reconstruction of monsoon circulation, emphasis on Indian monsoon, El-Nino, LaLina, IOD (Indian Ocean Dipole), NAO (North Atlantic Oscillation), Arctic Oscillation, Indian Summer Monsoon. Precipitation and temperature change due to climate variations. NATCOM Report, Impacts on sectoral vulnerabilities, SRES, Different scenarios. Impact on water resources, Impact on agriculture, Impact on forest, Impact on Industry.

Unit-3

EXTREME EVENT ANALYSIS
Analysis for climatic change assessment, statistical analysis of long-term meteorological and hydrological data; Trend analysis, Need for vulnerability assessment, Steps for assessment, Approaches for assessment, Flood, Drought, Desertification, Erosion, Predictive models for extreme event.

Unit-4

CLIMATE MODEL

Climate Models, types of models, Global Circulation Models, Regional Circulation Models, Quantitative models, Economic model, Impact matrix approach, Box models, Zero-dimensional models, Radioactive-convective models, Higher-dimension models, EMICs (Earth-system models of intermediate complexity), Downscaling Methods.

Unit-5

VULNERABILITY ASSESSMENT

Climate Risk Assessment (CRA), Climate hazards, Floods, droughts, heat waves, cyclones, storm surge, climate impacts, susceptibility, climate risk, vulnerability, social vulnerability, adaptive capacity, Gender aspects, Participatory rural appraisal (PRA), focused group discussions, CRA for different sectors like Urban, Agriculture, Forest, Industry, Tools for carrying out CRA and ranking methods. Flood management strategies, Drought management strategies, Temporal and spatial assessment of water for Irrigation, Land use & cropping pattern, Coastal zone management strategies, Concept of Vulnerability Index.

Unit-6

ADAPTATION AND MITIGATION

Mitigation- Policy, regulation, economics, benefits and costs of mitigating climate change, international cooperation, Water-related adaptation to climate change in the fields of Ecosystems and biodiversity, -Agriculture and food security, land use and forestry, Human health, water supply and sanitation, infrastructure and Economy (insurance, tourism, industry and transportation) - Adaptation, vulnerability and sustainable development Sector-specific mitigation - Carbon dioxide capture and storage (CCS) , Bio-energy crops, Biomass electricity, Hydropower, Geothermal energy, Energy use in buildings, Land-use change and management, Cropland management, Afforestation and Reforestation - Potential water resource conflicts between adaptation and mitigation - Implications for policy and sustainable development, Circular Economy, analysis of co-benefits of adaptation and mitigation, Food-water-energy nexus.

References:

Sl. No.	Name of Book	Author
1	Climate Change and India: Vulnerability Assessment and Adaptation	P. R. Shukla
2	Climate Change Modeling, Mitigation, and Adaptation	Zhang, T. C., Ojha, C. S. P., & Kao, C. M
3	Handbook of climate change mitigation and adaptation	Chen, W. Y., Suzuki, T., & Lackner, M.
4	Climate Change and Climate Modeling	J. David Neelin
5	Demystifying Climate Models: A Users Guide to Earth System Models	Andrew Gettelman and Richard B. Rood
6	Impact of Climate Change on Water Resources: With Modeling Techniques and Case Studies	D. Nagesh Kumar and K. Srinivasa Raju

7	India: Climate Change Impacts, Mitigation and Adaptation in Developing Countries	Md. Nazrul Islam and André van Amstel
8	Food Security and Land Use Change under Conditions of Climatic Variability: A Multidimensional Perspective	Victor R. Squires and Mahesh K. Gaur
9	Trends and Changes in Hydroclimatic Variables: Links to Climate Variability and Change	Ramesh Teegavarapu
10	Understanding Climate Change Impacts on Crop Productivity and Water Balance	S. K. Jalota, B. B. Vashisht, Sandeep Sharma, Samanpreet Kaur

Course Outcome:

1. Students will be able to develop the basic knowledge of Climatic Systems.
2. Students will be able to understand the intricacies of climate change and its impacts.
3. Students will be able to comprehend the concepts and predictive methodologies of extreme events.
4. Students will be able demonstrate their capability on development and assessment of Global and Regional Climate Models
5. Students will be able to comprehend and apply the different methodology of vulnerability assessment with respect to the change in climate.
6. Students will learn about the various mitigation strategies for sustainable development in face of climatic vulnerabilities.

Table 1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE61E06.1	Students will be able to develop the basic knowledge of Climatic Systems.
PCE61E06.2	Students will be able to understand the intricacies of climate change and its impacts.
PCE61E06.3	Students will be able to comprehend the concepts and predictive methodologies of extreme events.
PCE61E06.4	Students will be able demonstrate their capability on development and assessment of Global and Regional Climate Models
PCE61E06.5	Students will be able to comprehend and apply the different methodology of vulnerability assessment with respect to the change in climate.
PCE61E06.6	Students will learn about the various mitigation strategies for sustainable development in face of climatic vulnerabilities.

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE61E05.1	3	2	3	2	2	2
PCE61E05.2	3	2	3	2	2	2
PCE61E05.3	3	3	3	2	2	2
PCE61E05.4	3	3	3	2	2	2
PCE61E05.5	3	3	3	2	2	2
PCE61E05.6	3	2	3	2	2	2
Total	18	15	18	12	12	8
Average	3	2.5	3	2	2	2
Equivalent Average Attainment	3	3	3	2	2	2

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE61E05.1	3	2
PCE61E05.2	3	3
PCE61E05.3	3	3
PCE61E05.4	3	3
PCE61E05.5	3	3
PCE61E05.6	3	3
Total	18	17
Average	3	2.83
Equivalent Average Attainment	3	3

WATER QUALITY MODELING AND MANAGEMENT
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To know about the introductory principles and concepts of water quality.
2. To know about the monitoring and management of water quality in water-based systems like river, wetlands, and irrigation
3. To know about modeling of pollutant transport, water quality variations and decay in different surface and ground water systems.
4. To understand about the mechanism of monitoring instruments including IoT based EWS.
5. To appreciate about water quality management vulnerabilities due to abruptness in water quality pattern of water bodies.
6. To know about the application of GIS in water quality analysis.

Course content:

Unit-1
INTRODUCTORY CONCEPTS
Principles of water quality, Water quality classification, Water quality standards, Water quality indices, TMDL Concepts, Water quality models, Water quality description, various characteristics of water, water quality criteria and standards, elements of reaction kinetics, spatial and temporal aspects of contaminant transport, transport mechanism-advection, diffusion, dispersion.

Unit -2
WATER QUALITY OF WATER BODIES AND IRRIGATION SYSTEMS
Water quality for irrigation, Salinity and permeability problem, Root zone salinity, Irrigation practices for poor quality water, Saline water irrigation, Future strategies, River and streams, convective diffusion equation and its application. Estuaries, Estuarine hydraulics, Estuarine water quality models; Lakes and reservoirs, eutrophication, spatial variation of water quality in wetlands.

Unit -3
WATER QUALITY MODELING
Numerical/mathematical modeling, pollutant transport processes Contaminant transport in unsaturated flows, solute transport models for conservative species, solute transport in spatially variable soils, Contaminant transports in ground water advection, dispersion, one dimensional transport with linear adsorption, dual porosity models, numerical models, bio degradation reaction, kinematic modeling, spatial modeling of surface and ground water.

Unit – 4
REMOTE MONITORING OF WATER QUALITY
Water quality investigation, Sampling design, Samplers and automatic samplers, Data collection platforms, Field kits, Water quality data storage, IOT and EWS, analysis and inference, Software, Sensors, Advanced Instruments, monitoring in water treatment plants, case studies.

Unit -5

MANAGEMENT AND VULNERABILITY ASSESSMENT OF WATER QUALITY

Surface and wastewater quality management, socio-economic aspects of water quality management, management alternatives for water quality control, waste load allocation process, lake quality management, and groundwater remediation. water quality indices, vulnerability index, water reuse and recycling, surface and waste water treatment plants and their vulnerability analysis..

Unit-6

SPATIAL ANALYSIS OF WATER QUALITY

Thematic mapping, Measurement in GIS: length, perimeter and areas, Query analysis, Reclassification, Buffering, Neighborhood functions, Map overlay: vector and raster overlay, Interpolation, Network analysis, Digital elevation modelling. Analytical Hierarchy Process, Object oriented GIS, AM/FM/GIS, Web Based GIS, DCS, SCADA.

References:

Sl. No.	Name of Book	Author
	Basic Water Quality Parameters: ASC	Dr. Ali Akshad M. et.al.
1	Wastewater Engineering: Treatment and Reuse	George Tchobanoglous, Franklin Louis Burton, Metcalf & Eddy, H. David Stense
2	Water Quality: Diffuse pollution and watershed Management,	Vladimir Novonty
3	Introduction to Environmental Engineering	Mackenzie L Davis, David A Cornwell
4	Aquatic Chemistry	Stum, M and Morgan, A.
5	Integrated Environmental Modeling - Pollutant Transport, Fate, and Risk in the Environment	Ramaswami A., Milford J. B., Small M. J
6	Principles of Geographical Information Systems	Burrough P.A. and McDonnell R.A
7	Water Quality Modelling for Rivers and Streams	Marcello Benedini and George Tsakiris
8	Handbook of Water Purity and Quality	Satinder Ahuja
9	Surface Water-Quality Modeling	CanaleChapra
10	Smart Sensors for Real-Time Water Quality Monitoring	Mukhopadhyay,S.C. and Mason,A.

Course outcome:

1. Students will become familiar with standards, principles, classifications and parameters of water quality.
2. Students will be aware of the characteristics and different phenomena of different water bodies and irrigation systems.

3. Students will gain knowledge about different water quality models and procedures to develop accurate and reliable numerical frameworks for temporal as well as spatial approximation of water quality in different water bodies.
4. Student will be acquainted about different monitoring devices used in discrete and real time monitoring of the vital water quality parameters.
5. Students will acquire knowledge about water quality management, control including groundwater remediation and vulnerability analysis.
6. Student will be able to apply the knowledge of spatial analysis to provide useful mitigation strategies for water pollution problems.

Table-1: To establish the correlation between COs & POs

No of course outcome(CO)	Course Outcome
PCE61E07.1	Students will become familiar with standards, principles, classifications and parameters of water quality.
PCE61E0.2	Students will be aware of the characteristics and different phenomena of different water bodies and irrigation systems.
PCE61E07.3	Students will gain knowledge about different water quality models and procedures to develop accurate and reliable numerical frameworks for temporal as well as spatial approximation of water quality in different water bodies
PCE61E07.4	Student will be acquainted about different monitoring devices used in discrete and real time monitoring of the vital water quality parameters.
PCE61E07.5	Students will acquire knowledge about water quality management, control including groundwater remediation and vulnerability analysis.
PCE61E07.6	Student will be able to apply the knowledge of spatial analysis to provide useful mitigation strategies for water pollution problems.

Table-2: Correlation between COs & POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE61E05.1	2	2	3	3	3	3
PCE61E05.2	3	2	3	3	3	3
PCE61E05.3	3	2	3	3	3	3
PCE61E05.4	3	2	3	3	3	3
PCE61E05.5	3	2	3	3	3	3
PCE61E05.6	3	3	3	3	3	3
Total	17	13	18	18	18	18
Average	2.83	2.16	3	3	3	3
Equivalent Average Attainment	3	2	3	3	3	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE61E05.1	2	2
PCE61E05.2	3	3
PCE61E05.3	3	3
PCE61E05.4	3	3
PCE61E05.5	3	3
PCE61E05.6	3	3
Total	17	17
Average	2.83	2.83
Equivalent Average Attainment	3	3

APPLICATION OF GEO-INFORMATICS IN WATER RESOURCE MANAGEMENT
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To impart knowledge about the planning and management of water resources.
2. To introduce the concepts of watershed management, integrated water resources management, environmental interaction of water resources and policies/framework related to water resources.
3. To enable student to understand the different components of water resources and their management

Course content:

Unit- 1

Management of hydrological data, Linear Programming and its application in water resources development, Inventory control.

Unit -2

Analysis of risk and uncertainties, Dynamics programming Statistical decision model, Water policies and institutional aspects of management of water resources.

Unit -3

Hierarchical modeling of water resources development, Management of watersheds and water quality.

Unit -4

Reservoir & stream flow routing, probability, risk and uncertainty analysis.

Unit – 5

Urban water supply planning/management, cost-benefit analysis in water resources planning, planning of watersheds
Watershed behaviour and conservation practices, trans-boundary water resources.

Unit – 6

National water policy, water withdrawals & uses, trans-boundary water resources.

References:

Sl. No.	Name of Book	Author
1	Water Management	Warren Viessman Jr. and Claire Welty
2	Developments in Water Science	S. K. Jain and V. P. Singh
3	Water Resources Engineering	Larry W. Mays

4	Water Resources Engineering	Ralph A. Wurbs and Wesley P. James
5	Water Resources Systems, Planning & Management	S. K. Jain & V. P. Singh
6	Modeling Water qualities and Management	Asit K. Biswas
7	Hierarchical Analysis of Water Resources System	Y.Y. Haimes
8	Waste Water Engineering Treatment and Reuse	Matfalf / Eddy
9	Sustainable water Management Solutions for Large Cities	Dragar A, Savic, Mignel A.
10	Principle of Water Resources History, Development, Management, Policy:	Thomas V. Cech

Course outcome:

1. Students will be able to identify different problems related to water resources planning, management and development.
2. Students will be able to describe various concept and problems of water related issues.
3. Students will be able to identify the risk and uncertainties of water related issues
4. Students will be able to do the cost-benefit analysis in water resources planning
5. Students will be able to do the urban water supply planning/management, cost-benefit analysis in water resources planning, planning of watersheds.
6. Students will be able to gain knowledge about the national water policy.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE61E08.1	Students will be able to identify different problems related to water resources planning, management and development
PCE61E08.2	Students will be able to describe various concept and problems of water related issues
PCE61E08.3	Students will be able to identify the risk and uncertainties of water related issues
PCE61E08.4	Students will be able to do the cost-benefit analysis in water resources planning
PCE61E08.5	Students will be able to do the urban water supply planning/management, cost-benefit analysis in water resources planning, planning of watersheds.
PCE61E08.6	Students will be able to gain knowledge about the national water policy.

Table-2: Correlation between COs & POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE61E09.1	3	2	3	3	3	3
PCE61E09.2	3	2	3	3	3	3
PCE61E09.3	3	2	3	3	3	3
PCE61E09.4	3	3	3	3	3	3
PCE61E09.5	3	3	3	3	3	3
PCE61E09.6	3	2	3	3	3	3
Total	18	14	18	18	18	18
Average	3	2.33	3	3	3	3
Equivalent Average Attainment	3	2	3	3	3	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE61E09.1	3	3
PCE61E09.2	3	3
PCE61E09.3	3	2
PCE61E09.4	3	2
PCE61E09.5	3	2
PCE61E09.6	3	2
Total	18	14
Average	3	2.33
Equivalent Average Attainment	3	2

SYSTEMS ANALYSIS IN WATER RESOURCES
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To interpret the concept of system analysis and design with respect to water-based system.
2. To understand the fundamental systems development life cycle and its four phases.
3. To interpret the evolution of systems development methodologies.
4. To be acquainted with the different roles played by and the skills of a systems analyst.
5. To be familiar with the basic understanding and modeling of systems.
6. To be comfortable with the basic role of system analyst and about the methods of optimization of the system operation.

Course Content:

Unit-1

Introduction
Definition, Systems, Roles, and Development Methodologies,Types of Systems,Integrating Technologies for Systems,The Systems Development Life Cycle (SDLC), Identifying Problems, Opportunities, and Objectives in SDLC, Analyzing, Evaluating and Implementing the System in SDLC.

Unit-2

The Systems Development Life Cycle
Planning, Analysis, Design, Implementation, 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-3

Systems Development Methodologies
Structured Design, Rapid Application Development (RAD), Agile Development, Selecting the Appropriate Development Methodology.Using data flow diagram; Using data dictionaries,Describing process specifications and structured decisions; The system proposal.

Unit-4

Understanding and Modeling Organizational Systems
Basic principles and concepts, Systems and the Entity-Relationship Model, Case Modeling, Case Relationships, Case Diagrams, Case Scenarios, Case Levels, Level of Management.

Unit-5

System Dynamics, Modeling and Optimization

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, Optimization Techniques, Multi Criteria Decision Making Techniques, Case Studies of Multi-reservoir Optimization, Case Studies of Agro-based Water Intensive Industries.

Unit-6

Operation Research and role of System Analyst
Business Analyst, Systems Analyst, Infrastructure Analyst, Change Management, Historical Background, Scope of Operations Research , Features of Operations Research, Phases of Operations Research, Types of Operations Research Models, Operations Research Methodology, Operations Research Techniques and Tools , Structure of the Mathematical Model, Limitations of Operations Research, Case Studies of Water Based Systems.

References:

Sl. No.	Name of the Book	Author
1	Systems Analysis and Design, 7th Edition	Alan Dennis, Barbara Wixom, Roberta M. Roth
2	Systems Life Cycle Costing Economic Analysis, Estimation, and Management	John V. Farr
3	Modeling and Analysis of Dynamic Systems, Second Edition	Ramin S. Esfandiari, Bei Lu
4	Systems Analysis and Design	Scott Tilley, Harry J. Rosenblatt
5	Systems Analysis & Design Fundamentals: A Business Process Redesign Approach	Ned Kock
6	Operations Research (3 Edition) : Theory And Applications	J K Sharma
7	Business Statistics	J. K. Sharma
8	Production and Operations Management	Kanishka Bedi
9	Optimization Methods in Operations Research and Systems Analysis	K.V. Mital
10	Optimization in Operations Research	Ronald L. Rardin

Course Outcome:

1. Students will be able to develop the basic knowledge of System Analysis and Design
2. Students will be able to understand the intricacies of Systems Development Life Cycle
3. Students will be able to grasp the concepts of System Development Methodologies.
4. Students will be able to discuss about the organization systems and simulate the same for finding the optimal operation level.
5. Students will be able to develop and model scenarios to find the optimal profitability under minimum loss in a system.
6. Students will be able to understand the role of system analyst in operation research.

Table 1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE61E04.1	Students will be able to develop the basic knowledge of System Analysis and Design.
PCE61E04.2	Students will be able to understand the intricacies of Systems Development Life Cycle.
PCE61E04.3	Students will be able to grasp the concepts of System Development Methodologies.
PCE61E04.4	Students will be able to discuss about the organization systems and simulate the same for finding the optimal operation level.
PCE61E04.5	Students will be able to develop and model scenarios to find the optimal profitability under minimum loss in a system.
PCE61E04.6	Students will be able to understand the role of system analyst in operation research.

Table-2: Correlation between COs & POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE61E04.1	3	3	3	2	2	2
PCE61E04.2	3	2	3	2	2	2
PCE61E04.3	3	2	3	2	2	2
PCE61E04.4	3	2	3	2	2	2
PCE61E04.5	3	3	3	2	2	2
PCE61E04.6	3	2	3	2	2	2
Total	18	14	18	12	12	12
Average	3	2.33	3	2	2	2
Equivalent Avgerage Attainment	3	2	3	2	2	2

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE61E04.1	3	2
PCE61E04.2	3	2
PCE61E04.3	3	3
PCE61E04.4	3	3
PCE61E04.5	3	3
PCE61E04.6	3	3
Total	18	16
Average	3	2.66
Equivalent Avg. Attainment	3	3

UNDERWATER REMOTE SENSING AND LIFE CYCLE ASSESSMENT (PCE62E08)

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To obtain fundamental understanding the phenomenon of aquatic ecology and environmental ecology.
2. To understand the concept of climate change and extreme events.
3. To obtain an understanding of water pollution and aquatic eco system.
4. To understand the analysis of water and wastewater.
5. To understand the importance and applicability of EIA and Environmental audit.

Course content:

Unit- 1

Greenhouse effect, Climate change, extreme events, Global energy balance.

Unit -2

Cycle- Carbon cycle, oxygen cycle, nitrogen cycle, sulpher cycle, phosphorous and other nutrients

Unit -3

Lakes and reservoirs - dissolved oxygen balance and model

Unit -4

Water pollution and aquatic eco-system

Unit – 5

Water and wastewater analysis, municipal solid waste disposal techniques-leachate generation model

Unit – 6

Environmental impact assessment (EIA), environmental audit

References:

Sl. No.	Name of Book	Author
1	Introduction to Environmental Engineering and Science	Gilbert M. Masters
2	Environmental Engineering	Noward S. Peavy and Donald R. Rowe
3	Environmental Hydrology	Andy D. Ward and Stanley W. Trimble
4	Chemistry for Environmental Engineering and Science	C. N. Sawyer, P. L. Mccarty and G. F. Parkin
5	Freshwater Ecology (Concepts and	Walter K. Dodds

	Environmental Applications):	
6	Water and Wastewater Technology	Mark J. Hammer

Course outcome:

1. Students will be able to describe the phenomenon of aquatic ecology and environmental ecology.
2. Students will be able to describe the concept of climate change and extreme events
3. Students will be able to analyze the waste water quality and can be able to prepare a report regarding the same.
4. Students will be able to describe the water pollution and aquatic eco system
5. Students will be able to do the EIA and Environmental audit assessment of any real life problem.
6.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE62E08.1	Students will be able to describe the phenomenon of aquatic ecology and environmental ecology.
PCE62E08.2	Students will be able to describe the concept of climate change and extreme events.
PCE62E08.3	Students will be able to analyze the waste water quality and can be able to prepare a report regarding the same.
PCE62E08.4	Students will be able to describe the water pollution and aquatic eco system.
PCE62E08.5	Students will be able to do the EIA and Environmental audit assessment of any real life problem.

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62E08.1	3	2	3	3	3	3
PCE62E08.2	3	2	3	3	3	3
PCE62E08.3	3	3	3	3	3	3
PCE62E08.4	3	2	3	3	3	3
PCE62E08.5	3	3	3	3	3	3
Total	15	12	15	15	15	15
Average	3	2.4	3	3	3	3
Equivalent Average Attainment	3	2	2	3	3	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62E08.1	2	2
PCE62E08.2	3	2
PCE62E08.3	3	2
PCE62E08.4	3	2
PCE62E08.5	3	2
Total	14	12
Average	2.8	2
Equivalent Average Attainment	3	2

GIS APPLICATIONS IN MONITORING AND MANAGEMENT OF GROUND WATER

Total Credit: 04
Contact Periods: 04 (1L+3T+P)

Courses Objective:

1. To impart the fundamental concepts of ground water hydraulics.
2. To provide the introduction of the basic principles of groundwater exploration.
3. To enable the student to develop the required skill and intuition for management of ground water.
4. To provide the introductory knowledge on the fundamentals of ground water pollution and ground water modeling.
5. To teach the methodology of vulnerability assessment of ground water with the help of advanced soft computation methods
6. To teach about the application of ground water in drainage engineering for sustainable management of both ground water and drainage.

Course Content:

Unit-1

GROUND WATER HYDRAULICS
Types of Aquifers, Vertical Distribution of Soil Water below the Ground, Porosity, Specific Yield, Hydraulic Conductivity and Storage Coefficient, their Practical Significance, Darcy's Law and its Validity, Ground Water Flow Contours and their Applications, Tracer Techniques in Ground Water Flow Studies, Derivation of Basic Differential Equation and its Solutions, Steady and Unsteady Radial Flow of Ground Water towards a Well in Confined and Unconfined Aquifers, Analysis of Pumping Test Data, Thesis type Curve Method, Jacob's Method for Time and Distance Draw Down Tests, Open Well Hydraulics, Recuperation Test.

Unit-2

GROUNDWATER EXPLORATION
Remote sensing, hydrogeological methods, Electrical Methods, Expression for Apparent Resistivity in Four Electrode Arrangements viz. – Werner, Schlumberger Arrays, Field Surveys, Interpretation Techniques in Sounding, Profiling and Imaging for Ground Water Investigation, Seismic Refraction Method – Principle and Propagation of Refracted Energy in Two and ThreeMedia Earth, Field Procedure and Interpretation Techniques, Ground Penetrating Radar principle field procedure and Interpretation, well logging.

Unit-3

GROUND WATER MANAGEMENT
Water Balance Studies, Perennial Yield, Concept of artificial recharge, Various types of artificial recharge techniques, Conjunctive use of surface and groundwater, Management of coastal aquifers – Ghyben Herzberg relation, upcoming of Saline Water, Methods of control of salt-water intrusion.

Unit-4

GROUND WATER POLLUTION AND MODELLING
Ground Water Quality, Ground Water Pollution, Elements and Source of Pollution, their Effects and Remedial Measures. Aquifer Modeling: Electrical Analog Models, RC Network Techniques, Principles of Digital Modeling of Aquifers, Flow Modeling Using Finite Difference Methods and Finite Element Methods, Advection Process, Diffusion and Dispersion Process, Solute Transport Modeling, Visual Groundwater, Case Studies.

Unit-5

GROUNDWATER VULNERABILITY ASSESSMENT
Index-based vulnerability mapping models, Comparative study and discussion, Assessment of effectiveness of drastic model, Multi-criteria evaluation of hydrogeological and anthropogenic parameters, Implementation of modified drastic model and AHP-DRASTICL model,

Unit-6

DESIGN AND MANAGEMENT OF DRAINAGE SYSTEMS
Drainage materials, Surface drainage systems, their components and applications in sloping areas, Subsurface drainage systems, Mole drainage, Tube well irrigation, Drainage application and design, Management, and maintenance of drainage systems.

References:

Sl. No.	Name of Book	Author
1	Groundwater Science	Charles R. Fitts
2	Groundwater Hydraulics	Kuniaki Sato
3	Groundwater Hydrology	David K. Todd and Larry W. Mays
4	Groundwater Hydrology: Conceptual and Computational Models	K. R. Rushton
5	Geophysical Techniques for Groundwater Exploration	Dr. K.R. Ramanuja Chary
6	A Practical Guide to Groundwater and Solute Transport Modeling	Karlheinz Spitz and Joanna Moreno
7	Groundwater Hydrology: Engineering, Planning, and Management	Mohammad Karamouz, Azadeh Ahmadi
8	Practical Problems in Groundwater Hydrology	Scott Bair and Terry Lahm
9	Ground-Water Hydrology and Hydraulics	David B. McWhorter and Daniel K. Sunada
10	Groundwater Vulnerability Assessment and Mapping using DRASTIC Model	Prashant Kumar, Praveen Thakur

Course Outcome:

1. Student will learn the basic concepts of the design and management of ground water hydraulics.

2. Students will be able to apply the knowledge of different ground water exploration techniques.
3. Students will be familiar with the concept and practice of groundwater management.
4. Students will be able to describe the cause and mitigation measure to prevent and model ground water pollution.
5. Students will be acquainted with the different mechanism of vulnerability assessment of ground water.
6. Students will be able to design and manage drainage network in connection to ground water.

Table-1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE62E04.1	Student will learn the basic concepts of the design and management of ground water hydraulics.
PCE62E04.2	Students will be able to apply the knowledge of different ground water exploration techniques.
PCE62E04.3	Students will be familiar with the concept and practice of groundwater management.
PCE62E04.4	Students will be able to describe the cause and mitigation measure to prevent and model ground water pollution
PCE62E04.5	Students will be acquainted with the different mechanism of vulnerability assessment of ground water.
PCE62E04.6	Students will be able to design and manage drainage network in connection to ground water

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62E04.1	3	2	3	2	2	3
PCE62E04.2	3	2	3	2	2	3
PCE62E04.3	3	2	3	2	2	3
PCE62E04.4	3	2	3	2	2	3
PCE62E04.5	3	2	3	2	2	3
PCE62E04.6	3	2	3	2	2	3
Total	18	12	18	12	12	18
Average	3	2	3	2	2	3
Equivalent Avg. Attainment	3	2	3	2	2	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62E04.1	2	2
PCE62E04.2	3	3
PCE62E04.3	3	3
PCE62E04.4	3	3
PCE62E04.5	3	3
PCE62E04.6	3	3
Total	17	17
Average	2.83	2.83
Equivalent Avg. Attainment	3	3

ELECTRICAL AND ENERGY ENGINEERING

POWER PLANT ENGINEERING
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To introduce students to different aspects of power plant engineering.
2. To familiarize the students to the working of power plants based on different fuels.
3. To expose the students to the principles of safety and environmental issues.

Course Content

Unit-1
Fundamental of Power Plant
Introduction, Concept of Power Plant, Classification Power Plant, Load-Duration Curve, Power Development in India, Resources for Power Generation, Indian Energy Scenario Future Planning for Power Generation.

Unit-2
Steam Cycles
Steam Power Plant, Rankine Cycle, Carnot Cycle, Reheat Cycle, Regenerative Cycle, Binary Vapour Cycle, Reheat-Regenerative Cycle.

Unit-3
Steam Power Plant
Introduction, Essentials of Steam Power Plant Equipment, Coal Handling, Fuel Burning Furnaces, Method of Fuel Firing, Automatic Boiler Control, Pulverized Coal, Pulverized Coal Firing, Pulverized Coal Burners, Water Walls, Ash Disposal, Soke and Dust Removal, Types of Dust Collector.

Unit-4
Steam Generator
Introduction, Types of Boilers, Cochran Boilers, Lancashire Boiler, Locomotive Boiler, Babcock Wilcox Boiler, Industrial Boiler, Merits and Demerits of Water Tube Boilers over Fire Tube Boilers, High Pressure Boilers, Boiler Maintenance.

Unit-5
Steam Turbine
Principle of Operation of Steam Turbine, Classification of Steam Turbine, Steam Turbine Governing, Steam Turbine Performance, Steam Turbine Testing, Choice of Steam Turbine, Steam Turbine Specification.

Unit-6
Diesel Power Plant
Introduction, Operating Principle, Basic Types of IC Engines, Advantage and Disadvantage of Diesel Power Plant, General Layout of Diesel Power Plant, Efficiency of Diesel Power Plant.

Unit-7
Nuclear Power Plant
Nuclear Energy, Summary of Nuclear Energy Concepts and Terms, Chemical and Nuclear Equations, Nuclear Fusion and Fission, Energy from Fission and Fuel Burn Up, Nuclear Reactor, Classification of Reactors, Cost of Nuclear Power Plant, Nuclear Power Station in India, Reactor Power Control, Site Selection and Commissioning Procedure, Major Nuclear Power Disasters, Chernobyl Nuclear Power Plant, Safety Problems in Chernobyl Reactor Design.

Unit-8
Hydro Electric Power Plant
Introduction, Site selection for Hydro Power Plant, Types of Hydro Power Plant, Powe Plant Accessories, Power House and Turbine Setting, Prime-Movers, Selection of Turbine.

Unit-9
Solar Energy
The Sun as a Source of Energy, Measurement of Solar Radiation, Solar Cell Fundamentals, Solar Cell Characteristics, Solar Cell Classification, Maximizing the Solar PV output, Solar PV Systems, Solar PV Applications.

Unit-10
Wind Energy
Origin of Wind, Wind Turbine Aerodynamics, Wind Turbine Types and Their Construction, Wind Energy Programme in India

Unit-11
Electrical Systems
Generators and Motors their cooling, Transformers and their cooling.

References:

Sl. No.	Name of Book	Author
1	Renewable Energy: Power for a Sustainable Future	Stephen Peake
2	Hydroelectric Energy: Renewable Energy and the Environment	Ajoy Karki and Bikash Pandey
3	Solar Energy	S P Sukhatme and J K Nayak
4	Solar Photovoltaics - Fundamentals, Technologies, and Applications	Solanki C.S
5	Wind Power Technology	Joshua Earnest and Sthuthi' Rachel
6	Wind Electrical Systems	S. N. Bhadra
7	Wave Energy Conversion	R. Bhattacharyya, M.E. McCormick

8	Handbook of Ocean Wave Energy	Arthur Pecher, Jens Peter Kofoed
9	Handbook of Energy Audit	Sonal Desai
10	Energy Management and Conservation	P. Venkataseshaiah K.V. Sharma
11	Power Plant Engineering	A.K. Raja, Amit Prakash Srivastav, Manish Dwivedi
12	Non-Conventional Energy Resources	B H Khan.
13	Power Plant Engineering	P K Nag.

Course Outcome:

1. Students will able to describe and analyze different types of sources and mathematical expressions related to thermodynamics and various terms and factors involved with power plant operation.
2. Students will able to analyze the working and layout of steam power plants and the different systems comprising the plant and discuss about its economic and safety impacts.
3. Students will able to combine concepts of previously learnt courses to define the working principle of diesel power plant, its layout, safety principles and compare it with plants of other types.
4. Students will able to describe the working principle and basic components of the nuclear power plant and the economic and safety principles involved with it.
5. Students will able to discuss the working principle and basic components of the hydro electric plants and the economic principles and safety precautions involved with it.
6. Students will able to discuss and analyze the mathematical and working principles of different electrical equipments involved in the generation of power.

Table-1: To establish the correlation between COs & Pos

No. of Course Outcome (CO)	Course Outcome
PCE61E02.1	Students will be able to describe and analyze different types of sources and mathematical expressions related to thermodynamics and various terms and factors involved with power plant operation.
PCE61E02.2	Students will be able to analyze the working and layout of steam power plants and the different systems comprising the plant and discuss about its economic and safety impacts
PCE61E02.3	Students will be able to understand combine concepts of previously learnt courses to define the working principle of diesel power plant, its layout, safety principles and compare it with plants of other types.
PCE61E02.4	Students will be able describe the working principle and basic components of the nuclear power plant and the economic and safety principles involved with it.
PCE61E02.5	Students will be able to discuss the working principle and basic components of the hydro electric plants and the economic principles and safety precautions involved with it.

PCE61E02.6	Students will be able to understand and analyze the mathematical and working principles of different electrical equipments involved in the generation of power.

Table-2: Correlation between COs & POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO1	PO4	PO5	PO6
PCE21E02.1	3	3	3	3	2	1
PCE21E02.2	3	3	3	3	2	1
PCE21E02.3	3	2	3	3	2	1
PCE21E02.4	3	2	3	3	2	1
PCE21E02.5	3	2	3	3	2	1
PCE21E02.6	3	3	3	3	2	1
Total	18	15	18	18	12	6
Average	3	2.5	3	3	2	1
Equivalent Avg. Attainment	3	3	3	3	2	1

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE21E02.1	3	2
PCE21E02.2	3	3
PCE21E02.3	3	3
PCE21E02.4	3	3
PCE21E02.5	3	3
PCE21E02.6	3	2
Total	18	16
Average	3	2.22
Equivalent Avg. Attainment	3	2

RENEWABLE ENERGY SYSTEM

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To impart the fundamental concepts of new and renewable energy systems.
2. To make quantitative judgments and perform computations of the different subsystems of solar energy systems.
3. To learn about the different technologies available in location selection, resource assessment and conversion of wind energy.
4. To provide the knowledge on the fundamentals of dams and hydropower generation
5. To describe the principles and technical solutions for different wave power concepts and use this knowledge to evaluate different wave power systems from technical, environmental and societal aspects.
6. To use numerical, analytical, and experimental tools to model and optimize the management of renewable energy system based on the concept of energy audit and economy of the same system.

Course Content:

Unit-1

FUNDAMENTAL CONCEPTS
Energy Scenario: Classification of Energy Sources, Energy resources (Conventional and nonconventional), Energy needs of India, and energy consumption patterns, Worldwide Potentials of these sources, Energy efficiency and energy security. Energy and its environmental impacts, Distributed generation, Energy storage and hybrid system configurations: Energy storage, Battery – types, equivalent, circuit, performance characteristics, battery design, charging and charge regulators, Battery management. Flywheel-energy relations, Location selection studies.

Unit-2

SOLAR ENERGY SYSTEMS
Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications. Photo voltaic (PV) technology: Present status, solar cells, cell technologies, characteristics of PV systems, equivalent circuit, array design, building integrated PV system, its components, sizing, and economics, Peak power operation. Standalone and grid interactive systems.

Unit-3

WIND ENERGY CONVERTERS
Wind resource assessment, Wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: classification, system components, Types of Turbines, Turbine rating. Choice of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation.

Unit-4

DAMS AND HYDROPOWER PLANT
Dam break analysis, Runs Test, Classification of Dams, Gravity and Arch Dams, Design and Management, Factor of Safety Analysis of Dams, Risk and Reliability Analysis, Introduction to hydropower, types of hydropower, location selection studies, penstock, turbine and generator design and optimization, microturbines, scheduling concepts.

Unit-5

WAVE ENERGY CONVERTERS
Ocean energy resources, Ocean energy routes, Classification, Ocean waves: formation, characterizations, wave climate, energy content, resources and measurement. Ocean thermal energy conversion, Wave energy conversion, Design of Power Takeoff, Mooring Structure, Hydraulic Circuits, Numerical Modelling of Wave Energy Converters. Tidal energy conversion.

Unit-6

AUDIT AND MANAGEMENT OF RENEWABLE ENERGY SYSTEMS
Energy Audit, Types of Audit, Vulnerability Assessment of Renewable Energy Systems, Application of Multi Criteria Decision Making Tools on Renewable Energy Systems, GIS in Renewable Energy, Reliability and Risk Analysis, Levelized cost of electricity.

References:

Sl. No.	Name of Book	Author
1	Renewable Energy System Design	Ziyad Salameh
2	Fundamentals of Renewable Energy Systems	D. Mukherjee and S. Chakrabarti
3	Solar Energy Fundamentals and Modeling Techniques	Z.Sen
4	Solar Energy for Beginners: The Complete Guide to Solar Power Systems, Panels & Cells	Catherine Gregory
5	Wind energy: Theory and Practice	Siraj Ahmed
6	A Practical Guide to Groundwater and Solute Transport ModelingA Practical Guide to Construction of Hydropower Facilities	Suchintya Kumar Sur
7	Wave Energy Conversion	John Brooke
8	Numerical Modelling of Wave Energy Converters	Matt Folley
9	Energy Audit Made Simple: Energy auditing Manual	Balasubramanian P
10	Energy Management, Audit and Conservation	Barun Kumar De

Course Outcome:

1. Student will learn about the basics, types, conversion mechanisms of new and renewable energy systems.

2. Student will be able to design solar based power farms for maximum conversion of available solar energy under minimum cost.
3. Student will become familiar about the various technologies available in location selection, resource assessment and conversion of wind energy potential.
4. Student will be acquainted about the fundamentals of dams and hydropower generation and related analytic tools and techniques.
5. Student will be conversant with the principles and technical solutions for different wave power converters and it applications for maximum utilization of available wave energy potential.
6. Student will be able to apply the numerical, analytical, and experimental tools to audit and manage any new and renewable energy systems for maximum utilization of the potential.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE62E02.1	Student will learn about the basics, types, conversion mechanisms of new and renewable energy systems.
PCE62E02.2	Student will be able to design solar based power farms for maximum conversion of available solar energy under minimum cost.
PCE62E02.3	Student will become familiar about the various technologies available in location selection, resource assessment and conversion of wind energy potential.
PCE62E02.4	Student will be acquainted about the fundamentals of dams and hydropower generation and related analytic tools and techniques.
PCE62E02.5	Student will be conversant with the principles and technical solutions for different wave power converters and it applications for maximum utilization of available wave energy potential.
PCE62E02.6	Student will be able to apply the numerical, analytical, and experimental tools to audit and manage any new and renewable energy systems for maximum utilization of the potential.

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62E02.1	3	2	3	2	2	2
PCE62E02.2	3	2	3	2	2	2
PCE62E02.3	3	2	3	2	2	2
PCE62E02.4	3	2	3	2	2	2
PCE62E02.5	3	2	3	2	2	2
PCE62E02.6	3	2	3	2	2	2

Total	18	12	18	12	12	12
Average	3	2	3	2	2	2
Equivalent Average Attainment	3	2	3	2	2	2

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62E02.1	3	3
PCE62E02.2	3	3
PCE62E02.3	3	3
PCE62E02.4	3	3
PCE62E02.5	3	3
PCE62E02.6	3	3
Total	18	18
Average	3	3
Equivalent Average Attainment	3	3

ADVANCE HYDROPOWER ENGINEERING

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses objective:

1. To discover principles of operation and design of specific types of hydropower plants and installation of the necessary accessories for a specific location.
2. To impart basic hydraulic solutions and proposals for hydraulic structures corresponds to hydropower and design of technological devices.
3. To enable student to develop independent problem-solving skill in the field of construction and design in hydroelectricity.

Course Content:

Unit- 1

Electrical Load on Hydro-Turbines
Overview. Load Curve. Load Factor. Capacity Factor. Utilization factor. Diversity Factor. Load Duration Curve. Firm Power. Secondary Power. Prediction of Load.

Unit -2

Low and High Head Plants
Classification of Hydel Plants. Runoff River Plants. General Arrangement of Runoff River Plants. Valley Dam Plants. Diversion Canal Plants. High Head Diversion Plants. Storage and Pondage.

Unit -3

Pumped Storage Power Plant
Basic features. Advantage and Types. Two unit and Three units arrangement. Reversible Pump-Turbines. Problems of operation. Topography. Reservoir and Water conveyance. Powerhouse. Efficiency of pumped storage plant.

Unit -4

Dams and Spillways
Dam- Overview. Function of a Dam. Classification of Dams. Selection of site and choice of Dam. Gravity Dams. Embankment Dams: Arch dams. Buttress Dams. Safety of Dams
Spillways- Types of spillways. Spillways Gate. Automatic and Non-automatic Gates. Dam sluices. Energy dissipation below spillways.

Unit – 5

Penstocks and Accessories
General. Classification of Penstocks. Design Criteria for Penstokes. Economical Diameter of Penstock. Anchor Blocks, Conduit Valves. Types of Valves. Bends and Mainfolds.

Unit – 6

Water Hammer, Surges, Intakes, Canals and Tunnels
Introduction. Water Hammer, Resonance in Penstocks. Channel Surges. Surge Tanks. Intakes, Types of Intakes, Losses in Intakes, Air entrainment in Intakes. Inlet aeration. Canals. Forebay. Tunnels.

Unit – 7

Electrical and Mechanical Equipment
Generators. Excitation. Ventilation. Cooling and Lubrication. Transformer, switch gear, Control Room equipment. Turbine. Mechanical Equipment. Transmission of Electric power.

Unit – 8

Power House Planning
Surface Power Station. Underground Power Station

Unit – 9

Tidal Power
Tidal Phenomenon. Tidal Power-Basic principle, location, difficulties in power generation, Components, modes of generation. Single basin arrangement. Double basin arrangement. Cooperating double basing system. Estimation of energy and power. Regulation of power output. Corrosion control and quality of concrete. Economic feasibility.

References:

Sl. No.	Name of Book	Author
1	Hydro-electrical Engineering	Creager and Justin
2	Water Power Engineering	H. K. Barrows
3	Water Power Development	Mosony L., Emil, Budapest, Pub
4	Water Power Engineering	M.M. Dandekar and K.N. Sharma
5	Hydro –Electric and Pump Storage Plants	MG Jog
6	Water Power Engineering-The theory, investigation and development of water power	Daniel, W. Mead, Member ASCE
7	A text Book of Water Power Engineering	R.K.Sharma and T.K.Sharma

Course Outcome:

1. Students will be able to describe the phenomenon water flow through a power station.
2. Students will be able to theoretical calculations on hydropower dams and spillway discharge.
3. Students will be able to describe the concept of electrical components and perform calculations of the parameters of the electrical system
4. Students will be able to describe the Electrical and Mechanical Equipment.
5. Students will be able to understand the environmental effects of hydropower installations

6. Students will be able to have the fundamental understanding about the Tidal Power.
7. Students will be able to utilize the concepts in the course to analyse similar systems and be able to do the project related work.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE62C02.1	Students will be able to describe the phenomenon water flow through a power station
PCE62C02.2	Students will be able to theoretical calculations on hydropower dams and spillway discharge
PCE62C02.3	Students will be able to describe the concept of electrical components and perform calculations of the parameters of the electrical system
PCE62C02.4	Students will be able to describe the Electrical and Mechanical Equipment
PCE62C02.5	Students will be able to understand the environmental effects of hydropower installations
PCE62C02.6	Students will be able to have the fundamental understanding about the Tidal Power.
PCE62C02.7	Students will be able to utilize the concepts in the course to analyse similar systems and be able to do the project related work.

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62C02.1	3	2	3	3	3	3
PCE62C02.2	3	2	3	3	3	3
PCE62C02.3	3	2	3	3	3	3
PCE62C02.4	3	2	3	3	3	3
PCE62C02.5	3	2	3	3	3	3
PCE62C02.6	3	2	3	3	3	3
PCE62C02.7	3	3	3	3	3	3
Total	21	15	21	21	21	21
Average	3	2.14	3	3	3	3
Equivalent Average Attainment	3	2	3	3	3	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62C02.1	2	2
PCE62C02.2	3	3
PCE62C02.3	3	3
PCE62C02.4	3	3
PCE62C02.5	2	2
PCE62C02.6	2	3
PCE62C02.7	3	3
Total	18	19
Average	2.57	2.71
Equivalent Average Attainment	3	3

HYDROLOGY AND HYDRAULIC INSTRUMENTS
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To introduce the students to know about importance of hydrology and measurement of hydrologic properties.
2. The students will learn how to measure the hydrologic properties using hydraulic instruments.
3. To enable student to find losses of water and help in better management of water resources

Course Content:

Unit-1

Introduction: The hydrological cycle, Inventory of Earth's water, Water Budget Equation, Applications in Engineering, History of Hydrology.

Unit-2

Precipitation: Forms of precipitation other than rain, Measurement of Precipitation, Rain gauge network, Preparation and presentation of rainfall data, the extension and interpretation of data, various graphical relationships, Rainfall data in India.

Unit-3

Evaporation and Transpiration: Transpiration, Methods of estimating evaporation, Direct measurement of evaporation by pans, Consumptive use, Evapotranspiration, Measurements of evapotranspiration, Potential and Actual evapotranspiration, Evaporation from land surfaces using Penman's E_0 value, Thornthwaite's formulae for evapotranspiration.

Unit-4

Infiltration and Percolation: Infiltration capacity of the Soil, Factors influencing, Classification of Infiltration capacities, Methods of determining infiltration capacity, Infiltration Indices, Soil Moisture.

Unit-5

Surface Runoff: The engineering problem, Catchment characteristics and their effects on runoff, Flow rating curves: their determination, adjustment and extension, Hydrograph, Estimation of mean flow Q_m, Graphical curves.

Unit-6

Floods and Flood Routing: Introduction, Rational method and empirical formulae, Unit Hydrograph method, Gumbel's method, Frequency Studies

The storage equation, Reservoir routing, Routing in a river channel, Graphical routing methods, Synthetic unit graphs from flood routing.

Unit-7

Hydrologic Instruments: Description and working of Water Level recorders (different types) , Water Velocity meters (different types) , Water Current meters (different types), the silt analysis, TDS, PH Value, Dissolved Oxygen and Water temperature equipment, River flow

simulator equipment

References

1. Advanced Hydrology, K.Subramanya.
2. Engineering Hydrology, E.M.Wilson.
3. Applied Hydrology,KN Mutreja.
4. Applied Principles of Hydrology, John C. Manning.
5. Hydraulics and Hydrology Equipment, Didac International.
6. Hydrologic Equipment, R. K.Engineering.

Course Outcome:

1. Students will be able to understand about Hydrologic cycle.
2. Students will be able to learn the methods of calculation and presentation of rainfall data.
3. Students will be able to know about loss of surface water due to evaporation, Infiltration and runoff.
4. Students will be able to understand about how crucial the infiltration losses are and how to calculate them using equations and indices.
5. Students will be able to learn calculation and graphical representation of various water losses.
6. Students will be able to understand about floods and flood routing and their calculation.
7. Students will be able to understand and learn about various hydrologic instruments.

Table 1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE61C02.1	Students will be able to understand about Hydrologic cycle.
PCE61C02.2	Students will be able to learn the methods of calculation and presentation of rainfall data.
PCE61C02.3	Students will be able to know about loss of surface water due to evaporation, Infiltration and runoff.
PCE61C02.4	Students will be able to understand about how crucial the infiltration losses are and how to calculate them using equations and indices.
PCE61C02.5	Students will be able to learn calculation and graphical representation of various water losses.
PCE61C02.6	Students will be able to understand about floods and flood routing and their calculation.
PCE61C02.7	Students will be able to understand and learn about various hydrologic instruments.

Table-2: Correlation between COs & POs

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21C02.1	3	2	3	2	2	2
PCE21C02.2	3	2	3	2	2	2
PCE21C02.3	3	2	3	2	2	2
PCE21C02.4	3	2	3	2	2	2
PCE21C02.5	3	2	3	2	2	2
PCE21C02.6	3	2	3	2	2	2
PCE61C02.7	3	2	3	2	2	2
Total	21	14	21	14	14	14
Average	3	2	3	2	2	2
Equivalent Avg. Attainment	3	2	3	2	2	2

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE21C02.1	3	2
PCE21C02.2	3	2
PCE21C02.3	3	3
PCE21C02.4	3	2
PCE21C02.5	3	3
PCE21C02.6	3	3
PCE61C02.7	3	2
Total	21	17
Average	3	2.42
Equivalent Avg. Attainment	3	2

AGRICULTURE/ SOFT COMPUTING/OTHERS

INTERNET OF THINGS APPLICATIONS IN AGRICULTURE

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To obtain fundamental understanding and application of the principles of irrigation
2. To be able to interpret the inherent mechanisms of irrigation systems with performance indicators.
3. To learn about the main components of irrigation systems.
4. To demonstrate the ability to apply management policies on participatory irrigation.
5. To apply and perform land grading and functional analysis.
6. To understand the concept of crop water requirement

Course content:

Unit-1

PRINCIPLES OF IRRIGATION
Principles of irrigation systems, evaluation of systems, selection of systems, basic irrigation scheduling, measurements of water flow, soil moisture, pump and system efficiencies. Importance of Irrigation in Agriculture, Historical evolution of irrigation in India, Irrigation development during pre-colonization, Colonization and post-colonization, Different types of Irrigation prevalent in India, Command area development approach and farmers‟ participation.

Unit-2

IRRIGATION SYSTEMS AND PERFORMANCE INDICATORS
Systems classification, Institutions for irrigation management, Diagnostic Analysis of Irrigation Systems, Rehabilitation and modernization, Performance indicators, Improving system performance, Conjunctive management, constraints faced.

Unit-3

SYSTEM MANAGEMENT
Main system components, Reservoir allocation rule, Operating rule and optimization methods to improve main system performance, irrigation scheduling, Constraints.

Unit-4

COMMAND AREA DEVELOPMENT AND PARTICIPATORY IRRIGATION MANAGEMENT
Command area development principles, Participatory Irrigation Management and Irrigation, management transfer, Case studies, Constraints.

Unit-5

LAND GRADING, FIELD LAYOUT AND DRAINAGE

Criteria for Land Leveling, Land Grading Survey and Design, Equipment of Land Grading, Field Layout suiting different crops. Conveyance of Irrigation Water, Field Channels, Different lining materials, Design of field channels, Drop structures, Conveyance of water through underground pipe lines, Drainage of Irrigated Lands: Salt problems in Soil and Water, Water logging in irrigated areas, Causes, Methods for Controlling water logging, Drainage, Surface and Subsurface Drainage Systems, Suitability of these methods, Design of Drainage Systems, Reclamation and Management of Salt Affected Soils.

Unit-6

WATER REQUIREMENT OF CROPS
Meteorological Parameters needed in estimating water requirement of crops, Their measurements, Methods for estimating evapotranspiration of crops, Consumptive Use, Irrigation Requirement of Principal Crops, Duty, Delta and Base Period and Interrelationships, Factors Affecting the Duty, Cropping Patterns, Irrigation Efficiencies.

References:

Sl. No.	Name of Book	Author
1	Irrigation system design - an engineering approach	Cuenca, R.H.
2	Sprinkle and Trickle Irrigation.	Keller, J.
3	Irrigation: Theory and Practice	Michael. A.M
4	Land and Water Management Engineering	V.V.N. Murthy
5	Irrigation Engineering	N NBasak
6	Crop Water Requirement Evapotranspiration Estimation	Mehta Rashmi

Course outcome:

1. Students will be able to apply different concepts of principles of irrigation.
2. Students will be able to develop an idea of performance indicators of irrigation systems.
3. Students will familiarize with different allocation and scheduling mechanisms.
4. Students will be able to generate designs and analyses the performance of irrigation systems.
5. Students will be able to analyze the designs of land grading, field layout and drainage engineering.
6. Students will be able to optimize and suggest the best variations for maximization of crop water requirement.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE61E08.1	Students will be able to apply different concepts of principles of irrigation
PCE61E08.2	Students will be able to develop an idea of performance indicators of irrigation systems.

PCE61E08.3	Students will familiarize with different allocation and scheduling mechanisms
PCE61E08.4	Students will be able to generate designs and analyses the performance of irrigation systems.
PCE61E08.5	Students will be able to analyze the risk and reliability of the designs of land grading, field layout and drainage engineering.
PCE61E08.6	Students will be able to optimize and suggest the best variations for maximization of crop water production and minimization of cost from the system

Table-2: Correlation between COs & POs

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE61E08.1	23	2	3	3	3	3
PCE61E08.2	3	3	3	3	3	3
PCE61E08.3	3	2	3	3	3	3
PCE61E08.4	3	3	3	3	3	1
PCE61E08.5	3	2	3	3	3	3
PCE61E08.6	3	3	3	3	3	3
Total	18	15	18	18	18	16
Average	3	2.5	3	3	3	2.7
Equivalent Average Attainment	3	3	3	3	3	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE61E08.1	2	2
PCE61E08.2	3	3
PCE61E08.3	3	3
PCE61E08.4	3	3
PCE61E08.5	3	3
PCE61E08.6	3	3
Total	17	17
Average	2.83	2.83
Equivalent Average Attainment	3	3

OPTIMIZATION TECHNIQUE
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To obtain fundamental understanding and application of estimation theory and basic statistics.
2. To be able to interpret the hypothesis testing and its related tests for identification of relationship.
3. To obtain an understanding about different types of correlation coefficient.
4. To demonstrate the ability to apply design of experiment in model formulation.
5. To apply and perform multivariate analysis.
6. To understand the concept of optimization and to learn about different optimization techniques.

Course Content:

Unit- 1

OPERATION RESEARCH
Introduction, Concept of OR, Decision Theory, Estimators: Unbiasedness, Consistency, Efficiency and Sufficiency, Maximum Likelihood Estimation, Method of moments, Outlier Detection, Model Development Steps.

Unit-2

STATISTICAL TESTS
Null Hypothesis, Tests based on Normal, t and F distributions for testing of means, variance and proportions, Analysis of r x c tables, Goodness of fit, X-bar, R-Chart, P-Chart, Chi-Square Test.

Unit-3

CORRELATION AND REGRESSION
Auto-Correlation, Cross Correlation, Auto-Regression and Cross Regression Models, Standard Error, Stochastic Error, Moving Average, Pearson Correlation, Covariance.

Unit-4

DESIGN OF EXPERIMENTS
Analysis of variance, One-way and two-way classifications, Completely randomized design, Randomized block design, Latin square design.

Unit-5

RELAIBILITY AND RISK ANALYSIS
Reliability analysis methods, Risk Engineering, Random vectors and Matrices, Mean vectors and Covariance matrices, Multivariate Normal density and its properties, Principal components, Components from standardized variables.

Unit- 6

OPTIMIZATION TECHNIQUES
Introduction to Optimization Technique, Region of Feasibility, Difference between Simulation, Prediction and Optimization, Classification of Optimization Techniques, Linear Programming, Dynamic Programming, Differential Evolution Techniques, Introduction to nature-based optimization techniques, meta-heuristic and heuristic techniques, Particle Swarm Optimization, Ant Colony Optimization, Fire Fly Algorithm,

References:

1. Handbook of Engineering Statistics. Hoang Pham.
2. Engineering Optimization: Theory and Practice, Singiresu S. Rao.
3. A First Course in Optimization Theory, Rangarajan K. Sundaram.
4. Modeling Hydrologic Change: Statistical Methods**,** Richard H. McCuen.
5. Statistics for Engineers: An Introduction**,** Jim Morrison.
6. Introduction to Operations Research, Frederick S. Hillier, Gerald J. Lieberman, Bodhibrata Nag, Preetam Basu.

Course Outcome:

1. Students will be able to apply different concepts of operational research, estimators and detect outliers.
2. Students will be able to develop an idea and know the procedure of developing statistical tests and hypothesis.
3. Students will be able to apply correlations and regression coefficients for initial analysis of model development and feasibility.
4. Students will be able to generate designs for experimental analysis followed by model development and testing.
5. Students will be able to analyze the risk and reliability of a project.
6. Students will be able to optimize and suggest the best variations for maximization of profit and minimization of cost from a system.

Table-1: To establish the correlation between COs & POs

No. of course outcome(CO)	Course Outcome
PCE61E01.1	Students will be able to apply different concepts of operational research, estimators and detect outliers
PCE61E01.2	Students will be able to develop an idea and know the procedure of developing statistical tests and hypothesis.
PCE61E01.3	Students will be able to apply correlations and regression coefficients for initial analysis of model development and feasibility.
PCE61E01.4	Students will be able to generate designs for experimental analysis followed by model development and testing.
PCE61E01.5	Students will be able to analyze the risk and reliability of a project.

PCE61E01.6	Students will be able to optimize and suggest the best variations for maximization of profit and minimization of cost from a system

Table-2: Correlation between COs &POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATIO

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21E02.1	3	2	3	3	3	3
PCE21E02.2	3	3	3	3	3	3
PCE21E02.3	3	2	3	3	3	3
PCE21E02.4	3	3	3	3	3	1
PCE21E02.5	3	3	3	3	3	3
PCE21E02.6	3	3	3	3	3	3
Total	18	16	18	18	18	16
Average	3	2.66	3	3	3	2.7
Equivalent Average Attainment	3	3	3	3	3	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE21E02.1	2	2
PCE21E02.2	3	3
PCE21E02.3	3	3
PCE21E02.4	3	3
PCE21E02.5	3	3
PCE21E02.6	3	3
Total	18	18
Average	3	3
Equivalent Average Attainment	3	3

SMART-INSTRUMENTATION IN WATER RESOURCES APPLICATIONS

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To make the students review the instruments used for measurement of basic process parameters like level, flow, pressure and temperature.
2. To explore the various types of analyzers used in industrial applications.
3. To make the students to understand the requirement of safety instrumented system, standards and risk analysis techniques
4. To make students familiarize with Instrumentation standards such as BS1042, ISA 75, ISA 84 and ISA 88.
5. To make students familiarize with Instrumentation Symbols, Abbreviations and Identification for Instruments, Process Flow diagrams, Instrument Loop diagrams, Instrument Hookup diagrams and Piping and Instrumentation Diagrams.

Course Content:

Unit- 1
Instrumentation: Frequency meter, measurement of time and frequency (mains), tachometer, phase meter, capacitance meter, Automation in digital instrumentation.

Unit -2
Analyzer
Wave analyzers and Harmonic distortion, Basic wave analyzer, Frequency selective wave analyzer, Harmonic distortion analyzer and Spectrum analyzer.

Unit -3
Measuring Instruments
Output power meters, Field strength meter Vector impedance meter, Q meter applications-Z, Z 0 and Q. Basic LCR bridge, RX meters.

Unit -4
Recorders
Strip chart recorder- applications of Strip chart recorder, Magnetic recorders, Frequency modulation (FM) recording, Digital data recording, Digital memory waveform recorder.

Unit – 5
Transducers
Synchro's, Capacitance Transducers, Load cells, Piezo electrical Transducers, IC type temperature sensors, Pyrometers, Ultrasonic temperature Transducer, Reluctance pulse pick-ups, Flow measurement-mechanical Transducers; Magnetic flow meters, turbine flow meters. β-gaug.

Unit – 6
Data acquisition and conversion
Generalized data acquisition system (DAS), Signal conditioning of inputs, single channel DAS, multichannel DAS, data loggers, compact data logger.

Unit – 7

Measurement of power

Measurement of large amount of RF power (calorimetric method), measurement of power on a transmission line, standing wave ratio measurements, measurement of standing wave ratio using directional couplers.

Unit – 8

Data transmission

Serial, asynchronous interfacing, data line monitors, RS-232 standard, universal serial bus,IEEE1394,Long distance data transmission(modems).IEEE 488 bus, Electrical interface.

References:

Sl. No.	Name of Book	Author
1	Plant Hazard analysis and Safety Instrumentation systems	SwapanBasu
2	Industrial Instrumentation	Al.Sutko,Jerry.D.Faulk
3	Advances in Instrumentation	WIEDEMANN
4	Modern Electronic Instrumentation and Measurement Techniques	Helfrick
5	Measurement Techniques in Industrial Instrumentation	S K Sen
6	Geoscience: Instrumentation and Analytical Techniques	Joe Carry
7	Fundamentals of Bioanalytical Techniques and Instrumentation	Ghoshal and Sabari

Course Outcome:

1. Students will be able to explain theoretical principles of, MASS and NMR spectroscopy.
2. Students will be able to learn basic instrumentation of NMR and mass spectrometer.
3. Students will be able to theoretical principles of x-rays, instrumentation and identification of organic compounds.
4. Students will be able to learn basic principles and instrumentation of thermal analysis.
5. Students will be able to describe general principles and procedures involved in extraction techniques.
6. Students will be able to learn basic instrumentation and applications of hyphenated techniques.
7. Students will be able to explain general principal and instrumentation of radioimmuno assay.

Table-1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE62E01.1	Students will be able to understand the concept of soil as a multiphase system
PCE62E01.2	Students will be able to understand the concept of soil- environment interaction
PCE62E01.3	Students will be able to understand the concept of soil mineralogy
PCE62E01.4	Students will be able to understand the concept of soil-water-contaminant interaction.
PCE62E01.5	Students will be able to understand the concept of unsaturated soil mechanics
PCE62E01.6	Students will be able to understand the concept of waste containment facilities
PCE62E01.7	Students will be able to understand the concept of advanced soil characterization techniques

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62E01.1	3	2	3	2	2	2
PCE62E01.2	3	2	3	2	2	2
PCE62E01.3	3	2	3	2	2	2
PCE62E01.4	3	2	3	2	2	2
PCE62E01.5	3	2	3	2	2	2
PCE62E01.6	3	2	3	2	2	2
PCE62E01.7	3	3	3	2	2	2
Total	21	15	21	14	14	14
Average	3	2.14	3	2	2	2
Equivalent Avg. Attainment	3	2	3	2	2	2

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62E01.1	2	2
PCE62E01.2	3	3
PCE62E01.3	3	3
PCE62E01.4	3	3
PCE62E01.5	2	2
PCE62E01.6	2	3
PCE62E01.7	3	3
Total	18	19

Average	2.57	2.71
Equivalent Avg. Attainment	3	3

IMAGE PROCESSING

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To introduce the students to the fundamental techniques and algorithms used for acquiring, processing and extracting useful information from digital images.

2. The students will learn how to apply the methods to solve real-world problems in several areas including medical, remote sensing and surveillance and develop the insight necessary to use the tools of digital image processing (DIP) to solve any new problem.

Course Content:

Unit- 1
Introduction and Digital Image Fundamentals: The origins of Digital Image Processing, Examples of Fields that Use Digital Image Processing, Fundamentals Steps in Image Processing, Elements of Digital Image Processing Systems, Image Sampling and Quantization, Relationships between pixels.

Unit -2
Image Enhancement in the Spatial Domain: Some basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic and Logic operations, Combining Spatial Enhancement Methods, Basics of Spatial Filters, Smoothening and Sharpening Spatial Filters.

Unit -3
Image Enhancement in the Frequency Domain: Introduction to Fourier Transform and the frequency Domain, Computing and Visualizing the 2D DFT (MATLAB), Smoothing Frequency Domain Filters, Sharpening Frequency Domain Filters, Homomorphic Filtering.

Unit -4
Image Restoration: A model of The Image Degradation / Restoration Process, Noise Models, Restoration in the presence of Noise Only Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear Position-Invariant Degradations, Estimation of Degradation Function, Inverse filtering, Wiener filtering, Geometric Mean Filter, Geometric Transformations.

Unit – 5
Image Compression: Fundamentals, image compression models, error free compression, Compression standards, Inter-pixel and Psycho-visual Redundancy.

Unit – 6
Image Segmentation: Detection of Discontinuities, Edge linking and boundary detection, Thresholding, Region- based segmentation.

Unit – 7

Morphological Image Processing: Dilation and Erosion, Opening and Closing, Some basic morphological algorithms, Extensions to gray level images.

Unit – 8

Object Recognition: Patterns and Pattern Classes, Decision-Theoretic Methods, Structural Methods.

References

Sl. No.	Name of Book	Author
1	Fundamentals of Digital Image Processing	Anil.K.Jain
2	Image Processing, The Fundamentals	M. Petrou, P. Bosdogiann
3	Digital Image Processing	P.Ramesh Babu
4	Practical Handbook on Image Processing for Scientific Application	B. Jähn
5	The Image Processing Handbook	J. C. Russ
6	Digital image processing	W. K. Pratt
7	Image processing, analysis and machine vision	Milan sonka, Roger Boyle
8	Introduction to digital Image processing with MATLAB	Alasdair McAndrew
9	Computer vision and Image processing	Adrian Low

Course Outcome:

1. Students will be able to understand the need for image transforms different types of image transforms and their properties.
2. Students will be able to develop any image processing application.
3. Students will be able to understand the rapid advances in Machine vision.
4. Students will be able to learn different techniques employed for the enhancement of images.
5. Students will be able to learn different causes for image degradation and overview of image restoration techniques.
6. Students will be able to learn different feature extraction techniques for image analysis and recognition.
7. Students will be able to understand need for image compression and to learn the spatial and frequency domain techniques of image compression.

Table-1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE62E03.1	Students will be able to understand the need for image transforms different types of image transforms and their properties
PCE62E03.2	Students will be able to develop any image processing application.

PCE62E03.3	Students will be able to understand the rapid advances in Machine vision.
PCE62E03.4	Students will be able to learn different techniques employed for the enhancement of images.
PCE62E03.5	Students will be able to learn different causes for image degradation and overview of image restoration techniques.
PCE62E03.6	Students will be able to learn different feature extraction techniques for image analysis and recognition.
PCE62E03.7	Students will be able to understand need for image compression and to learn the spatial and frequency domain techniques of image compression.

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62E03.1	3	2	2	2	3	3
PCE62E03.2	3	2	2	2	3	3
PCE62E03.3	3	2	2	2	3	3
PCE62E03.4	3	2	2	2	3	3
PCE62E03.5	3	2	2	2	3	3
PCE62E03.6	3	2	2	2	3	3
PCE62E03.7	3	2	2	2	3	3
Total	27	14	14	14	21	21
Average	3.42	2	2	2	3	3
Equivalent Avg. Attainment	3	2	2	2	3	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62E03.1	3	2
PCE62E03.2	3	2
PCE62E03.3	3	2
PCE62E03.4	3	2
PCE62E03.5	3	2
PCE62E03.6	3	2
PCE62E03.7	3	2
Total	27	14
Average	3.42	2
Equivalent Avg. Attainment	3	2

HYDRAULIC STRUCTURE ENGINEERING
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses objective:

1. To understand the state of art concerning Hydraulic structure engineering.
2. To understand about the Dams and barrages and the necessity in real life.
3. To understand the Design of various hydraulic structure.
4. To understand the knowledge about water power generation techniques.
5. To understand about the Hydraulic loading on structures.

Course content:

Unit- 1

Overview- Dams in general – types and selection, Theories of seepage, Wave theory

Unit -2

Dams and barrages- Design of weirs and barrages, designing of reservoir capacity with capacity elevation & area elevation curves of a reservoir site.

Unit -3

Design & construction- Force acting on gravity dams, failure mode of gravity dams and Design of gravity dam

Unit – 4

Water Conveying Channels and Structures- Penstocks, Water Hammer and Surge Tanks, Gates in Hydraulic, Installations, Spillways, River Training and Control Works.
Waves- Wind generated waves, shallow and deep water waves, storm surges, harbour resonance.

Unit – 5

Water Power Generation- Hydroelectric generation, Tidal power – principle, components, ebb-cycle, tide-cycle, estimate of energy & power.

Unit – 6

Hydraulic loading on structures – static and dynamic effects, codes of practice, design and construction of offshore structures.

References:

Sl. No.	Name of Book	Author
1	Hydraulics in Civil and Environmental Engineering	Andrew Chadwick, John Morfett and Martin Borthwick
2	Engineers for Dams	Creezer, Justin and Hinds (Vol.I, II, III)
3	Designing of Dam Percolation and Erosion	S. Leliavsky
4	Concrete Dams	R.S. Varshaney

5	Hydraulic Structure Vol. I & II	M. M. Grishin
6	Water Power Engineering	Dandekar & Sharma

Course outcome:

1. Students will be able to identify the types and selection of dams and barrages.
2. Students will be able to do the design of weirs and barrages.
3. Students will be able to do the designing of reservoir capacity with capacity elevation & area elevation curves of a reservoir site.
4. Students will be able to design and construction of the gravity dam.
5. Students will be able to analyze the possible causes of failure of different Hydraulic Structure.
6. Students will be able to describe the water conveying channels and structures.
7. Students will be able to analyze the water power generation.
8. Students will be able to describe the hydraulic loading on structures.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE62E09.1	Students will be able to identify the types and selection of dams and barrages.
PCE62E09.2	Students will be able to do the design of weirs and barrages.
PCE62E09.3	Students will be able to do the designing of reservoir capacity with capacity elevation & area elevation curves of a reservoir site.
PCE62E09.4	Students will be able to design and construction of the gravity dam.
PCE62E09.5	Students will be able to analyze the possible causes of failure of different Hydraulic Structure.
PCE62E09.6	Students will be able to describe the water conveying channels and structures.
PCE62E09.7	Students will be able to analyze the water power generation.
PCE62E09.8	Students will be able to describe the hydraulic loading on structures.

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62E09.1	3	2	2	3	3	3
PCE62E09.2	3	3	3	3	3	3
PCE62E09.3	3	2	3	3	3	3
PCE62E09.4	3	3	3	3	3	1
PCE62E09.5	3	2	2	3	3	3
PCE62E09.6	3	2	3	3	3	3
PCE62E09.7	3	2	3	3	3	1

PCE62E09.8	3	2	3	3	3	1
Total	24	18	22	24	24	18
Average	3	2.25	2.75	3	3	2.25
Equivalent Average Attainment	3	2	3	3	3	2

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62E09.1	3	2
PCE62E09.2	3	3
PCE62E09.3	3	3
PCE62E09.4	3	3
PCE62E09.5	3	3
PCE62E09.6	3	3
PCE62E09.7	3	3
PCE62E09.8	3	3
Total	24	23
Average	3	2.87
Equivalent Average Attainment	3	3

RIVER ENGINEERING
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To impart the knowledge of river engineering.
2. To comprehend theoretical concepts of water and sediment movements in rivers.
3. To indoctrinate the benefits of fluvial system to the society.

Course content:

Unit- 1

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

Unit -2

Open Channel Flow
Open Channel Flow and Manning Equation, Energy, Specific Energy, and Gradually Varied Flow, Rapidly Varied Flow, Momentum (Hydraulic Jump), Computation: Direct Step Method and Channel Transitions, Application of HEC-RAS, Design of Stable Channels.

Unit -3

Water Surface Profiles
Normal and Critical Depth, Classification of Water Surface Profiles, Classification based on slope, Classification according to the relative position of the actual flow depth, Classification based on Flow Profile, Super and Sub-Critical Flow.

Unit -4

Sediment Transport
Introduction, Competence, capacity and sediment supply, Modes of Sediment Transport, Vertical Profiles of Suspended Sediments, Sediment Concentration Profile, Sediment Diffusivity, Suspended Sediment Concentration Profiles, Power-law (linear diffusivity), Power-law (parabolic diffusivity), Settling Velocity, Reference Concentration and Height, Suspended Load Transport. Shields Entrainment Function, Total Load Transport.

Unit –5

River Surveys and Modelling
Mapping, Stage and Discharge Measurements, Water Quality and ecological model, Recursive Equation, KKT Condition, LaGrange Multiplier, Floyd Warsaw.

Unit – 6
GIS Application in River Basin Modelling and Management
Location Selection Studies, Decision Support Systems, GIS Data Models, Projections and Coordinate Systems, Data Sources and Data Entry, Digitizing, GPS, Remote Sensing, Attribute Data: Queries and Analysis; Spatial Data: Spatial Queries and Basic Spatial Analysis.

References:

Sl. No.	Name of Book	Author
1	River Engineering	KD.Gupta
2	Flow in Open Channels	K Subramanya
3	Flow through Open Channels	K.G. Ranga Raju
4	Hydraulics in Civil and Environmental Engineering	Andrew Chadwick, John Morfett, Martin Borthwick
5	Water Flow: Effects Of Stream Erosion: Stream Channel River	Danille Nattress
6	Hydraulics of Sediment Transport	Walter Hans Graf
7	Sediment Transport: Monitoring, Modeling and Management	Abdul A. Khan and Weiming Wu
8	Breaking the HEC-RAS Code: A User's Guide to Automating HEC-RAS	Christopher R Goodell
9	Linear Programming: For Beginners	Buhari Adejare
10	GIS and Geocomputation for Water Resource Science and Engineering	Barnali Dixon, Venkatesh Uddameri

Course outcome:

1. Student will be able to inculcate the knowledge of river functions.
2. Students will be able to describe about the Open Channel Flow and its application with the help of HEC RAS software
3. Students will be able to classify water surface profiles based on slope and flow depth.
4. Student will have the concept of sediment transport and how it affect on river basin erosion
5. Students will be able to develop model based on the collected data and different linear programming technique..
6. Students will be able to demonstrate the knowledge of GIS and Remote Sensing on different river basin management and fluid dynamic problems.

Table-1 : To establish the correlation between COs & POs

No of Course Outcome (CO)	Course Outcome
PCE62E07.1	Student will be able to inculcate the knowledge of river functions.
PCE62E07.2	Students will be able to describe about the Open Channel Flow and its application with the help of HEC RAS software.
PCE62E07.3	Students will be able to classify water surface profiles based on slope and flow depth
PCE62E07.4	Student will have the concept of sediment transport and how it affect on river basin erosion
PCE62E07.5	Students will be able to develop model based on the collected data and different linear programming technique.

PCE62E07.6	Students will be able to demonstrate the knowledge of GIS and Remote Sensing on different river basin management and fluid dynamic problems.

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62E07.1	3	2	3	2	2	3
PCE62E07.2	3	3	3	2	2	3
PCE62E07.3	3	2	3	2	2	3
PCE62E07.4	3	2	3	2	2	3
PCE62E07.5	3	3	3	2	2	3
PCE62E07.6	3	3	3	2	2	3
Total	18	15	18	12	12	18
Average	3	2.5	3	2	2	3
Equivalent Average Attainment	3	3	3	2	2	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62E07.1	2	2
PCE62E07.2	3	3
PCE62E07.3	3	3
PCE62E07.4	3	3
PCE62E07.5	3	3
PCE62E07.6	3	3
Total	17	17
Average	2.83	2.83
Equivalent Average Attainment	3	3

SMART MONITORING AND MANAGEMENT OF PIPE NETWORK
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To understand technology in transportation of fluids.
2. To know various equipment and their operation in pipeline transportation.
3. To understand standards and practices in piping design.
4. Have a basic understanding of water, process and power piping systems.

Course content:

Unit- 1
Introduction and Elements of pipeline design: Purpose of piping, Types of piping systems; transmission lines, In-plant piping systems, Distribution mains, Service lines. Types of Water distribution networks; serial networks, branched networks and looped networks. Network components and Network model. Basic hydraulic principles; continuity and Energy principle.

Unit -2
Frictional Head loss in Pipes: Major and Minor losses, Artificially roughened pipes, moody diagram. Friction coefficient relationships, Empirical formulae, Simple pipe flow: problems, Equivalent pipes, pipes in series, parallel, series-parallel: problems. Water Hammer and energy transmission through pipes: gradual and Instantaneous closure.
Unit -3
Reservoirs, Pumps and Valves:
Types of Reservoirs, Pumps: introduction, system head-discharge, pump head and head-discharge relationships, characteristic curves, pump combination. Valves: check valves, flow control valves, Pressure reducing valves, both Flow control and Pressure Reducing Valves.

Unit -4
Network Parameters and Types of analysis:
Network Parameters, Parameter Interrelationships, Necessity of Analysis, Common Assumptions, Types of Analysis, Rule for Solvability of Pipe networks.
Network Formulation of Equations:
States of parameters, Single-Source Networks with known pipe Resistances, Multisource Networks with known pipes resistances, Networks with unknown pipe resistances, Inclusion of Pumps, Check Valves, Flow Control Valves and Pressure Reducing Valves – Problems.

Unit – 5
Network analysis:
Hardy Cross Method, Methods of balancing heads (Loop Method), Method of Balancing Flows (Node Method), Modified Hardy Cross Method, Convergence Problem, Different software for WDN analysis and design.

Unit - 6
Basics of Pipe Stress Analysis:

Objective of Stress Analysis, Stresses in Piping systems, Sustained, Expansion and Occasional Piping stresses, Reducing piping stresses, Basic allowable stress, Loads on piping systems, work flow diagram for piping stress analysis, Stress criticality and analysis methods.

Unit- 7

Piping Vibration: Causes, Limits & Remedies:

Calculate the natural frequency of a pipe, VIV (Vortex Induced Vibration) affecting the pipe, effect of flow induced vibration as flow rates change, Determine the severity of the vibration: Is it acceptable or does it need modifications?

Unit – 8

Materials selection and quality management: Materials designation standards, Quality management.Pipeline construction: Construction – Commissioning.

Pipeline protection, Instrumentation, pigging & Operations:

Pipeline coating, Cathodic protection, Cathodic protection calculations for land pipelines, Internal corrosion, Flow meters and their calibration, Sensors, Pigs-Pipeline Operations and maintenance.

References:

Sr. No.	Name of Book	Author
1	Analysis of Water Distribution Networks	P.R. Bhave and R. Gupta
2	Pipeline Engineering	Henry Liu
3	Piping and Pipeline Engineering: Design, Construction, Maintenance Integrity and Repair	George A. Antaki,
4	Piping Calculation Manual	E. Shashi Menon
5	Pipeline Rules of Thumb Handbook	E. W. McAllister
6	Liquid Pipeline Hydraulics	E. Shashi Menon
7	Piping Vibration: Causes, Limits & Remedies	RON FREND
8	Basics of Pipe Stress Analysis	Anup Kumar Dey

Course outcome:

1. Students will be able to understand purpose of piping and its use, along with the classification of design consideration involved.
2. Students will be able to understand different types of valves, tanks, pumps, pressure vessels and calculations involved.
3. Students will be able to understand pipe networks work in series, parallel, and branching and will be able to calculate flow-rate, frictional and head losses.
4. Students will be able to review the Hardy Cross Method and know pipe size criteria.
5. Students will have the understanding of basic stress analysis in piping network system.
6. Students will be able to understand pipe vibrations concepts and the calculations involved in it.
7. Students will have the knowledge of pipeline material selection, its construction and protecting techniques.
8. Students will be able to understand the pipe network parameters and various types of network analysis.

Table-1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE62E04.1	Student will learn the basic concepts of the design and management of ground water hydraulics.
PCE62E04.2	Students will be able to apply the knowledge of different ground water exploration techniques.
PCE62E04.3	Students will be familiar with the concept and practice of groundwater management.
PCE62E04.4	Students will be able to describe the cause and mitigation measure to prevent and model ground water pollution
PCE62E04.5	Students will be acquainted with the different mechanism of vulnerability assessment of ground water.
PCE62E04.6	Students will be able to design and manage drainage network in connection to ground water

Table-2: Co-relation between COs and Pos
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62E04.1	3	2	3	2	2	3
PCE62E04.2	3	2	3	2	2	3
PCE62E04.3	3	2	3	2	2	3
PCE62E04.4	3	2	3	2	2	3
PCE62E04.5	3	2	3	2	2	3
PCE62E04.6	3	2	3	2	2	3
Total	18	12	18	12	12	18
Average	3	2	3	2	2	3
Equivalent Average Attainment	3	2	3	2	2	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62E04.1	2	2
PCE62E04.2	3	3
PCE62E04.3	3	3
PCE62E04.4	3	3
PCE62E04.5	3	3
PCE62E04.6	3	3
Total	17	17
Average	2.83	2.83
Equivalent Average Attainment	3	3

FREE SURFACE FLOW

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To understand the basic areas of open channel flow.
2. To understand phenomenon and types of flowing water in a natural and artificial structure.
3. To understand the Concepts of boundary layer.
4. To understand the knowledge about flow over small hydraulic structure.
5. To understand about the wave propagation.

Course content:

Unit- 1
Overview- Types of channel, classification of flow, velocity distribution, Flow analysis, Pressure Distribution**,** Energy Equation. Momentum Equation, Equation of Continuity.

Unit -2
Energy and momentum in free surface flow-Critical Flow, Uniform Flow, Design of Non-Erodible, Erodible Channels & Grassed Channels.

Unit – 3
Concepts of boundary layer- surface roughness, velocity distribution & instability of uniform flow, gradually varied flow, spatially varied flow, rapidly varied flow.

Unit – 4
Flow over spillways- Supercritical Flows and Oblique Flows, Hydraulic Jump, Gradually Varied & Rapidly Varied Unsteady Flow.

Unit – 5
Wave propagation- Wave propagation and surge in canals, discharge measuring methods, free surface flow in closed conduits.

References:

Sl. No.	Name of Book	Author
1	Open-Channel Hydraulics	Ven Te Chow
2	Hand Book of Applied Hydraulics	Calvin Victor Davis and Kenneth E. Sorensen
3	Open-Channel Flow	M. Hanif Choudhury
4	Engineering Hydraulics	Hunter Rouse
5	Open-Channel Flow	K.Subhramanya

Course outcome:

1. Students will be able to identify the types of channel and velocity distribution in the natural or man-made structure.
2. Students will be able to describe the energy and momentum in free surface flow.
3. Students will be able to do describe the concepts of boundary layer in open channel flow.
4. Students will be able to analyze and describe the flow over spillways.
5. Students will be able to analyze the Wave propagation in open channel flow.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE61C03.1	Students will be able to identify the types of channel and velocity distribution in the natural or man-made structure
PCE61C03.2	Students will be able to describe the energy and momentum in free surface flow.
PCE61C03.3	Students will be able to do describe the concepts of boundary layer in open channel flow.
PCE61C03.4	Students will be able to analyze and describe the flow over spillways.
PCE61C03.5	Students will be able to analyze the Wave propagation in open channel flow.

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE62E04.1	3	2	3	3	3	3
PCE62E04.2	3	2	3	3	3	3
PCE62E04.3	3	2	3	3	3	3
PCE62E04.4	3	2	3	3	3	1
PCE62E04.5	3	2	3	3	3	3
Total	15	10	15	15	15	13
Average	3	2	3	3	3	2.6
Equivalent Average Attainment	3	2	3	3	3	3

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE62E04.1	2	2
PCE62E04.2	3	3
PCE62E04.3	3	3
PCE62E04.4	3	3
PCE62E04.5	3	3
Total	14	14
Average	2.8	2.8
Equivalent Average Attainment	3	3

COMPUTATIONAL FLUID DYNAMICS
Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To provide the student with a significant level of experience in the use of modern CFD software for the analysis of complex fluid-flow systems.
2. To improve the student's understanding of the basic principles of fluid mechanics.
3. To improve the student's research and communication skills using a self-directed, detailed study of a complex fluid-flow problem and to communicate the results in written form

Course Content:

Unit- 1
Introduction to Computational Fluid Dynamics (CFD)
Introduction and application of CFD, Taylor Series Expansion, Discretization, Forward Difference, Backward Difference, Central Difference, Conservation of Mass and Momentum, Navier Stokes Equation,Condition of Convergence & Stability.

Unit-2
Finite Difference Equations
Introduction. Solving Ordinary Differential Equation by Finite Difference Equation, Procedure, Exact Solution, Error Calculation.

Unit -3
Partial Differential Equation (PDE)
Overview. Classification. Parabolic, Hyperbolic and Elliptic Equation, Classification Procedure, Wave Equation, Heat Transfer Equation, Laplace Equation.

Unit -4
Discretization of PDE
Basic features. Discretization of Parabolic, Elliptic and Hyperbolic Equations, Direct Method, Explicit Method, Gauss Seidel Method, Lieberman Method. Numerical Algorithms for Solving PDEs, Calculation of Errors.

Unit -5
Numerically Solving PDE: Crank Nicolson Algorithm Boundary conditions, Interpretation, Simplified Solution: Rectangular Formula, Heat Equation.

Unit –6
Numerically Solving PDE: Richardson Extrapolation Initial and Boundary Condition, Significance of Error, True Value, Approximate Value,Differentiation by Richardson Extrapolation.

References:

Sl. No.	Name of Book	Author
1	Dynamics of Fluids in Porous Media	Bear, J., Dover Publications.
2	Computational Fluid Dynamics: The Basics with Applications	Anderson, J.D.
3	Computational Fluid Mechanics and Heat Transfer	Anderson, D. A., J. C. Tannehill, and R. H. Pletcher
4	Computational Methods for Fluid Dynamics	Ferziger, J. H. and M. Peric,
5	Computational Techniques for Fluid Dynamics	Fletcher, C. A. J.

Course Outcome:

1. Student will learn the introductory concepts of Computational Fluid Dynamics and learn about the essential definitions and laws of fluid dynamics.
2. Students will be enlightened about the working principle for solving Ordinary Differential Equation with the help of Finite Difference Method.
3. Students will be able to classify different PDEs into Parabolic, Elliptic and Hyperbolic Equations.
4. Student will demonstrate an ability to solve PDEs with the help of discretization and different methods of solving the major PDEs.
5. Students will be able to understand the concept of numerically solving PDEs with the help of Crank Nicolson Method.
6. Students will be able to apply the knowledge of Richardson Extrapolation Method to solve various PDEs numerically and can calculate the Approximate Value of the solutions.

Table-1: To establish the correlation between COs & POs

No of course outcome (CO)	Course Outcome
PCE61E05.1	Student will learn the introductory concepts of Computational Fluid Dynamics and learn about the essential definitions and laws of fluid dynamics.
PCE61E05.2	Students will be enlightened about the working principle for solving Ordinary Differential Equation with the help of Finite Difference Method
PCE61E05.3	Students will be able to classify different PDEs into Parabolic, Elliptic and Hyperbolic Equations.
PCE61E05.4	Student will demonstrate an ability to solve PDEs with the help of discretization and different methods of solving the major PDEs
PCE61E05.5	Students will be able to understand the concept of numerically solving PDEs with the help of Crank Nicolson Method
PCE61E05.6	Students will be able to apply the knowledge of Richardson Extrapolation Method to solve various PDEs numerically and can calculate the Approximate Value of the solutions..

Table-2: Correlation between COs & POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21E05.1	3	2	3	2	2	2
PCE21E05.2	3	3	3	2	3	2
PCE21E05.3	3	2	3	2	3	2
PCE21E05.4	3	3	3	2	2	2
PCE21E05.5	3	2	3	2	2	2
PCE21E05.6	3	3	3	2	2	2
Total	18	15	18	12	14	12
Average	3	2.5	3	2	2.33	2
Equivalent Average Attainment	3	3	3	2	2	2

Table-3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE21E05.1	3	2
PCE21E05.2	3	2
PCE21E05.3	3	2
PCE21E05.4	3	3
PCE21E05.5	3	3
PCE21E05.6	3	3
Total	18	15
Average	3	2.5
Equivalent Average Attainment	3	3

Third Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	Third Semester			
1	**PCE23P01**: Project & Thesis - I	**10**	**-----**	**100**

Project & Thesis (PCE63P01)
Total Credit: 10
Contact Periods: Full Time

Each student will devote full time in the Third Semester on a Thesis/Project on an assigned research problem of Design/Development work under the supervision of a Faculty Member. They will present a part of the Thesis/Project Report at the end of the Third Semester which will be evaluated by a Board of Examiners consisting of the Supervisor and External Examiner. The evaluation of the above said Thesis will be followed by a viva-voce in front of faculty members and other post-graduate students.

Fourth Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	Fourth Semester			
1	**PCE23P02**: Project & Thesis - II	**20**	**-----**	**300**

Project & Thesis (PCE64P01)
Total Credit: 10
Contact Periods: Full Time

Each student will devote full time in the Fourth Semester on a Thesis/Project on an assigned research problem of Design/Development work under the supervision of a Faculty Member. They will present a Final Thesis/Project Report at the end of the Fourth Semester which will be evaluated by a Board of Examiners consisting of the Supervisor and External Examiner. The evaluation of the above said Thesis will be followed by a viva-voce in front of faculty members and other post-graduate students.