DETAILED

COURSE CURRICULUM

FOR

POSTGRADUATE PROGRAMME

(M.TECH.)

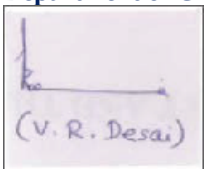
IN

CIVIL ENGINEERING

Specialization in

WATER RESOURCES ENGINEERING

Approved by Prof. V .R .Desai
Department of Civil Eng., IIT Kharagpur



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 programs 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 programs are designed considering the following three Program outcomes (POs) as formulated by National Board of Accreditation (NBA)

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

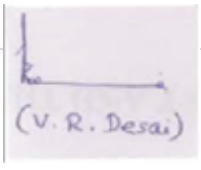
PO2: An ability to write and present a substantial technical report/document.

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

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

In the Final year of M.Tech. program (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 National Association of Software and Service Companies (NASSCOM), Federation of Indian Chamber of Commerce and Industries (FICCI) and other such industry bodies.
b. The selected industry needs is approved by the Departmental Postgraduate Program Co--mmittee (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.



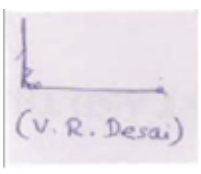
CONTENT

(V. R. Desai)

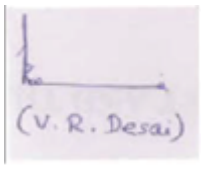
POSTGRADUATE PROGRAMME

M.Tech. (Water Resources Engineering)

FIRST SEMESTER		No. of Classes/Week			Total Credits	Total Marks
Sl. No.	**Subject**	**Lecture**	**Tutorial**	**Practical**		
1	**Basic Core** PCE51CB01: Free surface Flow	03	01	00	4	100
2	**Core Subject-I** PCE51C01: Applied Hydrology	03	01	00	4	100
3	**Core Subject-II** PCE51C02: Advanced Mathematics	03	01	00	4	100
4	**Elective Paper-I (Any one)** PCE51E01: Advanced Fluid Mechanics PCE51E02: River Engineering PCE51E03: Geo-Hydraulics	03	01	00	4	100
5	**Elective Paper-II (Any one)** PCE51E04: Hydropower Engineering PCE51E05: Water Resources systems, Analysis , Planning & Management PCE51E06: Geographical Information systems & its Applications	03	01	00	4	100
6	PCE51P01: Hydraulic and water resources Engg. lab - I	00	00	03	2	100
7	PCE51P02: Computer Applications in free surface flow and applied hydrology	00	00	03	2	100
8	PCE51P03: Seminar	00	00	02	1	100
Total		**15**	**05**	**08**	**25**	**800**



SECOND SEMESTER		No. of Classes/Week			Total Credits	Total Marks
Sl. No.	**Subject**	**Lecture**	**Tutorial**	**Practical**		
1	**Basic Core** PCE52CB01: Advanced Computational Hydraulics	03	01	00	4	100
2	**Core Subject-I** PCE52C01: Hydraulics of Sediment Transport	03	01	00	4	100
3	**Core Subject-II** PCE52C02: Hydraulic Structure	03	01	00	4	100
4	**Elective Paper-III (Any one)** PCE52E01: Viscous Fluid Flow PCE52E02: Transient Flow Analysis PCE52E03: Integrated Watershed Management	03	01	00	4	100
5	PCE52P01: Project Preliminaries	00	00	06	3	100
6	PCE52P02: Hydraulics and Water Resources Engg. Lab.-II	00	00	03	2	100
7	PCE52P03: Computer applications in Water Resources Engineering	00	00	03	2	100
8	PCE52P04: Comprehensive Viva-voce	00	00	00	2	100
	Total	**12**	**04**	**12**	**25**	**800**



THIRD SEMESTER		No. of Classes/Week			Total Credits
Sl. No.	**Subject**	**Lecture**	**Tutorial**	**Practical**	
1	PCE53P01: Project & Thesis - I	00	00	Full	10

FOURTH SEMESTER		No. of Classes/Week			Total Credits
Sl. No.	**Subject**	**Lecture**	**Tutorial**	**Practical**	
1	PCE54P04: Project & Thesis - II	00	00	Full	20

In the Final year of M.Tech, it is suggested to provide the students an option for industrial research. If any student wants to pursue his research in reputed industries he/she may be allowed to do so, provided:

e. The selected industry has to be a permanent member of National Association of Software and Service Companies (NASSCOM), Federation of Indian Chamber of Commerce and Industries (FICCI) and other such industry bodies.

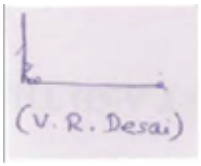
f. The selected industry needs to be approved by the Departmental Postgraduate Program Co--mmittee (DPPC) of the concerned Department.

g. The student has to select one supervisor from industry and another supervisor from the Institute.

h. He/ She will not receive any scholarship from the institute in this tenure, even if he/she wants to return back. In such cases student will be allowed to complete his/her project in the institute but without any scholarship.

Total Credits (First to Fourth): 80

Total Marks (First to Fourth): 2000



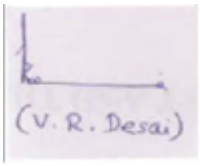
SYLLABUS FOR M.TECH. (Water Resource Engineering)

FIRST SEMESTER

Sl. No.	Subject Code	Name of the Subject	No. of Classes/Week			Credits	Marks
			L	T	P		
1	PCE51CB01	Free surface Flow	3	1	0	4	100
2	PCE51C01	Applied Hydrology	3	1	0	4	100
3	PCE51C02	Advanced Mathematics	3	1	0	4	100
4	PCE51E01-03	Elective Paper-I	3	1	0	4	100
5	PCE51E04-06	Elective Paper-II	3	1	0	4	100
Total			**15**	**5**	**0**	**20**	**500**

PRACTICAL/SESSIONAL

Sl. No.	Subject Code	Name of the Subject	No. of Classes/Week			Credits	Marks
			L	T	P		
6	PCE51P01	Hydraulic and Water Resources Engg. lab - I	0	0	3	2	100
7	PCE51P02	Computer Applications in free surface flow and applied hydrology	0	0	3	2	100
8	PCE51P03	Seminar	0	0	2	1	100
Total			**0**	**0**	**08**	**5**	**300**



SYLLABUS

M.TECH. WATER RESOURCES ENGINEERING

FIRST SEMESTER

FREE SURFACE FLOW

Subject No: PCE51CB01 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

- To know about theoretical models for multi-phase flow
- To develop better understanding to describe and derive mathematical models for a class of selected free surface flow phenomena
- To describe some instability that are driven and inhibited by surface tension
- To describe bubble/droplet dynamics, film dynamics, capillary and wetting phenomena, fluid flows driven forces at the free surface

Course Content:

Unit-1

Introduction, Energy and momentum of flow; critical flow; channel control and transitions; discharge measurement methods

Unit-2

Uniform flow and flow resistance; composite roughness and compound channels, generalized flow relation, design of irrigation canals

Unit-3

Gradually varied flow; classifications and computations of free surface profiles; spatially varied flow; supercritical flows and oblique flows; rapidly varied flow; hydraulic jump

Unit-4

Supercritical-flow transitions, wave propagation and surge; method of characteristics; dam-break problem; flow in channel bends; supercritical expansion and contractions, stability of supercritical flow

Unit-5

Unsteady flow; continuity and dynamic equations of unsteady flow, unsteady flow positive and negative surges

Unit-6

Basic mechanics of turbulent jets, buoyant surface jet, vertical and transvers diffusion and longitudinal dispersion, numerical dispersion.

References:

1. Ranga Raju, K.G., Flow through Open Channel, Tata McGraw Hill, New Delhi,1996

2. Chow, V.T, Open Channel Hydraulics, McGraw Hill, New York, 1959

3. Hendersen, F.M., Open Channel Flow, McGraw Hill, New York, 1966.

4. Chaudhry, M. H., Open Channel Flow, Prentice Hall of India, 1998.

5. K. Subramanya, Flow in Open Channels,Tata-McGraw-Hill, 2000

Course Outcomes (COs):

1. To know the fundamentals of energy and momentum of flow, critical flow, channel control and transitions.
2. Basic understanding of discharge measurement methods; uniform flow and flow resistance; composite roughness and compound channels; gradually varied flow.
3. To learn the basics and fundamentals of classifications and computations of free surface profiles; spatially varied flow; supercritical flows and oblique flows.
4. To gather overall knowledge and latest advancements in the field of rapidly varied flow; hydraulic jump; continuity and dynamic equations of unsteady flow
5. Comprehensive knowledge, background, and recent progress in wave propagation and surge; method of characteristics
6. Analysis and knowledge related to flow in channel bends; buoyant and submerged jets.

Table 1: To establish a correlation between Course outcome (Cos) & Program outcome (POs)

No. of Course Outcome (CO)	Course Outcome
PCE51CB01.1	To know the fundamentals of energy and momentum of flow, critical flow, channel control and transitions.
PCE51CB01.2	Basic understanding of discharge measurement methods; uniform flow and flow resistance; composite roughness and compound channels; gradually varied flow.
PCE51CB01.3	To learn the basics and fundamentals of classifications and computations of free surface profiles; spatially varied flow; supercritical flows and oblique flows
PCE51CB01.4	To gather overall knowledge and latest advancements in the field of rapidly varied flow; hydraulic jump; continuity and dynamic equations of unsteady flow
PCE51CB01.5	Comprehensive knowledge, background, and recent progress in wave propagation and surge; method of characteristics
PCE51CB01.6	Analysis and knowledge related to flow in channel bends; buoyant and submerged jets.

Table 2
Slight (Low): 1; Moderate: 2; Substantial (High):3; No Correlation:

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE51CB01.1	2	3	3	2	1	1
PCE51CB01.2	3	3	2	2	1	2
PCE51CB01.3	3	3	2	3	2	1
PCE51CB01.4	3	4	3	2	1	2
PCE51CB01.5	3	4	3	3	1	2
PCE51CB01.6	2	2	2	1	1	1
Total	16	19	15	13	8	9
Average	2.6	3.2	2.5	2.16	1.3	1.5
Equivalent Average Attainment	3	3	3	2	1	2

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE51CB01.1	2	3
PCE51CB01.2	3	3
PCE51CB01.3	3	3
PCE51CB01.4	3	4
PCE51CB01.5	3	4
PCE51CB01.6	2	2
Total	16	19
Average	2.6	3.2
Equivalent Average Attainment	3	3

APPLIED HYDROLOGY

Subject No: PCE51C01 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

1. To analyze and quantify the various components within the hydrological cycle that move within various states.
2. To introduce students to advanced techniques of hydrological analysis that are of particular relevance to engineering and environmental design and planning.
3. To understand the various losses of hydrologic processes and concept of Hydrograph in hydrological analysis.
4. To introduce concepts of probability and modeling of hydrologic time series with data generation in hydrologic analysis and forecasting.

Course Content:

Unit- 1

Introduction - hydrologic cycle, applications of hydrology, hydrology for engineers; precipitation - forms, types and measurement of precipitation, depth-area-duration and frequency analysis of precipitation, variations in precipitation;

Unit - 2

Streamflow - measurement of streamflow, stage-discharge relationship, characteristics and synthesis of hydrographs, catchment characteristics affecting streamflow;

Unit - 3

Hydrologic losses - evaporation, transpiration, evapotranspiration, interception, depression storage, infiltration;

Unit - 4

Statistics in hydrologic analysis - probability concepts and distributions, curve fitting, covariance, correlation and regression, time series analysis;

Unit– 5

Hydrologic synthesis and simulation - mass curve analysis, random generation, precipitation-runoff event simulation models.

References:

1. Chow, V.T., Maidment, D.R., Mays, L.W., Applied Hydrology, McGraw Hill, 1988.

2. Todd, D.K., Ground Water Hydrology, Wiley India, New Delhi, 2011.

3. Mays, L.W., Water Resources Engineering, John Wiley and Sons, US, 2001.

4. Haan, C. T., Statistical Methods in Hydrology, Iowa State University Press, 1977.

5. Maidment, D. R., Handbook of Hydrology, McGraw Hill, 1993.

Course Outcomes (Cos):

Upon successful completion of the course, the students will be able to

1. Understand the concept of hydrology and gain knowledge of precipitation types and characteristics.

2. Analyze different hydrological processes like infiltration and evaporation, and able to assess runoff using various measurements.
3. Analyze different components of hydrograph, derivation of various types of hydrograph and model the stage discharge relation.
4. Apply concepts of probability and statistics in time series and flood frequency analysis. Understand the application of various computer models for hydrological prediction.

Table 1: To establish a correlation between Course outcome (Cos) & Program outcome (POs)

No. of Course Outcome(CO)	Course Outcome
PCE51C01.1	Understand the concept of hydrology and gain knowledge of precipitation types and characteristics
PCE51C01 .2	Analyze different hydrological processes like infiltration and evaporation, and able to assess runoff using various measurements.
PCE51C01.3	Analyze different components of hydrograph, derivation of various types of hydrograph and model the stage discharge relation.
PCE51C01.4	Apply concepts of probability and statistics in time series and flood frequency analysis.
PCE51C01.5	Understand the application of various computer models for hydrological prediction.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 4. No Correlation:

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE51C01.1	2	2	2	1	1	1
PCE51C01 .2	2	3	3	2	2	1
PCE51C01.3	3	3	3	3	2	2
PCE51C01.4	3	2	2	1	1	1
PCE51C01.5	2	2	3	3	2	2
Total	12	12	12	10	8	7
Average	2.4	2.4	2.4	2	1.6	1.4
Equivalent Avg. Attainment	2	2	2	2	2	1

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE51C01.1	2	2
PCE51C01 .2	2	3
PCE51C01.3	3	3
PCE51C01.4	3	2
PCE51C01.5	2	2
Total	**12**	**12**
Average	**2.4**	**2.4**
Equivalent Avg. Attainment	**2**	**2**

ADVANCE MATHEMATICS

Subject No: PCE 51C02 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

- Introduce students to ordinary differential equations and the methods for solving these equations Use differential equations as models for real world phenomena
- Integrate the knowledge accumulated in the calculus sequence to solve applied problems
- Introduce the fundamentals of Linear Algebra and Complex Analysis
- Provide a rigorous introduction to upper level mathematics which is necessary for students of engineering, physical sciences and mathematics

Course Content:

Unit-1

Calculus of Variations – Variation and its properties – Euler's equation – Conditional extreme – Isoperimetric problems – Functional dependant on first and higher order derivatives – Functional dependent on functions of several independent variables – some applications – Direct methods – Ritz and Kantorovich methods, Euler's finite difference method.

Unit-2

Laplace Transforms and Fourier Transforms. Application of Fourier Transform in solving initial and boundary value problems. Laplace Equation, Heat equation and wave equation.

Unit-3

Hankel's Transform, elementing properties of Hankel transforms, Hankel inversion and transform theorems. Hankel transforms of derivatives of functions. Parsevel's theorem. Hankel transforms of $\frac{d^2 f}{dx^2} + \frac{1}{x}\frac{df}{dx} = \frac{n^2}{x^2} f$.

Unit-4

Simulation – Types, case studies in various fields using simulation techniques, simulation softwares used, use of mathematical models based on probabilistic and statistical methods.

Partial Differential Equations – Formation of PDE, Solutions of PDE, Equations solvable by direct integration, Linear equations of the first order, Non-linear equations of the first order, Charpit's Method, Homogeneous Linear equations with constant coefficient, Non-Homo geneous Linear equations, Non-Linear equations of the second order.

Unit-5

Solution of Parabolic and Hyperbolic equations – Implicit and Explicit Schemes, ADI methods, Non Linear parabolic equations – Iteration method, Solution of elliplic equation – Jacobi method, Gauss - Seidel & SOR method. Richardson method, RKF4

Unit-6

Introduction to finite element method and its scope.

References:

1. Kreyszig Erwin, Advanced Engineering Mathematics, John Wiley & Sons (Asia) Pvt Ltd.
2. Krishnamurthy & Sen, Numerical Algorithms, Affiliated East-west press private Limited, New Delhi.
3. Ramana, B. V., Higher Engineering Mathematics, The McGraw-Hill Companies, New-Delhi.

Course Outcomes (Cos):

- To utilize various methods for solving ODEs and solve initial value problems, understand the existence and uniqueness of such solutions and to Recognize ODEs of varying order and use these to solve problems involving population dynamics, oscillation of a spring and resistance in a circuit
- Ability to Work with and solve homogeneous and non-homogeneous ODEs and systems of ODEs. Moreover, to learn additional methods for solving ODEs including Euler's method, the power series method and Laplace transforms.
- Perform basic operations with matrices, find the inverse of a matrix, determinant of a square matrix, as well as Eigen values and Eigen vectors and investigate associated applications, and to use matrices to solve systems of equations.
- Express complex numbers in trigonometric and polar form, and to perform operations with complex numbers, including finding the roots of unity.
- Explore functions of a single complex variable and calculate derivatives of analytic functions
- Calculate line integrals in the complex plane, and Study Cauchy-Riemann equations, Cauchy's integral theorem and Cauchy's integral formula

Table 1: To establish a correlation between Course outcome (COs) & Program outcome (POs)

No. of Course Outcome (CO)	Course Outcome
PCE 51E01.1	To utilize various methods for solving ODEs and solve initial value problems, understand the existence and uniqueness of such solutions and to Recognize ODEs of varying order and use these to solve problems involving population dynamics, oscillation of a spring and resistance in a circuit
PCE 51E01.2	Ability to Work with and solve homogeneous and non-homogeneous ODEs and systems of ODEs. Moreover, to learn additional methods for solving ODEs including Euler's method, the power series method and Laplace transforms.
PCE 51E01.3	Perform basic operations with matrices, find the inverse of a matrix, determinant of a square matrix, as well as Eigen values and Eigen vectors and investigate associated applications, and to use matrices to solve systems of equations.
PCE 51E01.4	Express complex numbers in trigonometric and polar form, and to perform operations with complex numbers, including finding the roots of unity.
PCE 51E01.5	Explore functions of a single complex variable and calculate derivatives of analytic functions
PCE 51E01.6	Calculate line integrals in the complex plane, and Study Cauchy-Riemann equations, Cauchy's integral theorem and Cauchy's integral formula

Table 2

Slight (Low): 1; Moderate: 2; Substantial (High):3; No Correlation:

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE 51E01.1	3	3	2	2	2	1
PCE 51E01.2	2	2	2	3	2	3
PCE 51E01.3	3	2	3	2	1	2
PCE 51E01.4	3	3	2	2	3	2
PCE 51E01.5	2	2	2	2	1	1
PCE 51E01.6	3	2	1	3	2	2
Total	16	14	12	14	11	11
Average	2.67	2 .33	2	2.33	1.8	1.8
Eq. Average Attainment	3	2	2	2	2	2

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE 51E01.1	2	2
PCE 51E01.2	1	1
PCE 51E01.3	1	2
PCE 51E01.4	2	3
PCE 51E01.5	2	2
PCE 51E01.6	2	3
Total	10	13
Average	1.67	2.16
Equivalent Average Attainment	2	2

ELECTIVE PAPER- I

ADVANCED FLUID MECHANICS

Subject No: PCE51E01 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

- To understand the fundamentals of theoretical fluid mechanics: fluid's characteristics and equations of motion
- To comprehend the simplifications that can be made leading to models such as incompressible flow, inviscid flow, ideal fluid flow, boundary layer flow, turbulent flow
- To realize how classical solution techniques may be used to solve a range of problems involving these simplified flow problems

Course Content:

Unit 1: Preliminary concepts of Fluid Mechanics

Elementary introduction to Cartesian tensors and tensor operations, spatial (Eulerian) and material (Lagrangian) description of motion; Fluid flow patterns; Kinematics of fluid flow, Dynamics of Inviscid Flows and Reynolds Transport Theorem

Unit 2: Dynamics of viscous flows

Derivation of Navier-Stokes equation, exact solutions of Navier-Stokes equation-Steady Flows, Unsteady Flows and Practical Applications

Unit 3: Dimensional Analysis

Dimensional analysis and scaling; Pi Theorem, Bridgman's equation; Dynamic similarity; the dimensionless Navier-Stokes equations and the importance of the Reynolds number; limiting cases and their physical meaning.

Unit 4: Boundary layer theory

Introduction, Boundary layer equation, Displacement thickness, Momentum thickness, shape factor, flow over flat plate similarity transformation, integral equation for momentum and energy, Falkner-Skan similarity solution; skin friction coefficient and Nusselt number; separation of boundary layer, critical Reynolds number; control of boundary layer separation.

Unit 5: Turbulent flow

Introduction; structure and origin of turbulent flow; Reynolds average concept, Reynold equation of motions; zero equation model for fully turbulent flow and other turbulence model; turbulent flow pipes and losses bends.

Unit 6: Introduction to Microflows

Molecules, continuum description, compressible flow in long channels, Gases, Couette flow in gases, Poiseuille flow in gases, Gas flow over sphere; Liquid flows in tubes and channels, Liquid flows near walls.

References:

1. Ligett, J. A., Fluid Mechanics, McGraw-Hill International Editions, 1994.

2. Batchelor, G. K., An Introduction to Fluid Mechanics, Cambridge University Press, London, 2005.

3. Shames, L. H., Mechanics of Fluids, McGraw-Hill, 1992

4. Schlichting, H et al. Boundary Layer Theory, 8th Ed. Springer Verlag, 1999.

5. Batchelor, G.K. An Introduction to Fluid Dynamics. Cambridge, 1967

6. White, F.M. Fluid Mechanics, 7th edition, McGraw Hill, 1991.

Course Outcomes (Cos):

2. Describe variables and basic equations of fluid mechanics
3. Define and describe the potential and vortex flows of ideal and viscous fluids
4. Describe the fluid flow around symmetric bodies and determine the drag and lift forces arising due to this flow
5. Describe the transition from laminar flow to turbulent flow and calculate the characteristics of the boundary layer both for laminar and turbulent flows
6. Apply dimensional analysis for a qualitative description of fluid flows
7. Describe the main features of wave phenomena in various fluids and determine the properties of surface and internal gravity waves
8. Define and analyses the stability of fluid flows

Table 1: To establish a correlation between Course outcome (COs) & Program outcome (POs)

No. of Course Outcome (CO)	Course Outcome
PCE51C02.1	Apply the fundamentals of kinematics and conservation laws of fluid flow systems.
PCE51C02.2	Apply the principles of high and low Reynolds number flows to fluid flow systems.
PCE51C02.3	Review the concepts of boundary layer and flow in transition.
PCE51C02.4	Analyze and apply the fundamentals of turbulent flow to various fluid flow systems.
PCE51C02.5	Apply the fundamentals of one dimensional isentropic flow to variable area duct.
PCE51C02.6	Analyze the principles of normal shock formation and its effects and apply the principles of compressible flow to constant area duct subjected to friction or heat transfer.

Table 2

Slight (Low): 1; Moderate: 2; Substantial (High):3; No Correlation:

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE51C02.1	2	3	2	1	2	2
PCE51C02.2	3	3	3	2	1	1
PCE51C02.3	2	2	3	1	2	2
PCE51C02.4	1	2	2	2	3	1
PCE51C02.5	2	2	2	3	1	2
PCE51C02.6	2	3	3	1	2	2
Total	12	15	15	10	11	10
Average	2	2.5	2.5	1.7	1.8	1.7
Eq. Average Attainment	2	3	3	2	2	2

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE51C02.1	2	3
PCE51C02.2	3	3
PCE51C02.3	2	2
PCE51C02.4	1	2
PCE51C02.5	2	2
PCE51C02.6	2	3
Total	12	15
Average	2	2.5
Equivalent Average Attainment	2	3

RIVER ENGINEERING

Subject No: PCE 51E02 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

- The objective of this course is to impart the knowledge of hydrology and fluvial process that deals with the occurrence, distribution, movement and properties of water on the earth.
- To impart the knowledge of various techniques, and how to manage the water resources, to protect against flooding, or to make passage along or across rivers easier,
- To learn about the sediment problems associated with natural stream and reservoir.

Course Content:

Unit-1

Overview of river engineering- river classifications, thresholds in river morphology, hydraulic geometry, meander plan form, geomorphic analysis of river channel responses

Unit-2

Hydraulics of river flow- fundamentals of alluvial channel flows, uniform and unsteady cases, shear stress distribution, flow resistance in rivers

Unit-3

Scouring and its criteria- physical properties of sediments, sediment movement in rivers, shear stress, Shields diagram, scouring around bridge piers and embankments, river bed forms

Unit-4

Regime rivers- analysis of river meanders, design of stable alluvial channels-regime concept, dimensional model studies for rivers, braided rivers, scaling and hierarchy in braided rivers, alternate bars, bed load transport in braided gravel-bed rivers;

Unit-5

River training and stabilization- stream bank erosion, bank protection, flow control structures, bank protection and river training along braided rivers, river flood control, and bridge scour

Unit-6

Waves and tides in river estuaries, surface waves, tides in river estuaries, saline wedges in river estuaries.

References:

1. Chang, H. H., Fluvial Processes in River Engineering, John Wiley, 1988.

2. Charlton, R., Fundamentals of Fluvial Geomorphology, Taylor and Francis, 2007.

3. Gregory H., Braided Rivers: Process, Deposits, Ecology and Management Blackwell Publishing, 2006.

4. Yang, C. T., Sediment Transport-Theory and Practice, McGraw Hill Companies, Inc., New Delhi, 1996.

5. Knighton, D., Fluvial Forms and Processes. Edward Arnold, Baltimore, MD., 1984.

6. Richards, K., Rivers Form and Process in Alluvial Channels, Methuen, NY, 1982.

7. Shen, H.W., River Mechanics, Vol. I and II, Water Resources Publication, Fort Collins, CO., 1971.

8. Thorne, C R, Hey, R. D. and Newson, M. D. Applied fluvial geomorphology for river engineering management, John Wiley & Sons, 1997.

Course Outcomes (Cos):

- Demonstrate an advanced understanding of hydrological and river engineering processes.
- Identify methods of flood control and describe their appropriate application and use it to hold water
- Recognize the movement of sediments and its impact on river flow
- Apply knowledge of mathematics, science, and technology in the field of river engineering.
- An ability to communicate effectively
- Develop an archive that will be accessible for future research

Table 1: To establish a correlation between Course outcome (COs) & Program outcome (POs)

No. of Course Outcome (CO)	Course Outcome
PCE 51E02.1	Demonstrate an advanced understanding of hydrological and river engineering processes.
PCE 51E02.2	Identify methods of flood control and describe their appropriate application and use it to hold water
PCE 51E02.3	Recognize the movement of sediments and its impact on river flow
PCE 51E02.4	Apply knowledge of mathematics, science, and technology in the field of river engineering.
PCE 51E02.5	An ability to communicate effectively
PCE 51E02.6	Develop an archive that will be accessible for future research

Table 2:

Slight (Low): 1; Moderate: 2; Substantial (High):3; No Correlation:

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE 51E02.1	3	4	3	3	2	2
PCE 51E02.2	3	4	3	2	2	3
PCE 51E02.3	3	2	2	2	1	1
PCE 51E02.4	3	3	2	3	2	2
PCE 51E02.5	3	4	3	2	1	2
PCE 51E02.6	3	3	2	3	2	2
Total	18	20	15	15	10	12
Average	3	3.3	2.5	2.5	1.7	2
Eq. Avg. Attainment	3	3	3	3	2	2

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE 51E02.1	3	4
PCE 51E02.2	3	4
PCE 51E02.3	3	2
PCE 51E02.4	3	3
PCE 51E02.5	3	4
PCE 51E02.6	3	3
Total	18	20
Average	3	3.33
Equivalent Avg. Attainment	3	3

GROUNDWATER HYDROLOGY

Subject No: PCE51E03 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

- To introduce the basic theory and computational techniques for modeling multiphase flow in subsurface porous media
- To describe and investigate porous media, together with relevant single and multi-phase transport phenomena.
- To focused on the achievement of a clear and rigorous understanding of the fundamental properties,
- Concepts and theories which are of importance in treating storage and multiphase fluid flow in sub-surface porous media.

Course Content:

Unit-1

Occurrence and movement of ground water, Surface and subsurface investigation of ground water, Flow through saturated porous medium.

Unit-2

Mechanics of well flow, Aquifer parameters, Pumping tests, Design of water wells, Monitoring well design and construction, Well development, Well maintenance and rehabilitation, Natural and artificial recharge of ground water,

Unit-3

Salt water intrusion, Ghyben-Herzberg interface, shape of the fresh-salt water interface, upconing of saline water, control of saline water intrusion, recognition of seawater in ground water.

Unit-4

Ground water pollution in relation to water use, attenuation of pollution, distribution of pollution underground, evaluation of pollution potential, monitoring groundwater quality.

Unit-5

Management of ground water, technical procedures of basin managements, planning ground water investigations, water budget of ground water basins, Analytical methods

Unit-6

Introduction to analog and numerical models to solve ground water problems, Application of finite difference method in ground water.

References:

1. Bear, J., Dynamics of Fluids in porous Media, Dover Publications, 1972.
2. Fetter, C.W., Contaminant Hydrogeology, Prentice Hall, 1999.
3. Bear, J. and Verruijt, A., Modeling Groundwater Flow and Pollution, Reidel Publishing Company, 1990.
4. Fetter, C.W., Applied Geohydrology, Prentice Hall, 2001.

Course Outcomes (Cos):

1. The students will be able to understand the occurrence and movement of ground water,

2. The students will be able to understand the surface and subsurface investigation of ground water, Flow through saturated porous medium
3. The students will be able to understand the mechanics of well flow, Aquifer parameters, Pumping tests,
4. The students will be able to understand the design of water wells, monitoring well design and construction, well development, well maintenance and rehabilitation
5. The students will be able to understand the natural and artificial recharge of ground water, Salt water intrusion
6. The students will be able to understand the introduction to analog and numerical models to solve ground water problems, Application of finite difference method in ground water

Table 1: To establish a correlation between Course outcome (COs) & Program outcome (POs)

No. of Course Outcome (CO)	Course Outcome
PCE51E03.1	The students will be able to understand the occurrence and movement of ground water,
PCE51E03.2	The students will be able to understand the surface and subsurface investigation of ground water, Flow through saturated porous medium
PCE51E03.3	The students will be able to understand the mechanics of well flow, Aquifer parameters, Pumping tests,
PCE51E03.4	The students will be able to understand the design of water wells, monitoring well design and construction, well development, well maintenance and rehabilitation
PCE51E03.5	The students will be able to understand the natural and artificial recharge of ground water, Salt water intrusion
PCE51E03.6	The students will be able to understand the introduction to analog and numerical models to solve ground water problems, Application of finite difference method in ground water

Table 2

Slight (Low): 1; Moderate: 2; Substantial (High):3; No Correlation:

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE51E03.1	2	2	3	3	1	2
PCE51E03.2	3	3	2	2	2	2
PCE51E03.3	3	3	2	3	1	2
PCE51E03.4	3	3	3	3	2	2
PCE51E03.5	2	3	2	2	2	2
PCE51E03.6	3	3	3	3	2	3
Total	16	17	15	16	10	13
Average	2.7	2.8	2.5	2.7	1.7	2.2
Eq. Avg. Attainment	3	3	3	3	2	2

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE51E03.1	2	2
PCE51E03.2	3	3
PCE51E03.3	3	3
PCE51E03.4	3	3
PCE51E03.5	2	3
PCE51E03.6	3	3
Total	16	17
Average	2.67	2.83
Equivalent Avg. Attainment	3	3

ELECTIVE PAPER – II

HYDROPOWER ENGINEERING

Subject No: PCE51E04 **(L-T-P: 3-1-0 Credit: 4)**

Courses Objectives:

1. To make the students conversant with power potential of water and to have adequate knowledge on sources of energy.
2. To have adequate knowledge on various types of hydropower plants.
3. To have adequate knowledge on various components of hydropower projects like penstocks, surge tanks, power canals, canal intakes, turbines, generators, power houses.
4. To understand the basics of tidal power.
5. To study typical hydropower projects.

Course Content:

Unit-1

Introduction – Sources of energy; place of hydropower in a power system; estimation of water power potential.

Unit-2

Classification of hydropower plants: Run-of-River plants; Valley dam plants; Diversion canal plants; High head diversion plants; pumped storage plants.

Unit-3

Classification, design criteria and economic diameter of penstocks; water hammer; surge tanks; surges in power canals; types, energy losses in canal intakes; types, hydraulics of water turbines; cavitation in turbines; draft tubes; generators; types, advantages & limitations of power houses.

Unit-4

Basic principle of tidal power; modes of tidal power generation- single cycle, double cycle, single basin, double basin, cooperating basin arrangements; Small hydropower feasibility and implementation.

Unit-5

Typical hydropower projects of various types in India and abroad.

References:

1. Dandekar, M. M. and Sharma, K. N.; (2013) "Water Power engineering", 2nd Ed., Vikas Publishing, New Delhi.
2. Creager, W. P., and Justin, J. D., (1963) "Hydro-Electric Handbook", John Wiley, New York, NY, USA.
3. Davis, S., (2004) "Micro Hydro -Clean power from water", Mother Earth News Books for wiser Living, Odgen Publications, Topeka, Kansas, USA.
4. Punmia, B. C., and Pande B. B. Lal (2021) "Irrigation and water power engineering", 17th Edition, Laxmi Publications, New Delhi.
5. Breeze, P, (2018) "Hydropower", Science Direct, Elsevier Publishers BV, Amsterdam, The Netherlands

Course Outcomes (Cos):

1. Students will be able to analyze energy sources, place of hydropower in a power system and to estimate hydropower potential.
2. Students will be able to classify and describe salient features of different types of hydropower plants.
3. Students will be able to understand design criteria and limitations of power houses.
4. Students will be able to understand the basic principle of tidal power; modes of tidal power generation.
5. Students will be able to classify the various types of typical hydropower projects in India and abroad.

Table 1: To establish the correlation between COs &POs

No. of Course Outcome(CO)	Course Outcome
PCE51E04.1	Students will be able to analyze energy sources, place of hydropower in a power system and to estimate hydropower potential.
PCE51E04.2	Students will be able to classify and describe salient features of different types of hydropower plants.
PCE51E04.3	Students will be able to understand design criteria and limitations of power houses.
PCE51E04.4	Students will be able to understand the basic principle of tidal power; modes of tidal power generation.
PCE51E04.5	Students will be able to classify the various types of typical Hydropower projects in India and abroad.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation:

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE41C01.1	3	3	3	3	3	3
PCE41C01.2	3	2	3	3	2	2
PCE41C01.3	3	3	2	3	2	3
PCE41C01.4	2	3	3	2	3	3
PCE41C01.5	3	2	3	3	3	3
Total	**14**	**13**	**14**	**14**	**13**	**14**
Average	**2.8**	**2.6**	**2.8**	**2.8**	**2.6**	**2.8**
Equivalent Avg. Attainment	**3**	**3**	**3**	**3**	**3**	**3**

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE51E04.1	3	3
PCE51E04.2	3	3
PCE51E04.3	2	3
PCE51E04.4	3	2
PCE51E04.5	3	3
Total	14	14
Average	2.8	2.8
Equivalent Avg. Attainment	**3**	**3**

WATER RESOURCES SYSTEM ANALYSIS, PLANNING & MANAGEMENT

Subject No: PCE51E05 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

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

Course Content:

Unit-1

Basic concepts of systems need for systems approach in water resources, system design techniques, problem formulation, modeling of water resource system

Unit-2

Optimization techniques, LP, NLP, dynamic programming, multi-objective optimization, stochastic optimization

Unit-3

Simulation, reservoir operation problems, case studies; planning, role of a planner, sensitivity analysis, performance measures

Unit-4

National water policies, public involvement, social impact, economic analysis.

Unit-5

Water resources system modelling, river basin planning and management, water distribution system, ground water system, water quality modelling, floodplain management, urban storm water management

Unit-6

Fuzzy optimization, genetic algorithm, multi criteria decision making, decision support system, expert systems.

References:

1. Loucks, D.P., Stedinger, P.J.R., Haith, D.A., "Water Resources Systems Planning and Management", Prentice Hall, New Jersy, 1987.
2. Hall, K., A and Draoup, J.A., Water Resources Systems Engineering, Tata McGraw Hill, 1970.
3. Neil, G.S., Water Resources Planning, McGraw Hill, 1985.
4. National Water Policy, Ministry of Water Resources, Government of India, 1987.

Course Outcomes (Cos):

1. The students will be able to understand the basic concepts of systems, need for systems approach in water resources, system design techniques, problem formulation.
2. The students will be able to understand the optimization techniques, LP, NLP, dynamic programming, genetic algorithm, and sensitivity analysis.
3. The students will be able to understand the capacity expansion; reservoir operation problems, simulation, case studies.
4. The students will be able to understand the planning, role of a planner, National water policies, public involvement, social impact, economic analysis.

Table 1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE51E05.1	The students will be able to understand the basic concepts of systems, need for systems approach in water resources, system design techniques, problem formulation.
PCE51E05.2	The students will be able to understand the optimization Techniques, LP, NLP, dynamic programming, genetic algorithm, and sensitivity analysis.
PCE51E05.3	The students will be able to understand the capacity expansion; reservoir operation problems, simulation, case studies.
PCE51E05.4	The students will be able to understand the planning, role of a planner, National water policies, public involvement, social impact, economic analysis.

Table 2

Slight (Low): 1; Moderate: 2; Substantial (High):3; No Correlation: -

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE52C01.1	3	3	3	3	3	2
PCE52C01.2	3	2	3	3	2	3
PCE52C01.3	3	3	2	2	2	2
PCE52C01.4	3	3	4	3	2	1
Total	12	11	12	11	9	8
Average	3	2.8	3	2.8	2.25	2
Eq. Average Attainment	3	3	3	3	2	2

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE52C01.1	3	3
PCE52C01.2	3	2
PCE52C01.3	3	3
PCE52C01.4	3	3
Total	12	11
Average	3	2.75
Equivalent Average Attainment	3	3

GEOGRAPHICAL INFORMATION SYSTEMS AND ITS APPLICATION

Subject no: PCE51E06 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

- Understanding the need of CAD and GIS,
- Understanding map projection and working with coordinate systems,
- Understanding vector-based and raster-based data analysis,
- Review of application areas of GIS in Civil Engineering,
- Understanding basic principles of remote sensing.

Course Content:

Unit-1

Introduction to Geographical information systems (GIS), Data bases and data base management systems, spatial databases, Coordinate systems and geo-refencing.

Unit-2

Interpolation methods: deterministic and Statistical, Digital elevation models and their applications, Strategies for development

Unit-3

Implementation and management of GIS, Case studies on use of GIS selected from various areas such as water and land resources, environment, transportation, land use application.

Unit-4

Projects involving creation of small GIS modules related to water resources problems and other generic area.

Unit-5

Introduction to basic concepts of vector GIS using several industry specific software programs including nomenclature of cartography and geography.

References:

1. Lillesand, K., Remote Sensing and Image Interpretation, John Wiley & Sons, 1979.
2. Tideman, E.M., Watershed Management – Guidelines for Indian Conditions, Omega Scientific Publishers, New Delhi, 1996.
3. FAO Watershed management and Field manual, 13/1, 13/2, 13/3,13/4,13/5 FAO, UN, Rome, 1988.
4. Reeves, R.G., Manual of Remote Sensing, Volume I and II, American Society of Photogrammetr, Falls Church, 1975.

Course Outcomes (Cos):

- The students will be able to understand the principles of remote sensing,
- The students will be able to understand the principles of geographic information systems,
- The students will be able to understand and apply remote sensing and GIS to solving problems of Civil Engineering,
- The students will be able to understand and maximize the efficiency of planning and spatial decision making,
- The students will be able to understand and integrate geographically referenced data and develop queries to generate usable information.
- Students will be able to study the applications of Image Analysis, Limitations and future of Digital Image Processing Technique.

Table 1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE51E06.1	The students will be able to understand the principles of remote sensing,
PCE51E06.2	The students will be able to understand the principles of geographic information systems
PCE51E06.3	The students will be able to understand and apply remote sensing and GIS to solving problems of Civil Engineering
PCE51E06.4	The students will be able to understand and maximize the efficiency of planning and spatial decision making
PCE51E06.5	The students will be able to understand and integrate geographically referenced data and develop queries to generate usable information
PCE51E06.6	Students will be able to study the applications of Image Analysis, Limitations and future of Digital Image Processing Technique

Table 2

Slight (Low): 1; Moderate: 2; Substantial (High):3; No Correlation

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE 51E01.1	2	3	3	3	2	2
PCE 51E01.2	3	3	2	2	2	3
PCE 51E01.3	3	3	3	3	1	1
PCE 51E01.4	2	3	3	2	2	3
PCE 51E01.5	3	3	3	3	2	2
PCE 51E01.6	3	3	2	2	2	3
Total	16	18	16	15	11	14
Average	2.7	3	2.7	2.5	1.8	2.3
Eq. Average Attainment	3	3	3	3	2	2

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE 51E01.1	2	3
PCE 51E01.2	3	3
PCE 51E01.3	3	3
PCE 51E01.4	2	3
PCE 51E01.5	3	3
PCE 51E01.6	3	3
Total	16	18
Average	2.67	3
Equivalent Average Attainment	3	3

PRATICAL/ SESSIONAL

HYDRAULICS & WATER RESOURCES ENGINEERING LAB.-I

Subject no: PCE51P01 **(L-T-P: 0-0-3 Credit: 2)**

Course Objectives:

- To learn the basic hydrological measurement technique – measurement of rainfall and rainfall intensities.
- To determine the abstraction losses like evaporation, infiltration etc. through experiments and estimate the infiltration characteristics and evaporation in catchments.
- Study of flow measurement in natural stream and laboratory.

Course Content:

Unit 1

Measurement of rain fall, evaporation, infiltration,

Unit 2

Experiments on Frequency analysis of hydrologic data by Gumbel's method, flood hydrograph.

Unit 3

To determine the velocity of a running of a stream in a canal by current meter and calculate the approximate discharge of the canal.

Course Outcomes (Cos):

- The students will be able to apply their knowledge about fluid mechanics in addressing problems in open channels.
- The students will be able to know hydrological measurement technique – measurement of rainfall and rainfall intensities, abstractions in hydrological processes like evaporation, infiltration, etc.
- The students will be able to measure velocity of flow in rivers using current meter.
- The students will be able to analysis flood frequency using Gumbles method and flood hydrograph.
- The students will be able to predict the flood inundation forecast and quantify the bank erosion problem.

Table1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE51P01.1	The students will be able to apply their knowledge about fluid mechanics in addressing problems in open channels.
PCE51P01.2	The students will be able to know hydrological measurement technique – measurement of rainfall and rainfall intensities, abstractions in hydrological processes like evaporation, infiltration, etc.

PCE51P01.3	The students will be able to measure velocity of flow in rivers using current meter.
PCE51P01.4	The students will be able to analysis flood frequency using Gumbles method and flood hydrograph.
PCE51P01.5	The students will be able to predict the flood inundation forecast and quantify the bank erosion problem.

Table 2

Slight (Low): 1; Moderate: 2; Substantial (High): 3; No Correlation:

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE51P01.1	3	3	3	3	2	3
PCE51P01.2	3	3	2	2	3	3
PCE51P01.3	3	2	2	3	2	2
PCE51P01.4	2	2	2	2	1	2
PCE51P01.5	3	2	3	3	2	2
Total	14	12	12	13	10	12
Average	2.8	2.4	2.4	2.6	2	2.4
Eq. Avg. Attainment	3	2	2	3	2	2

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	PSO1	PSO2
PCE51P01.1	3	3
PCE51P01.2	3	3
PCE51P01.3	3	2
PCE51P01.4	2	2
PCE51P01.5	3	2
Total	14	12
Average	2.8	2.4
Eq. Avg. Attainment	3	2

COMPUTATIONAL APPLICATION ON FREE SURFACE FLOW AND APPLIED HYDROLOGY

Subject No: PCE51P02 **(L-T-P: 0-0-3 Credit: 2)**

Course Objectives:

- To provide basic knowledge on how to implement software's for solving practical and research related problems.
- To provide skills for writing programs, and study of topographical and contour maps for watershed characterization
- To enable and motivate the students perform analysis using software's for various research works and projects.

Course Content:

Unit 1
Introduction: study and application of various software's in water resource engineering.
Unit 2
Computer programming in solving the free surface flow problem.
Unit 3
Hydrologic analysis and simulation problem related to ground water.

Course Outcomes (COs):

- Perform MATLAB, GIS/Arc-GIS, ANSYS and MIKE/MIKE-21C effectively and efficiently.
- Design and develop programming skills, study area maps.
- Analyze various practical problems.

Table 1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE51P02.1	Perform MATLAB, GIS/Arc-GIS, ANSYS and MIKE/MIKE-21C effectively and efficiently.
PCE51P02.2	Design and develop programming skills, study area maps.
PCE51P02.3	Analyze various practical problems.

Table 2
Slight (Low): 1; Moderate: 2; Substantial (High):3; No Correlation

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE51P02.1	3	3	3	3	2	3
PCE51P02.2	3	2	3	2	3	2
PCE51P02.3	3	2	3	3	1	3
Total	9	7	9	8	6	8
Average	3	2.33	3	2.7	2	2.7
Eq. Average Attainment	3	2	3	3	2	3

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	PSO1	PSO2
PCE51P02.1	3	3
PCE51P02.2	3	2
PCE51P02.3	3	2
Total	9	7
Average	3	2.33
Equivalent Average Attainment	3	2

SEMINAR

(PCE51P03)

Total Credits	**01**	**L – T – P**	**0– 0 – 2 = 1**

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. The student shall submit copy of the paper to the Department. Grades will be awarded on the basis of contents of the paper and the presentation.

SYLLABUS FOR M.TECH. (Water Resource Engineering)

SECOND SEMESTER

Sl. No.	Subject Code	Name of the Subject	No. of Classes/Week			Credits	Marks
			L	T	P		
1	PCE52CB01	Advanced Computational Hydraulics	03	01	00	4	100
2	PCE52C01	Hydraulics of Sediment Transport	03	01	00	4	100
3	PCE52C02	Hydraulic Structure	03	01	00	4	100
4	PCE52E01-E03	Elective Paper-III	03	01	00	4	100
Total			**12**	**04**	**00**	**16**	**400**

PRACTICAL/SESSIONAL

Sl. No.	Subject Code	Name of the Subject	No. of Classes/Week			Total Credits	Total Marks
			L	T	P		
5	PCE52P01	Project Preliminaries	00	00	06	3	100
6	PCE52P02	Hydraulics and Water Resources Eng. Lab.-II	00	00	03	2	100
7	PCE52P03	Computer application in Water Resources Engineering	00	00	03	2	100
8	PCE52P04	Comprehensive Viva-voce	00	00	00	2	100
Total			**00**	**00**	**12**	**9**	**400**

ADVANCED COMPUTATIONAL HYDRAULICS

Subject No: PCE52CB01 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

- To understand and apply numerical methods for solution of differential equations in Water Resources Engineering
- To understand and apply finite difference schemes for solution of hydraulic and hydrologic models
- To acquire and develop expertise knowledge to perform statistical analysis of water resources and environmental engineering systems.

Course Content:

Unit-1

Introduction, Mathematical behavior of Ordinary and partial differential equations; Quasi-linear partial differential equations; Classification of mathematical equations: Hyperbolic, Parabolic, Elliptic and Mixed type equations

Unit-2

Solution of linear equation systems: Direct methods, iterative methods, coupled equations and their applications, non-linear equation and their application, convergence criteria, error analysis

Unit-3

Methods for unsteady problems: Initial value problems in ODE: two-level method, Runge-Kutta methods, Predictor-corrector and multipoint methods, Application to genetic transport equations: explicit methods, implicit method, and other methods

Unit-4

Introduction to numerical methods: Approaches to Fluid dynamics problems, possibilities and limitation of numerical methods, components of numerical solution methods, properties of numerical solution methods, discretization approaches.

Unit-5

Finite difference method, implicit and explicit scheme, accuracy, convergence and stability; approximation of first, second and mixed derivatives, boundary conditions; algebraic equation system; discretization errors

Unit-6

Finite volume method, approximation of surface and volume integrals, interpolation and differentiation practices, boundary conditions, algebraic equation system; applications to steady and unsteady flows

References:

1. Anderson, J.D., *"Computational Fluid Dynamics: The Basics with Applications",* McGrawHill, 1995.

2. Wilcox, D.C., *"Turbulence Modeling for CFD",* DCW Industries, Third Edition, 2006.

3. Anderson, D. A., J. C. Tannehill, and R. H. Pletcher, Computational Fluid Mechanics and Heat Transfer, 1984, Hemisphere Publishing Co., New York, ISBN 0-89116-471-5.

4. Ferziger, J. H. and M. Peric, Computational Methods for Fluid Dynamics, 1996, Springer Verlag, New York, ISBN 3-540-59434-5.

5. Fletcher, C. A. J., Computational Techniques for Fluid Dynamics, Volume 1, Fundamental and General Techniques, 2nd Edition, 1991, Springer Verlag, New York, ISBN 0-387-53058-4.

Course Outcomes (Cos):

1. Basic understanding of ordinary and partial differential equations;
2. The students will be able to understand the solution of linear and non-linear system of equation and their application.
3. The students will be able to understand the concepts of unsteady flow problem and application to genetic transport equations.
4. The students will be able to understand the applications of numerical method on steady and unsteady flows problems.
5. The students will be able to understand the finite difference method and their application on various fields.
6. The students will be able to understand the applications of finite volume method with computer programming.

Table 1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE52CB01.1	Basic understanding of ordinary and partial differential equations;
PCE52CB01.2	The students will be able to understand the solution of linear and non-linear system of equation and their application
PCE52CB01.3	The students will be able to understand the concepts of unsteady flow problem and application to genetic transport equations.
PCE52CB01.4	The students will be able to understand the applications of numerical method on steady and unsteady flows problems.
PCE52CB01.5	The students will be able to understand the finite difference method and their application on various fields.
PCE52CB01.6	The students will be able to understand the applications of finite volume method with computer programming.

Table 2

Slight (Low): 1; Moderate: 2; Substantial (High):3; No Correlation: --

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE52CB01.1	4	3	4	4	3	4
PCE52CB01.2	2	3	3	3	3	2
PCE52CB01.3	4	2	3	3	2	3
PCE52CB01.4	3	3	2	4	3	3
PCE52CB01.5	3	4	3	3	2	2
PCE52CB01.6	4	3	3	3	3	3
Total	20	18	18	20	16	17
Average	3.3	3	3	3.3	2.7	2.8
Eq. Average Attainment	3	3	3	3	3	3

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE52CB01.1	4	3
PCE52CB01.2	2	3
PCE52CB01.3	4	2
PCE52CB01.4	3	3
PCE52CB01.5	3	4
PCE52CB01.6	4	3
Total	20	18
Average	3.3	3
Equivalent Average Attainment	3	3

HYDRAULICS OF SEDIMENT TRANSPORT

Subject No: PCE52C01 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

- To impart knowledge about the mechanics of river flow and transport of sediments
- To introduce the fundamental concepts relevant to river mechanics, regime channels, sediment transport and sediment load.
- To enable the students to understand the processes that governs sediment transport and behavior of river flow.

Course Content:

Unit-1

Sediment properties; initiation of motion; bed load; bed forms; effective bed roughness; armoring.

Unit-2

Sediment transport, bed load, suspended load; total load; transport of sediment due to unsteady flow; meandering of rivers; braided river; local scour at different structures; sediment sampling; density current.

Unit-3

Mathematical models of sediment transport; effect of coherent turbulence on sediment transport.

Unit-4

Shear stress in turbulent flow, velocity distribution in turbulent flow.

References:

1. R. J. Garde, K. G. Ranga Raju "Mechanics of Sediment Transportation and Alluvial Stream Problems" New age publications.
2. S. Lawrence Dugwan "Fluvial hydraulics' Oxford university press.
3. Leo C, and V. Raju, "Principle of sediment transport in Rivers, estuarine and coastal seas" Aqua Publication.

Course Outcomes (COs):

1. The students will be able to understand the sediment properties, initiation of motion, bed load, bed forms, effective bed roughness, armoring; suspended load, and total load
2. The students will be able to understand the transport of sediment due to unsteady flow, meandering of rivers; braided river; local scour at different structures; sediment sampling; density current.
3. The students will be able to understand the mathematical models of sediment transport; effect of coherent turbulence on sediment transport
4. The students will be able to understand the shear stress in turbulent flow, velocity distribution in turbulent flow

Table 1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE52C01.1	The students will be able to understand the sediment properties, initiation of motion, bed load, bed forms, effective bed roughness, armouring; suspended load, and total load
PCE52C01.2	The students will be able to understand the transport of sediment due to unsteady flow, meandering of rivers; braided river; local scour at different structures; sediment sampling; density current
PCE52C01.3	The students will be able to understand the mathematical models of sediment transport; effect of coherent turbulence on sediment transport
PCE52C01.4	The students will be able to understand the shear stress in turbulent flow, velocity distribution in turbulent flow

Table 2

Slight (Low): 1; Moderate: 2; Substantial (High): 3; No Correlation: ---

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE52C01.1	3	3	3	3	3	3
PCE52C01.2	2	2	2	3	2	2
PCE52C01.3	3	2	3	3	2	3
PCE52C01.4	3	3	3	2	2	2
Total	11	10	11	11	9	10
Average	2.8	2.5	2.8	2.8	2.3	2.5
Eq. Average Attainment	3	3	3	3	2	3

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE52C01.1	3	3
PCE52C01.2	2	2
PCE52C01.3	3	2
PCE52C01.4	3	3
Total	11	10
Average	2.75	2.5
Equivalent Average Attainment	3	3

HYDRAULIC STRUCTURE

Subject No: PCE52C02 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

1. To understand the basics of dam, site selection and types of dam.
2. To know the basics of design of embankment dams, upgradation and rehabilitation of dams.
3. To get knowledge of various types of concrete dams and design different elements of dam.
4. To analyze various hydraulic structures for energy dissipation like spillway.
5. To get knowledge on dam safety, regulations and risk assessment.

Course Content:

Unit-1

Elements of Dam engineering: Introduction; Site assessment and selection of type of dam.

Unit-2

Embankment Dam Engineering: Introduction; Principle of Embankment Dam Design; Seeoage analysis; Geosynthetic in environmental dam; Upgrading and rehabilitation of Embankment Dam.

Unit-3

Concrete Dam Engineering: Loading: Concept & Criteria; Gravity Dam Analysis; Concrete for Dams; of masonry and concrete Dam.

Unit-4

Energy dissipation: Introduction; Energy dissipation on spillways; stilling basin.

Unit-5

Dam Safety: Introduction; Instrumentation; Surveillance; Dam safety legislation; Reservoir hazards and risk assessment.

References:

1. P.Novak, A.I.B.Moffa, C.Nalluri and R. Narayan "Hydraulic Structures' Fourth Edition, Taylor & Francis.
2. Walter O.W "Hydraulic Structure" ASCE press
3. Mikhail, M.G. "Hydraulic Structure" Vol.1; Mir publication 1982

Course Outcomes (COs):

Upon completion of this course students will be able to:

1. Enhance knowledge on various concepts of dam types and selection criteria.
2. Perform design and analysis of embankment dams, their upgradation and rehabilitation.
3. Design various types of concrete dams and perform stability analysis, fix section of dam.
4. Perform structural design and analyze the various types of hydraulic structures.
5. Enhance knowledge on dam safety, instrumentation, risks and hazard assessment

Table 1: To establish the correlation between COs &POs

No. of Course Outcome(CO)	Course Outcome
PCE52C02.1	Enhance knowledge on various concepts of dam types and selection criteria.
PCE52C02.2	Perform design and analysis of embankment dams, their upgradation and rehabilitation.
PCE52C02.3	Design various types of concrete dams and perform stability analysis, fix section of dam.
PCE52C02.4	Perform structural design and analyze the various types of hydraulic structures.
PCE52C02.5	Enhance knowledge on dam safety, instrumentation, risks and hazard assessment.

Table- 2

Slight (Low): 1; Moderate: 2; Substantial (High): 3; No Correlation: --

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE52C02.1	2	2	2	3	2	2
PCE52C02.2	3	3	3	3	2	3
PCE52C02.3	2	3	3	2	3	2
PCE52C02.4	3	2	3	3	2	3
PCE52C02.5	2	2	2	2	3	2
Total	12	11	13	13	12	12
Average	2.4	2.2	2.6	2.6	2.4	2.4
Eq. Avg. Attainment	2	2	3	3	2	2

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE52C02.1	2	2
PCE52C02.2	3	3
PCE52C02.3	2	3
PCE52C02.4	3	2
PCE52C02.5	2	2
Total	12	11
Average	2.4	2.2
Equivalent Avg. Attainment	2	2

ELECTIVE PAPER – III

VISCOUS FLUID FLOW

Subject No: PCE52E01 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

Viscous fluid flow covers the fundamentals of fluid mechanics from an advanced point of view. This course focusses largely on viscous flows in the incompressible regime. The course will give the audience physical insights through the use of mathematical tools for solving real-flow problems. The course will help students, faculty members, and researchers in the field to get in-depth understanding of concepts in viscous fluid flow.

Course Content:

Unit-1

Properties of Fluids: Kinematics of fluid flow, Velocity and stress fields, Continuity; Euler's equation; N-S and vorticity equations; Exact solutions; Stokes' problems; Poiseuille and Couette flows More exact solutions; inclined plane, immiscible flows Creeping flows.

Unit-2

Viscous flow: Boundary conditions for viscous flow, Viscous particle motion, Flow of viscous fluid through circular pipes, flow between two parallel plates, loss of head in viscous flow, viscous stagnation flows.

Unit-3

Boundary layer theory: Boundary layer equation; Blasius velocity profile for flow over a flat plate; Integral methods; Karman integral relation, Falkner-Skan equation, Karman-Pohlhausen method, Thwaite's method, Separation of boundary layaer, laminar shear flow, Potential flow and flow past immersed bodies.

Unit-4

Stability of laminar flows: Introduction, linearized stability of parallel viscous flow, parametric effects in linear stability theory, Orr-Sommerfeld equation, viscous stability, Taylor instability of coquette flow, transition in free surface flow, transition to turbulence.

Unit-5

Introduction, characteristic of turbulent flows, Reynolds' averaging; RANS equations, closure models; mixing length theories, energy cascade, and turbulent structures.

References:

1. Schlichting, H. and Gersten, K., "*Boundary Layer Theory"*, 8th Revised and Enlarged Edition, Springer-Verlag, 2000.

2. White, F.M., "Viscous Fluid Flow", McGrawHill, 1991.

3. Pope, S., "*Turbulent Flows",* Camebridge University Press, 2000

4. J. O. Hinz., Turbulent flow, McGraw Hill , Newyork 1975

Course Outcomes (COs):

On successful completion of the course unit students will be able to

- Understand the kinematics of fluid flow, and the continuum mechanical derivation of the Navier-Stokes equations and the appropriate boundary conditions.
- Perform analysis of the effects of formation of boundary layers on the parallel plate, pipes.
- Understand the fundamental concepts of viscous flows in related to boundary layers flows and the mechanics of viscous flow about immersed boundaries.
- Understand the fundamental concepts of linear stability of laminar flows and transition to turbulence.
- Understand the basic concepts of turbulent flow characteristics, turbulent structure and energy cascade. Apply the equations to various fluid problems giving a mathematical description of the flow.

Table 1: To establish the correlation between COs &POs

No. of Course Outcome(CO)	Course Outcome
PCE52E01.1	Understand the kinematics of fluid flow, and the continuum mechanical derivation of the Navier-Stokes equations and the appropriate boundary conditions.
PCE52E01.2	Perform analysis of the effects of formation of boundary layers on the parallel plate, pipes. Apply macroscopic balances to fluid flow design problems for processes that are commonly involved in civil engineering units.
PCE52E01.3	Understand the fundamental concepts of viscous flows in related to boundary layers flows and the mechanics of viscous flow about immersed boundaries.
PCE52E01.4	Understand the fundamental concepts of linear stability of laminar flows and transition to turbulence
PCE52E01.5	Understand the basic concepts of turbulent flow characteristics, turbulent structure and energy cascade.

Table- 2

Slight (Low): 1; Moderate: 2; Substantial (High): 3; No Correlation: --

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE52E01.1	2	2	3	3	2	1
PCE52E01.2	3	3	2	3	2	2
PCE52E01.3	3	2	3	3	3	3
PCE52E01.4	3	3	3	3	2	3
PCE52E01.5	2	2	2	3	2	1
Total	13	12	13	15	11	10
Average	2.6	2.4	2.6	3	2.2	2
Equivalent Avg. Attainment	3	2	3	3	2	2

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE52E01.1	2	2
PCE52E01.2	3	3
PCE52E01.3	3	2
PCE52E01.4	3	3
PCE52E01.5	2	2
Total	13	12
Average	2.6	2.4
Equivalent Avg. Attainment	3	2

TRANSIENT FLOW ANALYSIS

Subject No: PCE52E02 **(L-T-P: 3-1-0 Credit: 4)**

Course Objectives:

- To implement comprehensive and effective flow control, achieving efficient water utilization, and maintaining rich fluvial environments.
- To solve a variety of problems on flow structures mainly in open channels closed conduits and other related structures.

Course Content:

Unit-1

Introduction: wave propagation and reflection in single pipeline, classification of hydraulic transients, causes of transients, system design and operation

Unit-2

Equation of unsteady flow through closed conduits: Dynamic and continuity equations and methods for solving their equations, velocity of water hammer waves

Unit-3

Method of characteristic: Characteristic equations, boundary conditions, stability and convergence conditions, combined implicit characteristic method, analysis of piping system

Unit-4

Transients in long pipeline: Causes of transients, methods of controlling transient in pipes; analysis of surge tanks; transient ground water flow

Unit-5

Transient flows in open channels: Causes of transients, wave height and celerity, derivation of continuity and dynamic equations, method of characteristics, explicit-implicit finite difference method, boundary condition, and stability.

References:

1. Chaudhry, H., Hydraulic Transients, Tata McGraw Hill, 1998.
2. Chaudhry, H., Applied hydraulic transients, Van Nostrand Reinhold, New York, 1987.
3. Streeter, V.L. and Wylie, E.B., Hydraulic Transients, McGraw Hill, New York,1967

Course Outcomes (COs):

- Basic understanding of wave propagation and reflection in single pipeline, classification of hydraulic transients, causes of transients.
- The students will be able to understand dynamic and continuity equations and methods for solving their equations.
- The students will be able to understand the characteristic equation their application in analysis of piping system.

- The students will be able to understand the transients caused in long pipes, methods of controlling transient in pipes.
- The students will be able to understand the causes and analysis of transient in open channel flow.

Table 1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE52E02.1	Basic understanding of wave propagation and reflection in single pipeline, classification of hydraulic transients, causes of transients
PCE52E02.2	The students will be able to understand Dynamic and continuity equations and methods for solving their equations
PCE52E02.3	The students will be able to understand the characteristic equation their application in analysis of piping system
PCE52E02.4	The students will be able to understand the transients caused in long pipes and methods of controlling transient in pipes
PCE52E02.5	The students will be able to understand the causes and analysis of transient in open channel flow

Table 2

Slight (Low): 1; Moderate: 2; Substantial (High): 3; No Correlation: --

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE52E02.1	3	3	3	3	3	2
PCE52E02.2	3	3	2	2	2	3
PCE52E02.3	3	3	3	3	3	3
PCE52E02.4	2	2	2	2	1	2
PCE52E02.5	2	3	3	3	2	3
Total	13	14	13	13	11	13
Average	2.6	2.8	2.6	2.6	2.2	2.6
Eq. Average Attainment	3	3	3	3	2	3

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE52E02.1	3	3
PCE52E02.2	3	3
PCE52E02.3	3	3
PCE52E02.4	2	2
PCE52E02.5	2	3
Total	13	14
Average	2.6	2.8
Equivalent Average Attainment	3	3

INTEGRATED WATERSHED MANAGEMENT

Subject No: PCE52E03 **(L-T-P: 3-1-0 Credit: 4)**

Courses Objectives:

1. To understand the need for integrated watershed management and preparation of land drainage schemes.
2. To study the types, preliminary design of surface & subsurface drainage structures; to study soil erosion & soil salinity problems along with their mitigation.
3. To study the types, preliminary design of water conservation & water harvesting structures; to estimate design storm, design flood for spillways & other outlet structures.
4. To study flood routing through reservoirs, channels & basins; to study flood mitigation through reservoir operation.
5. To study types and design considerations for flood forecasting & flood protection structures; to study the flood damage quantification along with flood case studies.
6. To study various drought types and their preliminary analysis.

Course Content:

Unit-1

Introduction to integrated watershed management and preparation of land drainage schemes.

Unit-2

Types and preliminary design of surface and subsurface drainage structures; Study and Mitigation of soil erosion and soil salinity.

Unit-3

Types and preliminary design of water conservation and water harvesting structures; Estimation of design flood and design storm for spillways and other outlet structures.

Unit-4

Flood routing through reservoirs, channels and basins; Flood mitigation through reservoir operation.

Unit-5

Types and design considerations for flood forecasting and flood protection structures; Flood damage quantification and case studies.

Unit-6

Types and preliminary analysis of droughts.

References:

1.Murty, J. V. S., (1998), "Watershed management", 2nd Ed., New Age International publishers, New Delhi.

2. Brooks, K. N., Ffolliott, P. F., Magner, J. A., (2003) "Hydrology and management of watersheds", Wiley-Blackwell, Ames, Iowa, USA.

3. Mal, B. C., (1995), "Soil and water conservation engineering", Kalyani Publishers, Ludhiana, Punjab.

4. Ghosh, S. N., (2006), Flood control & drainage engineering", 3rd Ed., Oxford & IBH Publishing, New Delhi.
5. Patel, A. S. and Shah, D. L., (2008) "Water management", New Age International publishers, New Delhi.
6. Subramanya, K., (2013), "Engineering hydrology", 4th Ed., McGraw Hill Education (India), New Delhi.

Course Outcomes (COs):

Upon successful completion of the course, the students will be able to

CO1: Understand the various concepts of conservation practices in watershed management and develop related actions for land drainage.

CO2: Design and apply various management techniques to prevent soil and water conservation measures according to land capability.

CO3: Understand and apply new strategies for watershed planning measures and flood management.

CO4: Design various water harvesting and conservation structures in management of watersheds.

CO5: Use of modern techniques in droughts and watershed management.

Table 1: To establish the correlation between COs &POs

No. of Curse Outcome(CO)	Course Outcome
PCE52E03.1	Understand the various concepts of conservation practices in watershed management and develop related actions for land drainage.
PCE52E03.2	Design and apply various management techniques to prevent soil and water conservation measures according to land capability.
PCE52E03.3	Understand and apply new strategies for watershed planning measures and flood management.
PCE52E03.4	Design various water harvesting and conservation structures in management of watersheds.
PCE52E03.5	Use of modern techniques in droughts and watershed management.

Table- 2

Slight (Low): 1; Moderate: 2; Substantial (High): 3; No Correlation: --

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE52E03.1	2	3	3	2	3	3
PCE52E03.2	3	2	2	3	2	2
PCE52E03.3	3	2	3	2	3	2
PCE52E03.4	3	2	3	2	3	3
PCE52E03.5	3	2	3	3	3	2
Total	**14**	**11**	**2.8**	**11**	**14**	**12**
Average	**2.8**	**2.2**	**3**	**2.2**	**2.8**	**2.4**
Equivalent Avg. Attainment	**3**	**2**	**3**	**2**	**3**	**2**

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	PSO1	PSO2
PCE42C01.1	2	2
PCE42C01.2	2	3
PCE42C01.3	3	2
PCE42C01.4	3	3
PCE42C01.5	2	2
Total	12	12
Average	2.4	2.4
Equivalent Avg. Attainment	2	2

PRACTICAL / SESSIONAL

PROJECT PRELIMINARIES

(PCE52P01)

Total Credits	**03**	**L – T – P**	**0 – 0 – 6 = 6**

Each student will be given a Thesis/Project problem at the beginning of Second Semester. They will work on the literature survey, scope of work, equipment development etc. and submit a report/dissertation. The main Thesis/Project work will, however, be done in Third and Fourth Semester.

HYDRAULICS & WATER RESOURCES ENGINEERING LAB-II

Subject No: PCE52P02 **Contact Periods: (L-T-P: 0-0-3) Credit: 2**

Course Objectives:

- To compare the results of analytical models introduced in lecture to the actual behaviour of real fluid flows.
- To discuss and practice standard measurement techniques of fluid mechanics and their applications.
- To learn and practice writing technical reports and enable the students to work on small design projects.

Course Content:

Unit 1

Experiment on hydraulic jump, verification of Reynolds number,

Unit 2

Measurement of velocity profiles in straight open channel flow, measurement of shear stress, and experiment on boundary layer.

Unit 3

Manning's roughness coefficient, experiment on bed load.

Course Outcomes (COs):

- Identify and characterize flow patterns and regimes.
- Demonstrate practical understanding of principles, equations and instruments of fluid flow related phenomena.
- Discuss the differences among measurement techniques, their relevance and applications.
- Demonstrate the ability to produce a working model through hands-on experience in fluid mechanics design.
- Demonstrate the ability to write clear lab reports and understand ethical issues associated with decision making and professional conduct.

Table 1: To establish the correlation between COs & POs

No. of Course Outcome (CO)	Course Outcome
PCE52E02.1	Identify and characterize flow patterns and regimes.
PCE52E02.2	Demonstrate practical understanding of principles, equations and instruments of fluid flow related phenomena.
PCE52E02.3	Discuss the differences among measurement techniques, their relevance and applications.
PCE52E02.4	Demonstrate the ability to produce a working model through hands-on experience in fluid mechanics design.
PCE52E02.5	Demonstrate the ability to write clear lab reports and understand ethical issues associated with decision making and Professional conduct.

Table 2

Slight (Low): 1; Moderate: 2; Substantial (High): 3; No Correlation: --

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE52P02.1	2	3	3	3	2	2
PCE52P02.2	2	2	2	2	1	2
PCE52P02.3	3	2	3	3	3	3
PCE52P02.4	1	3	3	2	2	2
PCE52P02.5	3	3	2	3	3	2
Total	11	13	13	13	11	11
Average	2.2	2.6	2.6	2.6	2.2	2.2
Eq. average attainment	2	3	3	3	2	2

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE52P02.1	2	3
PCE52P02.2	2	2
PCE52P02.3	3	2
PCE52P02.4	1	3
PCE52P02.5	3	3
Total	11	13
Average	2.2	2.6
Equivalent average attainment	2	3

COMPUTER APPLICATIONS IN WATER RESOURCES ENGINEERING

Subject No: PCE52P03 **(L-T-P: 0-0-3, Credit: 2)**

Course Objectives:

- To provide basic knowledge on how to implement software's for solving practical and research related problems.
- To provide skills for writing programs.
- To enable and motivate the students perform analysis using software's for various research works and projects.

Course Content:

Unit 1. Computer programming on solving free surface flow problem, Ground water hydrology, and Surface hydrologic analysis and simulation problem,

Unit 2. GIS application in various field.

Unit 3. Study of LIDAR, IOT, UAV etc.

Course Outcomes (COs):

- Perform MATLAB, ANSYS and MIKE/MIKE-21C effectively and efficiently.
- Case studies on use of GIS selected from various areas such as water and land resources, environment, transportation, and land use application.
- Analyze various practical problems using GIS/Arc-GIS, LIDAR, IOT, UAV

Table 1: To establish the correlation between Cos & POs

No. of Course Outcome (CO)	Course Outcome
PCE51P02.1	Perform MATLAB, ANSYS and MIKE/MIKE-21C effectively and efficiently.
PCE51P02.2	Case studies on use of GIS selected from various areas such as water and land resources, environment, transportation, landuse application.
PCE51P02.3	Analyse various practical problems using GIS/Arc-GIS, LIDAR, IOT, UAV

Table 2

Slight (Low): 1; Moderate: 2; Substantial (High): 3; No Correlation: --

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE51P02.1	3	3	4	4	3	3
PCE51P02.2	3	2	3	3	3	2
PCE51P02.3	3	2	3	3	3	3
Total	9	7	10	10	9	8
Average	3	2.33	3.33	3.33	3	2.7
Eq. Average Attainment	3	2	3	3		3

Table 3: To establish a correlation between Course outcomes (Cos) & Program specific objectives (PSOs)

CO	[PSO]1	[PSO]2
PCE51P02.1	3	3
PCE51P02.2	3	2
PCE51P02.3	3	2
Total	9	7
Average	3	2.33
Equivalent Average Attainment	3	2

COMPREHENSIVE VIVA-VOCE

Subject code: PCE52P04 **Credit-2**

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

THIRD SEMESTER

PROJECT & THESIS (PCE53P01) Credit: 10

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. He/She 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.

THIRD SEMESTER			No. of Classes/Week			Total Credit
Sl.no.	Subject Code	Name of the Subject	Lecture	Tutorial	Practical	
1	PCE53P01	Project & Thesis	00	00	Full	10

FOURTH SEMESTER

PROJECT & THESIS (PCE54P01) Credit: 20

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. He/She 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.

FOURTH SEMESTER			No. of Classes/Week			Total Credit
Sl.no.	Subject Code	Name of the Subject	Lecture	Tutorial	Practical	
1	PCE54P01	Project & Thesis	00	00	Full	20