

## SEMESTER-V

S. No.	Subject Code	Subject	L	T	P	Credit
1	PCC-CE508	Hydraulic Engineering	3	1	2	5
2	PCC-CE509	Geotechnical Engineering	3	1	2	5
3	PCC-CE510	Environmental Engineering	3	1	2	5
4	PCC-CE511	Transportation Engineering	3	1	2	5
5	PCC-CE512	Hydrology & Water Resources	3	1	0	4
6	PEC-CE501	Elective-I	3	0	0	3
<b>Total</b>						<b>27</b>

<b>PCC-CE508</b>	<b>Hydraulic Engineering</b>	<b>3L:1T:2P</b>	<b>5 credits</b>
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### **Objectives:**

To introduce the students to various hydraulic engineering problems like open channel flows and hydraulic machines. At the completion of the course, the student should be able to relate the theory and practice of problems in hydraulic engineering

**Module 1:** Laminar Flow- Laminar flow through: circular pipes, annulus and parallel plates. Stoke's law, Measurement of viscosity.

**Module 2:** Turbulent Flow- Reynolds experiment, Transition from laminar to turbulent flow. Definition of turbulence, scale and intensity, Causes of turbulence, instability, mechanism of turbulence and effect of turbulent flow in pipes. Reynolds stresses, semi-empirical theories of turbulence, Prandtl's mixing length theory, universal velocity distribution equation. Resistance to flow of fluid in smooth and rough pipes, Moody's diagram.

**Module 3:** Boundary Layer Analysis-Assumption and concept of boundary layer theory. Boundary-layer thickness, displacement, momentum & energy thickness, laminar and Turbulent boundary layers on a flat plate; Laminar sub-layer, smooth and rough boundaries. Local and average friction coefficients. Separation and Control.

**Module 4:** Dimensional Analysis and Hydraulic Similitude: Dimensional homogeneity, Rayleigh method, Buckingham's Pi method and other methods. Dimensionless groups. Similitude, Model studies, Types of models. Application of dimensional analysis and model studies to fluid flow problem.

**Module 5:** Introduction to Open Channel Flow-Comparison between open channel flow and pipe flow, geometrical parameters of a channel, classification of open

channels, classification of open channel flow, Velocity Distribution of channel section.

**Module 6:** Uniform Flow-Continuity Equation, Energy Equation and Momentum Equation, Characteristics of uniform flow, Chezy's formula, Manning's formula. Factors affecting Manning's Roughness Coefficient "n". *Most economical section of channel.* Computation of Uniform flow, Normal depth.

**Module 7:** Non-Uniform Flow- Specific energy, Specific energy curve, critical flow, discharge curve Specific force Specific depth, and Critical depth. Channel Transitions. Measurement of Discharge and Velocity – Venturi Flume, Standing Wave Flume, Parshall Flume, Broad Crested Weir. Measurement of Velocity-Current meter, Floats, Hot-wire anemometer. Gradually Varied Flow-Dynamic Equation of Gradually Varied Flow, Classification of channel bottom slopes, Classification of surface profile, Characteristics of surface profile. Computation of water surface profile by graphical, numerical and analytical approaches. Direct Step method, Graphical Integration method and direct integration method.

**Module 8:** Hydraulic Jump- Theory of hydraulic jump, Elements and characteristics of hydraulic jump in a rectangular Channel, length and height of jump, location of jump, Types, applications and location of hydraulic jump. Energy dissipation and other uses, surge as a moving hydraulic jump. Positive and negative surges. Dynamics of Fluid Flow- Momentum principle, applications: Force on plates, pipe bends, moments of momentum equation,

**Module 9:** Flow through Pipes: Loss of head through pipes, Darcy-Wiesbatch equation, mi- nor losses, total energy equation, hydraulic gradient line, Pipes in series, equivalent pipes, pipes in parallel, flow through laterals, flows in dead end pipes, siphon, power transmission through pipes, nozzles. Analysis of pipe networks: Hardy Cross method, water hammer in pipes and control measures, branching of pipes, three reservoir problem.

**Module 10:** Computational Fluid Dynamics: Basic equations of fluid dynamics, Grid generation, Introduction to in viscous incompressible flow, Boundary layer flow as applicable to C.F.D. Hydro informatics: Concept of hydro informatics – scope of internet and web based modeling in water resources engineering.

### Practical Work:

1. Flow Visualization
2. Studies in WindTunnel
3. BoundaryLayer
4. Flow around an Aerofoil / circular cylinder
5. UniformFlow
6. Velocity Distribution in Open channel flow
7. VenturiFlume
8. Standing Wave Flume
9. Gradually VariedFlow
10. HydraulicJump
11. Flow under SluiceGate
12. Flow through pipes
13. Turbulent flow through pipes
14. Flow visualization

15. Laminar flow through pipes
16. Major losses / Minor losses in pipe

**Text/Reference Books:**

1. Hydraulics and Fluid Mechanics, P.M. Modi and S.M. Seth, Standard BookHouse
2. Theory and Applications of Fluid Mechanics, K. Subramanya, Tata McGrawHill.
3. Open channel Flow, K. Subramanya, Tata McGrawHill.
4. Open Channel Hydraulics, Ven TeChow, Tata McGrawHill.
5. Burnside, C.D., "Electromagnetic Distance Measurement," Beekman Publishers, 1971.

**Outcomes:**

- The students will be able to apply their knowledge of fluid mechanics in addressing problems in open channels.
- They will possess the skills to solve problems in uniform, gradually and rapidly varied flows in steady state conditions.
- They will have knowledge in hydraulic machineries (pumps and turbines).

<b>PCC-CE509</b>	<b>Geotechnical Engineering</b>	<b>3L:1T:2P</b>	<b>5 credits</b>
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**Module 1:** *Introduction*—Types of soils, their formation and deposition, Definitions: soil mechanics, soil engineering, rock mechanics, geotechnical engineering. Scope of soil engineering. Comparison and difference between soil and rock. Basic Definitions and Relationships- Soil as three-phase system in terms of weight, volume, voids ratio, and porosity. Definitions: moisture content, unit weights, degree of saturation, voids ratio, porosity, specific gravity, mass specific gravity, etc. Relationship between volume weight, voids ratio- moisture content, unit weight- percent air voids, saturation- moisture content, moisture content- specific gravity etc. Determination of various parameters such as: Moisture content by oven dry method, pycnometer, sand bath method, torsional balance method, nuclear method, alcohol method and sensors. Specific gravity by density bottle method, pycnometer method, measuring flask method. Unit weight by water displacement method, submerged weight method, core-cutter method, sand-replacement method.

On completion of this module, the students must be able to:

- Understand the different types of soil based on their formation mechanism;
- Understand the various phase diagrams and derive various phase relationships of the soil;
- Perform various laboratory experiments to determine moisture content, specific gravity;
- Perform field experiments to estimate the field density of the soil mass.

**Module 2:** *Plasticity Characteristics of Soil* - Introduction to definitions of: plasticity of soil, consistency limits-liquid limit, plastic limit, shrinkage limit,

plasticity, liquidity and consistency indices, flow & toughness indices, definitions of activity and sensitivity. Determination of: liquid limit, plastic limit and shrinkage limit. Use of consistency limits. Classification of Soils-Introduction of soil classification: particle size classification, textural classification, unified soil classification system, Indian standard soil classification system. Identification: field identification of soils, general characteristics of soil in different groups. On completion of this module, the students must be able to:

- Understand the behaviour of soils based on their moisture contents;
- Perform laboratory experiments to estimate various Waterberg limits and evaluate index properties of soils;

Classify any soils based on their particle size distribution and index properties;

**Module 3: Permeability of Soil** - Darcy's law, validity of Darcy's law. Determination of coefficient of permeability: Laboratory method: constant-head method, falling-head method. Field method: pumping- in test, pumping- out test. Permeability aspects: permeability of stratified soils, factors affecting permeability of soil. Seepage Analysis- Introduction, stream and potential functions, characteristics of flow nets, graphical method to plot flow nets.

On completion of this module, the student must be able to:

- Determine the permeability of soils through various laboratory and field tests;
- Analytically calculate the effective permeability of anisotropic soil mass;
- Determine the seepage quantities and pore water pressures below the ground; graphically plot the equipotential lines and flow lines in a seepage flow.

**Module 4: Effective Stress Principle** - Introduction, effective stress principle, nature of effective stress, effect of water table. Fluctuations of effective stress, effective stress in soils saturated by capillary action, seepage pressure, quick sand condition.

On completion of this module, the student must be able to:

- Understand the physical significance of effective stress and its relation with pore pressure;
- Plot various stress distribution diagrams along the depth of the soil mass;
- Understand the effect of capillary action and seepage flow direction on the effective stress at a point in the soil mass.

**Module 5: Compaction of Soil**-Introduction, theory of compaction, laboratory determination of optimum moisture content and maximum dry density. Compaction in field, compaction specifications and field control.

On completion of this module, the student must be able to:

- Perform laboratory test to determine the maximum dry density and optimum moisture content of the soil;
- Variation in compaction curve with compaction effort and soil type;
- Determine the compactive effort required to obtain necessary degree of compaction in situ;
- Differentiate among various field methods of compaction and their

usage based on the type of soil.

**Module 6: Stresses in soils** – Introduction, stresses due to point load, line load, strip load, uniformly loaded circular area, rectangular loaded area. Influence factors, Isobars, Boussinesq's equation, Newmark's Influence Chart. Contact pressure under rigid and flexible area, computation of displacements from elastic theory.

On completion of this module, the student must be able to:

- Analytically compute the vertical stress in a semi-infinite soil mass due to various loading conditions;

Plot isobars due various loading conditions.

**Module 7: Consolidation of Soil** - Introduction, comparison between compaction and consolidation, initial, primary & secondary consolidation, spring analogy for primary consolidation, interpretation of consolidation test results, Terzaghi's theory of consolidation, final settlement of soil deposits, computation of consolidation settlement and secondary consolidation.

On completion of this module, the student must be able to:

- Understand the basic mechanism of consolidation of soil;
- Determine various consolidation parameters of soil through laboratory test;
- Evaluate ground settlements against time.

**Module 8: Shear Strength** - Mohr circle and its characteristics, principal planes, relation between major and minor principal stresses, Mohr-Coulomb theory, types of shear tests: direct shear test, merits of direct shear test, triaxial compression tests, test behaviour of UU, CU and CD tests, pore-pressure measurement, computation of effective shear strength parameters .un-confined compression test, vane shear test

On completion of this module, the student must be able to:

- Determine graphically and analytically the stress state in any plane of the soil mass;
- Perform various shear strength tests and appreciate the different field conditions which they simulate;
- Understand the significance of shear strength parameters in various geotechnical analyses;
- Evaluate the stiffness of soil using shear strength parameters

**Module 9: Stability of Slopes** - Introduction, types of slopes and their failure mechanisms, factor of safety, analysis of finite and infinite slopes, wedge failure Swedish circle method, friction circle method, stability numbers and charts.

On completion of this module, the student must be able to:

- Differentiate various modes of slope failure;
- Evaluate factor of safety of infinite slopes based on different ground conditions;
- Understand various methods for computation of factor of safety for finite slopes.

**Module 10:Soil Exploration-** Introduction, methods of site exploration and soil investigation, methods of boring, soil samplers, sampling procedures, trail pits, borings, penetrometer tests, analysis of borehole logs, geophysical and advance soil exploration methods.

On completion of this module, the student must be able to:

- Specify a strategy for site investigation to identify the soil deposits and determine the depth and spatial extent within the ground;
- Understand various site investigation techniques and their in-situ applications;
- Prepare a soil investigation report based on borehole log data and various in-situ tests like SPT, CPT, etc.

**Practical Work:** List of tests on-

1. Field Density using Core Cutter method.
2. Field Density using Sand replacement method.
3. Natural moisture content using Oven Drying method.
4. Field identification of Fine Grained soils.
5. Specific gravity of Soils.
6. Grain size distribution by Sieve Analysis.
7. Grain size distribution by Hydrometer Analysis.
8. Consistency limits by Liquid limit
9. Consistency limits by Plastic limit
10. Consistency limits by Shrinkage limit.
11. Permeability test using Constant-head test method.
12. Permeability test using Falling-head method.
13. Compaction test: Standard Proctor test.
14. Compaction test: Modified Proctor test.
15. Relative density.
16. ConsolidationTest.
17. Triaxial Test(UU)
18. Vane shear Test
19. Direct ShearTest
20. Unconfined Compression StrengthTest.

**Text/Reference Books:**

1. Soil Mechanics by Craig R.F., Chapman & Hall
2. Fundamentals of Soil Engineering by Taylor, John Wiley & Sons
3. An Introduction to Geotechnical Engineering, by Holtz R.D. and Kovacs, W.D., Prentice Hall,NJ
4. Principles of Geotechnical Engineering, by Braja M. Das, CengageLearning
5. Principles of Foundation Engineering, by Braja M. Das, CengageLearning
- Essentials of Soil Mechanics and Foundations: Basic Geotechnics by David F. McCarthy
6. Soil Mechanics in Engineering Practice by Karl Terzaghi, Ralph B. Peck, and GholamrezaMesri.
7. Geotechnical Engineering: Principles and Practices of Soil Mechanics andFoundation Engineering (Civil and Environmental Engineering) by V.N.S.Murthy.

<b>PCC-CE510</b>	<b>Environmental Engineering</b>	<b>3L:1T:2P</b>	<b>5 credits</b>
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**Module 1: Water:** -Sources of Water and quality issues, water quality requirement for different beneficial uses, Water quality standards, water quality indices, water safety plans, Water Supply systems, Need for planned water supply schemes, Water demand industrial and agricultural water requirements, Components of water supply system; Transmission of water, Distribution system, Various valves used in W/S systems, service reservoirs and design. **Water Treatment:** aeration, sedimentation, coagulation flocculation, filtration, disinfection, advanced treatments like adsorption, ion exchange, membrane processes

**Module 2: Sewage-** Domestic and Storm water, Quantity of Sewage, Sewage flow variations. Conveyance of sewage- Sewers, shapes design parameters, operation and maintenance of sewers, Sewage pumping; Sewerage, Sewer appurtenances, Design of sewerage systems. Small bore systems, Storm Water- Quantification and design of Storm water; Sewage and Sulage, Pollution due to improper disposal of sewage, National River cleaning plans, Wastewater treatment, aerobic and anaerobic treatment systems, suspended and attached growth systems, recycling of sewage – quality requirements for various purposes.

**Module 3: Air** - Composition and properties of air, Quantification of air pollutants, Monitoring of air pollutants, Air pollution- Occupational hazards, Urban air pollution automobile pollution, Chemistry of combustion, Automobile engines, quality of fuel, operating conditions and interrelationship. Air quality standards, Control measures for Air pollution, construction and limitations

**Module 4: Noise-** Basic concept, measurement and various control methods.

**Module5: Solid waste management**-Municipal solid waste, Composition and various chemical and physical parameters of MSW, MSW management: Collection, transport, treatment and disposal of MSW. Special MSW: waste from commercial establishments and other urban areas, solid waste from construction activities, biomedical wastes, Effects of solid waste on environment: effects on air, soil, water surface and ground health hazards, Disposal of solid waste-segregation, reduction at source, recovery and recycle. Disposal methods- Integrated solid waste management. Hazardous waste: Types and nature of hazardous waste as per the HW Schedules of regulating authorities.

**Module 6: Building Plumbing**-Introduction to various types of home plumbing systems for water supply and waste water disposal, high rise building plumbing, Pressure reducing valves, Break pressure tanks, Storage tanks, Building drainage for high rise buildings, various kinds of fixtures and fittings used.

**Module 7:** Government authorities and their roles in water supply, sewerage disposal Solid waste management and monitoring/control of environmental pollution.

### **Practical Work: List of Experiments**

1. Physical Characterization of water: Turbidity, Electrical Conductivity, pH
2. Analysis of solids content of water: Dissolved, Settleable, suspended, total, volatile, inorganic etc.
3. Alkalinity and acidity, Hardness: total hardness, calcium and

magnesiumhardness

4. Analysis of ions: copper, chloride andsulfate
5. Optimum coagulantdose
6. Chemical Oxygen Demand(COD)
7. Dissolved Oxygen (D.O) and Biochemical Oxygen Demand(BOD)
8. Break pointChlorination
9. Bacteriological quality measurement:MPN,
10. Ambient Air quality monitoring (TSP, RSPM, SO<sub>x</sub>,NO<sub>x</sub>)
11. Ambient noisemeasurement

### **Text/Reference Books:**

1. Introduction to Environmental Engineering and Science by Gilbert Masters, Prentice Hall, New Jersey.
2. Introduction to Environmental Engineering by P. AarneVesilind, Susan M. Morgan, Thompson /Brooks/Cole; Second Edition2008.
3. Peavy, H.s, Rowe, D.R, Tchobanoglous, G. *Environmental Engineering*, Mc-Graw - Hill International Editions, New York1985.
4. MetCalf and Eddy. *Wastewater Engineering, Treatment, Disposal and Reuse*, Tata McGraw-Hill, NewDelhi.
5. Manual on Water Supply and Treatment. Ministry of Urban Development, NewDelhi.
6. Plumbing Engineering. Theory, Design and Practice, S.M. Patil,1999
7. Integrated Solid Waste Management, Tchobanoglous, Theissen&Vigil. McGrawHill Publication
8. Manual on Sewerage and Sewage Treatment Systems, Part A, B and C. Central Public Health and Environmental Engineering Organization, Ministry of Urban Development.

### **Outcomes:**

After successfully studying this course, students will:

- Understand the impact of humans on environment and environment onhumans
- Be able to identify and value the effect of the pollutants on the environment: atmosphere, water andsoil.
- Be able to plan strategies to control, reduce and monitorpollution.
- Be able to select the most appropriate technique for the treatment of water, wastewater solid waste and contaminatedair.
- Be conversant with basic environmentallegislation.

<b>PCC-CE511</b>	<b>Transportation Engineering</b>	<b>3L:1T:2P</b>	<b>5 credits</b>
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**Module 1:** Highway development and planning-Classification of roads, road development in India, Current road projects in India; highway alignment and project preparation.

**Module 2:** Geometric design of highways:- Introduction; highway cross section elements; sight distance, design of horizontal alignment; design of vertical alignment; design of inter- sections, problems

**Module 3:** Traffic engineering & control- Traffic Characteristics, traffic engineering studies, traffic flow and capacity, traffic regulation and control; design of road intersections; design of parking facilities; highway lighting; problems

**Module 4:** Pavement materials- Materials used in Highway Construction- Soils, Stone aggregates, bituminous binders, bituminous paving mixes; Portland cement and cement concrete: desirable properties, tests, requirements for different types of pavements. Problems

**Module 5:** Design of pavements- Introduction; flexible pavements, factors affecting design and performance; stresses in flexible pavements; design of flexible pavements as per IRC; rigid pavements- components and functions; factors affecting design and performance of CC pavements; stresses in rigid pavements; design of concrete pavements as per IRC; problems

**Text/Reference Books:**

1. Khanna, S.K., Justo, C.E.G and Veeraragavan, A, 'Highway Engineering', Revised 10th Edition, Nem Chand & Bros,2017
2. Kadiyalai, L.R., ' Traffic Engineering and Transport Planning', KhannaPublishers.
3. Partha Chakraborty, ' Principles Of Transportation Engineering, PHILearning,
4. Fred L. Mannering, Scott S. Washburn, Walter P. Kilaresski,'Principles of Highway Engineering and Traffic Analysis', 4th Edition, JohnWiley
5. Srinivasa Kumar, R, Textbook of Highway Engineering, Universities Press,2011.
6. PaulH.WrightandKarenK.Dixon,HighwayEngineering,7<sup>th</sup>Edition, WileyStudent Edition, 2009.

**On completion of the course, the students will be able to:**

- carry out surveys involved in planning and highway alignment
- design the geometric elements of highways and expressways
- carry out traffic studies and implement traffic regulation and control measures and intersection design
- characterize pavement materials and
- design flexible and rigid pavements as per IRC

PCC-CE512	Hydrology and Water Resources	3L:1T:0P	4 credits
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**Module 1:** *Introduction* - hydrologic cycle, water-budget equation, history of hydrology, world water balance, applications in engineering, sources of data.

**Module 2:** *Precipitation* - forms of precipitation, characteristics of precipitation in India, measurement of precipitation, rain gauge network, mean precipitation over an area, depth- area-duration relationships, maximum intensity/depth-duration-frequency relationship, Probable Maximum Precipitation (PMP), rainfall data in India.

**Module 3:** *Abstractions from precipitation* - evaporation process, evaporimeters, analytical methods of evaporation estimation, reservoir evaporation and methods for its reduction, evapo-transpiration, measurement of evapo-transpiration, evapo-transpiration equations, potential evapo-transpiration over India, actual evapotranspiration, interception, depression storage, infiltration, infiltration capacity, measurement of infiltration, modelling infiltration capacity, classification of infiltration capacities, infiltration indices.

**Module 4:** *Runoff*- runoff volume, SCS-CN method of estimating runoff volume, flow- duration curve, flow-mass curve, hydrograph, factors affecting runoff hydrograph, components of hydrograph, base flow separation, effective rainfall, unit hydrograph surface water resources of India, environmental flows.

**Module 5:** *Ground water and well hydrology* - forms of subsurface water, saturated formation, aquifer properties, geologic formations of aquifers, well hydraulics: steady state flow in wells, equilibrium equations for confined and unconfined aquifers, aquifer tests.

**Module 6:** *Water withdrawals and uses* – water for energy production, water for agriculture, water for hydroelectric generation; flood control. Analysis of surface water supply, Water requirement of crops-Crops and crop seasons in India, cropping pattern, duty and delta; Quality of irrigation water; Soil-water relationships, root zone soil water, infiltration, consumptive use, irrigation requirement, frequency of irrigation; Methods of applying water to the fields: surface, sub-surface, sprinkler and trickle / drip irrigation.

**Module 7:** *Distribution systems* - canal systems, alignment of canals, canal losses, estimation of design discharge. Design of channels- rigid boundary channels, alluvial channels, Kennedy's and Lacey's theory of regime channels. Canal outlets: non-modular, semi-modular and modular outlets. Water logging: causes, effects and remedial measures, Lining of canals, types of lining. Drainage of irrigated lands: necessity, methods.

**Module 8:** *Dams and spillways* - embankment dams: Classification, design considerations, estimation and control of seepage, slope protection. Gravity dams: forces on gravity dams, causes of failure, stress analysis, elementary and practical profile. Arch and buttress dams. Spillways: components of spillways, types of gates for spillway crests; Reservoirs- Types, capacity of reservoirs, yield of reservoir, reservoir regulation, sedimentation, economic height of dam, selection of suitable site.

#### **Text/Reference Books:**

1. K Subramanya, Engineering Hydrology, Mc-GrawHill.
2. K N Muthreja, Applied Hydrology, Tata Mc-GrawHill.
3. K Subramanya, Water Resources Engineering through Objective Questions, Tata Mc- Graw Hill.
4. G L Asawa, Irrigation Engineering, WileyEastern
5. L W Mays, Water Resources Engineering, Wiley.
6. J D Zimmerman, Irrigation, John Wiley & Sons
7. C S P Ojha, R Berndtsson and P Bhunya, Engineering Hydrology, Oxford.

## **Outcomes:**

At the end of the course, students must be in a position to:

- Understand the interaction among various processes in the hydrologic cycle
- Apply the application of fluid mechanics and use of computers in solving a host of problems in hydraulic engineering
- Study types and classes of hydrologic simulation models and design procedures for safe and effective passage of flood flows for design of hydraulic structures
- Understand the basic aquifer parameters and estimate groundwater resources for different hydro-geological boundary conditions
- Understand application of systems concept, advanced optimization techniques to cover the socio-technical aspects in the field of water resources
- Apply the principles and applications of remote sensing, GPS and GIS in the context to hydrological extreme flood and drought events in water resources engineering