COURSE STRUCTURE

PH.D.

CIVIL ENGINEERING

Under

Choice Based Credit System (CBCS)

Program Elective

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS	CONTACTS HRS/WK
			L	T	P		
1	PCEC 0002	Advanced Concrete Technology	4	0	0	4	4
2	PCEC 0001	Non Conventional Construction Materials & elements	4	0	0	4	4
3	PCEC 0003	Retrofitting of Structures	4	0	0	4	4
4	PCEC 0004	Numerical Methods and Applied Statistics	4	0	0	4	4
5	PTEC 0002	Numerical Methods and Applied Statistics	4	0	0	4	4
6	PCEC 0005	Environmental Impact and Risk Assessment	4	0	0	4	4
7	PTEC 0001	Pavement Analysis and Design	4	0	0	4	4
8	PREC 0001	Research Methodology	4	0	0	4	4
9	PMG 1001	Research Methodology	4	0	0	4	4
10	PREC 0010	Research and Publication Ethics	4	0	0	4	4
11	PCEC 0101	Ground Improvement Method	4	0	0	4	4
12	PCEC 0006	Durability and Chemical Degradation of Concrete	4	0	0	4	4
13	PCEC 113	Advance remote sensing and GIS	4	0	0	4	4
14	PCEC 114	Advance Hydrology	4	0	0	4	4

PCEC 0002: ADVANCED CONCRETE TECHNOLOGY

Objective: *This course provides a comprehensive treatment of the materials and civil engineering principles which results in production and construction of high quality concrete for buildings and Infrastructure*

Credits: 04 **L-T-P: 4-0-0**

Module No.	Content	Teaching Hours
I	**Cement production, composition and cement chemistry:** Importance of Bogue's compounds, Structure of a Hydrated Cement Paste, Volume of hydrated product, porosity of paste and concrete, transition Zone, Elastic Modulus, factors affecting strength and elasticity of concrete **Aggregates for concrete:** Review of types and classification; chemical composition; origin and manufacture; actions and interactions; usage; effects on properties of concretes **Chemical admixtures**: Mechanism of chemical admixture, Plasticizers and super Plasticizers and their effect on concrete property in fresh and hardened state, Marsh cone test for optimum dosage of super plasticizer, retarder, accelerator, Air-entraining admixtures, new generation superplasticizer. **Mineral admixtures:** Fly ash, Silica fume, GCBS, and their effect on concrete property in fresh state and hardened state.	20
II	**Fresh concrete:** Rheology of concentrated suspensions, pastes, mortars and concretes; workability, segregation and bleeding. Theory and principles governing the correct placing and compaction of concrete. **Properties of hardened concrete:** Plastic settlement and plastic shrinkage; exothermic characteristics; early age thermal movements; strength development; maturity, accelerated curing Strength; deformation under load; elasticity; creep; drying shrinkage and other volume changes. Thermal properties. **Durability of concrete:** Durability concept; pore structure and transport processes; reinforcement corrosion; fire resistance; frost damage; sulfate attack; alkali silica reaction; delayed Ettringite formation; methods of providing durable concrete; short-term tests to assess long-term behaviour.	20

Reference Books:

- M. Neville, Properties of Concrete, Pearson education (2012).
- Performance Criteria for Concrete Durability, E & F N Spon, London.- J. Kroop and H.K.Hilsdorf(2004).
- Concrete Construction Engineering Hand Book, CRC Press, New York.- Edward G Nawy (2008).
- Concrete Technology, theory and Practice, S.Chand- M. S. Shetty(2000)
- Concrete Technology, Theory and Practice, McGraw Hill.- M. L. Gambhir(2013)
- Concrete, Tata Mc Graw Hill.,- P.K.Mehta & Paulo J.M.Monterio (2005)
- Advances in Cement Technology, Tech Book International, New Delhi.-S.N.Ghosh (2006).

Focus: This course focuses on employability aligned with CO3 and CO4

Course Outcomes:

- Understand the structure and properties of concrete making materials
- Discuss the concrete ingredients and its influence at gaining strength.
- Understand the durability requirements of fresh concrete
- Identify Quality Control tests hardened concrete

- Design concrete mixes as per IS codes

PCEC 0001: NON-CONVENTIONAL CONSTRUCTION MATERIALS & ELEMENTS

Objective: This course provides knowledge on the application and uses of various different types of concrete which results in production and construction of high quality concrete for buildings and infrastructure

Credits: 04 **L-T-P: 4-0-0**

Module No.	Contents	Teaching Hours
I	**Ferro cement:** Introduction to Ferro cement design principals, materials used, manufacture of Ferro cement elements, Type of members commonly used, use of Ferro cement in rehabilitation of Structures. **Fiber reinforced concrete:** Various types of fibers like glass, steel, asbestos etc. Physical & Mechanical Properties, Use of Fiber Reinforced Concrete in structural elements.	19
II	**Light weight concrete:** Various types of light weight aggregate, physical and mechanical properties. Introduction to structural plastics and similar elements. Smart materials, Environment friendly materials **Polymers and Polymer Concrete:** Physical and mechanical properties and its use in Civil Engineering. Introduction to Bamboo in Civil Construction, Cementitious composite reinforced with vegetable and hybrid fibers, Construction with Earth	21

Reference Books:

- A. M. Neville, Properties of Concrete, Pearson education (2012).
- Concrete for High Temperature, Maclaren and sons, London- A. Petzold & M.Rohrs (1970).
- Advances in Cement Technology, Tech Book International, New Delhi.- S.N. Ghosh (2006).
- Concrete, Tata Mc Graw Hill.,- P.K.Mehta & Paulo J.M.Monterio(2005)

- **Focus:** This course focuses on employability & Skill development aligned with CO3 and CO4

Focus: This course focuses on employability aligned with CO1

Course Outcomes:

- Understand the application and use of Ferro cement
- Describe the application and use of Fiber reinforced concrete
- Describe the application and use of Light weight concrete
- Understand the application and use of Polymers and Polymer Concrete
- Understand the application and use of Construction with Earth

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PCEC 0003: RETROFITTING OF STRUCTURES

Objective: The objective of this course is to develop knowledge about various mechanisms of deterioration of reinforced and plain concrete, its estimate and rehabilitation

Credits: 04 **L-T-P: 4-0-0**

Module No.	Contents	Teaching Hours
I	Durability of concrete: Factors affecting durability of concrete, Corrosion of reinforcements in concrete, Carbonation, Chloride ingress, Alkali-silica reaction, Freeze-thaw effects, Chemical attack, Abrasion, erosion and cavitation, Weathering and efflorescence Defects and deterioration in buildings, Survey and assessment of structural conditions in RCC structures. Damage/condition assessment and various methods (for quantification) for its evaluation, Rapid Visual Screening (RVS) and ways to do RVS of damaged/deteriorated structures, Overview of health monitoring techniques.	20
II	Non-destructive testing of concrete quality, Non-destructive testing of connections in steel, Corrosion assessment in reinforcements in RCC elements and components in steel structures; Design principles, techniques and working mechanism various instruments used for NDT evaluations (for strength, durability etc.) like Rebound Hammer, UPV, impact echo etc.; Technology used in various advanced instruments like Imaging techniques, GPR, Thermography, Tomography etc. Materials for repairs, rehabilitation and retrofitting processes, Methods for repairs, rehabilitation and retrofitting including surface preparation, Study of failures of buildings and lesson learnt, Role of quality control in construction as Preventive measures Maintenance of buildings.	20

Reference Books:

- Technology of Building Repairs, Raikar R N
- The Bombay Building Repairs & Reconstruction Board Act 1969, Govt. of Maharashtra
- Maintenance & Repairs of Buildings, P. K. Guha
- Concrete Structures Protection Repair and Rehabilitation, R. Dodge Woodson, Elsevier Publication
- Construction, Maintenance & Restoration and Rehabilitation of Highway Bridges, K. S. Rakshit
- Retrofitting of Concrete Structures by Externally Bonded FRP's – CEB – FIP, Technical report,

Focus: This course focuses on employability aligned with CO3 and CO4

Outcome: After completion of course, the student will be able to:

- CO1: Detect defects and deterioration in buildings.
- CO2: Assessment of structural conditions in R.C.C. structures.
- CO3: Understand and apply rehabilitation and retrofitting process and their field applications
- CO4:Analyze non-destructive testing methods and their field applications
- CO5: Interpretation of the results for concrete and steel structures.

PCEC0004: NUMERICAL METHODS AND APPLIED STATISTICS

Objective: *To provides the tools and techniques for data collection and analysis.*

Credits: 04 **L-T-P-J: 4-0-0-0**

Module No.	Content	Teaching Hours
01	**Sampling Theory**: Population Parameter, Sample Statistics, Sampling distributions, Sample mean, Sampling distribution of means, the sample variance, the sampling distribution of variance. **Estimation Theory:** Point estimate and interval estimates, reliability, confidence interval estimates of population parameters, confidence intervals for means, proportions and variance. **Tests of Hypothesis and Significance:** Statistical decisions, tests of hypotheses and significance, Type I and Type II errors, level of significance, one tailed and two tailed tests. Tests involving small samples and large samples, fitting theoretical distributions to sample frequency distribution, The chi, square test for goodness of fit. **Linear Programming:** Formulation of linear programming problem, Graphical solution, simplex method	20
02	**Introduction**, roots of a non-linear equation and roots of a polynomial of nth degree [incremental search method, method of successive approximations, Newton's method, bisection method, secant method, Müller's method, synthetic division, Bairstow's method] and convergence study Solution of (non-homogeneous) linear algebraic equations, review of matrix algebra, Gauss elimination method, Cholesky's decomposition method, householder method, Gauss-Siedal iterative method 12 II **Solution of non-linear algebraic equations**, method of successive approximation, Newton's method, modified Newton – Raphson method, secant method Eigen values and Eigen vectors, reduction of generalized Eigen value problem to the standard Eigen value problem, methods for obtaining Eigen values and Eigen vectors [polynomial method, vector iteration method, Mises power method, Jacobi method]	20

Reference Books:

- M.R. Speigel, Probability and Statistics, McGraw Hill,
- C.R. Kothari, Research methodology: Methods and techniques. New Age International.
- H.A. Taha, Operation Research, Prentice Hall of India Pvt. Ltd.
- Miller and Freund, Probability and Statistics for Engineers.
- J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, New Delhi.
- Chapra, S. C. and Canale R. P., "Numerical Methods for Engineers", Tata McGraw hill.
- Carnahan, B., Luther, H. A. and Wilkes, J. O., "Applied Numerical Methods", John Wiley.
- Douglas Faires, J. and Richard Burden, "Numerical Methods", Thomson.
- Rajasekaran, S., "Numerical Methods in Science and Engineering", S. Chand.

Focus: This course focuses on employability aligned with CO1, CO3 and CO4

Outcome: After completion of course, the student will be able to:

- CO1: Understand the concept of sampling theory and estimation theory
- CO2: Understand the concept of Hypothesis and testing of Hypothesis
- CO3: Analyze the polynomial of nth degree
- CO4: Understand the matrix algebra and solution of non-linear algebraic equations

PTEC0002: NUMERICAL METHODS AND APPLIED STATISTICS

Objective: *To provides the tools and techniques for data collection and analysis.*

Credits: 04 **L-T-P-J: 4-0-0-0**

Module No.	Content	Teaching Hours
01	**Sampling Theory**: Population Parameter, Sample Statistics, Sampling distributions, Sample mean, Sampling distribution of means, the sample variance, the sampling distribution of variance. **Estimation Theory:** Point estimate and interval estimates, reliability, confidence interval estimates of population parameters, confidence intervals for means, proportions and variance. **Tests of Hypothesis and Significance:** Statistical decisions, tests of hypotheses and significance, Type I and Type II errors, level of significance, one tailed and two tailed tests. Tests involving small samples and large samples, fitting theoretical distributions to sample frequency distribution, The chi, square test for goodness of fit.	20
02	**Linear Programming:** Formulation of linear programming problem, Graphical solution, simplex method (including Big M method and two phase method), dual problem, duality theory, dual simplex method, revised simplex method. **Transportation problem:** existence of solution,degeneracy, MODI method; Assignment problem, traveling salesman problem Nonlinear programming problem (NLPP): Constrained NLPP, Lagrange's multipliers method, convex NLPP, Kuhn,Tucker conditions	20

Reference Books:

- M.R. Speigel, Probability and Statistics, McGraw Hill,
- Kothari, C.R., 2004. Research methodology: Methods and techniques. New Age International.
- H.A. Taha, Operation Research, Prentice Hall of India Pvt. Ltd.
- Miller and Freund, Probability and Statistics for Engineers.
- J.C. Pant, Introduction to Optimisation : Operations Research, Jain Brothers, New Delhi.

Focus: This course focuses on employability aligned with CO1, and CO4

Outcome: After completion of course, the student will be able to:

- CO1: Apply various sampling methods
- CO2: Understand problem of statistical inference, problem of point and interval estimation
- CO3: Understand hypothesis testing
- CO4: Analyze the various transportation problem

PCEC0005: ENVIRONMENTAL IMPACT AND RISK ASSESSMENT

Objective: *Objective of this course is to identify, predict and evaluate the economic, environmental and social impact of development activities*

Credits: 04 **L-T-P-J: 4-0-0-0**

Module No.	Content	Teaching Hours
01	Environmental impact assessment (EIA)- definitions and concepts, Evolution of EIA, Initial environmental examination, environmental appraisal, environmental impact factors and areas of consideration, measurement of environmental impact, organization, scope and methodologies of EIA, Post project monitoring, EIA report and environmental impact statement (EIS); Post project monitoring, Review process. Status of EIA in India; Case studies on project, regional and sectoral EIA	20
02	Environment Risk assessment: Introduction, Objectives, Risk assessment methodology, Pre and post mitigation risk assessment.	20

Reference Books:

- Canter, L. W., Environmental Impact Assessment, McGraw-Hill, 2 nd Ed., 1997.
- Agarwal, N. P., Environmental Reporting and Auditing, Raj Pub., 2002.
- J. G. Rau and D. C. Wooten, Environmental Impact Analysis Handbook, McGraw-Hill, 1980.
- C. H. Eccleston, Environment Impact Statements: A Comprehensive Guide to Project and Strategic Planning, John Wiley & Sons, 2000.

Focus: This course focuses on employability aligned with CO1, and CO4

Outcome: After completion of course, the student will be able to:

- CO1: Understand the concept of environmental impact assessment and its evolution
- CO2: Evaluate the impact of development activities on environment.
- CO3: Analyze the environment risk and its assessment
- CO4: Understand the pre and post mitigation risk assessment.

MTEC 0002: PAVEMENT ANALYSIS AND DESIGN

Objective: *To impart knowledge of pavement types and their functions, analysis and design of flexible and Rigid pavement based on recent IRC/AASHTO codes.*

Credits: 04 **L-T-P-J: 4-0-0-0**

Module No.	Content	Teaching Hours
I	**Pavements:** History of Pavements, Pavements types, Advantages and Disadvantages **Pavement Mix Analysis:** Aggregate blending, bituminous mix design, Marshall Stability approach, concrete mix design for roads. **Pavement Basics:** Types & comparison, vehicular loading pattern, loading pattern on airport pavement, factors affecting design and performance of pavements, airport pavement, environmental impact on pavements, sub grade requirements.	18
II	**Design of Flexible Pavements:** Analytical approach, flexible pavement layers, ESWL, repetitions of load, techniques of design methods, wheel load analysis, traffic analysis, stress distribution in subgrade soil, Burmister's theories, group index method, CBR approach, IRC guidelines, CRV method, triaxial & McLeod method, present practices, shoulder design. **Design of Concrete Pavements:** Westergaard's approach, temperature & frictional stresses, design of expansion & longitudinal joints, design of dowel & tie bars, IRC guidelines, present design practices.	22

Text Books:

- Yoder and Witezak, *Principles of Pavement Design,* John Wiley and sons
- Yang, *Design of functional pavements,* McGraw, Hill

Reference Books:

- IRC codes : 37, 58, 15 and other relevant codes

Focus: This course focuses on employability aligned with CO3 and CO6

Outcome: After completion of course, the student will be able to:

- CO1: Classify the pavement types and their properties.
- CO2: Explain mix design for flexible and rigid pavement.
- CO3: Understand the different loading patterns on different pavements.
- CO4: Design the flexible pavement using CBR method and IRC guidelines
- CO5: Learn about present practices for flexible pavement and shoulder design.
- CO6: Design the Rigid Pavement using Westergaard's approach and IRC guidelines.

PCEC 0101: GROUND IMPROVEMENT METHOD

Objective: *To make the students aware of techniques of soil improvement for different types of soils, and help them assess the appropriate selection of foundation types, to be used before launching actual project works.*

Credits:04 **L-T-P: 4-0-0**

Module No.	Contents	Teaching Hours
I	**Introduction to Ground Improvement:** Objective for ground improvement, fundamental soil behavior of Problematic soil and soil improvement; Collapse Mechanism **Ground Improvement Methods:** Principal of Ground Improvement, Ground improvement technique in granular soil and cohesive soil. Mechanical Stabilization– Cement, Lime, Bituminous. Chemical stabilization, Hydraulic modification, Deep compaction. **Vertical drains:** Fundamentals of vertical drain, Types of vertical drain, Design Procedure with vertical drain on soft soil.	24
II	**Stone Column Principal and Design:** Performance and types of Stone-column; Methods of Installation of Stone column; Design and specification of Stone column. Relevant IS Code. **Designing with Geosynthetic:** Soil reinforcement principles Designing of geosynthetics in bearing capacity improvement and Slope stability on embankments on soft soil, and pavements.	20

Text Books:

- Korner, R. "Design with geosynthetics" New Jersey: Prentice Hall; 2002.
- Murthy, V. "Principles and practices of soil mechanics and foundation engineering" New Delhi: Dhanpat Rai Publications, 2002.
- Purushothama, R. "Ground improvement techniques" New Delhi: Tata McGraw-Hill; 1995.

Reference Books

- Bowles, J. "Foundation analysis and design" New York: McGraw-Hill; 1996.
- IS Code 1309-4-1992 Selection of ground improvement techniques for foundation in weak soils- Guidelines. BIS, India.
- Kasmalkar, J. "Foundation engineering" Pune: VidyarthiGrihaPrakashan; 1997.

Course Outcomes: After completion of this course, student will be able to:

- CO1 Understand the need of Ground Modification/Improvement
- CO2 Asses the mechanical/physical modes of ground improvement
- CO3 Identify the effectiveness of drainage on soil densification
- CO4 Learn the chemical modes of ground improvement: admixtures
- CO5 Asses the improvement of soil under existing structure

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1, PO2, PO9/ PSO1
CO2	PO1, PO2, PO3, PO9, PO11/ PSO1

CO3	PO1, PO2, PO3, PO5, PO9 / PSO1
CO4	PO1, PO2, PO3, PO9 / PSO1
CO5	PO1, PO2, PO3, PO5, PO9 / PSO1

PCEC 0006 : Durability and Chemical Degradation of Corrosion

Objective: *To impart knowledge of durability and deterioration of concrete such as corrosion damages, crack propagation and chemical mechanism.*

Credits: 04 **Semester - II** **L-T-P: 4-0-0**

Module No.	Contents	Teaching Hours
I	**Durability:** Physical mechanisms of concrete degradation, Plastic and Drying Shrinkage, Autogenous shrinkage, Thermal expansion and contraction cracking, Factors influencing, Freeze–thaw attack, Action of ice formation in concrete, Mechanisms of Abrasion and erosion.	22
II	**Chemical Degradation:** Chemical mechanisms, Sulphate attack, Magnesium sulphate attack, Delayed ettringite formation (DEF), Alkali–aggregate reactions (ASR), Acid attack. Corrosion: Causes and mechanisms, Carbonation, Chloride attack, Corrosion estimation and monitoring, physical and chemical repair.	22

Reference Books:

1. Concrete Durability: Thomas Dyer
2. Corrosion of Steel in Concrete Understanding, Investigation and Repair: John P. Broomfield
3. Fundamentals of Corrosion Mechanisms, Causes, and Preventative Methods: Philip A. Schweitzer

Outcome: After completion of course, the student will be able to:

- CO1: Understand basic concepts of Durability.
- CO2: Understand the concepts of Shrinkage and type.
- CO3: Understanding thermal deformations.
- CO4: Understanding the freeze-thaw effect.
- CO5: Understanding the chemical attacks and their effect.
- CO6: Understanding the chemical and mechanical effects of corrosion.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1,PO5 /PSO3
CO2	PO1,PO2,P05,P012 /PSO3
CO3	PO1,PO2,P05,P012 /PSO3
CO4	PO1,PO2,PO3 /PSO1
CO5	PO1,PO2 /PSO3
CO6	PO1,PO2,P03 /PSO3

PCEC 0114: ADVANCE HYDROLOGY

Objective: *To build on the student's background in hydrology and hydraulics and understanding of water resources systems and to develop the skills in hydrological modeling and also to develop skills in the ground water flow, type of aquifer and yield from the well.*

Credits: 04 **L-T-P-J: 4-0-0-0**

Module No.	Contents	Teaching Hours
I	**Introduction**: Hydrologic system and hydrologic budget, fundamental laws of hydrology; atmospheric water vapor. **Hydrologic Inputs**: Precipitation and its forms, snowfall and rainfall; measurement techniques and space-time characteristics. **Stream Flow Measurement**: Factors affecting stream flow, Measurement of stream flow	18
II	**Hydrologic Abstractions**: Infiltration, depression, storage, evapotranspiration; measurement techniques, Hydrological routing: Flood forecasting techniques. **Application of Statistics in Hydrology**: Probability Analysis, Methods of Frequency Analysis. **Groundwater Hydrology**: Definition of ground water, role of ground water in hydrological cycle, ground water bearing formations, classification of aquifers, flow and storage characteristics of aquifers, Darcy's law	22

Reference Books:

- Chow, V.T., Maidment, D.R. and Mays, W.L., "Applied Hydrology", McGraw Hill, {1988}.

Text Book:

- Ojha, C.S.P., Berndts son, R. and Bhunya, P., "Engineering Hydrology", Oxford University Press, {2008}.
- Wanielista, M., Kersten, R. and Eaglin, R., "Hydrology", John Wiley, {1996}.

Course Outcome: *After completion of course, the student will be able to:*

- CO1: Analyze hydro-meteorological data
- CO2: Estimate abstractions from precipitation
- CO3: Compute yield from surface and subsurface basin
- CO4: Understand the role of groundwater in hydrology

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1,PO2 /PSO1
CO2	PO1,PO2 /PSO1
CO3	PO1,PO2 /PSO1

CO4	PO1,PO2 /PSO1

PCEC 0113: ADVANCE REMOTE SENSING AND GIS

Objective: *This course introduces students with basics of remote sensing, GIS and also theoretical knowledge*
to develop a transportation GIS model.

Credits: 04 **L-T-P-J: 4-0-0-0**

Module No.	Contents	Teaching Hours
I	**Remote Sensing**: Physics of remote sensing, Ideal remote sensing system, Remote sensing satellites and their data products, Sensors and orbital characteristics, Spectral reflectance curves, resolution and multiconcept, FCC, Interpretation of remote sensing images. **Digital Image Processing**: Satellite image, characteristics and formats, Image histogram, Introduction to image rectification, Image enhancement, Land use and land cover classification system.	18
II	**Geographic Information System (GIS):** Basic concept of geographic data, GIS and its components, Data acquisition, Raster and vector formats, Topography and data models, Spatial modeling, Data output, GIS applications. **Photogrammetry**: Types of photogrammetry, applications of photogrammetry, Scales relief displacement, flight planning. **Applications of Remote sensing and GIS in Water Resource Engineering**: Uses of GPS, In dams & reservoir, in irrigation practices etc.	22

Reference Books:

- Burrough, P.A. and McDonnel, R.A., "Principles of Geographic Information System", Oxford University Press, {2000}.
- Chrisman, Nicholas R., "Exploring Geographic Information Systems", John,2002 Wiley.
- Demers, Michael N., "Fundamentals of Geographic Information System",2ndEd. Wiley, {2008}.

Text Book:

- Ghosh, S.K. and Chandra, A.M., "Remote Sensing and GIS", Narosa Publishing House, {2008}.
- Lo, C.P. and Young, A.K.W., "Concepts and Techniques of Geographical Information System", Prentice Hall India, {2002}.
- Longley, Paul A, Good child, Michael F., Maguire, David J. and R hind, David W., "Geographic Information Systems and Science", Wiley, {2001}.

Course Outcome: *After completion of course, the student will be able to:*

- CO1: Describe remote sensing and GIS.
- CO2: Illustrate digital image processing methods
- CO3: Interpret satellite images

- CO4: Application of remote sensing and GIS in water resource engineering

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/ PSOs
CO1	PO1, PO2, PO3, PO4, PO5, PO6 / PSO1, PSO2
CO2	PO1, PO2, PO3, PO5, PO8, PO9, PO10 / PSO1, PSO2
CO3	PO1, PO2, PO3, PO5, PO9, PO10, PO11 / PSO1, PSO2
CO4	PO1, PO2, PO3, PO6, PO7, PO8, PO9, PO11 / PSO1, PSO2