

UNIT I: Basis of Structural Design and Connection Design

Introduction; Metallurgy of steel; Structural properties of steel; Design philosophies; Limit state method; Partial load factors; Loading and load combination on structures; Local buckling and section classification.

Types of connections; Welded connections; Types of joints and welds; Connection design; Concentric connection; Eccentric connections; Truss connections; Bolted connections; Force transfer mechanism; Failure mechanism; Analysis of bolt groups; Beam column connections, shear connection; Moment connection.

UNIT II: Design of Compression and Tension Members

Types of tension member; Behaviour of tension members; Factors affecting the strength of tension members; Design of tension member; for yielding; Net section rupture; Block shear; Tension splices; Lug angles; Concept of shear lag.

Types of compression members; Basis of current codal provision for compression member design; Slenderness ratio; Elastic buckling; Strength curves; Design of compression members.

UNIT III: Design of Flexural Members

Beam types; Lateral stability of beams; Lateral torsional buckling of symmetric beams; Design strength of Laterally supported and Unsupported beams in bending; Shear strength of steel beams; Web buckling and crippling; Design of beams; Built-up beams; Design of plate girders; Types of stiffeners; Flange and web splices; Design of beam-columns subjected to combined tension and bending.

UNIT IV: Design of Columns and Column Bases

Design of single section and compound section ; Design of laced and battened type columns; Design of column bases; Slab base; Gusseted base; Grillage foundation

UNIT V: Design of Industrial Buildings

Introduction, Frames; Multistory frames; Various types of trusses and their selection; Design of purlin and elements of truss; Effect of wind loads on purlin and truss; Bracing systems ,Design of Gantry Girder ,

References:

1. Gambhir M. L., Fundamentals of Structural Steel Design, McGraw Hill Education., First edition, 2017.
2. Dayaratnam P., Design of Steel Structures, A. H. Wheeler & Co. Ltd., Allahabad, 2008
3. Arya and Ajmani, Design of Steel Structures, NemChand Brothers, Roorkee, 2007
4. Punmia B.C., Ashok Kumar Jain and Arun Kumar Jain, Design of Steel Structures, Arihant Publications, Bombay, 2008

5. Shiyekar M. R., Limit State Design in Structural Steel, Prentice Hall of India Pvt. Ltd, Learning Pvt. Ltd., 2nd Edition, 2013.
6. Subramanian N, Design of Steel Structures, Oxford University Press, New Delhi, 2013.
7. Narayanan R.et.al., Teaching Resource on Structural Steel Design, INSDAG, Ministry of Steel Publications, 2002
8. Duggal S. K., Limit State Design of Steel Structures, Tata McGraw Hill Publishing Company, Third edition, 2019.
9. Bhavikatti S. S, Design of Steel Structures by Limit State Method as per IS:800-2007, IK International Publishing House Pvt. Ltd., 2009
10. IS 800: latest version, General Construction in Steel - Code of Practice, Bureau of Indian Standards, New Delhi.
11. IS 875 (Part 1): latest version, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures Part 1 Dead Loads - Unit Weights of Building Materials and Stored Materials, Bureau of Indian Standards, New Delhi.
12. IS 875 (Part 2): latest version, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures Part 2 Imposed Loads, Bureau of Indian Standards, New Delhi.
13. IS 875 (Part 3): latest version, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures Part 3 Wind Loads, Bureau of Indian Standards, New Delhi.
14. IS 875 (Part 4): latest version, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures Part 4 Snow Loads, Bureau of Indian Standards, New Delhi.
15. IS 875 (Part 5): latest version, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures Part 5 Special Loads and Combinations, Bureau of Indian Standards, New Delhi.

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

New Scheme Based On AICTE Flexible Curricula

Civil Engineering, VIII-Semester

Departmental Elective CE 802(A) Engineering Hydrology

UNIT I

Hydrological cycle, water budget, Practical applications of Hydrology, Hydrometeorology, airmasses. Formation of precipitation, types of precipitation, meteorological observations, probability & random variables, regression analysis, catchment its type and importance, measurement of precipitation, Raingauges, location of raingauges, interpretations & analysis of rainfall data, calculation of average rainfall, Hyetograph, Intensity-duration, Frequency curves , Mass curve.

UNIT II

Stream flow measurement and various methods, stage-discharge relations. Rating curve and its extension, stream gauge Networking, stage & discharge hydrographs, evaporation & evapotranspiration-calculation, factors affecting measurement, Reducing evaporation.

UNIT III

Infilleration, Factors affecting it, measurement of Infilleration, Infilleration equation and Indices. Occurance of ground water, Darcey's law, flow in wells (steady & unsteady). Ground water exploration. Yield of well, determination of yield.

UNIT IV

Runoff and its components, factors affecting runoff, Basin yield, Rainfall-Runoff relationships, flow-duration curve, flow mass curve, Hydrograph, separation of hydrograph, unit hydrograph - theory & application, derivation of unit hydrograph convolution equation, unit hydrograph from complex storms unit hydrograph for various durations, synthetic unit hydrograph, S-curve hydrograph, distribution graph, use & applications of unit hydrograph, Dimensionless unit Hydrograph.

UNIT V

Instantaneous unit Hydrograph, Derivation of IUH, flood routing, reservoir routing, different methods, storage discharge relationship, ISD method, puls method, channel routing –muskingham method, design flood –Empirical & rational formula, frequency analysis, Gumbel's distribution, Reservoir sedimentation-causes, factors affecting & control.

Books:

1. Engineering Hydrology by Subramanyam
2. Introduction to hydrology By: Viessman & lewis
3. Applied Hydrology By: CW Fetter
4. A text Book of Hydrology By: Reddy
- 5.

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

New Scheme Based On AICTE Flexible Curricula

Civil Engineering, VIII-Semester

Departmental Elective CE 802(B) Foundation Engineering

UNIT 1. Selection of foundation and Sub-soil exploration/investigation: Types of foundation, Factors affecting the selection of type of foundations, Steps in choosing types of foundation based on soil condition. Objectives and planning of exploration program, methods of exploration-wash boring and rotary drilling-depth of boring, Soil samples and soil samplers-representative and undisturbed sampling, Field penetration tests: SPT, SCPT, DCPT. Introduction to geophysical methods, Bore log, report writing.

UNIT 2. Shallow Foundation: Introduction, significant depth, design criteria, modes of shear failures. Detail study of bearing capacity theories (Prandtl, Rankine, Terzaghi, Skempton, Meyerhof), Bearing capacity determination using IS Code. Settlement, components of settlement & its estimation, permissible settlement, Proportioning of footing for equal settlement, allowable bearing pressure. Bearing capacity from in-situ tests (SPT, SCPT, PLATE LOAD), Factors affecting bearing capacity, Contact pressure under rigid and flexible footings. Floating foundation.

UNIT 3. Pile foundations: Introduction, Load transfer mechanism, Types of piles and their function, Factors influencing selection of pile, their method of installation and their load carrying characteristics for cohesive and granular soils, Piles subjected to vertical loads- pile load carrying capacity from static formula, dynamic formulae (ENR and Hiley), Pile load test, Pile group: carrying capacity, efficiency and settlement. Negative skin friction.

UNIT 4. Foundations on problematic soil & Introduction to Geosynthetics: Significant characteristics of expansive and collapsible soils, footing on such soils, Problems and preventive measures. Under-reamed pile foundation-its concept, design & field installation. Introduction to geosynthetics-materials, types, functions and uses.

UNIT 5. LATERAL EARTH PRESSURE: Active, Passive and Earth pressure at rest. Rankine's theory of earth pressure, Earth pressures in layered soils, Coulomb's earth pressure theory, Culmann's graphical method.

RETAINING WALLS: Types of retaining walls- stability of retaining walls against overturning, sliding, bearing capacity and drainage from backfill. Reinforced earth retaining walls.

Reference Book:

1. Murthy, V.N.S., "Text book of Soil Mechanics and Foundation Engineering", CBS Publishers Distribution Ltd., New Delhi, 2014.
2. Arora, K.R., "Soil Mechanics and Foundation Engineering", Standard Publishers and Distributors, New Delhi, 7th Edition, 2017 (Reprint).
3. Punmia, B.C., "Soil Mechanics and Foundations", Laxmi Publications Pvt. Ltd. New Delhi, 16th Edition 2017.
4. Joseph E bowles, "Foundation Analysis and design", McGraw Hill Education, 5th Edition, 28th August 2015.

5. Shamsheer Prakash et al, "Analysis, Design of foundations and Retaining Structures" Sarita Prakashan.
6. Murthy, V.N.S., "Advanced Foundation Engineering", CBS Publishers and Distributors
7. Coduto D.P., Foundation design; principles and practices, Pearson Publication

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

New Scheme Based On AICTE Flexible Curricula

Civil Engineering, VIII-Semester

Departmental Elective CE 802(C) Bridge Engineering

UNIT 1: Types of Bridge Super Structures

Introduction and types, temporary bridge superstructures, military bridges, other temporary bridges, permanent bridges, R.C.C. bridges, Pre-stressed concrete bridges, steel bridges, movable steel bridge.

Consideration of loads and stresses in road bridges: Introduction, loads, forces and stress, dead loads, bridge loading as per relevant IRC and IRS specifications traffic lanes, foot way, kerbs, railing and parapet loading, impact, wind load, longitudinal forces, Temperature effect of live load on back fill and on the abutment.

UNIT 2: Design of R.C. Bridge

Slab culvert, pipe culvert, T-beam, box culvert bridge super structure, Courbon's theory for load distribution, balanced cantilever bridges, design examples.

UNIT 3: Design of Steel Bridges

Types of steel superstructure, plate girder bridge, truss bridge, wind forces of lattice girder bridge, bracings, arch and bowstring girder bridge, design example.

UNIT 4: Pier, Abutment and Wing Walls

Types of piers and abutments, stability analysis of piers and abutments, design of piers, Forces on piers, stability, abutment, bridge code provision for abutments, wing walls, design examples.

UNIT 5: Foundations and Bearings

Types of bridge foundations and general design criteria, shallow foundations, deep foundations, piles, wells and pneumatic caissons, river training works.

Bearings: functions and types of bearings, necessity of bearings, design of elastomeric bearings, expansion joints, necessity and types of expansion joints, design considerations.

References Books:

1. Victor, D.J., Essential of Bridge Engineering , Oxford & IBH Publishing Co., New Delhi.
2. Rowe, R.E., Concrete Bridge Design , C.R. Books Ltd., London
3. Krishna Raju N, Design of Bridges, Oxford & IBH Publishing Co., New Delhi.
4. Bakht. B and Jaeger, L.C., Bridge Analysis Simplified, McGraw Hill Book Co. Inc.
5. Ponnuswamy, S., Bridge Engineering, Tata McGraw Hill, New Delhi.
6. Bakht, B. and Jaeger, L.G., Bridge Deck Analysis Simplified, McGraw Hill International Edition, Singapore
7. Aswani M.G., Vazirani V.N. and Ratwani M.M., Design of Concrete Bridges, Khanna publishers, New Delhi.
8. Hambly E.C., Bridge Deck Behaviour.
9. Sastry V.V., Design of Bridges, Dhanpat Rai & Co
10. Raina V.K., Concrete Bridge Design and Practice, Tata McGraw Hill, New Delhi.

11. Jagadeesh .T.R. and Jayaram.M.A., "Design of Bridge Structures", Prentice Hall of India Pvt. Ltd, Learning Pvt. Ltd., 2013
12. Indian Standard Codes and IRC codes related to bridges.

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

New Scheme Based On AICTE Flexible Curricula

Civil Engineering, VIII-Semester

Departmental Elective CE 802(D) Earthquake Resistant Design of Structures

Unit I

Engineering Seismology: Introduction to engineering seismology, Geological and tectonic features of India, Origin and propagation of seismic waves, Earthquake measurement parameters, Characteristics of earthquake and its quantification- Magnitude and Intensity scales, Seismic instruments. Seismic zoning map of India.

Unit II

Response Spectrum: Response history and strong motion characteristics. Response Spectrum- elastic and inelastic response spectra, tripartite (D-V-A) response spectrum, use of response spectrum in earthquake resistant design .Computation of seismic forces in multi-storeyed buildings - using procedures as per codal provisions.

Unit III

Aseismic Structural Modelling: Structural configuration for earthquake resistant design, Concept of plan irregularities and vertical irregularities, Soft storey, Torsion in buildings. Design provisions for these in IS-1893. Effect of infill masonry walls on frames, modeling concepts of infill masonry walls. Behaviour of masonry buildings during earthquakes, failure patterns, strength of masonry in shear and flexure, Slenderness concept of masonry walls,

Unit IV

Design of structure for earthquake resistance: Seismic design philosophy, Load combinations, Ductility and energy absorption in buildings. confinement of concrete for ductility, design of columns and beams for ductility, ductile detailing provisions as per IS-1893. Lateral load resisting structural systems.

Unit V

Seismic control of structures: Introduction, concept and types of seismic control systems as active, passive and semi-active systems. Requirements of efficient earthquake resistant structural system, damping devices, base isolation systems. Retrofitting of structures.

Reference Books:

1. Chopra Anil Kumar, Dynamics of Structures - Theory and Application to Earthquake Engineering, Pearson Education.

2. Hosur Vinod, Earthquake Resistant Design of Building Structures, Wiley (India).
3. Duggal S. K., Earthquake Resistant Design of Structures, Oxford University Press.
4. Agarwal Pankaj, Shrikande Manish, Earthquake Resistant Design of Structures, Prentice Hall of India, New Delhi India.
5. Pauley & Priestly, Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley & Sons.
6. Stratta J. L, Manual of Seismic Design, Prentice-Hall India Pvt Ltd.
7. Kramer S. L., Geotechnical Earthquake Engineering, Prentice-Hall India Pvt Ltd.
8. All relevant IS codes:
IS 1893: Criteria for earthquake resistant design of structures, Bureau of Indian Standards, New Delhi.
IS 4326: Code of practice for earthquake resistant design and construction of buildings, Bureau of Indian Standards, New Delhi.
IS 13920: Ductility detailing of reinforced concrete structures subjected to seismic forces, Bureau of Indian Standards, New Delhi.

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

New Scheme Based On AICTE Flexible Curricula

Civil Engineering, VIII-Semester

Open Elective CE 803(A) Artificial Intelligence

Course Objectives

After studying this course, students will be able to

1. learn about importance of AI techniques. Adoption of Artificial Intelligence (AI) technologies is widely expanding in our society. Applications of AI include: self-driving cars, personal assistants, surveillance systems, robotic manufacturing, machine translation, financial services, cyber security, web search, video games, code analysis and product recommendations.
2. Know the exact application of AI Techniques. Such applications use AI techniques to interpret information from a wide variety of sources and use it to enable intelligent, goal-directed behavior.
3. understand the working of Modern AI based systems. It often involves self-learning systems that are trained on massive amounts of data, and/or interacting intelligent agents that perform distributed reasoning and computation.
4. Know about sensors used in AI based systems. AI connects sensors with algorithms and human-computer interfaces, and extends itself into large networks of smart devices.
5. know the opportunities after having knowledge of AI techniques. The knowledge of Artificial Intelligence opens career opportunities in companies that are building the next generation of intelligence and language understanding for their products: for example intelligent personal assistants, opinion mining systems, customer support system, biomedical applications, computer games, smart adaptive devices, robots, smart planning systems.

Syllabus

Unit 1: Introduction to Artificial Intelligence

Main components and characteristics of AI (Feature Engineering, ANN, Deep Learning), Applications of AI, Advantages and disadvantages of AI, Goals of AI, Comparison of Programming of a System with AI and without AI, Challenges in AI, Programming languages preferably used in AI, Techniques/Algorithms used in AI, AI Software platforms, Future of AI

Unit 2: Various types of production systems and search techniques: Types of production systems, Characteristics of production systems, Study and comparison of breadth first search and depth first search. Techniques, other Search Techniques like hill Climbing, Best first Search. A* algorithm, AO* algorithms etc, and various types of control strategies.

Unit 3: Knowledge Representation and Probabilistic Reasoning: Problems in representing knowledge, knowledge representation using propositional and predicate logic, comparison of propositional and predicate logic, Resolution, refutation, deduction, theorem proving, inferencing, monotonic and nonmonotonic reasoning. Probabilistic reasoning, Baye's theorem, semantic networks, scripts, schemas, frames, conceptual dependency, fuzzy logic, forward and backward reasoning.

Unit 4: Game playing techniques: Minimax procedure, alpha-beta cut-offs etc, planning, Study of the block world problem in robotics, Introduction to understanding and natural languages processing.

Unit 5: Introduction to learning ,ANN: Various techniques used in learning, introduction to Artificial neural networks, common sense, reasoning, Convolution Neural Network, Feedforward Neural Network, Recurrent Neural Network, Multilayer perceptron, Architecture / Three Layers in Artificial Neural Networks, Implementation of ANN, Applications of ANN in images, signals and languages some example of expert systems.

References:-

1. Rich E and Knight K, "Artificial Intelligence", TMH, New Delhi.
2. Nilsson N.J., "Principles of Artificial Intelligence", Springer Verlag, Berlin.
3. Stuart Russell, Artificial Intelligence: A Modern Approach, 3rd Edition, Peter Norvig, PHI, ISBN-13: 978-0136042594, ISBN-10: 0136042597
4. B. Yegnanarayana, Artificial Neural Networks, PHI
5. Schalkoff, Artificial Neural Networks. McGraw Hill Education

Evaluation:

Evaluation will be continuous and integral part of the class as well as through external assessment

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

New Scheme Based On AICTE Flexible Curricula

Civil Engineering, VIII-Semester

Open Elective CE 803(B) Data Analytics

Course Objectives:

Data Analytics is the science of analyzing data to convert information to useful knowledge. This knowledge could help us understand our world better, and in many contexts enable us to make better decisions. While this is broad and grand objective, the last 20 years has seen steeply decreasing costs to gather, store, and process data, creating an even stronger motivation for the use of empirical approaches to problem solving.

This course will enable you with a wide range of data analytic techniques and is structured around the broad contours of the different types of data analytics, namely, descriptive, inferential, predictive, and prescriptive analytics.

Pre-requisites:

This course requires that you are familiar with high-school level linear algebra, and calculus. Knowledge of probability theory, statistics, and programming is desirable

UNIT-I

DESCRIPTIVE STATISTICS :Probability Distributions, Inferential Statistics ,Inferential Statistics through hypothesis tests Regression & ANOVA ,Regression ANOVA(Analysis of Variance).

UNIT-II

INTRODUCTION TO BIG DATA: Big Data and its Importance, Four V's of Big Data, Drivers for Big Data, Introduction to Big Data Analytics, Big Data Analytics applications.

BIG DATA TECHNOLOGIES: Hadoop's Parallel World, Data discovery, Open source technology for Big Data Analytics, cloud and Big Data, Predictive Analytics, Mobile Business Intelligence and Big Data, Crowd Sourcing Analytics, Inter- and Trans-Firewall Analytics, Information Management.

UNIT-III

PROCESSING BIG DATA: Integrating disparate data stores, Mapping data to the programming framework, Connecting and extracting data from storage, Transforming data for processing, subdividing data in preparation for Hadoop Map Reduce.

UNIT-IV

HADOOP MAPREDUCE: Employing Hadoop Map Reduce, Creating the components of Hadoop Map Reduce jobs, Distributing data processing across server farms, Executing Hadoop Map Reduce jobs, monitoring the progress of job flows, The Building Blocks of Hadoop Map Reduce Distinguishing Hadoop daemons, Investigating the Hadoop Distributed File System Selecting appropriate execution modes: local, pseudo-distributed, fully distributed.

UNIT-V

BIG DATA TOOLS AND TECHNIQUES: Installing and Running Pig, Comparison with Databases, Pig Latin, User- Define Functions, Data Processing Operators, Installing and Running Hive, Hive QL, Querying Data, User-Defined Functions, Oracle Big Data.

Reference Books and Study Materials:

1. Hastie, Trevor, et al. ♦ The elements of statistical learning. Vol. 2. No. 1. New York: springer, 2009.
2. Montgomery, Douglas C., and George C. Runger. ♦ Applied statistics and probability for engineers. John Wiley & Sons, 2010
3. NPTEL Video Course :Introduction to Data Analytics by Dr. Balaraman Ravindran Department of Computer Science and Engineering IIT Madras and Dr. Nandan Sudarsanam Department of Management Studies IIT Madras.

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

New Scheme Based On AICTE Flexible Curricula

Civil Engineering, VIII-Semester

Open Elective CE 803(C) Retrofitting and Rehabilitation of Structures

Unit – I

Introduction and Definition for Repair, Retrofitting, Strengthening and rehabilitation. Physical and Chemical Causes of deterioration of concrete structures, Evaluation of structural damages to the concrete structural elements due to earthquake.

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

Unit II

Damage Assessment:

Purpose of assessment, Rapid assessment, Investigation of damage, Evaluation of surface and structural cracks, Damage assessment procedure, destructive, non-destructive and semi destructive testing systems

Unit - III

Influence on Serviceability and Durability:

Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors, corrosion mechanism, Effects of cover thickness and cracking, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, and cathodic protection.

Unit – IV

Maintenance and Retrofitting Techniques:

Definitions: Maintenance, Facts of Maintenance and importance of Maintenance Need for retrofitting, retrofitting of structural members i.e., column and beams by Jacketing technique, Externally bonding(ERB) technique, near surface mounted (NSM) technique, External post-tensioning, Section enlargement and guidelines for seismic rehabilitation of existing building

Unit - V

Materials for Repair and Retrofitting:

Artificial fibre reinforced polymer like CFRP, GFRP, AFRP and natural fiber like Sisal and Jute. Adhesive like, Epoxy Resin, Special concretes and mortars, concrete chemicals, special elements

for accelerated strength gain, Techniques for Repair: Rust eliminators and polymers coating for rebar during repair foamed concrete, mortar and dry pack, vacuum concrete, Guniting and Shotcrete Epoxy injection, Mortar repair for cracks, shoring and underpinning.

Suggested Books: -

Properties of Concrete A. M. Neville Pearson Education

Materials for construction - Lai, James, S.

Structural Condition Assessment Robert T. Ratay

Sidney, M. Johnson, "Deterioration, Maintenance and Repair of Structures"

Denison Campbell, Allen & Harold Roper, "Concrete Structures – Materials, Maintenance and Repair"- Longman Scientific and Technical.

R.T.Allen and S.C. Edwards, "Repair of Concrete Structures"-Blakie and Sons Raiker R.N., "Learning from failure from Deficiencies in Design, Construction and Service"- R&D Center (SDCPL).

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

New Scheme Based On AICTE Flexible Curricula

Civil Engineering, VIII-Semester

Open Elective CE 803(D) Integrated Water Management

Course Objectives

1. To study the paradigm shift in water management with global and national perspectives of water crisis. It also aims to understand the concepts of 'blue water', 'green water' and 'virtual water' and their roles in water management.
2. To study the sustainable water resources management and to plan and develop framework for future.
3. To study the modern principles of water management and planning.
4. To develop surface and subsurface water systems along with water balance equation.
5. To study the conventional and non-conventional techniques for water security.

UNIT I: Paradigm Shift in Water Management

Global and national perspectives of water crisis, water scarcity, water functions in the life-support systems, water availability and requirements for humans and nature, concepts of 'blue water', 'green water' and 'virtual water' and their roles in water management, human-landscape interventions, and salient water management issues and challenges.-landscape interventions, and salient water management issues and challenges.

UNIT II: Sustainable Water Resources Management

Concept of sustainable development, sustainability principles for water management, goals for guiding sustainable water resource management, important preconditioning in water policy approaches, framework for planning a sustainable water future.

UNIT III: Integrated Water Resources Management (IWRM) Approach

IWRM Principles: Modern principles for water management and planning, definition, components, and critique of IWRM. *IWRM Implementation:* Socio-scientific, economic, political and ecological factors affecting the implementation of IWRM principles Salient examples of river basin management, lessons from best practices in river-basin management.

UNIT IV: Surface and Subsurface Water Systems

Impacts of development activities on the water cycle, precipitation, evapotranspiration, infiltration, runoff, streamflow, erosion and sedimentation, types of aquifer systems and their hydraulic characteristics, environmental impacts on groundwater systems, estimation of groundwater recharge and discharge, assessment of groundwater potential, surface water-groundwater interaction, concept of sustainable groundwater development and management, water balance, balance of water resources and needs, minimum water table and minimum discharges.

UNIT V: Conventional and Non-conventional Techniques for Water Security

Rainwater harvesting, groundwater mining and artificial recharge, conjunctive use of surface water and groundwater resources, long-distance water conveyance and transport, conservation of 'green water', desalination, treatment of poor-quality waters.

Course Outcomes:

After studying this course, students will be able to:

1. Assess the potential of groundwater and surface water resources.
2. Address the issues related to planning and management of water resources.
3. Know how to implement IWRM in different regions.
4. Understand the legal issues of water policy.
5. Select the method for water harvesting based on the area.

Text Books:

2. K. Subramanya, Engineering Hydrology, Tata McGraw Hill Publishers, New Delhi.
3. H.M. Raghunath, Ground Water, Wiley Eastern Publication, New Delhi.
4. Daniel P. Loucks and Eelco van Beek, Water Resources Systems. Planning and Management, UNESCO Publication.
5. Mollinga, P. et al, Integrated Water Resources Management, Water in South Asia Volume I, Sage Publications, 2006.
6. Singh, Chhatrapati Water Rights in India, Ed: Chhatrapati Singh. Water Law in India: The Indian Law Institute, New Delhi, 1992.
7. Dhruva Narayana, G. Sastry, V. S. Patnaik, Watershed Management, CSWCTRI, Dehradun, ICAR Publications, 1997.

Reference Books:

1. Lal, Ruttan. Integrated Watershed Management in the Global Ecosystem. CRC Press, New York.
2. Heathcote, I. W. Integrated Watershed Management: Principles and Practice. 1988. John Wiley and Sons, Inc., New York.