INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-501 **Course Title:** Environmental Separation Processes

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Environmental contaminants, unit operations, processes in water, wastewater treatment processes; Separation of suspended impurities; coagulation and flocculation fundamentals, rapid mixing, different types of mixers and flocculators; Adsorption, fundamentals, different types of adsorption, factors affecting adsorption, adsorption isotherms, activated carbon as adsorbent; Ion exchange, types of ion exchangers, organic-based ion exchange resins; Gas-liquid separation; Membrane-based processes.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-503 **Course Title:** Wastewater Treatment

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Process Analysis; Sewerage System; Activated Sludge Process; Activated sludge process design for nutrient removal; Process operation; Biofilm Process; Anaerobic Processes.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-505 **Course Title:** Environmental Chemistry

L-T-P: 3-1-2 **Credits:** 5 **Subject Area:** PCC

Course Outlines: Fundamentals of chemical processes, Acid/Base Reactions, Aqueous Complex Formation, Precipitation/Dissolution, Oxidation/Reduction, Fundamentals of Environment Organic Chemistry, Surface Complex Adsorption Models.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-507 **Course Title:** Environmental Modelling and Simulation

L-T-P: 3-0-2 **Credits:** 4 Subject Area: PCC

Course Outlines: Modeling and simulation; development process and applications; Lumped and distributed parameter models, solution methods using MATLAB; Design of experiments; Reactor Modeling, kinetics, parameter estimation; RTD studies and flow regimes; Cluster analysis; Microbial dynamics; Modeling transport phenomena; Environmental risk management.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-511 **Course Title:** Surveying Measurements and Adjustments

L-T-P: 3-0-2 **Credit:** 4 **Subject Area:** PCC

Course Outlines: Maps and their scales, Surveying principles, measuring equipment and techniques, Leveling, Traversing, Triangulation, Trilateration, Modern surveying equipment, Concept of observation and model, Errors, Model adjustments.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-513 **Course Title:** Principles of Photogrammetry

L-T-P: 3-0-2 **Credit:** 4 **Subject Area:** PCC

Course Outlines: Types of photograph, Scale determination, Flying height, Relief and Tilt Displacements, Stereovision, Flight planning, Concept of orientation, Methods of relative orientation, Residual errors and precision of orientation, Stereo-plotting instruments, Close-range photogrammetry.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-515 **Course Title:** Principles of Remote Sensing

L-T-P: 2-0-2 **Credit:** 3 **Subject Area:** PCC

Course Outlines: Energy sources and radiation principles, Interaction of EMR with atmosphere and earth surface, Radiation Calculations, Visual image interpretation, Multispectral, Thermal, Hyperspectral and Microwave Sensing, Platforms and Sensors.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-517 **Course Title:** Geodesy and GNSS Surveying

L-T-P: 2-0-2 **Credit:** 3 **Subject Area:** PCC

Course Outlines: Geodesy and its development, Size, shape and motion of Earth, Earth and its gravity field, Earth's atmosphere and its gravitational field, GNSS and its components, GNSS Instrumentation, data collection and processing, GNSS observables, Errors in GNSS data.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-519 **Course Title:** Field Survey Camp

L-T-P: 0-0-4 **Credit:** 2 **Subject Area:** PCC

Course Outlines: Survey fieldwork, GPS surveying, Total station surveying, Drone surveying, Geospatial data collection, Topographic mapping.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-521 **Course Title:** Advanced Numerical Analysis

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PCC

Course outlines: Errors in computation: source and types of errors, error propagation. Computer representation of numbers. Roots of a non-linear equation and roots of a polynomial of nth degree using various methods, solution of (non-homogeneous) linear and non-linear algebraic equations, Cholesky's decomposition method, Eigen values and Eigen vectors, time marching schemes, Integration using interpolation: Newton-Cotes formulas, Gauss quadrature rules, different solutions of ordinary and partial differential equations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-523 **Course Title:** Advanced Soil Mechanics

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PCC

Course outlines: Soil characteristics, Weight volume relationship, Flow of water through soils, Effective stress concept, Permeability, Seepage, Laplace Theory, Flownet, Consolidation, Terzaghi's consolidation theory in 1-D and 3-D, Variation of pore water pressure with depth, Consolidation in layered soils, Secondary consolidation, Sand drains, Shear strength of soils, Mohr's circle, Laboratory tests, UU, CU and CD conditions, Drained and undrained conditions, Determination of PWP parameters, Stress path, Critical state soil mechanics, NCL, CSL, Roscoe surface, Hvorslev surface.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-525 **Course Title:** Engineering Behaviour of Rocks

L-T-P: 3-0-2/2 **Credits:** 3 **Subject Area:** PCC

Course outlines: Applications of rock mechanics; concept of intact rocks, laboratory testing and analysis for UCS, and tensile tests, shear tests; triaxial strength of rocks, Coulomb's theory, Mohr's envelope and p-q plots; failure criteria for intact rocks; classification of intact rocks; concept of rock masses; classification of rock masses; deformational behavior of jointed rocks; flow through jointed rock mass.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-527 **Course Title:** Soil Dynamics and Machine Foundations

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course outlines: Theory of Vibrations; Wave Propagation in Elastic Media; Evaluation of Dynamic Soil Properties; Seismic Earth Pressure; Seismic Bearing Capacity; Pile Foundations; Assessment of Liquefaction Potential; Machine Foundations: Evaluation of Design Constants, Reciprocating Machines and Impact Foundations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-529 **Course Title:** FEM in Geotechnical Engineering

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PCC

Course outlines: Fundamentals of discretization, Iso-parametric element, Lagrange polynomial; One-dimensional element, Beam element; Constant strain triangle (plane-stress, plane-strain and axisymmetric); Bilinear quadrilateral element; Modelling considerations (geometry, symmetry, mesh, boundary); Modelling of soil behaviour, Undrained and drained behaviour, Effective stress and total stress analysis; Mohr-Coulomb yield criterion, Associated flow rule, Non-associated flow rule, Material parameters for advanced soil models (Von Mises, Tresca, Drucker Prager, Mohr Coulomb, Hardening soil, Cam Clay); Modelling excavation and tunnel problems; Modelling consolidation.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-531 **Course Title:** Advanced Hydrology

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course outlines: Hydrological systems; hydrologic inputs and abstractions; stream flow; space-time characteristics of various input and abstraction variables; introduction to the systems approach; mathematical models in surface hydrology; hydrological and hydraulic routing methods; fundamental and advanced methods of frequency analysis and design floods.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-533 **Course Title:** Advanced Fluid Mechanics

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PCC

Course outlines: Equation of continuity in various coordinate systems; Standard 2D Flow Patterns; Laplace Equation and its solution by different methods; Laminar Flow; Navier-Stokes equations; Boundary Layers, similarity solutions; Turbulent Flow and its measurements of turbulence; Statistical Theory of Turbulence.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-535 **Course Title:** Free Surface Flows

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course outlines: Concepts of free surface flow, governing equation and computation of gradually varied flows, hydraulic jump in a variety of situations; Supercritical Flows; Spatially Varied Flows; De Marchi equations; Aerated Flows; Stratified Flow and its modelling; Unsteady Flows; St. Venant's equations; Various Channel Transitions, applications free surface flow in flood control; design of drainage and waterways.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-537 **Course Title:** Modelling, Simulation and Optimization

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PCC

Course outlines: Systematic Approach; Classification of Models; Linear, non-linear and time-(in)variant, models; Linear and Multiple Regression analysis, the concept of random variables, marginal and bivariate distributions, commonly used Probability Distributions; Frequency Analysis; Goodness of fit tests; Return level Estimation; Time Series Analysis and different smoothening and filtering techniques; Spatial Distributions; Bayesian Inference; Monte Carlo simulation; Bootstrap Techniques; Basics of optimization.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-539 **Course Title:** Ground Water Engineering

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course outlines: Groundwater hydrology; Governing Equations for Groundwater Flow; Wells and Well Hydraulics; Groundwater budget and resources assessment; Groundwater quality aspects including contamination source, remedies and preventive measures; Groundwater Flow Modelling; Hele-Shaw and analog models; Planning of Groundwater Development.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-541 **Course Title:** Continuum Mechanics

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Vector and Tensors Algebra, Stresses; Translational and Rotational Equilibrium; Principal Stresses and Principal Planes in 3D, Stress Invariants, Cauchy and Kirchhoff Stress Tensor; Deviatoric and Volumetric Components; Work Conjugancy; Octahedral and von-Mises stresses; Kinematics, Linearized Kinematics; Strain Quadric of Cauchy, Principal Strains, Invariants; Compatibility, Finite Deformation, Deformation Gradient; Polar Decomposition, Volume change, Area Change; Generalized Hooke's Law, Anisotropic, Orthotropic and Isotropic Elasticity Tensor; Plane Stress and Strain Problems; Airy Stress Functions; Isotropic Hyper elasticity; Three-Dimensional Elasticity Solutions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-543 **Course Title:** Advanced Concrete Design

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Plastic Section, Theory for Reinforced Concrete including interaction of flexure, Shear-Axial effects, Upper bound and lower bound plastic theorems, Plastic analysis to frames – instantaneous centre of rotations, Pushover Analysis, Strut-Tie Models, Strut-Tie Models for Deep Beams, Beam-Column Joints& Shear walls, Yield line analysis and application for slabs, raft foundations etc., Pre-stressed concrete and behaviour for simple elements, Creep/shrinkage and long term effects for RCC and prestressed concrete, Crack widths and crack control designs.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-545 **Course Title:** Structural Dynamics

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Single Degree of Freedom System, Free Vibrations: undamped and damped systems, logarithmic decrement method. Equation of motion for generalized SDOF dynamic problems, virtual work method, Response of SDOFS systems to Harmonic, Periodic, Impulse Loads, Equation of motion for two/three DOF systems. Mode shapes and frequencies: determinantal equation, and iterative techniques. Sweeping matrices for higher modes. Convergence. Modal superposition and Response Spectrum Methods. Response of single and multiple DOFS systems to Earthquake Loading, Time Stepping Methods based on Forward Cauchy Euler, Backward Cauchy Euler and Trapezoidal Rule. Accuracy, stability and algorithmic damping in step-by-step methods. Earthquake response analysis of Multi-DOF systems. Modal mass and mode participation factors, Newark and Hall's linear and inelastic response spectra for earthquakes, Introduction to IS codes.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-547 **Course Title:** Behavior & Design of Steel Structures

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Stability, Buckling of Columns, Stability of Beam-Columns and Frames, Lateral Instability of Beams, Local Buckling and Post Buckling of Plates, Behaviour and Design of Cold Formed Thin Walled Structures, Plastic Analysis and Design of Steel Structures, LRFD, Advanced Topics in Bolted and Welded Connections, Steel Concrete Composite Construction, Introduction to Brittle, Fracture and Fatigue, Design of Steel Truss Bridges.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-551 **Course Title:** Traffic Analysis and Design

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Traffic Engineering, road users, vehicle and road characteristics; Traffic stream parameters, Traffic studies, Capacity Analysis concepts for urban and rural highways, Statistical applications in traffic engineering, Statistical distributions relevant to traffic data analysis, Microscopic traffic flow modelling, Time series analysis, Traffic Management Techniques, Car Following Models, Queueing Theory.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-553 **Course Title:** Highway Material Characterisation

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Soil; Mineral aggregates; Bitumen and bituminous binders; Bituminous mixes (hot and cold), mix design and performance tests; Cement; Mix design of pavement quality concrete, dry lean concrete, and pervious concrete; Alternate pavement materials.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-555 **Course Title:** Pavement Evaluation and Management

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Pavement Evaluation, pavement performance evaluation, pavement functional and structural evaluation, design alternatives, analysis, vehicle damage factor, pavement management system, pavement maintenance management.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-557 **Course Title:** Geometric Design

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Factors affecting Geometric design; Sight Distances; Cross-sectional elements and layouts; Design of Horizontal and Vertical Alignment; Types of Intersections, layouts, design considerations, auxiliary lanes; Capacity of Roads with different functional classification; Design of facilities – Parking spaces, Bus bays and shelters, Truck lay-byes, BRT Corridors and station/terminals, Toll plazas, Pedestrian Foot Over bridges.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Civil Engineering

Subject Code: CEC-559 **Course Title:** Transportation Planning

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Fields of transportation, Characteristics and objectives of planning, Transportation data needs, and sources, types of trips, trip generation, trip distribution, mode choice, traffic assignment, planning for sustainable transportation modes.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-507 **Course Title:** Systems Engineering

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Basic concepts of systems, system control, systems modeling and model development, System synthesis, economic analysis, conflicts and role of optimization in their resolution, (Un)constrained optimization – analytical and numerical, Integer programming, Geometric programming, Linear programming, Dynamic programming, Stochastic programming.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-509 **Course Title:** Statistics and Instrumentation for Environmental Engineers

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Experimental design, hypothesis testing, environmental monitoring, sampling and testing, regression and data analysis, molecular spectroscopy, chromatography, mass spectroscopy, High Performance Liquid Chromatography.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-516 **Course Title:** Constitutive Models for Geological Materials

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Elastic Constitutive behaviour, Basic concepts of Constitutive model, Yield function, Plastic Potential function, Hardening/softening rule, Elasto-plastic constitutive matrix, Simple elasto-plastic models, Tresca, Von Mises, Mohr Coulomb Drucker Prager, Cam Clay models, Advanced Constitutive models, Hardening Soil, HS Small, Elasto-plastic models with two yield surfaces.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-517 **Course Title:** Earthquake Resistant Design of Geotechnical Structures

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Seismology and Earthquakes, Different scales of Measuring Earthquake Magnitudes and Intensity, Ground Motion Parameters, Attenuation Relationships, Deterministic and Probabilistic Seismic Hazard Analysis, Return Period, G-R Relationship, Analysis of geotechnical structures like soil slopes, retaining structures, reinforced soil walls, waterfront retaining structures, shallow and deep foundations considering earthquake forces, Codal provisions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-519 **Course Title:** Foundations on Weak Rocks

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Engineering properties of weak rocks, different rock mass classification systems; Failure criteria for weak rocks, bi-linear Mohr-Coulomb failure criterion, Hoek and Brown criterion and modified Hoek and Brown failure criterion; Effect of structural planes on rock foundations; Requirements for satisfactory performance of foundations; Pressure-settlement characteristics, the effect of layering, anisotropy, heterogeneity, and in-elasticity; Shallow foundations; Piles in weak rocks; Dam foundations, the influence of discontinuities like faults, fault zones, shear zones, seams, etc.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-520 **Course Title:** Probabilistic Methods in Geomechanics

L-T-P: 3-0-2/2 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Fundamentals of modeling and simulation in geomechanics covering fundamentals of systems and models, regression analysis, parameters, simulations: random variables, basic concepts, discrete and continuous random variables, probability density and distribution functions (uniform, exponential, normal, lognormal etc), fitting distributions to raw data, goodness-of-fit tests, central limit theorem, various algorithms for generation of random numbers, Monte Carlo simulations, applications in geomechanics.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-526 **Course Title:** Tunnelling and Underground Excavation

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Planning and exploration, stereographic projection method, elastic stress distribution around tunnels, Greenspan method, application of rock mass classification systems, ground conditions in tunneling, jacking tests, Tunneling Methods, Rock mass-tunnel support interaction analysis, Ladanyi's elasto-plastic analysis of tunnels, load carrying capacity of rock bolts, permeability and grouting.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-527 **Course Title:** Advanced Foundation Engineering

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Soil exploration methods, shallow foundations, methods for estimating bearing capacity, settlement of footings and rafts, pile settlements, methods for estimating load transfer of piles, settlement of pile foundation, pile group capacity and settlement, laterally loaded piles, lateral and uplift capacity of piles, well foundations, IS code, elastic theory and ultimate resistance methods, arching in soils, sheeting and bracing systems in open cuts, sheet pile walls, cofferdams, soil-structure interaction.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-535 **Course Title:** Water Resources Systems Planning

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Systemic water resource planning, multi-objective planning, Water Plan Optimization, analytical and numerical optimization, Deterministic River Basin Modeling, estimation of various reservoir storage requirements, Conjunctive Use/Groundwater Management Models, Water Quality Management Models.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-538 **Course Title:** Tall Buildings

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Structural systems for multi-storey buildings, gravity and lateral loads on buildings, Analysis of multi-storey frames. Framed tube, tube-in-tube systems, and bundled tube systems, Symmetry and regularity in plan, and regularity in elevation, Torsion in buildings, Buildings with shear walls and coupled shear walls, Design and detailing of various members and beam-column joints for ductility. Capacity design. Performance based design, Design of floor slabs, raft and pile foundations, Application of MS-Excel, ETABS and SAFE software.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-540 **Course Title:** Pavement Analysis and Design

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Components of pavement structure, properties on pavement performance, stresses in pavements, design elements of flexible pavements, design methods of flexible pavements, rigid pavements, types of concrete pavements.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-541 **Course Title:** Transportation Data Analysis Techniques

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Overview of transportation data, data preparation and visualization, inferential statistics, parametric and non-parametric tests, univariate and multivariate distributions, concept of copula and its application in transportation analysis, statistical techniques for modelling continuous, multinomial and ordinal variables; user perception data and modelling concepts; data interpretation using statistical software.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-545 **Course Title:** Finite Element Analysis

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Boundary value problem, Strong form, Weak form, Galerkin approximation, Discretization, Global formulation and element level formulation, Basis functions and Shape functions, Compatibility and Completeness, Isoparametric Formulations, Element formulations in one, two and three dimensions, Numerical Integration, Stiffness Matrix, Force Vector, Boundary condition imposition, Numerical Errors and Convergence, Application in Structural analysis: Truss, Beams, Frames, Plates; Application to Structural Dynamics and Vibrations: Mass and Damping Matrices; Modal Analysis, Time History Analysis.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-546 **Course Title:** Advanced Highway Construction and Maintenance

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Role of subgrade in pavement system, & its construction; construction of base, sub-base, and bituminous layers; Prime coat, Tack coat, Stress Absorbing Membrane Interlayer (SAMI), Crack relief layer, Long Life Pavements, Full-Depth Reclamation Technique of Road Construction; construction of concrete pavements; maintenance activities in flexible and rigid pavements; pavement evaluation using BBD and FWD.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-563 **Course Title:** Urban Mass Transit Systems

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Mass transit systems, elements/ components of transit systems, urban mass transit systems, types, transit system planning, transit demand estimation and evaluation, transit system operations, transit networks and system analysis, economics and financing of transit systems.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-565 **Course Title:** Planning, Design, and construction of Rural Roads

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Planning of Rural Roads, Various Network Planning Models including CRRI Model, NATPAC Model, Gravity Model, FBRNP Model, PMGSY Roads, Geometric Design, Pavement Design of Flexible and Rigid Pavements, , Mix Design Methods, Rothfutch Method Various Waste Materials, Steel Slags, Construction Methods, Tractor Bound Technology, Full Depth Reclamation (FDR), Drainage, Hill Roads, Maintenance and Case Studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-567 **Course Title:** Transportation Systems Analysis

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Introduction to Transportation System Analysis, Transportation Technologies, Analysis of Systems, Transportation Economics, Sustainable Transportation Planning; practical components: Traffic data collection- Field study using videography; laboratory experiments- Simulator Studies; Transportation Network Analysis using MATLAB, Sumo Simulation Exercises.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-602 **Course Title:** Water Quality Management

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Water quality parameters; Advection, diffusion, dispersion; River water quality modelling, Streeter Phelps Equation and its various forms; Transformation of pollutants, physicochemical process and biodegradation; Lake water quality modelling, lake mixing and thermal stratification; Estuarine circulation and its model.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-604 **Course Title:** Environmental Impact and Risk Assessment

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: The Environmental Impact Assessment: MoEF Notifications; Prediction and Assessment of Impacts on the Air, Surface Water, Groundwater, Socio-economy and Land; Dispersion, Hydrogeological Models, Vulnerability Mapping, Subsurface Transport and Fate, Impacts and Propagation of Noise Environment from Point and Line Sources, Biological Impact Prediction and Assessment, Risk Assessment: Hazard Identification, Effect Assessment, Risk characterization, Environmental audit.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-605 **Course Title:** Solid Waste Management

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Planning and Design of Solid Waste Management System, Current issues, Generation, characterization, Collection, transfer, transport, separation, processing of Municipal Solid Waste, Ultimate Disposal and Landfill Design.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-606 **Course Title:** Environmental Remediation of Contaminated Sites

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Regulations and the Process of Remediation, Risk Assessment, Remedial Options, Administrative Options, Remedial Options: Groundwater, Plume Containment, Pump and Treat, Source Control, Permeable Reactive Barriers, Monitored Natural Attenuation, Remedial Options: Soils/Sediments, Excavation, Landfill, Solidification/Stabilization, Chemical Treatment, Bioremediation, Phytoremediation.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-611 **Course Title:** Analytical and Digital Photogrammetry

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Historical Development, Applications, Coordinate Systems, Condition Equations, Orthogonal Matrices, Image Measurement, Digital Images, Acquisition Methods, Storage, Corrections, Analytical Orientation, Plotter Functioning, Image Matching, Digital Correlation, Model Formation, DEM Generation, Photogrammetric Systems, Design, Add-ons, Aerial Triangulation, Applications.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-612 **Course Title:** Advanced Digital Image Processing

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Various types of remote sensing images and applications, Atmospheric, Radiometric and Geometric corrections, Image enhancement, Image compression, Supervised and unsupervised image classification methods, Spatial filtering techniques, DEM generation, Empirical modeling, Open source image processing software, ANN, Fuzzy Logic, Object based classification.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-613 **Course Title:** Thermal, Microwave and Hyperspectral Remote Sensing

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Utility, interpretation, merits and demerits of thermal, hyperspectral and microwave remote sensing, Thermal infrared region models, Active and Passive Microwave remote sensing, SAR Interferometry for DEM generation, Principles of hyperspectral remote sensing, Spectral mixing theory and methods.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-614 **Course Title:** Theory and Applications of GIS

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Introduction and Utility of GIS, FIS Packages, Raster and Vector Data, Data pre-processing, compression and reduction techniques, Database structure, Spatial and mathematical operations in GIS, Programming languages in GIS, Virtual GIS, Web GIS, Applications of GIS to natural resources mapping and monitoring.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-616 **Course Title:** Geoinformatics for Landuse Surveys

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Land use land cover mapping and analysis, LULC analysis based on spectral and temporal characteristics, Digital image classification, Classification accuracy assessment, Issues in urban and regional planning, Mapping of parcels and buildings, Role of remote sensing and GIS for urban planning.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-617 **Course Title:** Satellite Geodesy

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Reference coordinate systems, Time, Signal Propagation, Satellite Orbital Motion, Celestial Mechanics, Geodetic Satellites and their usages in geodesy, Satellite altimetry, Laser ranging, VLBI, Application of Geodetic Satellite Methods.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-618 **Course Title:** Modeling and Analysis of Geospatial Data

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Types of geospatial data, Multi criterion decision making, Coordinate transformations, Geospatial data structures and database management systems, Measurements and analysis of geospatial data, Principles of least squares, Confidence intervals and statistical testing, Uncertainty modeling of geospatial data.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-623 **Course Title:** Stability Analysis of Slopes

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines: Modes of failures in slopes and study of safety aspects including provision of remedial measures, continuum and discontinuum approaches ,seepage analysis, Limit Equilibrium analysis of slopes by Bishop's modified method, Bishop's rigorous method, Janbu's method, Morgenstern and Price, Spencer's method for soil slopes and Hoek, Hoek and Bray Analyses of rock slopes for planer, wedge and toppling modes, Application of stereographic projections, Stabilization measures along with instrumentation and monitoring of the slopes, Computer aided analysis.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-625 **Course Title:** Ground Improvement Engineering

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Principles of ground improvement, Classification of ground improvement techniques; Densification techniques, shallow and deep compaction; Consolidation methods, design using PVDs, preloading; Design of stone columns; Admixture Stabilisation, in-situ mixing and grouting techniques, mechanism of cement/lime stabilisation; Reinforcement techniques, Introduction to geosynthetics, types, functions, properties and testing, reinforced earth walls, reinforced slopes/embankments, geosynthetics for drainage and filtration; Soil nailing, mechanism, failure modes, design approach; Advanced techniques.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-636 **Course Title:** Hydro Power Engineering

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Fundamentals of hydropower, estimation of Water Power Potential, Types of Hydropower Plants, General classification and design criteria of Penstocks, design and features of Trash racks, various types of intake structures, air entrainment, types of turbines, cavitation, turbine model testing, Water Hammer and Surges.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-642 **Course Title:** Analysis and Design of Bridges

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Structural Forms and Design Loads for Bridges, Effective Width Concept and Load Distribution in Multi-Beam Bridges, Grillage Analogy, R.C. and Pre-Stressed Concrete Slab Bridges, R.C. and Pre-Stressed Concrete Girder Bridges, Box-Girder Bridges, Arch Bridges, Suspension and Cable Stayed Bridges, Types of Bearings and Design of Elastomeric Bearings, Secondary Effects, Temperature, Shrinkage, Creep. Construction Techniques and Effects of Construction Sequence on Design.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-647 **Course Title:** Condition Assessment and Retrofitting of Structures

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Deterioration Mechanisms, Corrosion, Moisture & Thermal Effects, Structural Effects, Construction Defects, Evaluation: Non-Destructive and Semi-Destructive Testing, Repair Techniques: Repair Analysis, Repair Strategy, Materials, Preparation, Placement Methods, Retrofitting: Shear Strengthening, Shear Transfer Strengthening, Column Strengthening, Flexural Strengthening, and Crack Stabilization, member and Global Strengthening Techniques, Case Studies of Repair & Retrofitting.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-649 **Course Title**: Fracture Mechanics in Quasi-Brittle Materials

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Linear Elastic Fracture Mechanics (LEFM), Elastic solution of plate with a crack, Griffith's theory, Energy release rate, Crack resistance, Stress intensity factors, Mixed mode crack propagation, Elasto-plastic fracture mechanics (EPFM), Crack tip plastic zone, J-integral, Crack Tip Opening Displacement, Fracture in quasi-brittle materials: Fracture process zone, Size effect, Fictitious and Effective elastic crack approaches, Applications: Fracture of Reinforced concrete structures, Crack propagation in bi-material interface; Fatigue crack propagation: Constant and variable amplitude loading, Overload effect, Crack closure.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-662 **Course Title:** Intersection Design and Control

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Intersection geometries and their influence on design/operation, Operational analysis of two-way and all-way stop controlled intersections and roundabouts by US and Indian methods, Analysis of roundabouts, Analysis of signal controlled intersections by US, British and Swedish methods, delay and its evaluation; Types of signals, Design of signals by Indian, US and British methods; signal coordination; Grade separated intersections and interchanges; Weaving sections and their operational evaluation; Intersection signs, marking and lighting.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-665 **Course Title:** Road Traffic Safety

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Road traffic accident scenario, crash data and its management, methods for identifying hazardous locations, crash causation and countermeasure selections for different traffic facilities, such as intersections and midblocks/segments, urban and rural roads, and various road users including VRUs, evaluation methods for road safety interventions, human factors contributing to the crash occurrences, safety performance functions/crash prediction models, crash modification factors (CMFs), concept of Potential for Safety Improvement (PSI), road safety audits, road safety analyses and improvements using traffic conflict techniques, naturalistic driving studies, AI/ML and data analytics applications in road traffic safety.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Civil Engineering

Subject Code: CEL-666 **Course Title:** Transport Economics

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Basic components of transport, economic theory, transport as an economic activity, transportation demand and congestion, elasticities, congestion pricing, transport supply and regulation, transport costs and pricing, appraisal and evaluation of transportation projects, funding and financing of transportation projects.