INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

Subject Code: EQC-521 **Course Title:** Seismological Modelling and Simulation

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

Course Outlines: Introductory plate tectonics; earthquake recording; earthquake magnitude and intensity scales; theory of elasticity; elastodynamic wave equations; laws governing seismic wave propagation and attenuation; factors affecting SGM characteristics; finite-difference (FD) modelling – spatial and temporal discretization, free surface and absorbing boundary conditions; point source and finite source implementation; kinematic and dynamic rupture simulation; stochastic point-source and finite-source models; basic signal processing.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

Subject Code: EQC-523 **Course Title:** Seismic Vulnerability and Risk Analysis

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

Course Outlines: Components of seismic risk – hazard, vulnerability and exposure; assessment of vulnerability via empirical, analytical, experimental and hybrid approaches; use of intensity scales; capacity spectrum method; HAZUS methodology; displacement-based approach; approaches for assessment of exposure quantification of risk, loss ratios, and indoor and outdoor casualty rates; case studies (e.g., RADIUS, HAZUS, PAGER, GEM, EU-RISK); earthquake damage surveys; classification of damage; estimation of fragility from damage data; risk communication

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

Subject Code: EQC-525 **Course Title:** Seismic Hazard Assessment

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Introductory seismic hazard, risk and vulnerability, cases, seismicity data, seismicity catalogues and statistical analyses; earthquake sources, earthquake occurrence models (ETAS, EEPAS); time and slip predictable earthquake forecasting, Gutenberg-Richter and Gumbel models; ground motion prediction, elastic and inelastic response spectra, displacement spectra, deterministic and probabilistic seismic hazard analysis, logic-tree and bed-rock level hazard estimation, exceedance probability, return periods; earthquake simulations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

Subject Code: EQC-511 **Course Title:** Structural Dynamics

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

Course Outlines: Dynamic equilibrium and mathematical models; dissipation mechanisms; Undamped and damped, free and forced vibrations; Steady-state and transient response, impulse response; Harmonic response and applications to vibration isolation; Seismometers, accelerometers; Convolution integral; Numerical methods for time marching; response/shock spectra; Fourier transforms and frequency domain; Lagrange's equations; MDOF systems; Algebraic eigenvalue problem and free vibration analysis; Undamped and damped normal modes; Mode superposition method; Mode-truncation and correction for the missing mass; Hamilton's principle; Axial and transverse vibrations of beams, torsional vibrations of shafts; Vibrations of elastic half-space.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

Subject Code: EQC-513 **Course Title:** Earthquake Resistant Design of Structures

L-T-P: 3-0-2 **Credits:** 04 **Subject Area:** PCC

Course Outlines: Seismic performance of structures during earthquakes; ground motion parameters; response spectrum, design spectrum. Concept of strength, overstrength and ductility, Concept of equal displacement and equal energy principles, Capacity Design; buildings with irregularities. Equivalent static analysis, response spectrum analysis, Time history analysis; Modelling concept of building. Seismic resistant properties of reinforced concrete; Seismic Behaviour and design of linear reinforced concrete elements; design of water storage tanks, codal provisions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

Subject Code: EQC-515 **Course Title:** Continuum Mechanics of Solids

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Tensor calculus, eigenvalues and eigenvectors, integral theorems; kinematics of deformation Lagrangian and Eulerian description, material derivative, strains, polar decomposition; stress and equilibrium, conservation laws, closure conditions and constitutive laws; linear elastic constitutive law, Lame's parameters; stress and strain transformation, stress invariants, principal stresses; isotropy, anisotropy and elastic symmetry; Airy's stress functions, elastic limits, Mohr-Coulomb, Tresca and von-Mises criteria, and Drucker-Prager models, flow rules, post-yield behaviour, isotropic and kinematic hardening, plastic stress-strain equations, plastic potential theory

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

Subject Code: EQL-513 **Course Title:** Structural Response Control for Seismic Protection

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

Course Outlines: Historical development of structural control and base isolation, active control, passive control, hybrid control, semi active control; Principle of base isolation; linear and nonlinear procedures of isolation design, Laminated rubber bearing, lead rubber bearing, high damping rubber bearing, PTFE sliding bearing, friction pendulum system and sleeved pile system; modelling of isolation bearings; design process for multi-layered elastomeric bearings and buckling behaviour of elastomeric bearings; isolation system testing, implementation of energy dissipation devices; metallic yield dampers, friction dampers, viscoelastic dampers, tuned mass dampers, tuned liquid dampers; shape memory alloy dampers; modelling, linear and nonlinear procedures; detailed system requirements; application to multistorey buildings; testing of energy dissipation devices.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

Subject Code: EQL-514 **Course Title**: Random Vibration

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

Course Outlines: Meaning and axiom of probability, events, random variables, discrete and continuous distribution, some examples; Functions of random variables, expectations, characteristic functions; Orthogonality principles, sequence of random variables. Counting process, random walk, Markov chain, Gaussian process, filtered point process, Markov process and non-stationary Gaussian process; Stochastic continuity and differentiation, integral, time average, ergodicity; Correlation and power spectrum; Threshold crossing, peak, envelope distribution and first passage problem. Single degree and multi-degree of freedom systems; Continuous system and non-linear system- equivalent linearisation and Gaussian closure technique.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

Subject Code: EQL-520 **Course Title:** Earthquake Precursors and Early Warning Systems

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

Course Outlines: Precursor definition, scope and its relation with earthquake prediction, forecast and warning; types of precursors; precursor's relation to main event; physical phenomenon associated with precursors; case studies; earthquake precursor models; seismic gaps for large earthquakes; concept of earthquake early warning (EEW) systems; onsite and regional EEW; description of some world-wide EEW systems; requirements of EEW system; algorithms for EEW systems; advantages and limitations of EEW systems.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Departments of Earthquake Engineering

Subject Code: EQL-507 **Course Title:** Numerical Methods for Dynamic Systems

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

Course Outlines: Elementary concepts of vector spaces, subspaces; Column and row space of a matrix; ortho-normal bases, vector and matrix norms, errors in floating point arithmetic. Formulation of stiffness matrix for prismatic, non-prismatic frame elements, global stiffness matrix, response analysis of frame structure using stiffness method. solution of large system of equations for dynamic problems, Implementation details for band and/or skyline solvers, vector processing and parallel processing. techniques in the eigen solution of large problems. Interpolation and extrapolation, numerical differentiation and quadrature methods. Response by the Integration of ODEs with emphasis on accuracy and stability, integration of stiff ODE, concepts of A-stability and stiff-stability.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Departments of Earthquake Engineering

Subject Code: EQC-501 **Course Title:** Dynamics of Soil and Structures

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

Course Outlines: Vibrations and the nature of time-dependent phenomena, mathematical models of physical systems; energy storage and dissipation mechanisms; idealization of soils and structures; damping; Dynamics of Single Degree of Freedom Systems; Numerical methods for solution of linear and non-linear equations of motion; Dynamics of Multi-Degree of Freedom Systems: Lagrange's equations; equations of motion for MDOF systems; Dynamics of Continuous Systems.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Departments of Earthquake Engineering

Subject Code: EQC-503 **Course Title:** Finite Element Methods

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

Course Outlines: Method of weighted residuals; Variational principles and approximate solutions; Convergence of approximate solutions; Rules of domain discretization; discretization errors. Continuity requirement; Truss/rod/shaft, beam bending; Modeling of framed structures; Skewed boundary conditions; plane stress, plane strain and axi-symmetric idealizations; Triangular and rectangular elements; Interpolation functions; Evaluation of domain and surface integrals; Tetrahedral and brick elements; Numerical integration; Full reduced and selective integration; Finite elements for plates and shells; Semi-analytical procedure for axi-symmetric shells. Consistent mass matrix; lumping procedures.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Departments of Earthquake Engineering

Subject Code: EQC-505 **Course Title:** Geotechnical Earthquake Engineering

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

Course Outlines: Seismic hazards and lessons learnt from past earthquakes; Wave Propagation; Seismic response of soil at low and high strains using field and laboratory tests; Stress-strain behavior of cyclically loaded soils; Ground Response Analysis; Liquefaction; Earth Pressure; Seismic design of retaining wall; Seismic Slope Stability: Types of earthquake induced landslides; Evaluation of seismic slope stability, yield acceleration, displacement analysis; Ground Improvement Techniques: Densification, reinforcement, and grouting and mixing, drainage.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Departments of Earthquake Engineering

Subject Code: EQC-507 **Course Title:** Earthquake Resistant Design of Foundations

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Design Seismic Data; Seismic analysis and design of shallow Foundations; Seismic analysis and design of pile Foundations; Laterally loaded piles, elastic analysis; Reese and Matlock approach, fixity of pile heads, dimensionless factors; Well Foundations & Caissons: Types of wells, casting, floating and sinking of caissons; Well sinking scour depth, depth & bearing capacity of wells; Pseudo-static analysis with earthquake induced loads, displacement dependent earth pressures for wells; Lateral load resistance of well foundation; IRC, IS and Indian Railway Codes, their limitations.