DETAIL

COURSE CURRICULUM

FOR

POSTGRADUATE PROGRAMME

M.TECH

IN

CIVIL ENGINEERING

Specialization in

Seismic Science and Engineering

NATIONAL INSTITUTE OF TECHNOLOGY AGARTALA (TRIPURA)

PREFACE

Civil Engineering Department of NIT Agartala, awards the degree of Master of Technology (M. Tech) in seven different specializations viz, Environmental Engineering, Geotechnical Engineering, Hydro-Informatics Engineering, Structural Engineering, Seismic Science and Engineering, Transportation Engineering and Water Resources Engineering.

The course structures of all post graduate degree programmes are carrying a total of 80 credits and 2000 marks. Semester wise distribution of course and credits are as follows: First semester: 25 credits and 800 marks for five theory subjects (comprises basic core, core and elective subjects), two laboratory subjects and seminar; Second semester: 25 credits and 800 marks for four theory subject (comprises basic core, core and elective subjects), two laboratory subjects, comprehensive viva-voce and project preliminaries; Third semester: 10 credits and 100 marks; and Fourth semester: 20 credits and 300 marks. Third and fourth semester of PG courses will be fully devoted to project works. Minimum requirement of number of class hours for each theory course is 40 hours per semester.

There will be continuous assessment of the performance of students throughout the semester. Each theory subject in a semester is evaluated for 100 marks, with the following weightages. Sub-component weightage:Continuous evaluation: 30 Marks (Attendance: 5 Marks, Quiz: 5 Marks, Class test: 10 Marks, Assignment: 10 Marks); Mid-semester Examination: 20 Marks; and End-semester Examination: 50 Marks

The course curriculum of M Tech Seismic Science and Engineering programme is designed considering the following six Programme Outcomes (POs):

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO4: An ability to identify, formulate and solve Seismic Science and Engineering related problems using advanced level computing techniques

PO5: An ability to understand the impact of Seismic Science and Engineering solutions in a global, economic, environmental and societal context

PO6: Ability to demonstrate the knowledge of Seismic Science and Engineering and management principles and apply these to multidisciplinary environments.

The course curriculum of M Tech Seismic Science and Engineering programme is also designed considering two Program Specific Outcome (PSOs).

PSO1: Analysis, design, investigation of complex problems in ways which are sustainable and environmental friendly.

PSO2: Handling of any Civil Engineering projects ethically either as an individual or as a team.

Expert opinions are being taken in regular basis in order to improve the quality of teaching learning process and to attain the programme outcomes efficiently.

In the Final year of M.Tech programmes (Third and Fourth Semesters) students may also opt for industrial research. If any student desire to pursue his/her research in reputed industries, he/she may be allowed to do so, provided:

a. The selected industry is a permanent member of NASSCOM, FICCI and other such industry bodies.

b. The selected industry needs is approved by the DPPC of the concerned Department.

c. The student selects one supervisor from industry and another supervisor from the Institute.

d. If any student opts for such industrial research he/she will not receive any scholarship from the institute in this tenure, even if he/she wants to return back. In such cases the student will be allowed to complete his/her project in the institute but without any scholarship.

Syllabus: M.Tech. (Seismic Science and Engineering)

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	First Semester			
1	**Basic Core** **PCE71B01**: Advanced Engineering Geology and Geo-Hazard Management	4	4	100
2	**Core Subject-I** PCE71C01: Dynamics of systems	4	4	100
3	**Core Subject-II** PCE71C02: Numerical Methods	4	4	100
4	**Elective Paper I (Any One)** **PCE71E01:**Geographical Information Systems and Remote Sensing **PCE71E02:** Structural Reliability **PCE71E03**: Seismic Microzonation	4	4	100
5	**Elective Paper II (Any One)** **PCE71E04**: Ground Improvement Techniques **PCE71E05:** Engineering Application of Geophysical Techniques **PCE71E06**: Seismic Hazrd&Risk Assessment	4	4	100
6	**PCE71P01**: Advanced Dynamics Laboratory	2	3	100
7	**PCE71P02**: Characterization of Rock and Fault	2	3	100
8	**PCE71P03**: Seminar	1	2	100
	Total	**25**	**28**	**800**
	Second Semester			
1	**PCE72B01**: Advanced Seismology	4	4	100
2	**Core Subject-I** **PCE72C01**: Geotechnical Earthquake Engineering	4	4	100
3	**Core Subject-II** **PCE72C02**: Seismic Analysis and Design of Structures	4	4	100
4	**Elective Paper III (Any One)** **PCE72E01**: Soil-Structure Interaction **PCE72E02**: Finite Element Method **PCE72E03**: Seismic Slope Stability: Earth Dam and Retaining Wall	4	4	100
5	**PCE72P01**: Software Application Lab	2	3	100
6	**PCE72P02**: Digital Image Processing and Seismic Signal Processing Lab	2	3	100
7	**PCE72P03**: Project Preliminary	3	6	100
8	**PCE72P04**: Comprehensive Viva-voce	2	0	100
	Total	**25**	**28**	**800**
	Third Semester			
1	**PCE73P06**: Project & Thesis - I	**10**	**-----**	**100**
	Fourth Semester			
1	**PCE74P01**: Project & Thesis - II	**20**	**-----**	**300**
			Total Marks	**2000**

First Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	First Semester			
1	**Basic Core** **PCE71B01**: Advanced Engineering Geology and Geo-Hazard Management	4	4	100
2	**Core Subject-I** PCE71C01: Dynamics of systems	4	4	100
3	**Core Subject-II** PCE71C02: Numerical Methods	4	4	100
4	**Elective Paper I (Any One)** **PCE71E01:**Geographical Information Systems and Remote Sensing **PCE71E02:** Structural Reliability **PCE71E03**: Seismic Microzonation	4	4	100
5	**Elective Paper II (Any One)** **PCE71E04**: Ground Improvement Techniques **PCE71E05:** Engineering Application of Geophysical Techniques **PCE71E06**: Seismic Hazrd&Risk Assessment	4	4	100
6	**PCE71P01**: Advanced Dynamics Laboratory	2	3	100
7	**PCE71P02**: Characterization of Rock and Fault	2	3	100
8	**PCE71P03**: Seminar	1	2	100
	Total	**25**	**28**	**800**

Basic Core

ADVANCED ENGINEERING GEOLOGY AND GEO-HAZARD MANAGEMENT(PCE71B01)

Total Credit: 04 **Contact Periods: 04 (4L+0T+0P)**

Course Objective:

1. To know about Geology and Geo-hazard Management

2. To understand origin of Earth, Earth surface topography, ocean floors, Earth's interior, fault, fold, rift and basin systems, tectonic plates, etc.

3. To understand geological and geophysical mapping for engineering projects.

4. To understand geohazards and disaster mitigation management, seismic zonation, building code.

5. To understand Earthquake, Volcano, Flood, Cyclone, Landslides, Tsunami, and various warning systems.

6. To understand Geo-environment, Climate & Tectonics.

7. To evaluate geological structures of a particular location/site and to go for geo-hazard management, if required.

Course Content:

Unit-1:

Origin of Earth, various hypothesis, figure of the Earth, geoid, Earth's interior structure and constitution. Mantle convection and self-dynamo theory, Earth's crust, oceanic and continental types, structure, composition and mineralogy.

Unit-2:

Continental drift theory, plate tectonics, plate margins, kinematics and relative movements of the major plates, surface manifestations, tectonic and seismic activity at the plate margins, sea mounts, ridges, ocean volcanoes, continental slope, shelf and hinge zones.

Unit-3:

Geological time scales, structure and composition of the crust in land and ocean. The Himalaya orogeny. Formation of different types of rocks and soils, geological classifications, rock hardness, strength, rock cycles, soil classification, soil erosion.

Unit-4:

Weathered layer, bed rock, strike, dip, rock texture, fractures, joints, shear strength, stability and slope, landslides, engineering properties of rocks (lab and in-situ) density, porosity, permeability, drilling / borehole lithologs, core, SPT.

Unit-5:

Faults. lineaments and fold structures in rocks, kinematics and dynamics of faulting and folding, crustal structures like graben, rift systems, sedimentary basin, dykes, sills and batholith. An introduction to geological and tectonic map of India.

Unit-6:

Global seismicity, seismic wave types and propagation, interior structure of the Earth based on seismological observations. Tsunami, Paleoseismicity and seismites.

Unit-7:

Geological mapping, weathered layer section from drilling data, lithology identification, dip and strike of bed rock formation, surface structural discontinuity, unconformity. Geophysical mapping (by resistivity and seismic refraction methods) of the subsurface structures, bed rock depth, hidden fault identification at the engineering project sites.

Unit-8:

Geohazards like earthquakes, floods, river behavior, draughts, landslides, cyclones, tsunamis, coastal hazards, sea level changes. Disaster mitigation and management.

Unit-9:

Seismic zoning map (BIS), building codes, preparation of microzonation maps for the engineering projects by multidisciplinary approaches (Geology, Geophysics, Seismology and Geotechnical).

Unit-10:

Earthquake, Tsunami, Cyclone, Flood, Volcano, Landslide and warning systems, and developing public awareness.

Unit-11:

An interactive discussion on geo-environment, tectonics and climate change.

Reference:

1. Legget, R.F. and Hathway, A., "Geology and Engineering", McGraw-Hill 1988

2. Bell, F.G., "Fundamentals of Engineering Geology", Elsevier 2007

3. Johnson, R.B. and DeGraft, J.V. "Principles of Engineering Geology", John Wiley & Sons 1988

4. Brown, G.C., Hawkesworth, C.J. and Wilson, R.C.L.(Eds.), "Understanding the Earth", Cambridge University Press 1992

5. Condie, K.C, "Plate Tectonics and Crustal Evolution", Butterworth-Heinemann 1982

6. Cox, A. and Hart, R. B "Plate Tectonics: How it Works", Wiley- Blackwell 1986

7. Davies, G.F., "Dynamic Earth: Plates, Plumes and Mantle Convection", Cambridge 2000

8. Hoek E. and Bray J.W., "Rock Slope Engineering", Spoon Press, 3rd edition. 1980

9. Petak W.J. and Aitkinson A.D., "Natural Hazard risk Assessment and Public Policy", Springer-Verlag. 1982

10. Haque C. E., "Mitigation of Natural Hazards and Disasters", International perspectives", Springer.

Course Outcome:

1. The students will know about Geology and Geo-hazard Management.

2. They will understand origin of Earth, Earth surface topography, Earth's interior, crustal structures like faults, folds, rift and basin systems, tectonic plates, etc.

3. They will understand geological and geophysical mapping for engineering projects.

4. They will learn geo-hazards and disaster mitigation management, seismic microzonation, building code.

5. They will also learn Earthquake, Volcano, Flood, Cyclone and Tsunami warning systems, geo-environment and climate.

6. They can evaluate geological and structural conditions of a particular location and take precautionary measures for geo-hazard management, if required.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE71B01.1	The students will know about Engineering Geology and Geo-hazard Management
PCE71B01.2	They will understand origin of Earth, Earth surface topography, Earth's interior structure, fault, fold, rift, basin, tectonic plates etc.
PCE71B01.3	They will understand geological and geophysical mapping for engineering projects.
PCE71B01.4	They will learn geo-hazards and disaster mitigation management, seismic microzonation, building code etc.
PCE71B01.5	They will also learn Earthquake, Volcano, Flood, Landslides, Cyclone, Tsunami and various warning systems, geo-environment and climate.
PCE71B01.6	They can evaluate surface and subsurface geological structures of a particular location and take necessary measures for geo-hazard management, if required

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE71B01.1	3	3	2	2	2	2
PCE71B01.2	3	3	2	2	2	2
PCE71B01.3	3	3	2	2	2	2
PCE71B01.4	3	3	2	2	2	2
PCE71B01.5	3	3	2	2	2	2
PCE71B01.6	3	3	2	2	2	2
Total	**18**	**18**	**12**	**12**	**12**	**12**
Average	**3**	**3**	**2**	**2**	**2**	**2**
Equivalent Avg. Attainment	**3**	**3**	**2**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE71B01.1	3	3
PCE71B01.2	3	3
PCE71B01.3	3	3
PCE71B01.4	3	3
PCE71B01.5	3	3
PCE71B01.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

Core Subject-I

DYNAMICS OF SYSTEMS (PCE71C01)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course Objective:

1. 1.To make the students understand the basics of structural dynamics, different types of dynamic loads and systems.
2. To make able the students to analyze different systems under dynamic loads.
3. To gain knowledge about application of structural dynamics to civil engineering problems.

Course Content:

Unit-1

An over view on basic features of dynamic loading and response – models for dynamic analysis –lumped mass, generalized displacements and finite element models. Formulation of equation of motion – irect equilibration, principle of virtual displacement and Hamilton’s principle. Degrees of freedom – Translational and rotational systems - Mass moment of inertia- Generalized single degree of freedom systems- Rigid body assemblage determination of characteristic properties.

Unit -2

Free vibration of single degree of freedom system: - Solution of equation of motion, undraped free vibration - Damped free vibration, critically damped, under damped and over damped systems, Negative damping.

Unit -3

Forced vibration of Single degree of freedom system –Response to harmonic loading, undamped system and damped system, Response to periodic loading -Fourier series expansion of the loading response to Fourier series loading Exponential form of Fourier series loading and response-Complex frequency transfer functions. Response to impulsive loads: - Suddenly applied load, sine wave impulse, rectangular impulse, triangular impulse, spike loading, approximate analysis. Response to general dynamic loading: - Duhamel integral for undamped system – unit impulse response function – numerical evaluation, response of damped system- numerical evaluation, Numerical analysis in the frequency domain, fast Fourier transform analysis.

Unit 4

Multi degree of freedom system: - Two degree of freedom system – equation of motion, characteristic equation, frequencies and mode shapes, coordinate coupling and choice of degree of freedom, orthogonality of modes, natural coordinates, superposition of natural

Modes, response of two degree of freedom system to initial excitation, beat phenomenon, response to harmonic excitation. Multi- degree of freedom system – analysis of multi-degree of freedom system- mode superposition analysis.

Unit 5

Distributed Parameter System: Partial differential equation of motion - Axial vibration of prismatic bars - Elementary case of flexural vibration of beams - Beam flexure including axial force effects. Orthogonality of modes- Normal Coordinates- Uncoupled Equations of flexible vibration of beams. Practical Vibration Analysis: - Determination of frequency by Rayliegh's method, beam flexure –selection of shape- improved Rayliegh's method.

References:

Sl No.	Name of Book	Author	Publisher
1.	Dynamics of structures – Theory and Application to Earthquake Engg.	Chopra, A.K.	Tata McGraw Hill.,
2.	Structural Dynamics	Mario Paz	CBS Publishers and Distributors
3.	IS 1893 – Criteria for Earthquake Resistant Design of Structures		
4.	SP 22: Explanatory Handbook on Codes for Earthquake Engineering		

Course Outcome:

At the end of the course, student will be able to

1. Understand different types of dynamic loading and will be able to convert structures into SDOF and MDOF system.
2. Evaluate the free and forced vibration response of SDOF system with damped and undamped conditions.
3. Evaluate free and forced vibration response of MDOF systems with damped and undamped conditions.
4. Apply numerical methods to evaluate response of SDOF and MDOF system.
5. Understand time history analysis and concept of response spectra.

Table-1

To establish the correlation between COs &POs

No. of Course Outcome (CO)	Course Outcome
PCE71C01.1	Students will be able to understand different types of dynamic loading and will be able to convert structures into SDOF and MDOF system
PCE71C01.2	Students will be able to calculate free and forced vibration response of SDOF system
PCE71C01.3	Students will be able to calculate free and forced vibration response of MDOF system
PCE71C01.4	Students will be able to apply numerical methods to evaluate response of SDOF and MDOF systems
PCE71C01.5	Students will be able to understand time history analysis and concept of response spectra

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE71C01.1	3	2	3	2	2	2
PCE71C01.2	3	2	3	2	2	2
PCE71C01.3	3	2	3	2	2	2
PCE71C01.4	3	2	3	2	2	2
PCE71C01.5	3	2	3	2	2	2
Total	15	10	15	10	10	10
Average	3	2	3	2	2	2
Equivalent Avg. Attainment	3	2	3	2	2	2

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE71C01.1	3	2
PCE71C01.2	3	2
PCE71C01.3	3	2
PCE71C01.4	3	2
PCE71C01.5	3	2
Total	15	10
Average	3	2
Equivalent Avg. Attainment	3	2

Core Subject-II

NUMERICAL METHODS (PCE71C02)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course Objective:

1. To understand about the necessity of approximations and errors in computation.
2. To explain the various methods of interpolation, numerical differentiation and integration.
3. To explain the numerical solution of algebraic and transcendental equations.
4. To explain the numerical solution of ordinary and partial differential equation.
5. To explain the numerical solution of eigen value problem.

Course Content:

Unit-1

Estimation of Errors: Approximation of numbers; Significant figures, Absolute, Relative and Percentage errors, Truncation and round-off errors, Accumulation and propagation of errors.

Unit -2

Concept of interpolation, difference operators, divided difference interpolation, Newton's forward, backward interpolation, Lagrange's interpolation, Central Difference Interpolation Formula, Starling and Bessel's interpolation, Hermite interpolation, Spline interpolation – cubic splines, least square approximation to discrete data. Numerical Differentiation using Newton's Forward and Backward Interpolation Formula. Newton-Cote's Formula, Trapezoidal Rule, Simpson's one-third Rule, Simpson's three-eighth Rule, Weddle's Rule, Euler- Maclaurin's Summation Formula, Gaussian Legendre and GaussainChebyshevs quadrature, Richardson extrapolation, Euler Maclaurins sum formula, Rombergs integration.

Unit -3

Solution of algebraic and transcendental equations by bisection method, iteration method, Regula-Falsi method (Method of False position), Newton-Raphson method, Complex roots by Lin-Bairstow's method, Solution of Simultaneous linear equations by Gauss Elimination Method, Gauss-Jordan Elimination Method and Gauss-Seidal Iteration Method, Matrix Inversion Method, Triangular factorization, relaxation method. Roots of Polynomial equations: Sensitivity of Polynomial Roots, Steffensen method, Bairstows method of quadratic factors, Graeffes root squaring method.

Unit -4

Taylor's method, Picard's method, Euler's method, Euler's modified method, Runge's method, Runge-Kutta's method, Predictor- corrector method (Milne's Method , ABM Method). Numerical Solution of Partial differential equation: Methods for solving Hyperbolic Equations by finite difference methods, explicit methods, implicit methods & by the method of characteristics.

Unit -5

LU decomposition of matrices, Power method of extreme eigen values, Jacobis method for symmetric matrices.

References:

Sl No.	Name of Book	Author	Publisher
1.	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons
2.	Numerical Methods in Engineering and Science	B. S. Grewal	Khanna Publishers
3.	Numerical Analysis	S.A.Mollah	Books & Allied Ltd

Course Outcome:

1. Students will be able to analyze and compute the error of estimation.
2. Students will be able to analyze and find the numerical solution of algebraic and transcendental equations.
3. Students will be able to analyze and find the numerical solution of ordinary and partial differential equations.
4. Students will be able to analyze and compute the numerical solution of eigen value problems.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE71C02.1	Students will be able to analyze and compute the error of estimation.
PCE71C02.2	Students will be able to analyze and find the numerical solution of algebraic and transcendental equations.
PCE71C02.3	Students will be able to analyze and find the numerical solution of ordinary and partial differential equations.
PCE71C02.4	Students will be able to analyze and compute the numerical solution of eigen value problems.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE71C02.1	2	2	2	2	2	2
PCE71C02.2	3	3	2	2	2	2
PCE71C02.3	3	3	2	2	2	2
PCE71C02.4	3	3	2	2	2	2
Total	**11**	**11**	**8**	**8**	**8**	**8**
Average	**2.75**	**2.75**	**2**	**2**	**2**	**2**
Equivalent Avg. Attainment	**3**	**3**	**2**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE71C02.1	2	2
PCE71C02.2	3	3
PCE71C02.3	3	3
PCE71C02.4	3	3
Total	**11**	**11**
Average	**2.75**	**2.75**
Equivalent Avg. Attainment	**3**	**3**

Elective Paper - I (Any One)

PCE71E01: Geographical Information Systems and Remote Sensing

PCE71E02: Structural Reliability

PCE71E03: Seismic Microzonation

GEOGRAPHICAL INFORMATION SYSTEMS AND REMOTE SENSING(PCE71E01)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course Objective:

1. To make the students conversant with the basics of GIS and its general applications in various fields.

2. To have adequate knowledge on Type of data and information handled in GIS.

3. To have adequate knowledge on various GIS analysis operations with vector data.

4. To have adequate knowledge on various GIS analysis operations with Raster data.

5. To understand Remote sensing and its basic along with its application in Environmental Engineering.

6. To have practical knowledge about handing geo-spatial data.

Course Content:

Unit-1:

Introduction to GIS (history of GIS, early developments in GIS, components of GIS, Applications of GIS etc).

Unit-2:

Spatial Data Modelling (Representation of spatial data, Raster & vector data model, TIN & DEM), Geo-referencing and Projection (Coordinate System, Map Projection, Transformation, Geo-referencing), Map and Map Scales (Introduction to Maps, Map Scales, Types of Maps, Map and Globe).

Unit-3:

Data Base Management system (Data Storage, Database Structure Models, GIS Data File Management), Spatial data (Primary data, Secondary data, Data pre-processing).

Unit-4:

Data Analysis (Vector operation & analysis, Raster operation & analysis, Network Analysis), Interpolation Technique (Global Methods of Interpolation, Local Methods of Interpolation).

Unit-5:

Cartographic Principles and Design (Introduction, Map layout, Toposheet, component of Map), GPS, Introduction to Remote sensing and its application.

References:

1. Burrough P A., (1986), "GIS for Land Resource Assessment", Oxford University Press, U.K.

2. Star J.L., and Estes J.E., (1990). "Geographic Information Systems; An Introduction". Prentice Hall Publications.

3. Laurini R. and Thompson D., (1992). "Fundamentals of Spatial Information Systems", Academic Press.

4. Mishra H.C., (1997), "GIS Handbook", GIS India, ShanthiNivas, Hyderabad.

5. Anji Reddy, (2001), "Remote Sensing and GIS", B.S. Publications, Hyderabad.

6. Floyd F. Sabins, (1996) "Remote Sensing - Principles and Interpretations", W.H. Freeman & Co

7. Michael N. Demas. (2000), "Fundamentals of GIS", John Wiley & Sons, Inc.

Course outcome:

1. Students will be able to understand basics about GIS and RS.

2. Students will be able to understand the practical application of GIS & RS in Environmental Engineering.

3. Students will be able to analysis and visualize their own data sets in GIS domain.

4. Students will be able to download and process various data obtained from various RS platform.

5. Students will be able to use the knowledge to solve practical real-life problem and help in planning & management.

Table 1

To establish the correlation between COs &POs

No. of Curse Outcome (CO)	Course Outcome
PCE71E01.1	Students will be able to understand basics about GIS and RS
PCE71E01.2	Students will be able to understand the practical application of GIS & RS in Environmental Engineering.
PCE71E01.3	Students will be able to analyse and visualize their own data sets in GIS domain
PCE71E01.4	Students will be able to download and process various data obtained from various RS platform
PCE71E01.5	Students will be able to use the knowledge to solve practical real-life problem and help in planning & management.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE71E01.1	3	3	3	2	2	2
PCE71E01.2	3	3	3	2	2	2
PCE71E01.3	3	3	3	2	2	2
PCE71E01.4	3	3	3	2	2	2
PCE71E01.5	3	3	3	2	2	2
Total	**15**	**15**	**15**	**10**	**10**	**10**
Average	**3**	**3**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**3**	**3**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE71E01.1	3	3
PCE71E01.2	3	3
PCE71E01.3	3	3
PCE71E01.4	3	3
PCE71E01.5	3	3
Total	**15**	**15**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

STRUCTURAL RELIABILITY(PCE71E02)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course Objective:

1. To understand about the probabilistic methods in engineering problems.

2. To understand the statistical modeling of engineering problem.

3. To understand the reliability assessment of structural performance with design optimization.

Course Content:

Unit-1

Concepts of structural safety.

Basic Statistics: - Introduction, data reduction.

Unit-2

Probability theory: Introduction, random events, random variables, functions of random variables, moments and expectation, common probability distributions.

Unit-3

Resistance distributions and parameters: - Introduction, Statistics of properties of concrete, steel and other building materials, statistics of dimensional variations, characterization of variables, Allowable stresses based on specified reliability. Probabilistic analysis of loads: gravity loads, wind loads.

Unit-4

Basic structural reliability: - Introduction, computation of structural reliability. Level 2 Reliability methods: Introduction, basic variables and failure surface, first order second moment methods (FOSM). Monte Carlo study of structural safety: -General, Monte Carlo method, applications.

Unit-5

Reliability based design: Introduction, determination of partial safety factors, development of reliability-based design criteria, optimal safety factors. Reliability of Structural system: Introduction, system reliability, modelling of structural systems, bounds of system reliability, reliability analysis of frames.

References:

Sl No.	Name of Book	Author	Publisher
1.	Reliability Analysis and Design of Structures	R. Ranganathan.	Tata McGraw Hill, 1990
2.	Probability Concepts in Engineering Planning and Design, Vol. I Basic Principles	Ang, A. H. S and Tang, W.	John Wiley & Sons, 1975
3.	Probability Concepts in Engineering Planning and Design, Vol. II Decision, Risks and Reliability	Ang, A. H. S and Tang, W. H.	John Wiley & Sons, 1984
4.	Probability, Statistics and Decision for Engineers	Jack R. Benjamin & C. Allin Cornell.	Tata McGraw-Hill
5	Reliability based structural design	Seung-Kyum Choi, Ramana V. Grandhi and Robert A. Canfield	Springer 2007

Course Outcome:

1. Students will be able to learn application of probabilistic methods in engineering problem.

2. Students will be able to learn linear and nonlinear reliability problems.

3. Students will be able to develop idea on reliability based structural design.

4. Students will be able to learn various statistical modeling techniques and method of analysis.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE71E02.1	Students will be able to learn application of probabilistic methods in engineering problem.
PCE71E02.2	Students will be able to learn linear and nonlinear reliability problems.
PCE71E02.3	Students will be able to develop idea on reliability based structural design.
PCE71E02.4	Students will be able to learn various statistical modelling techniques and method of analysis.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE71E02.1	2	2	3	2	2	2
PCE71E02.2	3	3	3	2	2	2
PCE71E02.3	3	3	3	2	2	2
PCE71E02.4	3	3	3	2	2	2
Total	**11**	**11**	**12**	**8**	**8**	**8**
Average	**2.75**	**2.75**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**3**	**3**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE71E02.1	2	2
PCE71E02.2	3	3
PCE71E02.3	3	3
PCE71E02.4	3	3
Total	**11**	**11**
Average	**2.75**	**2.75**
Equivalent Avg. Attainment	**3**	**3**

SEISMIC MICROZONATION
(PCE71E03)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course Objective:

1. To know about seismic microzonation including basic principle, prevailing practices, survey and techniques and estimation of spatial and temporal variation of ground motion characteristics.
2. To apply geological, geophysical, seismological and geotechnical methods for the determination of soil and rock properties and subsurface structures
3. To quantify the site effects and ground motion using both experimental and empirical methods.
4. To evaluate the seismic microzonation of an area using different methods like PSHA, DSHA and NDSHA.
5. To synthesize the results obtained by different researchers and present study.
6. To evaluate the most acceptable solution for seismic microzonation.

Course Content:

Unit-1:
Introduction: Seismic microzonation and its objectives, historical developments; geological, seismological, geophysical and geotechnical investigations, and data interpretation.

Unit-2:
Use of GIS and GPS in Microzonation: Type of surveys, map scales; GIS components, vector and raster data; GIS-techniques, methodology software; Use of GIS in microzonation; PS, mapping using GPS & GIS.

Unit-3:
Seismic Waves and Local Site Effects: Body and surface waves; Factors affecting ground motion characteristics; Local site effects basic physical concept, liquefaction potential, impedance contrast, resonance, predominant frequency (PF), amplification factors, basement topography, attenuation, trapping; basin-edge, topography, ridge, valley, slope; lateral discontinuity etc..

Unit-4:
Geological, geophysical, geotechnical and well logging investigations for bedrock configuration and also for determining soil properties; seismological methods for site response studies; steady state Rayleigh method, spectral analysis of surface waves, (SASW), MASW for Vs and ground penetrating radar (GPR) for profiling shallow structures etc.

Unit-5:
Quantification of Site Effects: Experimental methods; Microearthquake- standard spectral ratio method (SSR), ambient noise horizontal to vertical (H/V) spectral ratio method, determination of amplification factor, predominant frequency (PF), empirical relations; Analytical method; 1D ground response of layered medium.

Unit-6:
Site-specific Ground Motion Estimation: Empirical Green's function; Numerical methods; Basic concept, recent developments; Domain method, boundary method & hybrid method; Effects of nonlinearity on ground motion.

Unit-7:
Seismic Microzonation: PSHA, DSHA and NDSHA; Seismic microzonation of mega cities, scales used in seismic microzonation; Recent developments and case studies.

Unit-8:
Computer Programs: Computer programs to estimate seismic ground motion knowing the seismic response at given point using linear and non-linear properties of layered medium; Seismic hazard and risk assessment.

References:

Sl. No.	Name of Books/ Authors/ Publishers	Year of Publication
1	Dobrin, M.B. and C.H. Savit, "Introduction to Geophysical Prospecting, Fourth Edition, McGraw Hill Book Company", Singapore.	1988
2	Leon Reiter, "Earthquake Hazard Analysis", Columbia University Press", New York.	1990
3	Antoni Roca and Carlos Oliveria, "Earthquake Microzoning", BirkhauserVerlag, Berlin.	2002
4	Konency, G., "Geoinformation, Remote Sensing, Photogrammetry and Geographic Information System", Taylor and Francis, London.	2003
5	Kramer, S.L., "Geotechnical Earthquake Engineering, Second Indian reprint", Pearson Education.	2004

Course Outcome:

1. The students will know about seismic microzonation including basic principle, prevailing practices, survey and techniques and estimation of spatial and temporal variation of ground motion characteristics.
2. They can apply geological, geophysical, geotechnical and seismic methods for the determination of soil and rock properties, Vs of the soil cover, bed rock configuration etc. for seismic microzonation.
3. They can estimate the site effects, amplification factor, predominant frequency (PF), liquefaction potential, and ground motion using both experimental and empirical methods.
4. They can prepare a seismic microzonation map of an area using different methods like PSHA, DSHA and NDSHA.
5. They can synthesize the results obtained by different researchers and present study.
6. They can evaluate and update the most acceptable solution for seismic microzonation.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE71E03.1	The students will know about seismic microzonation including basic principle, prevailing practices, survey and techniques and estimation of spatial and temporal variation of ground motion characteristics.
PCE71E03.2	They can apply geological, geophysical, geotechnical and seismic methods for the determination of soil and rock properties, Vs of the soil cover, bed rock configuration etc. for seismic microzonation.
PCE71E03.3	They can estimate the site effects, amplification factor, predominant frequency (PF), liquefaction potential, and ground motion using both experimental and empirical methods.
PCE71E03.4	They can prepare a seismic microzonation map of an area using different methods like PSHA, DSHA and NDSHA.
PCE71E03.5	They can synthesize the results obtained by different researchers and present study.
PCE71E03.6	They can evaluate and update the most acceptable solution for seismic microzonation.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE71E03.1	3	2	3	2	2	2
PCE71E03.2	2	2	3	2	2	2
PCE71E03.3	3	2	3	2	2	2
PCE71E03.4	2	2	3	2	2	2
PCE71E03.5	3	2	3	2	2	2
Total	13	10	15	10	10	10
Average	2.6	2	3	2	2	2
Equivalent Avg. Attainment	3	2	3	2	2	2

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE71E03.1	3	2
PCE71E03.2	2	2
PCE71E03.3	3	2
PCE71E03.4	2	2
PCE71E03.5	3	2
Total	13	10
Average	2.6	2
Equivalent Avg. Attainment	3	2

Elective Paper - II(Any One)

PCE71E04: Ground Improvement Techniques

PCE71E05: Engineering Application of Geophysical Techniques

PCE71E06: Seismic Hazard & Risk Assessment

GROUND IMPROVEMENT TECHNIQUES (PCE71E04)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course Objective:

1. To understand the necessity of ground improvement techniques.
2. To understand the details of mechanical stabilization.
3. To understand the ground improvement by drainage.
4. To understand the applications of admixtures for ground improvement.
5. To understand the applications of grouting techniques.
6. To understand the in-situ soil treatment methods.
7. To understand the case studies of ground improvement projects.

Course Content:

Unit-1

Introduction: Need for Ground Improvement, Different types of problematic soils, Emerging trends in ground Improvement.

Unit-2

Mechanical stabilization: Shallow and deep compaction requirements, Principles and methods of soil compaction, Shallow compaction and methods. Properties of compacted soil and compaction control, Deep compaction and Vibratory methods Dynamic compaction.

Unit-3

Hydraulic modification: Ground Improvement by drainage, Dewatering methods. Design of dewatering systems, Preloading, Vertical drains, vacuum consolidation, Electro-kinetic dewatering, design and construction methods.

Unit-4

Modification by admixtures: Cement stabilization and cement columns, Lime stabilization and lime columns. Stabilization using bitumen and emulsions, Stabilization using industrial wastes Construction techniques and applications.

Unit 5

Grouting: Permeation grouting, compaction grouting, jet grouting, different varieties of grout materials, grouting under difficult conditions.

Unit-6

In situ soil treatment methods: Soil nailing, rock anchoring, micro-piles, design methods, construction techniques.

Unit-7

Case studies: Case studies of ground improvement projects.

References:

Sl No.	Name of the Books	Authors	Publishers
1.	Ground Improvement Techniques	P. Purushothama Raj	Laxmi Publications (P) Ltd.
2.	Engineering Principles of Ground Modification	Manfired R. Hausmann	McGraw-Hill Pub, Co.
3.	Designing with geosynthetics	R. M. Koerner	Prentice Hall Inc.
4.	Guidelines on ground improvement for structure and facilities	U. S. Army Corps of Engineers	U. S. Army Corps of Engineers, Washington DC
5.	Ground Control and Improvement	Petros P. Xanthakos, Lee W. Abramson and Donald A. Bruce	John Wiley, New York

Additional Readings: Journal and Conference papers in the area of Ground Improvement, Ground Engineering, Geotextiles and geomembranes, Geosynthetics, etc.

Course Outcome:

1. Students will be able to understand the necessity of ground improvement techniques.
2. Students will be able to understand the details of mechanical stabilization.
3. Students will be able to understand the ground improvement by drainage.
4. Students will be able to understand the applications of admixtures for ground improvement.
5. Students will be able to understand the applications of grouting techniques.

6. Students will be able to understand the in-situ soil treatment methods.
7. Students will be able to understand the case studies of ground improvement projects.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE71E04.1	Students will be able to understand the necessity of ground improvement techniques.
PCE71E04.2	Students will be able to understand the details of mechanical stabilization.
PCE71E04.3	Students will be able to understand the ground improvement by drainage.
PCE71E04.4	Students will be able to understand the applications of admixtures for ground improvement.
PCE71E04.5	Students will be able to understand the applications of grouting techniques.
PCE71E04.6	Students will be able to understand the in-situ soil treatment methods.
PCE71E04.7	Students will be able to understand the case studies of ground improvement projects.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE71E04.1	2	2	3	2	2	2
PCE71E04.2	3	2	3	2	2	2
PCE71E04.3	3	2	3	2	2	2
PCE71E04.4	3	2	3	2	2	2
PCE71E04.5	2	2	3	2	2	2
PCE71E04.6	2	2	2	2	2	2
PCE71E04.7	3	3	2	2	2	2
Total	18	15	19	14	14	14
Average	2.57	2.14	2.71	2	2	2
Equivalent Avg. Attainment	3	2	3	2	2	2

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE71E04.1	2	2
PCE71E04.2	3	2
PCE71E04.3	3	2
PCE71E04.4	3	2
PCE71E04.5	2	2
PCE71E04.6	2	2
PCE71E04.7	3	3
Total	18	15
Average	2.57	2.14
Equivalent Avg. Attainment	3	2

ENGINEERING APPLICATION OF GEOPHYSICAL TECHNIQUES (PCE71E05)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course Objective:

1. To study the applications of gravity and magnetic methods.
2. To study the applications of seismic refraction and reflection method.
3. To study the applications of electrical method.
4. To study the applications of well logging method.
5. To understand geophysical interpretation of the subsurface parameters.
6. To study the concept of geophysical mapping.
7. To understand and identification of subsurface structures.
8. To understand case studies of geophysical investigations for engineering applications.

Course Content:

Unit-1:
Introduction to Geophysics: Basic concepts and objectives of geophysical techniques, like gravity, magnetic, electrical, seismic and well logging; need of subsurface geophysical mapping in Earthquake Engineering.

Unit-2:
Seismic method: Seismic refraction method, time-distance relations for horizontal layers, dipping layer and linearly increasing velocity with depth, elevation and weathering time corrections, limitations of seismic refraction method; Seismic reflection method, Time-distance relation for horizontal and dipping layers, static and dynamic time corrections, simple interpretation techniques.

Unit-3:
Gravity Method: Earth gravitational field, gravimeters, gravity field measurements, gravity field reduction and interpretation of gravity map, gravity effects of subsurface bodies of simple shapes.

Unit-4:
Magnetic Method: Earth magnetic field, magnetism of rocks and minerals, magnetometers, field operations, local magnetic anomaly, magnetic effects of buried magnetic bodies and interpretation.

Unit-5:
Electrical Method: Electrical properties of rocks, resistivity method, various electrode arrangements, sounding and profiling, data acquisition, analysis and interpretation for engineering problems like bedrock depth, lateral discontinuity, hidden structure or pipeline etc.

Unit-6:
Well logging: Borehole and general aspects of well logging; single and multi-electrode Resistivity logging, SP logging, Density logging, Acoustic (Sonic) logging. Interpretation of the Well logs for evaluating the formation characteristics.

Unit-7:
Evaluating subsurface parameters: Identification of detailed lithology from the resistivity and SP logs, seismic velocity structures at depth by sonic logging, formation in-situ density by density logging, evaluation of strength index, water saturation, saline contamination, porosity, permeability etc. from the well logs.

Unit-8:
Site Investigations: Identification of seismically active fault, induced seismicity potential, hidden fault structure, study of the surface lineaments, weathered layer thickness, bedrock configuration, water table depth, water leakage, fault, dike, landfill sites etc.

Unit-9:
Identification of Subsurface Structures: Archaeological sites, weak zones, cavities and voids, tunnelling, underground excavation.

Unit-10:
Case studies: Illustration of Case studies of geophysical methods for engineering applications.

References:

1. Dobrin, M. B. and C. H. Savit, “Introduction to Geophysical Prospecting”, Fourth Edition, McGraw Hill Book CO. 1988.
2. Telford, W.M., Geldart, L.P. and Sheriff, R.E., “Applied Geophysics”, Second edition, Cambridge Univ. Press. 1990.
3. William Lowrie, “Fundamentals of Geophysics”, Cambridge Univ. Press. 1997.
4. Reynolds, John M., “An Introduction to Applied and Environmental Geophysics”, Wiley. 1997.
5. Darling, T. “Well Logging and Formation Evaluation” Gulf Professional Publishing. 2005.

Course Outcome:

1. Students will be able to understand the concept of geophysical techniques and its applications.
2. They will be able to understand the applications of seismic refraction and reflection methods and the velocity structures beneath the study or project area.
3. They will be able to understand the gravity and magnetic (G-M) surveys and interpretation of the G-M maps to find any lineament or fault in the study/project area.
4. They will be able to understand the applications electrical methods to investigate subsurface resistivity structures and its implications to engineering projects.
5. They will be able to understand applications of well logging methods to measure the in-situ physical properties of the rocks at depths.
6. They will be able to understand geophysical investigations at a selected site and interpretations of the results in terms of its engineering applications.

7. They will be able to identify seismically active fault, induced seismicity potential, subsurface hidden structures, the surface lineaments, weathered layer thickness, bedrock configuration, water table depth, water leakage, fault, dike, landfill sites etc.
8. They will be able to understand the case studies of geophysical methods for engineering applications

To establish the correlation between COs & POs
Table-1

No. of Course Outcome (CO)	Course Outcome
PCE71E06.1	Students will be able to understand the concept of geophysical techniques and its applications in Engineering projects.
PCE71E06.2	They will be able to understand the applications of seismic refraction and reflection methods, the velocity structures beneath the study or project area and its implications..
PCE71E06.3	They will be able to understand the gravity and magnetic (G-M) surveys and interpretation of the G-M maps to find any lineament or fault in the study or project area.
PCE71E06.4	They will be able to understand the applications of electrical methods to investigate subsurface resistivity structures and its implications to engineering projects.
PCE71E06.5	They will be able to understand applications well logging method to measure the in-situ physical properties of rocks at depths.
PCE71E06.6	They will be able to understand geophysical investigations at a selected site and interpretations of the results in terms of its engineering applications.
PCE71E06.7	They will be able to identify seismically active fault, induced seismicity potential, subsurface hidden structures, the surface lineaments, weathered layer thickness, bedrock configuration, water table depth, water leakage, fault, dike, landfill sites etc.
PCE71E06.8	They will be able to understand the case studies of geophysical methods for engineering applications.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE71E06.1	2	2	3	2	2	2
PCE71E06.2	3	2	3	2	2	2
PCE71E06.3	3	2	3	2	2	2
PCE71E06.4	3	2	3	2	2	2
PCE71E06.5	2	2	3	2	2	2
PCE71E06.6	2	2	3	2	2	2
PCE71E06.7	3	3	3	2	2	2
PCE71E06.8	3	3	3	2	2	2
Total	**21**	**18**	**24**	**16**	**16**	**16**
Average	**2.63**	**2.25**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**3**	**2**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE71E06.1	2	2
PCE71E06.2	3	2
PCE71E06.3	3	2
PCE71E06.4	3	2
PCE71E06.5	2	2
PCE71E06.6	2	2
PCE71E06.7	3	3
PCE71E06.8	3	3
Total	**21**	**18**
Average	**2.63**	**2.25**
Equivalent Avg. Attainment	**3**	**2**

SEISMIC HAZRD & RISK ASSESSMENT
(PCE71E06)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand the idea about seismic hazard and risk analysis
2. To understand the deterministic seismic hazard analysis (DSHA)
3. To understand probabilistic seismic hazard analysis (PSHA)
4. To understand seismicity, active faults, source processes etc.
5. To understand earthquake occurrences and seismotectonic models
6. To understand ground motion prediction relations.

Course Content:

Unit-1:
Introduction: Definitions, seismic hazard analysis, both probabilistic and deterministic approaches, earthquake source mechanisms, seismo-tectonic modeling; identification and evaluation of earthquake sources / active faults at depth: surface geological and geomorphological evidences, tectonic setting, historical seismicity, paleoseismological evidences, instrumental seismicity, Estimation of moment magnitude, maximum credible earthquake, design basis earthquake, maximum probable earthquake.

Unit-2:
Seismicity Data and Treatment: Seismicity catalogues, spatial coverage, temporal coverage, completeness in size and time, cut off or threshold magnitude, earthquake swarm, foreshocks and aftershocks, declustering of data, homogenization of catalogue, empirical relations, bivariate orthogonal regression.

Unit-3:
Earthquake Occurrence Models: Gutenberg Richter frequency magnitude distribution, return period; Poissonian model, time dependent Poisson process, characteristic earthquake model, periodicity, conditional probabilities, Gamma distribution, Weibul distribution, Gaussian distribution, log normal distribution, Markov and semi-Markov models, Gumbel distributions and mixed Gumble distribution; Time and slip predictable earthquake models

Unit-4:
Ground Motion Prediction Equations: Strong motion attenuation relationships, dependent and independent parameters, PGA and spectral accelerations, elastic and inelastic response spectra, displacement spectra, periods of interest.

Unit-5:
Deterministic and Probabilistic Seismic Hazard Analysis: Deterministic and probabilistic seismic hazard methods; Types of earthquake sources-point, line and areal sources, random seismicity method, seismotectonic providence method, geological slip rate method, Zoneless seismic hazard estimation: Epistemic and aleatory uncertainty estimation, deaggregation, logic tree, hazard estimation at the bedrock level, various types

of iso acceleration maps, probability of exceedance and return periods in earthquake engineering; Monte Carlo simulations.

References:

Sl No.	Name of the Books	Authors	Publishers
1	Geotechnical Earthquake Engineering	Steven L. Kramer	Prentice Hall
2	Bootstrap methods: A practitioner's guide, in Wiley Series in Probability and Statistics,	M. R. Chernick	W. A. Shewhart (Editor), John Wiley and Sons
3	Earthquake Hazard Analysis, Issues and Insights	L. Reiter	Columbia University Press
4	An Introduction to Seismology, Earthquake, and Earth Structure	Stein, Seth and Wysession, M	Blackwell Publishing
5	Seismic Hazard and Risk Analysis	McGuire, Robin K.	Earthquake Engineering Research Institute
6	Applied regression analysis	Draper, N.R. and Smith, H.	John Wiley & Sons (Asia)
7	Active faults, paleoseismology, and earthquake hazards in the western United States	R.E. Wallace	American Geophysical Union, Washington, D. C.
8	Seismic hazards: New trends in analysis using geologic data	D.P. Schwartz and K.J. Coppersmith	Academic Press, Orlando, Florida
9	IS 1893, Indian Standard Criteria for earthquake resistant Design of Structures	B.I.S.	B.I.S.

Additional Readings:

Journal and Conference papers in the area of Seismic Hazard Analysis and Risk Assessment.

Course Outcome:

1. Students will be able to understand about seismic hazard analysis and required parameters.
2. Students will be able to understand the deterministic seismic hazard analysis (DSHA).
3. Students will be able to understand the probabilistic seismic hazard analysis (PSHA).
4. Students will be able to understand the seismicity data and its analysis.
5. Students will be able to understand the earthquake occurrence models.
6. Students will be able to understand the ground motion prediction equations.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE71E06.1	Students will be able to understand the seismic hazard analysis and its applications
PCE71E06.2	Students will be able to understand the deterministic seismic hazard analysis.
PCE71E06.3	Students will be able to understand the probabilistic seismic hazard analysis.
PCE71E06.4	Students will be able to understand the seismicity data and its analysis.
PCE71E06.5	Students will be able to understand the earthquake occurrence models.
PCE71E06.6	Students will be able to understand the ground motion prediction equations.

Table-2

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE71E06.1	2	2	3	2	2	2
PCE71E06.2	2	2	3	2	2	2
PCE71E06.3	2	2	3	2	2	2
PCE71E06.4	2	2	3	2	2	2
PCE71E06.5	2	2	3	2	2	2
PCE71E06.6	2	2	3	2	2	2
Total	**12**	**12**	**18**	**12**	**12**	**12**
Average	**2**	**2**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE71E06.1	2	2
PCE71E06.2	2	2
PCE71E06.3	2	2
PCE71E06.4	2	2
PCE71E06.5	2	2
PCE71E06.6	2	2
Total	**12**	**12**
Average	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**

ADVANCED DYNAMICS LABORATORY
(PCE71P01)

Total Credit: 02 **Contact Periods: 02 (0L+0T+2P)**

Course Objective:

1. To know about different tests and software use under dynamic loading condition.
2. To apply the tests for evaluation of dynamic Soil properties.
3. To apply the dynamic soil properties in software analysis for different structures under dynamic loading condition.
4. To evaluate the response of different structures under dynamic loading condition.
5. To synthesize the results obtained from different study.
6. To evaluate the most acceptable experimental methodology and dynamic soil parameters.

Course Content:

Unit 1: Cyclic tri-axial test
Unit 2: Cyclic plate load test
Unit 3: Block Vibration Test
Unit 4: Shake table test
Unit 5: Cyclic Pile Load Test
Unit 6: Free vibration characteristic of structural systems-natural frequency and damping ratio
Unit 7: Harmonic forced vibration response of structural models and frequency response functions
Unit 8: Dynamic vibration absorber
Unit 9: Prototype testing and system identification.

References:

Corresponding IS Code (if available) and concerned manual.

Course Outcome:

1. Students will able to know about the different tests and software used under dynamic loading condition.
2. They can apply the tests for evaluation of dynamic Soil properties.
3. They can apply the evaluated dynamic soil properties in software analysis for different structures under dynamic loading condition.
4. They can evaluate the response of different structures under dynamic loading condition.
5. They can synthesize the results obtained from different experimental study.
6. They can find out the most acceptable methodology and dynamic soil parameters.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE71P01.1	Students will able to know about the different tests and software can be used under dynamic loading condition.
PCE71P01.2	They can apply the tests for the evaluation of dynamic Soil properties.
PCE71P01.3	They can apply the evaluated dynamic soil properties in software analysis for different structures under dynamic loading condition.
PCE71P01.4	They can evaluate the response of different structures under dynamic loading condition.
PCE71P01.5	They can synthesize the results obtained from different experimental study.
PCE71P01.6	They can find out the most acceptable methodology and dynamic soil parameters.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE71P01.1	3	3	3	2	2	2
PCE71P01.2	3	3	3	2	2	2
PCE71P01.3	3	3	2	2	2	2
PCE71P01.4	3	3	2	2	2	2
PCE71P01.5	3	3	2	2	2	2
PCE71P01.6	3	3	2	2	2	2
Total	**18**	**18**	**14**	**12**	**12**	**12**
Average	**3**	**3**	**2.33**	**2**	**2**	**2**
Equivalent Avg. Attainment	**3**	**3**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE71P01.1	3	3
PCE71P01.2	3	3
PCE71P01.3	3	3
PCE71P01.4	3	3
PCE71P01.5	3	3
PCE71P01.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

CHARACTERIZATION OF ROCK AND FAULT (PCE71P02)

Total Credit: 02 **Contact Periods: 02 (0L+0T+2P)**

Course Objective:

1. To know different Survey processes to characterize the rock and soil.
2. To apply different tests for characterization of rock and soil.
3. To study the ground motion using strong motion records.
4. To develop ground motion prediction equation and to analyse different structures under dynamic loading condition using ground motion prediction equation.
5. To synthesize the results obtained by earlier researchers with the present study.
6. To evaluate the most acceptable solution.

Course Content:

Unit 1: GPS Survey and collection of data.
Unit 2: Demonstration of GIS Software and GIS Map Preparation
Unit 3: Seismic Refraction Survey for bed rock information.
Unit 4: Soil Profile using MASW
Unit 5: Soil Profile using GPR
Unit 6: Use of SAR interferometry for surface displacement measurement.
Unit 7: Rock/ Soil Characterisation using Seismic Noise/ Signal Processing.
Unit 8: Ground Motion Study (using Strong Motion records) for earthquakes by different faulting (Normal, Thrust and Strike-slip).

References:
Related Manual and IS Code (if available).

Course Outcome:

1. Students will know about different seismic noise/ signal processing to characterize the rock and soil.
2. They can apply the tests for characterization of rock and soil.
3. They can evaluate the ground motion using strong motion records.
4. They can develop ground motion prediction equation and analyse different structures under dynamic loading condition using the ground motion prediction equation.
5. They can synthesize the results obtained by different researchers and present study.
6. They can determine the most acceptable solution.

To establish the correlation between COs & POs
Table-1

No. of Course Outcome (CO)	Course Outcome
PCE71P02.1	Students can know about different seismic noise/ signal processing to characterize the rock and soil.
PCE71P02.2	They can apply the tests for characterization of rock and soil.
PCE71P02.3	They can develop ground motion prediction equation using strong motion records.
PCE71P02.4	They can evaluate ground motion prediction equation and analyse different structures under dynamic loading condition using the ground motion prediction equation.
PCE71P02.5	They can synthesize the results obtained by different researchers and present study.
PCE71P02.6	They can determine the most acceptable solution.

Table-2
Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE71P02.1	3	3	3	2	2	2
PCE71P02.2	3	3	3	2	2	2
PCE71P02.3	3	3	3	2	2	2
PCE71P02.4	3	3	3	2	2	2
PCE71P02.5	3	3	3	2	2	2
PCE71P02.6	3	3	3	2	2	2
Total	**18**	**18**	**18**	**12**	**12**	**12**
Average	**3**	**3**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**3**	**3**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE71P02.1	3	3
PCE71P02.2	3	3
PCE71P02.3	3	3
PCE71P02.4	3	3
PCE71P02.5	3	3
PCE71P02.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

SEMINAR
(PCE71P03)

Total Credit: 01 **Contact Periods: 02 (0L+0T+2P)**

Each student shall prepare a Report and present a Seminar on topic related to the branch of specialization under the guidance of a Faculty member. The student shall submit a copy of the Report to the Department. Grades will be awarded on the basis of the Report and presentation.

Second Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	**Basic Core** **PCE72B01**: Advanced Seismology	4	4	100
2	**Core Subject-I** **PCE72C01**: Geotechnical Earthquake Engineering	4	4	100
3	**Core Subject-II** **PCE72C02**: Seismic Analysis and Design of Structures	4	4	100
4	**Elective Paper III (Any One)** **PCE72E01**: Soil-Structure Interaction **PCE72E02**: Finite Element Method **PCE72E03**: Seismic Slope Stability: Earth Dam and Retaining Wall	4	4	100
5	**PCE72P01**: Software Application Lab	2	3	100
6	**PCE72P02**: Digital Image Processing and Seismic Signal Processing Lab	2	3	100
7	**PCE72P03**: Project Preliminary	3	6	100
8	**PCE72P04**: Comprehensive Viva-voce	2	0	100
	Total	**25**	**28**	**800**

Basic Core

ADVANCED SEISMOLOGY
(PCE72B01)

Total Credit: 04 **Contact Periods: 04 (4L+0T+0P)**

Course Objective:

1. To understand different kinds of earthquakes, and seismic waves for local, regional and teleseismic events, identifying Earth's subsurface and deep interior structures from the seismic waves.
2. To understand earthquake magnitude and intensity scales, hypocenter locations, and source parameters determination by different computational methods.
3. To understand the Earth's structures by seismic tomography and by Receiver Function methods.
4. To understand fault plane solutions, tectonic stress systems and identifying active faults.
5. To understand earthquake power law relations: Frequency-magnitude relation (b-value), Aftershock attenuation (p-value) and Fractal correlation dimension (D2).
6. To understand Quality (Q) factor, seismic attenuation and anisotropy.
7. To understand seismic hazard microzonation and risk evaluation, and earthquake and tsunami early warning systems.
8. To understand earthquake precursors (Geophysical, Seismological and Geochemical).

Course Content:

Unit-1:
Earthquakes and different types of source zones, seismic waves for local, regional and telseismic events, identifying seismic phases, identifying the local crustal discontinuities and Earth's interior structures.

Unit-2:
Earthquake magnitude and intensity scales. Earthquake locations by computational methods: Least square method, Double difference method, Joint hypocenter method and simultaneous inversion (seismic tomography) method), Wadati plot, time-distance plot, computer analysis for source parameters (source time function, fault-slip, corner frequency f_c, seismic moment M_o, moment magnitude M_w, stress drop etc.

Unit-3:
Seismic velocity structure imaging (local tomography, regional tomography and global tomography), and imaging the crustal discontinuities (Moho) and discontinuities of the Earth's deeper interior by receiver function analysis.

Unit-4:
Reid's elastic rebound theory, double couple hypothesis, fault-plane solutions by P-wave first motion plot and by waveform inversion, identifying tectonic stress system, interpretation of seismically active faults.

Unit-5:
Power laws of earthquakes: frequency-magnitude relation (b-value), aftershock attenuation (p-value) and fractal correlation dimension (D_2).

Unit-6:
Q factor, seismic wave attenuation, scattering and intrinsic effects, shear wave splitting, anisotropy of the crustal and upper mantle structures.

Unit-7:
Seismic hazard microzonation, site response (H/V), weathered-layer shear wave velocity (Vs30), basement configuration (by geophysical methods), ground acceleration (SM) for engineering structures / projects.

Unit-8:
Earthquake precursors: Geophysical, Seismological and Geochemical precursors before a large earthquake, and earthquake and tsunami early warning system.

References:

1. Aki, K. and Richards, P.G; "Quantitative Seismology", W.H. Freeman & Co. 2002
2. Stein, S. and Wyssession, M., "An Introduction to Seismology, Earthquakes and Structure", Blackwell Publishing 2003
3. Lay, T. and Wallace, T.C., "Modern Global Seismology", Academic Press 1995
4. Garland, G D: An Introduction to Geophysics
5. Stacey, F D and Davis P. M: Physics of the Earth
6. Fowler C M R, Solid Earth: An Introductionto Global Geophysics
7. Howell, B F: An Introduction to Geophysics
8. Lowrie, W: Fundamentals of Geophysics
9. Tucker, R H et al.: Global Geophysics
10. Turcotte, D L and Schubert G: Geodynamics
11. Wyllie, Peter J: The Dynamic Earth
12. Kayal, J R: Microearthquake Seismology and Seismotectonics of South Asia.

Course Outcome:

1. The student will understand different kinds of earthquakes and earthquake waves, the seismic waves for local, regional and teleseismic events, identifying Earth's subsurface and deep interior structures from the seismic waves.
2. They can learn earthquake magnitude and intensity scales, hypocenter locations, and source parameters determinations by different computational methods.
3. They will also learn seismic imaging of the Earth's structure by seismic tomography and receiver function methods.
4. They will understand fault plane solutions, tectonic stress systems and identifying active faults and type of faulting (Normal, Thrust, and Strike-slip).
5. They will understand Power laws of earthquakes: frequency-magnitude relation (b-value), aftershock attenuation (p-value) and fractal correlation dimension (D2).
6. They will understand crustal Q factor, seismic wave attenuation, scattering and intrinsic effects, shear wave splitting, anisotropy of the crust and upper mantle structures.

7. They will understand Seismic hazard microzonation, risk evaluation, site response (H/V), weathered-layer shear wave velocity (Vs30), basement configuration (by geophysical methods), ground acceleration (SM) for engineering structures / projects.
8. They will understand Earthquake precursors: Geophysical, Seismological and Geochemical precursors before a large earthquake, and earthquake and tsunami early warning system.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE72B01.1	The student will understand different kinds of earthquakes and seismic waves for local, regional and teleseismic events, identifying Earth's subsurface and deep interior structures from the seismic waves.
PCE72B01.2	They can learn earthquake magnitude and intensity scales, hypocenter locations, and source parameters determinations by different computational methods.
PCE72B01.3	They will also learn seismic imaging of the Earth's structure by seismic tomography and receiver function methods.
PCE72B01.4	They will understand fault plane solutions, tectonic stress systems and identifying active faults and types of faulting.
PCE72B01.5	They will understand Power laws of earthquakes: frequency-magnitude relation (b-value), aftershock attenuation (p-value) and fractal correlation dimension (D_2).
PCE72B01.6	They will understand crustal Q factor, seismic wave attenuation, scattering and intrinsic effects, shear wave splitting, anisotropy of the crust and upper mantle structures.
PCE72B01.7	They will understand Seismic hazard microzonation, risk evaluation, site response (H/V), weathered-layer shear wave velocity (Vs30), basement configuration (by geophysical methods), ground acceleration (SM) for engineering structures / projects.
PCE72B01.8	They will understand Earthquake precursors: Geophysical, Seismological and Geochemical precursors before a large earthquake, and earthquake and tsunami early warning system.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE72B01.1	2	2	3	2	2	2
PCE72B01.2	2	2	3	2	2	2
PCE72B01.3	2	2	3	2	2	2
PCE72B01.4	2	2	3	2	2	2
PCE72B01.5	2	2	3	2	2	2
PCE72B01.6	2	2	3	2	2	2
Total	**12**	**12**	**18**	**12**	**12**	**12**
Average	**2**	**2**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE72B01.1	2	2
PCE72B01.2	2	2
PCE72B01.3	2	2
PCE72B01.4	2	2
PCE72B01.5	2	2
PCE72B01.6	2	2
Total	**12**	**12**
Average	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**

Core Subject-I

GEOTECHNICAL EARTHQUAKE ENGINEERING
(PCE72C01)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course Objective:

1. To understand the necessity of geotechnical earthquake engineering.
2. To understand the details of engineering seismology.
3. To understand the concept of strong ground motion.
4. To understand the concept of seismic hazard analysis.
5. To understand the concept of ground response analysis.
6. To understand the concept of liquefaction related phenomena.
7. To understand the concept of seismic slope stability.
8. To understand the seismic design considerations of retaining walls.

Course Content:

Unit-1
Introduction to Geotechnical Earthquake Engineering: Scope and objective; Nature and types of earthquake loading; Importance of Geotechnical Earthquake Engineering; Seismic hazards; Mitigation of seismic hazards.
Engineering Seismology: Causes of earthquake; Plate tectonics; Earthquake fault sources; Seismic waves; Elastic rebound theory; Quantification of earthquake; Intensity and magnitudes; Earthquake source models.

Unit-2
Strong Ground Motion: Introduction; Strong-motion Accelerograph; Ground motion parameters and their estimation; Effect of local site conditions on ground motions; Design earthquake; Design spectra; Development of site specification and code-based design.
Seismic Hazard Analysis: Introduction; Identification and evaluation of earthquake sources; Deterministic seismic hazard analysis; Probabilistic seismic hazard analysis.
Unit 3
Wave Propagation: Introduction; Waves in unbounded media; Waves in a semi-infinite body; Waves in a layered body; Attenuation of stress waves.
Ground Response Analysis: Ground response analysis – One-dimensional ground response analysis: Linear approaches; Equivalent linear approximation of non-linear approaches; Computer code “SHAKE”; Two-dimensional ground response analysis; Three-dimensional ground response analysis.
Unit-4
Dynamic Soil Properties: Introduction; Measurement of Dynamic Soil Properties; Stress-strain behavior of cyclically loaded soils; Strength of cyclically loaded soils.
Liquefaction and Lateral Spreading: Liquefaction related phenomena; Liquefaction susceptibility: Historical, Geological, Compositional and State criteria; Evaluation of liquefaction by cyclic stress and cyclic strain approaches; Lateral deformation and spreading; Criteria for mapping liquefaction hazard zones.

Unit-5

Seismic Slope Stability: Internal stability and weakening instability.

Seismic Design Considerations of Retaining Walls: Dynamic Response of Retaining Walls; Seismic Design Considerations of Gravity Walls; Cantilever Walls; Braced Walls and Reinforced Soil Walls.

References:

Sl No.	Name of the Books	Authors	Publishers
1.	Geotechnical Earthquake Engineering	Steven L. Kramer	Prentice Hall
2.	Geotechnical Earthquake Engineering Handbook	Robert W. Day	McGraw Hill
3.	Geotechnical Earthquake Engineering	IkuoTowhata	Springer
4.	Soil Behaviour in Earthquake Geotechnics	Kenji Ishihara	Oxford University Press, USA
5.	Soil Dynamics	ShamsherPrakash	McGraw Hill
6.	Basic Geotechnical Earthquake Engineering	Kamalesh Kumar	New Age International (P) Limited, Publishers
7.	Seismic behaviour of ground and Geotechnical structure	Seco e Pinto	A. A. Balkema
8.	The Seismic Design Handbook	F. Naeim	Kluwer Academic Publication
9.	SPT-based Liquefaction Triggering Procedures	I. M. Idriss and Ross W. Boulanger	Center for Geotechnical Modeling, University of California
10.	IS 1893, Indian Standard Criteria for earthquake resistant Design of Structures	B.I.S.	B.I.S.

Additional Readings: Journal and Conference papers in the area of Earthquake Geotechnical Engineering.

Course Outcome:

1. Students will be able to understand the necessity of geotechnical earthquake engineering.
2. Students will be able to understand the details of engineering seismology.
3. Students will be able to understand the concept of strong ground motion.
4. Students will be able to understand the concept of seismic hazard analysis.
5. Students will be able to understand the concept of ground response analysis.
6. Students will be able to understand the concept of liquefaction related phenomena.
7. Students will be able to understand the concept of seismic slope stability.
8. Students will be able to understand the seismic design considerations of retaining walls.

To establish the correlation between COs & POs
Table-1

No. of Course Outcome (CO)	Course Outcome
PCE72C01.1	Students will be able to understand the necessity of geotechnical earthquake engineering.
PCE72C01.2	Students will be able to understand the details of engineering seismology.
PCE72C01.3	Students will be able to understand the concept of strong ground motion.
PCE72C01.4	Students will be able to understand the concept of seismic hazard analysis.
PCE72C01.5	Students will be able to understand the concept of ground response analysis.
PCE72C01.6	Students will be able to understand the concept of liquefaction related phenomena.
PCE72C01.7	Students will be able to understand the concept of seismic slope stability.
PCE72C01.8	Students will be able to understand the seismic design considerations of retaining walls.

Table-2
Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE72C01.1	2	2	3	2	2	2
PCE72C01.2	2	2	3	2	2	2
PCE72C01.3	2	2	3	2	2	2
PCE72C01.4	2	2	3	2	2	2
PCE72C01.5	2	2	3	2	2	2
PCE72C01.6	2	2	3	2	2	2
PCE72C01.7	2	2	3	2	2	2
PCE72C01.8	2	2	3	2	2	2
Total	**16**	**16**	**24**	**16**	**16**	**16**
Average	**2**	**2**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE72C01.1	2	2
PCE72C01.2	2	2
PCE72C01.3	2	2
PCE72C01.4	2	2
PCE72C01.5	2	2
PCE72C01.6	2	2
PCE72C01.7	2	2
PCE72C01.8	2	2
Total	**16**	**16**
Average	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**

Core Subject-II

SEISMIC ANALYSIS AND DESIGN OF STRUCTURES (PCE72C02)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course Objective:

1. To make the students understand plate tectonics, earthquakes and seismic parameters.
2. To make the students understand the philosophy of earthquake resistant design of structure.
3. To make the students able to analyze and design different structures subjected to earthquake load.
4. To understand the strengthening measures of seismically deficient structures.

Course Content:

Unit 1:
Introduction to Earthquake: Plate tectonics and earthquakes; effects of earthquakes; seismic waves; earthquake recording, Earth's interior

Unit 2
Seismic response of soils and structures: Dynamic properties of soils, site response to earthquake, Seismic response of soil-structure system; seismic consideration for foundation; Elastic seismic response of structures; Non-linear seismic response of structures; level of damping in different structures; Interaction of frames and infill panels; Method of seismic analysis of structures.

Unit 3
Earthquake resistant Design Philosophy: Criteria for earthquake resistant design; Principles of reliable seismic behavior- form, materials and failure modes; specific structural forms for earthquake resistance-moment-resisting frames, shear wall, concentrically braced frames, hybrid structural system. Energy isolating and dissipating devices.

Unit 4
Earthquake resistant design of structures: Seismic response of masonry buildings, Design and construction details for reinforced masonry. Seismic response of reinforced concrete structures, Design and Detailing of Reinforced concrete Structures.

Unit 5
Restoration and Strengthening structures.

References:

Sl No.	Name of Book	Author	Publisher
1.	Seismic design of RC and masonry buildings	Paulay, T & Priestley	John Wiley & Sons,
2.	Design of multi-storey RC buildings for earthquake motions	Blume, J.A	Newmark and Corning – Portland Cement Association.
3.	Earthquake resistant design	Dowrick, D.J.	John Wiley & Sons,
4.	Earthquake Resistant Design of Structures	Agarwal &Shrikande	PHI
5.	I.S. 1893 - 2016, Criteria for Earthquake Resistance design of Structures.		
6.	IS.13920- 2016, Ductile detailing of Reinforced concrete structures subjected to seismic forces, Bureau of Indian Standards, New Delhi.		

Course Outcome:

At the end of the course, student will be able to

1. Understand the concept and terminology related to earthquakes and its effects on buildings/Engg structures.
2. Understand the philosophy of earthquake resistant design.
3. Analyze and design masonry and RC structures under the earthquake forces as per the recommendations of IS codes of practice.
4. Suggest retrofitting techniques for existing RCC and Masonry buildings.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE72C02.1	Students will be able to understand the concept and terminology related to earthquake and its effects on buildings and Engg structures.
PCE72C02.2	Students will be able to understand the philosophy of earthquake resistant design.
PCE72C02.3	Students will be able to analyze and design masonry and RC structures under the earthquake forces as per the recommendations of IS codes of practice.
PCE72C02.4	Students will be able to suggest retrofitting techniques for existing RCC and Masonry buildings.

Table-2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) And '-' For No correlation

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE72C02.1	2	2	3	2	2	2
PCE72C02.2	2	2	3	2	2	2
PCE72C02.3	2	2	3	2	2	2
PCE72C02.4	2	2	3	2	2	2
Total	**8**	**8**	**12**	**8**	**8**	**8**
Average	**2**	**2**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE72C02.1	2	2
PCE72C02.2	2	2
PCE72C02.3	2	2
PCE72C02.4	2	2
Total	**8**	**8**
Average	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**

Elective Paper III(Any One)

PCE72E01: Soil-Structure Interaction
PCE72E02: Finite Element Method
PCE72E03: Seismic Slope Stability: Earth Dam and Retaining Wall

SOIL STRUCTURE INTERACTION
(PCE72E01)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course objective:

1. To understand about the importance of interaction mechanics.
2. To understand the effect of soil-structure interaction on response of structural system.
3. To know the SSI modeling techniques and analysis.
4. To understand the design implications.

Course Content:

Unit-1
General soil-structure interaction problems, contact pressures and soil-structure interaction for shallow foundations, Concept of sub grade modulus, effects/parameters influencing subgrade modulus. Soil behaviour, Foundation behaviour, Interface behaviour.

Unit-2
Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behaviour, Time dependent behaviour. Isotropic elastic half space.

Unit-3
Beam on Elastic Foundation-Soil Models: Infinite beam, Two parameters, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness. Elastic Analysis of Pile: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions. Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap. Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts. Uplift capacity of piles and anchors.

Unit-4
Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.

Unit- 5
Dynamic Soil Structure interaction, Inertial and Kinematic Interaction, Direct and substructure approach of model analysis, Dynamic stiffness, Dynamic equilibrium equation.

References:

Sl No.	Name of Book	Author	Publisher
1.	Advanced Geotechnical Engineering Soil–Structure Interaction Using Computer and Material Models	Chandrakant S. Desai Musharraf Zaman	CRC Press Taylor and Francis Group 2014
2.	Elastic Analysis of Soil-Foundation Interaction	SelvaDurai, A. P. S	Elsevier, 1979.
3.	Pile Foundation Analysis and Design	Poulos, H. G., and Davis, E. H.	Prentice Hall, 1981
4.	Structure Soil Interaction		State of Art Report, Institution of Structural Engineers, 1978
5	Suggested Analysis and Design Procedures for combined footings and Mats	ACI 336. (1988)	American Concrete Institute,1988.
6	Foundation Analysis	Scott, R. F.	Prentice-Hall
7	Dynamic Soil Structure Interaction	John P Wolf	Prentice-Hall Inc, Englewood Cliffs N.J

Course Outcome:

1. Students will be able to learn the soil structure interaction problems.
2. Students will be able to learn linear and nonlinear behavior of soil-structure system.
3. Students will be able to develop in depth idea about design of foundation.
4. Students will be able to learn both static and dynamic SSI based design.

To establish the correlation between COs & POs
Table-1

No. of Course Outcome (CO)	Course Outcome
PCE72E01.1	Students will be able to learn the soil structure interaction problem.
PCE72E01.2	Students will be able to learn linear and nonlinear behavior of soil-structure system.
PCE72E01.3	Students will be able to develop in depth idea about design of foundation.
PCE72E01.4	Students will be able to learn both static and dynamic SSI based design.

Table-2
Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE72E01.1	2	2	3	2	2	2
PCE72E01.2	2	2	3	2	2	2
PCE72E01.3	2	2	3	2	2	2
PCE72E01.4	2	2	3	2	2	2
Total	**8**	**8**	**12**	**8**	**8**	**8**
Average	**2**	**2**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE72E01.1	2	2
PCE72E01.2	2	2
PCE72E01.3	2	2
PCE72E01.4	2	2
Total	**8**	**8**
Average	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**

FINITE ELEMENT METHOD
(PCE72E02)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course Objective:

1. To understand the mathematical and physical principles underlying the Finite Element Method (FEM) focussed on stress analysis of common geotechnical engineering problems.
2. To demonstrate the ability to formulate and implement to solve geotechnical engineering problems using Finite Element Analysis.
3. To evaluate accuracy of the Finite Element solutions using a range of techniques.
4. To develop FEM computer programs for simple problems.
5. To understand the importance of analysis using FEM in the broader context of engineering practices.

Course Content:

Unit- 1
Introduction: Boundary Value Problem - Approximate Solution - Variational and Weighted Residual Methods - Ritz and Galerkin Formulations - Concepts of Piecewise Approximation and Finite Elements - Displacement and Shape Functions - Weak Formulation - Minimum Potential Energy - Generation of Stiffness Matrix and Load Vector.

Unit- 2
Stress Analysis: Two Dimensional problems - Plane Stress, Plain Strain and Axisymmetric Problems - Triangular and Quadrilateral Elements - Natural Coordinates - Isoparametric Formulation - Numerical Integration - Plate Bending and Shell Elements - Brick Elements - Elements for Fracture Analysis.

Unit- 3
Meshing and Solution Problems: Higher Order Elements - p and h Methods of refinement - IIL conditioned Elements - Discretization Errors -Auto and Adaptive Mesh Generation Techniques - Error Evaluation.

Unit- 4
Nonlinear and Vibration Problems: Material and Geometric Nonlinearity - Methods of Treatment - Consistent System Matrices – Dynamic Condensation - Eigen Value Extraction.

Unit- 5
Thermal Analysis: Thermal analysis problems.

References:

Sl. No.	Name of the Book	Author	Publisher
1	Finite Element Method	Zeinkiewicz, O. C.	Tata Mcgraw Hill, 1988
2	The Finite Element Method- Vol. I	Zeinkiewicz& Taylor	Mcgraw-Hill International Editions
3	The Finite Element Method- Vol. II	Zeinkiewicz& Taylor	Mcgraw-Hill International Editions
4	The Finite Element Method- Vol. III	Zeinkiewicz& Taylor	Mcgraw-Hill International Editions
5	Vibrations, Dynamics and Structural System	Mukhopadhyay, M.	Oxford and IBH
6	An Introduction to the Finite Element Method	Reddy, J. N.	Mcgraw-Hill International Editions
7	The Finite Element Analysis	Seshu, P.	PHI
8	Finite Element Procedures	Bathe, K. J.	Prentice Hall, 1996
9	A First Course in Finite Elements	Fish, J. and Belytschko, T.	John Willey & Sons, 2007
10	Concepts and Applications of Finite Element Analysis	Cook, R. D.	John Willey & Sons
11	Finite Element Analysis- Theory and Programming	Krishnamurthy, C. S.	Tata Mcgraw Hill
12	Introduction to Finite Element Vibration Analysis	Petyt, M.	Cambridge University Press

Course Outcome:

At the end of the course, a student will be able to

1. Analyze linear 1D problem such as bars, beams, 2D problems using CST element, 4 node quadrilateral element, axi-symmetric problems with triangular elements, 3 and 4 node plate elements.
2. Write shape functions for 8 node quadrilateral, 6 node triangular (LST) elements, 8 node brick element, shell element, and apply numerical integration to solve; 1D and 2D; stiffness integrations.
3. Understand p and h Methods of refinement, discretization Errors and auto and adaptive mesh generation techniques.
4. Apply suitable boundary conditions to a global equation for various geotechnical engineering problems and solve them to determine displacements, stresses and strains.
5. Understand the finite element method to solve problems with material and geometric nonlinearity and vibration problems.
6. Critically assess a finite element analysis for correctness.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	Course Outcome
PCE72E02.1	Student will be able to analyze linear 1D problem such as bars, beams, 2D problems using CST element, 4 node quadrilateral element, axi-symmetric problems with triangular elements, 3 and 4 node plate
PCE72E02.2	Student will be able to write shape functions for 8 node quadrilateral, 6 node triangular (LST) elements, 8 node brick element, shell element, and apply numerical integration to solve; 1D and 2D; stiffness integrations.
PCE72E02.3	Student will be able to understand p and h Methods of refinement, discretization Errors and auto and adaptive mesh generation techniques.
PCE72E02.4	Student will be able to apply suitable boundary conditions to a global equation for various geotechnical engineering problems and solve them to determine displacements, stresses and strains.
PCE72E02.5	Student will be able to understand the finite element method to solve problems with material and geometric nonlinearity and vibration problems.
PCE72E02.6	Student will be able to critically assess a finite element analysis for correctness.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE72E02.1	2	2	3	2	2	2
PCE72E02.2	2	2	3	2	2	2
PCE72E02.3	2	2	3	2	2	2
PCE72E02.4	2	2	3	2	2	2
PCE72E02.5	2	2	3	2	2	2
PCE72E02.6	2	2	3	2	2	2
Total	**12**	**12**	**18**	**12**	**12**	**12**
Average	**2**	**2**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE72E02.1	2	2
PCE72E02.2	2	2
PCE72E02.3	2	2
PCE72E02.4	2	2
PCE72E02.5	2	2
PCE72E02.6	2	2
Total	**12**	**12**
Average	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**

SEISMIC SLOPE STABILITY: EARTH DAM AND RETAINING WALL (PCE72E03)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course objective:

1. It deals with the issues pertaining to Slope, dam, foundation and retaining wall and their analysis using classical and contemporary approaches for both the linear and non-linear models.
2. To analyse slope, dam, retaining wall and foundation using different analytical methods.
3. To perform the different experimental and numerical study on slope, dam, retaining wall and shallow foundation.
4. To synthesise the results obtained from different analytical, experimental and numerical study.
5. To evaluate the most acceptable solution and apply the same for field problem.

Course Content:

Unit-1:
Introduction to Slope: Performance of slope during past earthquakes, General features of slope, Analysis of slope under static and dynamic loading conditions, Numerical and Experimental study on slope, Case study on Slope.

Unit-2:
Introduction to Earth Dams: Performance of earth dam in past earthquakes; Homogenous and non-homogenous dams, general features, Seepage in earth dam, estimation of pore pressure by flow net, standard analytical solutions for seepage problems, piping. Analysis of dam under static and dynamic loading condition, Numerical and Experimental Study on dam; Case study.

Unit-3:
Introduction to Shallow Foundation: Performance of Shallow Foundation during past earthquakes, General features of Shallow Foundation, Analysis of Shallow Foundation under static and dynamic loading conditions, Numerical and Experimental study on Shallow Foundation, Case study on Shallow Foundation.

Unit-4:
Earth Pressures Under Static and Dynamic Conditions: History; Analysis of Retaining Wall under static and dynamic loading conditions, Numerical and Experimental study on Retaining Wall, Case study on Retaining Wall.

Unit-5:
Computer Applications for Earth Pressure: Software to evaluate static/dynamic earth pressures; Pressure distribution, stability of retaining structures and critical wall friction.

References:

Sl. No.	Name of Books/ Authors/ Publishers	Year of Publication
1	Duncan J.M., "State-of-the-art: static stability and deformation analysis," in R.B. Seed and R.W. Boulanger, Eds., Proc. Specialty Conf. on Stability and Performance of Slopes & Embankments, II, ASCE, New York, Vol. I, pp. 222-266.,	1992
2	Bharat Singh & R.S. Varshney , "Embankment Dam Engineering", Nem Chand & Bro., Roorkee	2004
3	Kramer S.L., "Geotechnical-Earthquake Engineering", Pearson Education – Indian Low Price Edition, New Delhi.	2004
4	Saran, S. , "Soil Dynamics and Machine Foundation", Galgotia	2015
5	Das, B. M., "Principle of Soil Dynamics", PWS-Kent Publishing Company	2020

Course Outcome:

1. Students will be able to know the issues pertaining to Slope, dam, foundation and retaining wall and their analysis using classical and contemporary approaches for both the linear and non-linear models.
2. They will be able to analyse slope, dam, retaining wall and foundation using different analytical methods.
3. They will be able to perform the different experimental and numerical study on slope, dam, retaining wall and shallow foundation.
4. They will be able to synthesise the results obtained from different analytical, experimental and numerical study.
5. They will be able to evaluate the most acceptable solution and apply the same for field problem.

To establish the correlation between COs & POs

Table 1

No. of course outcome (CO)	Course Outcome
PCE72E03.1	Students will be able to know the issues pertaining to Slope, dam, foundation and retaining wall and their analysis using classical and contemporary approaches for both the linear and non-linear models.
PCE72E03.2	They will be able to analyse slope, dam, retaining wall and foundation using different analytical methods
PCE72E03.3	They will be able to perform the different experimental and numerical study on slope, dam, retaining wall and shallow foundation
PCE72E03.4	They will be able to synthesise the results obtained from different analytical, experimental and numerical study
PCE72E03.5	They will be able to evaluate the most acceptable solution and apply the same for field problem.

Table 2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE72E03.1	2	2	3	2	2	2
PCE72E03.2	3	2	3	2	2	2
PCE72E03.3	2	2	3	2	2	2
PCE72E03.4	2	2	3	2	2	2
PCE72E03.5	3	2	3	2	2	2
Total	**12**	**10**	**15**	**10**	**10**	**10**
Average	**2.4**	**2**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE72E03.1	2	2
PCE72E03.2	3	2
PCE72E03.3	2	2
PCE72E03.4	2	2
PCE72E03.5	3	2
Total	**12**	**10**
Average	**2.4**	**2**
Equivalent Avg. Attainment	**2**	**2**

SOFTWARE APPLICATION LAB
(PCE72P01)

Total Credit: 02 **Contact Periods: 02 (0L+0T+2P)**

Course Objective:

1. Use of software to analyse ground motion parameters.
2. Use of software to analyse ground responses.
3. Use of software to analyse liquefaction potential of soil.
4. Use of software to analyse seismic slope stability.
5. Use of software to analyse seismic design of retaining walls.
6. Use of software to analyse seismic hazard and risk.

Course Content:

Unit-1:
Use of software to analyse the ground motion parameters

Unit-2:
Use of software to analyse the ground responses,
Unit-3:
Use of software to analyse liquefaction potential of soil

Unit-4:
Use of software to analyse seismic slope stability.
Unit-5:
Use of software to analyse seismic design of retaining walls

Unit-6:
Use of software to analyse seismic hazard and risk.

Course Outcome:

1. Students will know the use of software to analyze the ground motion parameters
2. They will know the use of software to analyze the ground response analysis
3. They will know the use of software to analyze the liquefaction analysis of soil
4. They will know the use of software to analyze the seismic slope stability analysis
5. They will know the use of software to analyze the seismic design of retaining walls
6. They will know the use of software to analyze the seismic hazard analysis.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE72P01.1	Students will know the use of software to analyze the ground motion parameters
PCE72P01.2	They will know the use of software to analyze the ground response analysis
PCE72P01.3	They will know the use of software to analyze the liquefaction analysis of soil
PCE72P01.4	They will know the use of software to analyze the seismic slope stability analysis
PCE72P01.5	They will know the use of software to analyze the seismic design of retaining walls
PCE72P01.6	They will know the use of software to analyze the seismic hazard a and risk

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE72P01.1	2	2	3	2	2	2
PCE72P01.2	2	2	3	2	2	2
PCE72P01.3	2	2	3	2	2	2
PCE72P01.4	2	2	3	2	2	2
PCE72P01.5	2	2	3	2	2	2
PCE72P01.6	2	2	3	2	2	2
Total	**12**	**12**	**18**	**12**	**12**	**12**
Average	**2**	**2**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE72P01.1	2	2
PCE72P01.2	2	2
PCE72P01.3	2	2
PCE72P01.4	2	2
PCE72P01.5	2	2
PCE72P01.6	2	2
Total	**12**	**12**
Average	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**

DIGITAL IMAGE PROCESSING AND SEISMIC SIGNAL PROCESSING LAB (PCE72P02)

Total Credit: 02 **Contact Periods: 02 (0L+0T+2P)**

Course Objective:

1. To know about the Seismographs, Strong Motion Accelerographs, reading of Seismograms and Accelerograms using Seisan computer program.
2. To understand earthquake effects and isoseismal maps.
3. To estimate the earthquake source parameters (origin time, epicentre, focal depth etc.) by manual method and computational method using Seisan software.
4. To determine fault plane solution by first-motion plot and waveform inversion.
5. To estimate frequency-magnitude relation (b-value), and Vp/Vs from Wadati plot.

Course Content:

Unit 1: Seismograph Operation
Unit 2: Calibration of Seismograph
Unit 3: Study of background noise
Unit 4: Strong Motion Accelerograph Operation and Processing
Unit 5: Estimation of Source Parameters
Unit 6: Familiarization with the instruments in seismological observatory
Unit 7: Interpretation of seismograms (seismic waves).
Unit 8. Processing of Seismic Records and reading of Seismic Phases.
Unit 8: Estimation of origin time, epicenter and focal depth of earthquakes using manual method and computational methods.
Unit 9: Preparation of isoseismal maps
Unit 11: Fault plane solutions by first-motion plot and waveform inversion.
Unit 12: Evaluation of b-value and V_p/V_s.

References:

Related Manuals.

Course Outcome:

1. Students will know about the Seismographs, Accelerographs, and recording system of earthquakes.
2. Students will know seismogram processing, reading of seismic phases, creating data files etc.
3. Students will know earthquake location (origin time, epicenter and focal depth) by manual method and computational method.
4. Students will know to estimate earthquake magnitude (Richter magnitude ML and Moment magnitude Mw), and from the reported damage data prepare isoseismal map etc.
5. Students will know to determine Fault plane solutions by first-motion plot and waveform inversion.
6. Students will know to estimate to estimate b-value and V_p/V_s.

To establish the co-relation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE72P02.1	Students will know about the Seismographs, Accelerographs, and recording system of earthquakes.
PCE72P02.2	Students will know seismogram processing, reading of seismic phases, creating data files etc.
PCE72P02.3	Students will know earthquake location (*origin time, epicenter and focal depth*) by manual method and computational method.
PCE72P02.4	Students will know to estimate earthquake magnitude (*Richter magnitude* M_L *and Moment magnitude Mw*), and from the reported damage data prepare isoseismal map etc.
PCE72P02.5	Students will know to determine Fault plane solutions by *first-motion plot and waveform inversion.*
PCE72P02.6	Students will know to estimate *b-value and* V_p/V_s.

Table-2

Slight (Low): 1 Moderate: 2 Substantial (High): 3 No Correlation: - '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE72P02.1	2	2	3	2	2	2
PCE72P02.2	2	2	3	2	2	2
PCE72P02.3	2	2	3	2	2	2
PCE72P02.4	2	2	3	2	2	2
Total	**8**	**8**	**12**	**8**	**8**	**8**
Average	**2**	**2**	**3**	**2**	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE72P02.1	2	2
PCE72P02.2	2	2
PCE72P02.3	2	2
PCE72P02.4	2	2
Total	**8**	**8**
Average	**2**	**2**
Equivalent Avg. Attainment	**2**	**2**

PROJECT PRELIMINARY (PCE72P03)

Each student will be given a Thesis/Project problem at the beginning of Second Semester. They will work on the literature survey, explore the scope of work, equipment development etc. and submit a report/dissertation. The main Thesis/Project work will, however, be done in Third and Fourth Semester.

COMPREHENSIVE VIVA-VOCE(PCE72P04)

Viva-voce will be conducted for the students at the end of the Second Semester in the department by the board of examiners constituted by the Geotechnical Engineering Section of Civil Engineering Department.

Third & Fourth Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	Third Semester			
1	**PCE73P01**: Project & Thesis - I	**10**	**-----**	**100**
	Fourth Semester			
1	**PCE74P01**: Project & Thesis - II	**20**	**-----**	**300**

Third Semester

Project & Thesis (PCE73P01)

Each student will devote full time in the Third Semester on a Thesis/Project on an assigned research problem of Design/Development work under the supervision of a Faculty Member. They will present a part of the Thesis/Project Report at the end of the Third Semester which will be evaluated by a Board of Examiners consisting of the Supervisor and External Examiner. The evaluation of the above said Thesis will be followed by a viva-voce in front of faculty members and other post-graduate students.

Fourth Semester

Project & Thesis (PCE74P01)

Each student will devote full time in the Fourth Semester on a Thesis/Project on an assigned research problem of Design/Development work under the supervision of a Faculty Member. They will present a Final Thesis/Project Report at the end of the Fourth Semester which will be evaluated by a Board of Examiners consisting of the Supervisor and External Examiner. The evaluation of the above said Thesis will be followed by a viva-voce in front of faculty members and other post-graduate students.