SYLLABUS

OF

M. TECH
(GEOTECHNICAL ENGINEERING)

II YEAR

(CBCS)

DEPARTMENT OF CIVIL ENGINEERING

INTEGRAL UNIVERSITY LUCKNOW

STUDY AND EVALUATION SCHEME (Full Time)

M.Tech. (Geotechnical Engineering)

(w.e.f. Batch 2024-25)

Semester – III

S. No.	Course Category	Code No	Name of Subject	Periods			Credits	Evaluation Scheme				Subject Total
				L	T	P	C	Continuous Assessment (CA)			Exam ESE	
								CT	TA	Total		
1	DE		Elective - II	3	1	-	4	40	20	60	40	100
2	DE		Elective - III	3	1	-	4	40	20	60	40	100
3	DE		Elective - IV	3	1	-	4	40	20	60	40	100
4	DC	CE675	Directed Study	-	-	-	4	-	-	-	100	100
5	DC	CE699	M.Tech Dissertation	-	-	-	4	-	-	60	40	100
Total							**20**					**500**

Semester – IV

S. No.	Course Category	Code No	Name of Subject	Periods			Credits	Evaluation Scheme				Subject Total
				L	T	P	C	Continuous Assessment (CA)			Exam ESE	
								CT	TA	Total		
1	DC	CE699	M.Tech Dissertation	-	-	-	4	-	-	60	40	100
2	DC	CE699	M.Tech Dissertation	-	-	-	4	-	-	60	40	100
3	DC	CE699	M.Tech Dissertation	-	-	-	4	-	-	60	40	100
4	DC	CE699	M.Tech Dissertation	-	-	-	4	-	-	60	40	100
Total							**16**					**400**

L – Lecture; T – Tutorial; P – Practical; C – Credits; CT – Class Tests; TA – Teacher Assessment
Continuous Assessment (CA) = Class Tests + Teacher Assessment

Subject Total = Continuous Assessment (CA) + End Semester Examination (ESE)

DC – Departmental Core **DE – Departmental Elective**

Departmental Elective – II
CE681 Slopes and Retaining Structures
CE682 Soil-Structure Interaction
CE683 Unsaturated Soil Mechanics
CE684 Seismology & Tectonics
CE685 Constitutive Modeling in Soil Mechanics

Departmental Elective – III
CE686 Offshore Geotechnical Engineering
CE687 Pavement Geotechniques and Materials
CE688 Design and Analysis of Foundation Structures
CE689 Remote Sensing and GIS in Geotechnical Engineering
CE690 Finite Element methods in Geotechnical Engineering

Departmental Elective – IV
CE691 Geotechnical Earthquake Engineering
CE692 Pavement Analysis and Design
CE693 Tunnelling Technology
CE694 Artificial Intelligence in Geotechnical Engineering
CE695 Machine Foundations

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE681	**Title of the Course**	Slopes and Retaining Structures	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	To introduce the fundamental principles of earth pressure theories and develop an understanding of their application in analyzing lateral pressures on retaining structures under various loading and drainage conditions. To familiarize learners with analytical and numerical methods for assessing slope stability under static and seismic conditions, and to explore modern stabilization techniques using soil reinforcement and ground improvement methods.						

Course Outcomes	
CO1	Given various types of retaining wall and backfill conditions, the student will be able to analyze earth pressure distributions using classical and graphical methods with correct identification of active, passive, and at-rest cases under external loads and wall movement.
CO2	Given different slope geometries and soil conditions, the student will be able to identify and analyze potential failure surfaces using limit equilibrium methods with proper distinction between total and effective stress analysis under both short-term and long-term stability conditions.
CO3	Given geotechnical slope conditions and stabilization requirements, the students will be able to evaluate slope stability using analytical techniques and propose suitable stabilization measures based on types of failure surface, seismic impact, and applicable soil reinforcement or treatment methods.
CO4	Given a reinforced earth retaining wall design scenario, the student will be able to design and evaluate the stability and performance of reinforced soil systems considering geosynthetic material properties, design mechanisms, and installation configurations.
CO5	Given the conditions of seismic loading and slope geometry for earth/rock fill structures, the student will be able to perform seismic stability analysis and propose design considerations in accordance with flow net interpretation, pore pressure control, and reservoir conditions.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Introduction	State of stress in retained soil mass – Earth pressure theories – Classical and graphical techniques – Active and passive cases – Earth pressure due to external loads, empirical methods - Wall movement and complex geometry - Lateral pressure due to compaction, strain softening, wall flexibility, influence of drainage.	8	CO1
2	Types of Failure: Failure surfaces	Planar surfaces, Circular surfaces, non-circular surfaces, Limit equilibrium methods, Total stress analysis versus effective Stress analysis, Use of Bishop's pore pressure parameters, short term and long-term stability in slopes	8	CO2
3	Methods of Slope Stability	Method of Slices, Effect of Tension Cracks, Vertical Cuts. Bishop's Analysis, Bishop and Morgenstern Analysis, Non-circular Failure Surfaces: Janbu Analysis, Sliding Block Analysis, Introduction to Seismic stability, Stabilization of slopes: Soil reinforcement (geosynthetics/soil nailing/micro piles etc), soil treatment (cement/lime treatment), surface protection (vegetation/erosion control mats/shotcrete).	8	CO3
4	Reinforced earth retaining wall	Principles, Concepts and mechanism of reinforced Earth – Design consideration of reinforced earth – Materials used in reinforced earth - Geotextile – Geogrids, Metal strips, facing elements.	8	CO4
5	Seismic Slope Stability	Slope stability analysis –Stability of infinite and finite slopes, Method of Slices, Bishop's method, Flow nets, Design consideration, Factors influencing design, Types of earth and rock fill dams, Design details, Provisions to control pore pressure - Stability conditions during construction, Full reservoir and drawdown - cut off walls – Trenches – Importance of drainage and filters	8	CO5

Reference Books:
Sherard, Woodward, Gizienski and Clevenger. Earth and Earth-Rock Dams. John Wiley &. Sons. 1963.
Bharat Singh and Sharma, H. D. – Earth and Rockfill Dams, 1999.
Sowers, G. F. and Salley, H. I. – Earth and Rockfill Dams, Willams, R.C., and Willace, T.S. 1965
Bromhead, E. N. (1992). The Stability of Slopes, Blackie academic and professional, London.
e-Learning Source:
https://www.youtube.com/watch?v=OPBEp3jauWs

PO-PSO-CO	**PO**											**PSO**	
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	0	0	3	0	2	0	0	0	0	0	0	2	1
CO2	0	0	0	3	0	0	0	0	0	0	1	2	2
CO3	0	0	0	3	0	0	2	0	0	0	1	2	1
CO4	0	0	0	3	2	0	0	0	0	0	0	1	1
CO5	0	0	0	3	2	0	0	0	0	0	0	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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Effective from Session: 2025-26							
Course Code	CE682	**Title of the Course**	Soil-Structure Interaction	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	These objectives aim to equip students with both the theoretical knowledge and practical skills to effectively account for and manage soil-structure interaction in engineering designs.						

Course Outcomes	
CO1	Students will be able to explain the key concepts of SSI, including the interdependence between soil and structural behavior, and its importance in civil engineering design.
CO2	Students will be able to evaluate how soil properties and foundation types influence the behavior of structures, such as buildings, bridges, and retaining walls, under various loading conditions.
CO3	Students will be able to evaluate how SSI affects structural stability, deformation, and vibration, particularly under static and dynamic loading conditions (e.g., earthquakes, wind, traffic)
CO4	Students will be able to integrate SSI considerations into the design of foundations, superstructures, and infrastructure systems, ensuring that the interaction is properly accounted for in engineering solutions.
CO5	Students will be able to assess how tall buildings, bridges, and other large structures respond to SSI, including phenomena such as base isolation and pile-soil interaction.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Soil-Foundation Interaction	Introduction to soil-foundation interaction problems, Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic-plastic behaviour, Time dependent behaviour.	8	CO1
2	Beam on Elastic Foundation-	Soil Models: Infinite beam, Two-parameters models, Isotropic elastic halfspace model, Analysis of beams of finite length, combined footings.	8	CO2
3	Plates on Elastic Continuum	Thin and thick rafts, Analysis of finite plates, Numerical analysis of finite plates.	8	CO3
4	Analysis of Axially and Laterally Loaded Piles	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, Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system.	8	CO4
5	Ground-Foundation-Structure Interaction	Effect of structure on ground-foundation interaction, Static and dynamic loads.	8	CO5
Reference Books:				
Rolando P. Orense, Nawawi Chouw & Michael J. Pender - Soil-Foundation-Structure Interaction, CRC Press, 2010 Taylor & Francis Group, London, UK				
Poulos, H. G., and Davis, E. H. - Pile Foundation Analysis and Design, 1980				
Soil Structure Interaction – The real behaviour of structures, the institution of structural engineers, London, March 1989.				
e-Learning Source:				
https://archive.nptel.ac.in/courses/105/105/105105200/				

PO-PSO-CO	PO											PSO	
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	0	0	3	0	0	0	1	0	0	0	0	3	1
CO2	0	0	0	3	2	0	0	0	0	0	0	3	2
CO3	0	0	0	3	1	1	2	0	0	0	0	3	2
CO4	0	0	3	0	2	2	0	0	0	0	1	3	1
CO5	0	0	0	3	2	0	0	0	0	0	0	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE683	**Title of the Course**	Unsaturated Soil Mechanics	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	• To understand the basic mechanisms of soil under specific conditions. • To enhance the ability of relating the basic mechanisms of soil to behaviour of the soil under various loading conditions.						

Course Outcomes	
CO1	Given the stress-strain behavior of soils under one-dimensional and isotropic compression conditions, the student will be able to analyze stress paths and define soil behavior using strain invariants and theoretical models, ensuring understanding of idealization and fundamental soil mechanics principles.
CO2	Given boundary conditions of soil loading and corresponding laboratory data, the student will be able to interpret drained and undrained responses using stress paths and critical state frameworks, including behavior of over-consolidated soils as defined by Roscoe and Hvorslev surfaces.
CO3	Given pre-failure soil behavior data and index test results, the student will be able to evaluate soil deformation using elasto-plastic models such as Modified Cam-Clay, by determining critical state parameters from test data and theoretical concepts.
CO4	Given soil samples exhibiting swell or collapse behavior and unsaturated soil data, the student will be able to classify expansive and collapsing soils and analyze their strength and hydraulic behavior, using effective stress, suction parameters, and soil classification standards.
CO5	Given laboratory results on swell and collapse potential, the student will be able to determine swell pressure, collapse characteristics, and soil suction parameters, using appropriate experimental tests and measurement techniques as per geotechnical engineering standards.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Introduction	Stresses and strains in soils - stress, strain paths invariants - one-dimensional and isotropic compression of soils and idealization	8	CO1
2	Stresses and strains Boundary Condition	State boundary of compression of soils; stress paths and soil tests; critical state line and Roscoe surface; Drained and undrained planes; Critical state line for sands; Behaviour of over-consolidated soils and Hvorslev surface	8	CO2
3	Elasto-plastic models	Behaviour of soils before failure; Interpretation of index tests in the light of critical state concepts; Cam-clay models, Determination of critical state parameters.	8	CO3
4	Expansive and collapsing soils	Identification and classification of expansive and collapsing soils, effective stress concepts, matric and osmotic suction, collapse, heave and strength characteristics of unsaturated soils, flow through unsaturated soils.	8	CO4
5	Swell pressure and swell potential	Laboratory evaluation of swell pressure and swell potential, tests to evaluate collapse potential. Measurements of soil suction.	8	CO5
Reference Books:				
Jean-Louis Briaud, Geotechnical Engineering: Unsaturated and Saturated Soils, John Wiley & Sons, Inc., New Jersey, 2013				
Murray E.J, Sivakumar V., Unsaturated Soils: A fundamental interpretation of Soil behaviour, Wiley-Blackwell, 2010.				
Ng C.W.W and Menzies B, Advanced unsaturated soil mechanics and engineering, CRC Press, 2019.				
e-Learning Source:				
https://archive.nptel.ac.in/courses/105/103/105103177/				

PO-PSO-CO	PO											PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	0	3	0	0	1	0	0	0	0	0	0	2	1
CO2	0	0	0	3	1	0	0	0	0	0	0	2	1
CO3	0	0	0	3	1	0	0	0	0	0	0	2	1
CO4	0	3	0	0	1	0	0	0	0	0	0	2	2
CO5	0	0	3	0	0	0	1	0	0	0	0	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE684	**Title of the Course**	Seismology & Tectonics	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	• To provide fundamental knowledge of seismic waves, earthquake mechanisms, and tectonic processes. • To understand plate tectonics, fault systems, and structural deformations. • To analyze seismological data and apply them in earthquake engineering and geotechnical investigations.						

Course Outcomes	
CO1	Given the fundamental concepts of earthquake generation and seismic wave characteristics, the student will be able to classify types of seismic waves and interpret earthquake magnitude and intensity using standard scales, to effectively understand the evolution and basic framework of seismology.
CO2	Given the structure of Earth's interior and tectonic plate movements, the student will be able to explain the mechanisms of continental drift, sea-floor spreading, and associated tectonic features, to evaluate seismic risks associated with different plate boundaries and hotspots.
CO3	Given various fault systems and deformation mechanisms in Earth's crust, the student will be able to distinguish between brittle and ductile deformation, classify fold structures, and analyze crustal stress conditions, for assessing tectonic geomorphology and structural behavior in seismic zones.
CO4	Given seismic data from instrumentation and historical records, the student will be able to perform seismic hazard assessments using PSHA techniques and interpret seismic zoning information, to support microzonation and hazard mitigation strategies.
CO5	Given geologic, tectonic, and seismic data, the student will be able to apply earthquake-resistant design principles and evaluate site suitability for infrastructure projects, through the analysis of case studies and early warning systems in engineering practice.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Introduction to Seismology	Historical development of seismology, Earthquake generation mechanisms, Types of seismic waves, Focus, epicenter, and earthquake magnitude & intensity scales	8	CO1
2	Plate Tectonics and Earth's Interior	Structure of the Earth's interior, Plate boundaries (divergent, convergent, transform), Continental drift and sea-floor spreading, Subduction zones and mid-ocean ridges, Tectonic features and hotspots	8	CO2
3	Faulting, Folding and Deformation Mechanisms	Types of faults and fault systems, Stress and strain in the Earth's crust, Fold structures and classification, Brittle vs. ductile deformation, Tectonic geomorphology	8	CO3
4	Seismic Hazard Assessment	Seismographs and seismometers, Earthquake recording and location, Ground motion parameters, Probabilistic seismic hazard analysis (PSHA), Seismic zoning and microzonation	8	CO4
5	Application in Engineering	Earthquake-resistant design principles, Role of geology in seismic site selection, Case studies of major earthquakes (Indian and global), Early warning systems, Role of tectonics in infrastructure planning	8	CO5
Reference Books:				
Forensic Geotechnical and Foundation Engineering. Robert W. Day.				
An Introduction to Seismology, Earthquakes and Earth Structure, Seth Stein and Michael Wysession, First published 2003 by Blackwell Publishing Ltd.				
e-Learning Source:				
https://onlinecourses.nptel.ac.in/noc23_ce104/preview				

PO-PSO-CO	PO											PSO	
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	0	0	0	0	2	0	0	0	0	0	2	1
CO2	3	0	0	0	0	0	0	0	0	0	1	2	2
CO3	0	3	0	0	0	1	0	0	0	0	0	2	2
CO4	0	0	0	3	1	0	0	0	0	0	0	2	1
CO5	0	0	0	3	2	0	1	0	0	0	0	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE685	**Title of the Course**	Constitutive Modelling in Soil Mechanics	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	• To introduce the fundamentals of stress-strain relationships in soils and how they govern soil behavior under various loading and environmental conditions. • To understand and classify different types of constitutive models, including linear elastic, elasto-plastic, and viscoplastic models, applicable to geotechnical engineering.						

Course Outcomes	
CO1	By studying stress and strain tensors and linear elasticity, the student will be able to formulate generalized Hooke's law and apply field equations in linear elasticity to solve fundamental stress-strain problems in soils.
CO2	Upon learning linear and incrementally non-linear elastic formulations, the student will be able to evaluate stress-strain relationships and volumetric responses, and perform basic incremental finite element analysis using appropriate model parameters.
CO3	Through understanding of plasticity theory and critical state soil mechanics, the student will be able to analyze drained and undrained responses of clays and apply elasto-plastic models such as Cam-clay to interpret the effect of stress history on soil behavior.
CO4	With knowledge of soil compressibility and yielding behavior, the student will be able to assess the influence of stress and strain history on plastic hardening and anisotropy evolution in soils.
CO5	By examining small and large strain responses, the student will be able to characterize non-linear and hysteretic behavior in soils and apply failure criteria such as Mohr-Coulomb, Von Mises, and Drucker-Prager to analyze soil strength under different loading conditions.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Stress strain relationships	Stress strain relationships. Definition of stress and strain tensors. Elasticity. Linear Elasticity. Generalized Hooke's law. Field equations in linear elasticity	8	CO1
2	Linear and Non-linear elasticity	Linear elasticity and incrementally non-linear elastic formulation. Stress-strain relationships, strength and volumetric response. Evaluation of model parameters. Incremental finite element analyses	8	CO2
3	Elastic and elastoplastic theory	Plasticity theory. Incrementally linearized elasto-plastic formulation. Linear elastic-perfectly plastic. Critical state soil mechanics framework (Cam-clay and modified cam-clay models). Drained and undrained response of clays. Effects of consolidation stress history	8	CO3
4	Compressibility of soils	Compressibility of soils. Yielding for soils. Stress and strain history. Plastic hardening. Evolving anisotropy.	8	CO4
5	Non-linear strain	Small strain non-linear "elastic" response. Hysteretic response. Large strain failure criteria: Von Mises, Drucker-Prager, Mohr Coulomb.	8	CO5
Reference Books:				
Desai, C.S., 2000. Mechanics of Materials and Interfaces:The Disturbed State Concept. CRC Press LLC.				
Desai, C.S. and Siriwardane, H. J., 1984. Constitutive Laws for Engineering Materials with Emphasis on Geologic Materials. Prentice-Hall, Inc., New Jersey.				
Hicher and Shao, 2008. Constitutive Modeling of Soils and Rocks. John Wiley				
e-Learning Source:				
https://archive.nptel.ac.in/courses/105/106/105106222/				

PO-PSO-CO	**PO**											**PSO**	
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	0	3	0	0	1	0	0	0	0	0	0	3	1
CO2	0	0	0	3	1	0	0	0	0	0	0	3	1
CO3	0	3	0	0	1	0	0	0	0	0	0	2	2
CO4	0	0	0	3	1	0	0	0	0	0	0	3	1
CO5	0	0	0	3	1	0	1	0	0	0	0	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE686	**Title of the Course**	Offshore Geotechnical Engineering	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	• To introduce the fundamental concepts of offshore geotechnical engineering, including the nature of offshore environments and the role of geotechnics in marine infrastructure development. • To understand geological, geophysical, and geotechnical site investigation techniques used for seabed characterization and assessment of soil properties under marine conditions.						

Course Outcomes	
CO1	After studying the marine environment and offshore engineering context, the student will be able to identify key challenges in offshore design and describe how environmental conditions influence offshore geotechnical practices.
CO2	Through the understanding of site investigation processes, the student will be able to describe the components of an offshore geotechnical investigation and interpret basic investigation data relevant to offshore foundation and structure design.
CO3	By examining various offshore foundation systems and design considerations, the student will be able to classify foundation types, describe design drivers, and perform basic foundation calculations to demonstrate soil-structure interaction.
CO4	With knowledge of pipeline–soil interaction and loading conditions, the student will be able to identify geotechnical factors influencing offshore pipeline design and perform illustrative calculations for design assessment.
CO5	Based on an understanding of codal guidelines and offshore structural mechanics, the student will be able to determine different types of loads acting on offshore structures and apply standard design procedures to ensure structural safety.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Introduction	Identify and describe key challenges of offshore engineering design - describe the aspects of the marine environment that feed into offshore engineering design.	8	CO1
2	Site Investigation	Describe the main components of an offshore site investigation; Interpret selected geotechnical site investigation data	8	CO2
3	Foundation Design	Identify the main types of offshore foundation systems and describe the drivers during foundation design, perform selected foundation design calculations to illustrate the interplaying mechanisms.	8	CO3
4	Pipeline design	Identify key aspects of geotechnical pipeline design and perform selected design calculations to illustrate the interplaying mechanisms	8	CO4
5	Offshore structures loads	Determine the various loads acting on the various offshore structures and their design as per codal provisions	8	CO5
Reference Books:				
Randolph M and Gourvene S, Offshore Geotechnical Engineering, CRC Press,2017.				
Ben C. Gerwick, “Construction of Marine and Offshore Structures”, CRC Press, 1999.				
B. Gou, S. Song, J. Chacko and A. Ghalambor, “Offshore Pipelines”, GPP Publishers, 2006.				
e-Learning Source:				
https://archive.nptel.ac.in/courses/114/106/114106015/				

PO-PSO-CO	PO											PSO	
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	0	3	0	0	1	0	0	0	0	0	0	2	1
CO2	0	0	0	3	1	0	0	0	0	0	0	2	2
CO3	0	3	0	0	1	0	0	0	0	0	0	2	2
CO4	0	0	3	0	1	0	0	0	0	0	0	3	1
CO5	0	0	0	3	1	0	1	0	0	0	0	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE687	**Title of the Course**	Pavement Geotechniques and Materials	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	• The course on Pavement Materials will deal with the basic and fundamental understanding about the behavior of various materials used in the construction of pavements.						

Course Outcomes	
CO1	After understanding the engineering behavior and classification of soils, the student will be able to evaluate soil properties such as shear strength, CBR, resilient modulus, and apply appropriate soil stabilization techniques for highway applications.
CO2	Through the study of aggregate properties and production techniques, the student will be able to classify aggregates, analyze gradation parameters, and perform strength and shape-related tests to assess suitability for pavement construction.
CO3	With knowledge of bituminous mix production and design methods, the student will be able to design hot and cold bituminous mixes using Marshall, Superpave, and performance-based approaches and evaluate their mechanical properties through laboratory testing.
CO4	Upon studying the production and hydration of cement, the student will be able to distinguish between types of cement and assess the role of pozzolanic and geopolymer materials as sustainable alternatives in pavement construction.
CO5	By applying principles of concrete mix design, the student will be able to proportion and design mixes for pavement quality concrete, dry lean concrete, and pervious concrete, and evaluate the use of innovative materials in both flexible and rigid pavement systems.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Soil	Introduction to soil as a highway material; Classification of soils; Consistency Limits; Soil compaction and role of moisture; Mechanical properties of soil (Shear strength, Unconfined compressive strength, Resilient modulus, California bearing ratio, Modulus of subgrade reaction etc.); Introduction to expansive soils, relevant tests, and soil stabilization techniques	8	CO1
2	Aggregate	Aggregate origin, types, production, and quarrying operation; Classification of aggregates; Aggregate gradation and gradation parameters; Theories of aggregate blending; Minerology of aggregates and its importance; Aggregate shape and texture: quantification and importance; Aggregate strength properties, and relevant tests	8	CO2
3	Bituminous Mixture	Production of bituminous mixtures: Laboratory and Plant; Role of bituminous mixture and desirable properties; Volumetrics of bituminous mixture; Mix design of bituminous mixture: Marshall and Superpave methods; Mechanical tests and characterization of bituminous mixtures; Introduction to performance-based mix design concepts; Mix design of cold bituminous mixtures; Mix design of hot recycled mixtures	8	CO3
4	Cement	Production of cement; Theory of hydration and importance of different hydration products; Physical and chemical properties of cement; Types of cement; Pozzolanic and geopolymer materials as alternate cement	8	CO4
5	Concrete Mix Design	Concrete proportioning and importance of various constituents; Introduction and mix design of pavement quality concrete, Dry lean concrete and Pervious concrete State of the art on various alternative materials for construction of flexible and rigid pavements	8	CO5

Reference Books:
Principles of Pavement Engineering by Nick Tom
Highway Engineering by R. Srinivas Kumar.
Highways Engineering -Khanna& Justo, pub. Nem Chand and Bros.
e-Learning Source:
https://archive.nptel.ac.in/courses/105/107/105107219/

PO-PSO-CO	**PO**											**PSO**	
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	0	3	0	0	0	0	1	0	0	0	0	2	1
CO2	3	0	0	0	0	0	1	0	0	0	0	1	2
CO3	0	3	0	0	0	0	1	0	0	0	0	2	2
CO4	3	0	0	0	0	0	1	0	0	0	0	2	1
CO5	0	0	0	3	0	0	1	0	0	0	0	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE688	**Title of the Course**	Design and Analysis of Foundation Structures	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	• To impart knowledge about limit state design of foundations. • To introduce the analysis and concepts of shallow and deep foundations as well as retaining walls. • To enable the students to design shallow, pile and well foundations and retaining structures.						

Course Outcomes	
CO1	After studying the fundamentals of Limit State Design for foundations, the student will be able to determine design soil pressures and apply limit state concepts to reinforced concrete elements in foundation systems.
CO2	With an understanding of structural behavior and loading conditions, the student will be able to design individual, continuous, and combined footings using standard structural analysis and detailing methods.
CO3	Upon analyzing various raft foundation types, the student will be able to design rectangular and circular rafts subjected to vertical, lateral, and moment loads, ensuring safe load transfer to subsoil.
CO4	By exploring pile behavior under axial and lateral loads, the student will be able to design piles, pile caps, under-reamed piles, piers, and caissons in compliance with structural standards and practices.
CO5	Through study of retaining wall mechanics and codal provisions, the student will be able to perform structural design of cantilever and counterfort retaining walls, incorporating appropriate earth pressure considerations.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Limit State Design	Introduction to Limit State Design of reinforced concrete in foundations; Soil pressure for structural design	8	CO1
2	Design of footing	Conventional structural design of continuous footings, individual footings, combined footings	8	CO2
3	Raft Foundation	Rafts of various types subjected to vertical and lateral loads and moments, Design of circular rafts	8	CO3
4	Pile Foundation	Structural design of piles including pile caps, under-reamed piles, piers and caissons	8	CO4
5	Retaining wall	Structural design of retaining walls, Codal provisions.	8	CO5
Reference Books:				
Design of Sub-structures by Swami Saran, Oxford & Ibh Publishing Co Pvt Ltd.				
Principles of Geotechnical Engineering by Braja M. Das, Thomson.				
Analysis & Design of Substructures by Swami saran, Oxford & Ibh Publishing Co. Pvt Ltd.				
e-Learning Source:				
https://onlinecourses.nptel.ac.in/noc22_ce65/preview#:~:text=Design%20of%20reinforced%20concrete%20structures%20is%20an%20introductory%20design%20course,blocks%20of%20the%20whole%20structure.				

PO-PSO-CO	PO											PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	0	0	0	3	0	0	1	0	0	0	0	2	1
CO2	0	0	0	3	0	0	1	0	0	0	0	1	2
CO3	0	0	0	3	0	0	1	0	0	0	0	2	2
CO4	0	0	0	3	0	0	1	0	0	0	0	2	1
CO5	0	0	0	3	0	0	1	0	0	0	0	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE689	**Title of the Course**	Remote Sensing and GIS in Geotechnical Engineering	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	• Understanding map projection and working with coordinate systems, • Understanding vector-based and raster-based data data analysis, • Review of application areas of GIS in Geotechnical Engineering, and • Understanding basic principles of remote sensing.						

Course Outcomes	
CO1	The students have the ability to learn basic items, parameters & concepts related with remote sensing
CO2	The students have the ability to apply techniques of visual image interpretation and digital image processing.
CO3	The students have an ability to understand image classification & analysis
CO4	The students will be able to prepare of thematic map.
CO5	Use GIS and its components for applications in Geo-Environmental engineering.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Remote Sensing	By exploring the physical basis of remote sensing and the electromagnetic spectrum, the student will be able to explain spectral signatures, sensor resolutions, and differentiate between passive and active remote sensing platforms.	8	CO1
2	Sensors	With an understanding of various sensors and satellite band designations, the student will be able to identify appropriate sensors for different applications and interpret aerial photographs using standard remote sensing techniques.	8	CO2
3	Digital image processing	After learning digital image formats and processing functions, the student will be able to enhance, transform, classify, and analyze remotely sensed imagery using digital image processing techniques.	8	CO3
4	Geographic Information System	Given the components and data structures of GIS, the student will be able to input, manage, and process spatial data, and generate thematic maps using remote sensing data within a GIS environment.	8	CO4
5	RS & GIS	By integrating remote sensing and GIS methodologies, the student will be able to apply geospatial techniques for solving problems in geo-environmental engineering, such as land use mapping, hazard assessment, and environmental monitoring	8	CO5
Reference Books:				
T.M. Lillesand and R.W. Kiefer, Remote Sensing and Image Interpretation, John Wiley & Sons.				
C.P. Lo & A.K.W. Yeung, Concepts & Techniques of Geographic Information Systems, PHI.				
B. Bhatta, Remote Sensing & GIS, Oxford University Press.				
e-Learning Source:				
https://nptel.ac.in/courses/105108077				

PO-PSO-CO	PO											PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	0	0	0	1	0	0	0	0	0	0	2	1
CO2	0	3	0	0	1	0	0	0	0	0	1	2	2
CO3	0	3	0	0	1	0	0	0	0	0	0	2	2
CO4	0	0	3	0	1	0	0	0	0	0	1	2	1
CO5	3	0	0	0	1	0	0	0	0	0	1	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE690	**Title of the Course**	Finite Element methods in Geotechnical Engineering	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	Understand the mathematical and physical principles underlying the Finite Element Method (FEM) focussed on stress analysis of common geotechnical engineering problems.						

Course Outcomes	
CO1	After understanding the basic concepts of finite element discretization, the student will be able to define and assemble element and global stiffness matrices and vectors, and differentiate between linear and quadratic elements based on their interpolation properties.
CO2	Upon learning Galerkin's Residual Method, Virtual Work Method, and Energy Principles, the student will be able to derive shape functions and formulate the beam element equation using various theoretical approaches.
CO3	By applying the basic displacement method, the student will be able to formulate stiffness matrices for triangular and rectangular elements and solve related problems using nodal variables in practical examples.
CO4	With knowledge of isoparametric concepts, plane stress/strain conditions, and numerical integration, the student will be able to apply Jacobian transformation and develop element matrices relevant to geotechnical applications.
CO5	After studying the formulation of 3D isoparametric elements, the student will be able to implement element formulations in simple programs and apply these to analyze geotechnical problems in three-dimensional space.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Introduction	Basics of FE, discretization, nodes, elements, mesh, stiffness, degrees of freedom, element stiffness matrix, element load vector, element displacement vector, assembly procedure, global stiffness matrix global load vector, global displacement vector, stresses and strains, types of elements and properties, interpolation functions. Difference between linear and quadratic elements	8	CO1
2	Different formulations	Galarkine's Residual Model, Virtual Work Model, Energy Principal etc. and derivation of shape functions in light of above of beam element.	8	CO2
3	Triangular and Rectangular Element	Formulation by basic method of displacement function with nodal variables. Examples.	8	CO3
4	Introduction of Isoparametric Elements	Plane stress and plane strain. Concept of Integration points, Jacobian matrix. Application in Geotechnical Engineering.	8	CO4
5	3D elements	Formulation as Iso-parametric element. Application in Geotechnical Engineering. Programming on Simple Element Formulation	8	CO5
Reference Books:				
Finite Element Analysis (Theory and Programming). C.S. Krishnamurthy. Tata McGrew Hills				
Finite Element Methods. Dhanraj Nair. Oxford				
Problems in Structural Analysis by Matrix method. P. Bhatt. Wheelers.				
e-Learning Source:				
https://archive.nptel.ac.in/courses/112/104/112104193/				

PO-PSO-CO	PO											PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	0	0	3	0	1	0	0	0	0	0	0	3	1
CO2	0	0	0	3	1	0	0	0	0	0	1	3	2
CO3	0	0	0	3	1	0	0	0	0	0	0	3	2
CO4	0	0	0	3	1	0	0	0	0	0	1	3	1
CO5	3	0	0	3	1	0	0	0	0	0	1	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE691	**Title of the Course**	Geotechnical Earthquake Engineering	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	To understand the effect of earthquake on soil structures and to design earthquake resistant geotechnical structures.						

Course Outcomes	
CO1	By studying the causes and mechanics of earthquakes, the student will be able to interpret strong ground motion records and quantify earthquake parameters such as magnitude, intensity, and frequency content, to assess seismic shaking characteristics.
CO2	After reviewing dynamic soil behavior and relevant case studies, the student will be able to evaluate site-specific dynamic soil properties and interpret seismic data in accordance with applicable codal provisions for site classification.
CO3	With an understanding of codal guidelines and seismic hazard concepts, the student will be able to develop design ground motions for engineering applications, ensuring alignment with national and international seismic codes.
CO4	Upon learning about earthquake response mechanisms, the student will be able to analyze slope stability and liquefaction potential under seismic loading and apply codal recommendations for designing earthquake-resistant geotechnical systems.
CO5	Through the study of seismic hazard assessment and mitigation strategies, the student will be able to interpret microzonation data and propose suitable measures for risk reduction in earthquake-prone regions.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Mechanism of Earthquakes	Causes of earthquake - Earthquake Fault sources - Elastic Rebound theory - Seismic wave in earthquake shaking - terminology - Locating an earthquake - Quantification of earthquakes. Strong Motion Records - characteristics of ground motion - Factors influencing Ground motion - Estimation of frequency content parameters	8	CO1
2	Seismic site investigations	Selected Case Studies - Evaluation of Dynamic soil properties – Codal Provisions	8	CO2
3	Design Ground Motion	Developing Design Ground Motion-Codal recommendations.	8	CO3
4	Earthquake Resistant Design	Design considerations -. Earthquake Response of slopes - Evaluation of slope stability – Liquefaction Susceptibility - Liquefaction Resistance-Codal recommendations	8	CO4
5	Risk mapping	Hazard assessment – Mitigation measures - Seismic micro zonation and its importance	8	CO5
Reference Books:				
Steven L. Kramer, "Geotechnical Earthquake Engineering", Prentice Hall Inc.1996.				
Robert W. Day, "Geotechnical Earthquake Engineering Handbook", McGraw Hill, New York, 2001.				
Ikuo Towhata, "Geotechnical Earthquake Engineering", Springer-Verlag Heidelberg, 2008.				
e-Learning Source:				
https://archive.nptel.ac.in/courses/105/101/105101134/				

PO-PSO-CO	PO											PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	0	3	0	0	0	0	0	0	0	0	1	2	2
CO2	0	0	3	0	0	0	2	0	0	0	1	3	2
CO3	0	0	0	3	0	0	2	0	0	0	1	3	2
CO4	0	0	0	3	0	0	2	0	0	0	1	3	1
CO5	3	0	0	3	1	0	2	0	0	0	0	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE692	**Title of the Course**	Pavement Analysis and Design	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	• Decide factor affecting selection of type of pavement to be constructed. • Identify the material to be used for pavement construction. • Design low volume as well as regular flexible pavement, rigid pavement. • Determine the quality of the constructed flexible as well as rigid pavement.						

Course Outcomes	
CO1	By understanding the classification and functional requirements of road and airport pavements, the student will be able to distinguish between different types of pavements and explain their design principles and suitability for various applications.
CO2	After studying the properties of subgrade soils, aggregates, bituminous materials, and concrete, the student will be able to evaluate their suitability for pavement construction and assess their influence on pavement performance.
CO3	Through the exploration of empirical, semi-empirical, and theoretical methods, the student will be able to design flexible pavements using practical approaches aligned with current engineering standards.
CO4	After learning about concrete mix design principles and relevant codal methods, the student will be able to design durable rigid pavements using IS and IRC guidelines, considering both urban and rural road applications.
CO5	With knowledge of structural evaluation techniques and deflection-based testing methods like FWD, the student will be able to assess pavement condition, perform back-calculation of layer moduli, and recommend appropriate strengthening measures.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Introduction	Introduction: Type of pavements, road pavement and airport pavements, design	8	CO1
2	Material Characterization	Materials of construction, subgrade soils, stone aggregates, bituminous material and cement concrete their suitability and effects.	8	CO2
3	Flexible Pavement	Design of flexible pavements empirical, semi empirical and theoretical methods, practical approach	8	CO3
4	Rigid Pavement	Introduction, cement, properties of cement, mineral aggregates, water, admixtures, properties of fresh concrete, test on hardened concrete, design of cement concrete mix, factors considered for durable concrete, the Bureau of Indian Standards Method of Cement Concrete Mix Design, Indian Road Congress Method of Cement Concrete Mix Design (IRC: 44-2008), Dry Lean Cement Concrete (MORTH 201), Concrete Mix Design for Rural Roads (IRC :SP:62-2004)	8	CO4
5	Evaluation and strengthening	Purpose, types, and methods of structural evaluation, structural evaluation by static loading, structural evaluation by steady – state Vibratory Loading, structural evaluation by impulse lading, Models of Falling Weight Deflectometer, structural evaluation of flexible pavement using FWD, back calculation of Layer Moduli from FWD Test data, uses of Back-calculated Pavement Layer Moduli, Structural Evaluation of Rigid Pavement using FWD.	8	CO5

Reference Books:
Principles of Pavement Engineering by Nick Tom
Highway Engineering by R. Srinivas Kumar.
Highways Engineering -Khanna& Justo, pub. Nem Chand and Bros.
e-Learning Source:
https://archive.nptel.ac.in/courses/105/107/105107219/

PO-PSO-CO	PO											PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	0	0	0	0	1	0	0	0	0	1	2	2
CO2	3	0	0	0	0	1	0	0	0	0	0	2	2
CO3	0	0	0	3	1	0	2	0	0	0	0	3	2
CO4	0	0	0	3	0	0	2	0	0	0	0	3	1
CO5	3	0	0	3	1	0	2	0	0	0	0	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE693	**Title of the Course**	Tunnelling Technology	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	• To explain the construction methodology, support systems like diaphragm walls, sheet piles and challenges in the constructions of tunnels, caverns, shafts, and stations.						

Course Outcomes	
CO1	After studying the types and functions of underground structures, the student will be able to identify tunnels, caverns, shafts, and underground stations, and explain tunnel design methodologies suitable for different geological and urban conditions.
CO2	With an understanding of site investigation and geological appraisal techniques, the student will be able to select appropriate tunneling methods such as TBM and DBM, and describe the design and construction approaches for deep excavations.
CO3	After learning construction practices and support systems, the student will be able to describe various tunnel construction methodologies, evaluate the use of diaphragm walls and sheet piles, and identify key challenges in underground construction.
CO4	By exploring instrumentation and construction methods, the student will be able to recommend suitable monitoring techniques for tunnel stability, ensuring safety and compliance during construction operations.
CO5	Based on real-world projects, the student will be able to analyze case studies of tunnel construction and evaluate the application of design philosophies under different geotechnical and operational conditions.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Introduction	Introduction to various underground structures such as tunnels, caverns, shafts and UG stations, Tunnel Design Methodologies	8	CO1
2	Design Philosophy	Site Investigation, Preliminary Geological appraisal for tunnels, Selection of options for method of execution - TBM, DBM, Design and Construction of Deep Excavations	8	CO2
3	Underground Tunnel	Construction methodology, support systems like diaphragm walls, sheet piles and challenges in the constructions of tunnels, caverns, shafts, and stations	8	CO3
4	Tunnel Monitoring	Tunnel Construction Methods, Instrumentation and Monitoring	8	CO4
5	Case study	Case Study of Tunnel Construction and Design Philosophy in different condition	8	CO5
Reference Books:				
Theory and Practice of Tunnel Engineering, DOI: 10.5772/intechopen.93583				
Handbook of Tunnel Engineering I, Wiley. Bernhard Maidl/ Markus Thewes/ Ulrich Maidl				
Handbook of Tunnel Engineering: Ananthakumar Paulraj				
e-Learning Source:				
https://onlinecourses.nptel.ac.in/noc21_ce76/preview				

PO-PSO-CO	**PO**											**PSO**	
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	0	0	0	0	1	0	0	0	0	0	2	2
CO2	0	0	0	3	0	0	1	0	0	0	1	2	2
CO3	0	0	3	0	1	0	2	0	0	0	0	3	2
CO4	3	0	0	0	0	1	0	0	0	0	1	3	1
CO5	0	0	3	3	1	0	1	0	0	0	0	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE694	**Title of the Course**	Artificial Intelligence in Geotechnical Engineering	**L**	**T**	**P**	**C**
Year	2nd	**Semester**	3rd	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	• To introduce the principles and applications of Artificial Intelligence (AI), Machine Learning (ML), and Data Analytics in geotechnical engineering. • To understand data-driven approaches for prediction, classification, and optimization in soil behavior and geotechnical design. • To develop models using AI techniques such as Artificial Neural Networks (ANN), Support Vector Machines (SVM), and Decision Trees for geotechnical problem-solving.						

Course Outcomes	
CO1	After studying the fundamentals of AI, machine learning, and deep learning, the student will be able to explain the role of data-driven approaches in geotechnical engineering and perform basic data acquisition and preprocessing from field and laboratory sources.
CO2	By applying supervised learning models, the student will be able to use techniques such as linear regression, logistic regression, SVM, and decision trees for geotechnical tasks like soil classification and settlement prediction.
CO3	With knowledge of ANN architecture and training processes, the student will be able to develop and validate neural network models for applications such as bearing capacity estimation, slope stability analysis, and liquefaction potential assessment.
CO4	After understanding clustering and optimization techniques, the student will be able to apply methods like K-means, PCA, and genetic algorithms for site classification and model calibration in geotechnical problems.
CO5	Through the analysis of practical applications, the student will be able to evaluate case studies involving AI in geotechnical monitoring and risk mapping, and discuss the integration of GIS and AI, along with associated ethical and practical challenges.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Introduction	Basics of Artificial Intelligence, Machine Learning, Deep Learning, Importance of data-driven approaches in geotechnical engineering, Data acquisition and preprocessing from field and lab tests	8	CO1
2	Supervised Learning Techniques in Geotechnics	Linear and logistic regression, Support Vector Machines (SVM), Decision Trees and Random Forest, Applications in classification of soil type, settlement prediction	8	CO2
3	Artificial Neural Networks (ANN) and Deep Learning	Concept and architecture of ANN, Training and validation of ANN models, Overfitting and regularization, Applications in bearing capacity, slope stability, and liquefaction assessment	8	CO3
4	Unsupervised Learning and Optimization	Clustering techniques: K-Means, Hierarchical, Principal Component Analysis (PCA), Genetic Algorithms and Particle Swarm Optimization, Applications in site classification and model calibration	8	CO4
5	Case Studies and Emerging Trends	Case studies: real-time settlement monitoring, landslide prediction, soil classification, Integration of GIS and AI in geotechnical risk mapping, AI in geotechnical instrumentation and monitoring, Ethical considerations and challenges in AI application	8	CO5
Reference Books:				
"Artificial Intelligence in Geotechnical Engineering" By G. S. Mani & S. Gopalakrishnan				
"Geotechnical Applications of Artificial Intelligence and Machine Learning" Edited by Sitharam T.G. and L. Govindaraju				
"Machine Learning Applications in Civil Engineering" By M. Zia Ur Rehman, Imran Shahzad, Zhen Shen				
e-Learning Source:				
https://nptel.ac.in/courses/106102220				

PO-PSO-CO	PO											PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	0	0	0	1	0	0	0	0	0	1	2	2
CO2	0	3	0	0	1	0	1	0	0	0	1	2	1
CO3	0	3	0	0	2	0	2	0	0	0	1	1	2
CO4	3	3	0	0	2	0	0	0	0	0	1	2	1
CO5	0	3	0	0	1	0	1	0	0	0	1	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2025-26							
Course Code	CE695	**Title of the Course**	Machine Foundation	**L**	**T**	**P**	**C**
Year	2^{nd}	**Semester**	3^{rd}	3	1	0	4
Pre-Requisite	NA	**Co-requisite**	NA				
Course Objectives	• To understand behaviour of soil under dynamics loads. • To design of foundations and retaining structures under dynamic load.						

Course Outcomes	
CO1	After learning the functional requirements of machine foundations, the student will be able to identify criteria for a satisfactory foundation and evaluate permissible amplitudes for various machine types to ensure safe and stable operation.
CO2	Through an understanding of different analytical approaches, the student will be able to apply linear elastic spring models, elastic half-space theory, and semi-graphical methods to analyze the dynamic response of machine foundations.
CO3	After studying vibration modes and damping behavior, the student will be able to determine soil spring constants in laboratory and field settings as per IS code guidelines and analyze complex vibration modes of block foundations.
CO4	By understanding the dynamic forces generated by machines, the student will be able to compute induced loads and design foundations for reciprocating and impact-type machines using IS code-based procedures.
CO5	With knowledge of vibration control principles, the student will be able to differentiate between active and passive isolation methods and design appropriate isolation systems to reduce transmissibility in machine foundations.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Introduction	Criteria for a satisfactory machine foundation - permissible amplitude of vibration for different type of machines	8	CO1
2	Linear elastic theory	Methods of analysis of machine foundations - methods based on linear elastic weightless springs - methods based on linear theory of elasticity (elastic half space theory) - methods based on semi graphical approach.	8	CO2
3	Determination of soil constants	Degrees of freedom of a block foundation - definition of soil spring constants - nature of damping - geometric and internal damping - determination of soil constants, Methods of determination of soil constants in laboratory and field based on IS code provisions - Vertical, sliding, rocking and yawing vibrations of a block foundation - simultaneous rocking, sliding and vertical vibrations of a block foundation.	8	CO3
4	Design criteria	Foundation of reciprocating machines - design criteria - calculation of induced forces and moments - multi-cylinder engines - numerical example (IS code method) - Foundations subjected to impact loads - design criteria - analysis of vertical vibrations - computation of dynamic forces - design of hammer foundations (IS code method).	8	CO4
5	Vibration in Machine Foundation	Vibration isolation - active and passive isolation - transmissibility - methods of isolation in machine foundations.	8	CO5
Reference Books:				
Swami Saran, “Soil Dynamics and Machine Foundation”, Galgotia publications Pvt. Ltd., New Delhi 1999.				
K.G. Bhatia, “Foundations for Industrial Machines: Handbook for Practising Engineers”, CRC Press, London, 2009.				
Sreenivasalu and Varadarajan, Handbook of Machine Foundations, Tata McGraw-Hill, 2007.				
e-Learning Source:				
https://nptel.ac.in/courses/105101005				

PO-PSO-CO	PO											PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	0	0	0	1	0	0	0	0	0	0	2	2
CO2	0	0	0	3	1	0	0	0	0	0	0	3	2
CO3	0	0	0	3	2	0	0	0	0	0	0	2	2
CO4	0	0	3	0	0	0	2	0	0	0	1	3	1
CO5	0	0	3	0	0	0	0	0	0	0	0	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation