Course Structure and Syllabi
ofthe
MTech programme
in
Geotechnical Engineering

1. Name of the Programme	:	**MTech in Geotechnical Engg**
2. Department	:	**Civil Engineering**
3. Nature	:	**Regular programme**
4. Duration	:	**Four semesters**
5. Admission & Scholarships	:	**As per the Institute norms**
6. Evaluation Scheme	:	**As per the Institute norms**
7. Version		**: As approved in the meeting of The BoS held on Sept 15, 2017**

DEPARTMENT OF CIVIL ENGINEERING
North Eastern Regional Institute of Science & Technology, Itanagar
Deemed-to-be-University
NIRJULI 791 109, Arunachal Pradesh
September 2017

Programme Structure

a) Break-up of Semester wise load :

Semester I	(courses)	: 22 credits
Semester II	(courses)	: 20 credits
Semester III	(Seminar/Dissertation)	: 8 credits
Semester IV	(Dissertation)	:16 credits
		66 credits

b) Structure :

SEMESTER I

Code	Title	Credits
1. MA7107	Advanced Mathematical Techniques	3-1-0 4
2. GTE 7120	Applied Geotechnical Engineering	3-1-0 4
3. GTE 7121	Design of Shallow Foundation 3-1-0	4
4. GTE 7122	Theory of Vibration	3-1-0 4
4. GTE 7123	Geotechnical Exploration, Sampling & Testing	0-0-32
5. GTE 70**	Elective I	3-1-0 4
		22

SEMESTER II

1. GTE 7220	Deep Foundations	3-1-0 4
2. GTE 7221	Numerical Methods in Geotechnical Engg	3-1-0 4
3. GTE 70**	Elective II	3-1-0 4
4. GTE 70**	Elective III	3-1-0 4
5. GTE 70**	Elective IV	3-1-04
		20

SEMESTER III

1. GTE 8110	Seminar on Selected Topics (Audit)	0-0-042
2. GTE 8099	Project/Dissertation	0-0-16 8
		8

SEMESTER IV

1. GTE 8099	Project/Dissertation	0-0-32 16
		16

LIST OF ELECTIVES

1. GTE 7001 Rock Mechanics
2. GTE 7002 Critical State Soil Mechanics
3. GTE 7003 Ground Improvement Techniques
4. GTE 7004 Earthquake Geotechnical Engineering
5. GTE 7005 Optimization Techniques in Geotechnical Engineering
6. GTE 7006 Geo-environmental Engineering
7. GTE 7007 Pavement Design

8. GTE 7008Ground Water Hydrology
9. GTE 7009Finite Element Analysis
10. GTE 7010Soil Dynamics
11. GTE 7011 Machine Foundations

Course Details

GTE 7120 Applied Geotechnical Engineering (3-1-0) 4Cr

Unit I	Earth pressure: Rankine, Coulomb and Graphical Methods.	10 lectures
Unit II	Retaining walls: Gravity, cantilever and counterfort retaining walls: Stability checks and design; Sheet Pile Structures: Cantilever sheet piling, Anchored sheet piling: Free and fixed earth support methods of analysis, anchorages for bulkheads; Braced excavations, heave at bottom of cohesion-less and cohesive soils; Arching in soils.	14 lectures
Unit III	Stability analysis of slope : Stability of infinite slopes; Stability of finite slopes; Effective and total stress approach; Shape of slip surface; Methods of slices- Swedish, Bishop, Morgenstern and Price methods; Location of critical slip circle	10 lectures
Unit IV	Earth and rock-fill dams: Types of Earth and Rockfill dams, Stability analysis of Earth and Rock-fill dams, Introduction to Reinforced earth structures.	8 lectures

References:

1. Saran, S,Analysis and Design of Substructures: Limit State Design, 2nd Ed, Oxford and IBH, New Delhi, 2015,
2. Murthy, V N S,Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering, CRC Press, Taylor and Francis, 2002.
3. Coduto, Donald P,Geotechnical Engineering: Principles and Practices, 2nd Ed, Pearson Education, New Delhi, 2017.
4. Budhu, Mun,iSoil Mechanics and Foundations, 2nd Ed, Wiley India, New Delhi, 2007.
5. RanjanGopal, and Rao, A S R,Basic and Applied Soil Mechanics, New Age International Pvt Ltd, 2006.

GTE 7121 Design of Shallow Foundations (3-1-0) 4Cr

Unit I	Bearing capacity of shallow foundations; Estimation of Bearing Capacity from Building Codes/Analytical Methods/Lab and Field Tests, Different analytical methods, Limit equilibrium analysis of bearing capacity, Effect of water table, Eccentric Loads, Footings on or near slopes.	12 lectures
Unit II	Settlement of shallow foundations, Elastic and consolidation settlements; Settlement estimates from penetration tests, Settlement tolerance. Allowable bearing pressure.	8 lectures
Unit III	Foundations on problematic soils. Remedial measures.	4 lectures
Unit IV	Principles of foundation design. Contact Pressure Distribution. Yield line analysis of footings subjected to uniform and non-uniform contact pressure distribution.	8 lectures
Unit V	Structural Design of spread, combined, strap, ring footings, and rafts.	10 lectures

References:

1. Saran, S,Analysis and Design of Substructures, Limit State Design, Oxford and IBH Publishing Co Private Limited, New Delhi, 1998.
2. Murthy, V N S,Advanced Foundation Engineering, CBS Publishers and Distributors, New Delhi, 2007.
3. Budhu, M,Soil Mechanics and Foundations, 2nd Edition, Wiley India Private Limited, New Delhi, 2007.
4. Bowles,J E,Foundation Analysis and Design, 5th Edition, McGraw Hill International Edition, Singapore, 1997.
5. McCarthy, D F,Essentials of Soil Mechanics and Foundations, 7th Edition, Pearson Prentice Hall, New Jersey, 2007.
6. Terzaghi, K,Peck, R B,and Mesri, G,Soil Mechanics in Engineering Practice, 3rd Edition, John Wiley and Sons, New York, 1996.
7. Varghese, P C,Foundation Engineering, Prentice Hall of India, New Delhi, 2005.
8. Brahma, S P,Foundation Engineering, Tata McGraw Hill Publishing Co Limited, New Delhi, 1991.
9. Recent Literature.

GTE 7122Theory of Vibrations (3-1-0) 4Cr

Unit I	Single degree of freedom systems - free vibration: introduction to dynamics of structures and their modelling, springs in series and parallel; Equation of motion and response, free vibration , damping, amplitude, natural frequency and logarithmic decrement.	6 lectures
Unit II	Single degree of freedom system - forced vibration under harmonic loading; Undamped and damped harmonic excitation; resonance; Half power method for damping; transmissibility, vibration isolation, seismic instruments; Introduction to Duhamel Integral, response to unit impulse, infinite duration step force, rectangular pulse force, linearly increasing force concept of response spectrum; Response to Seismic excitation.	12 lectures
Unit III	Multi degree of freedom system: Equation of motion, two degrees of freedom system, natural vibration, frequency and modes, orthogonally and normalisation of modes.	7 lectures
Unit IV	Solution of equation of motion: eigenvalue problem, estimating fundamental frequency by Rayleigh's method.	5 lectures
Unit V	Modal analysis: modal equation, modal expansion of displacement, modal displacement super position, response, element forces.	6 lectures
Unit VI	Continuous systems: undamped equation of motion, natural vibration frequencies and modes of uniform simply supported and cantilever beams.	6 lectures

References:

1. Paz, M,Structural Dynamics: Theory & Computations, CBS, New Delhi, 1985
2. Chopra, A K,Dynamics of Structures, Theory and Applications to Earthquake Engineering, Prentice Hall of India, New Delhi, 2000.

3. Claugh and Penzien, Dynamics of Structures, McGraw Hill International, New York, 1993.
4. Craig Jr, Structural Dynamics, John Wiley and Sons, New York, 1981.

GTE 7123 Geotechnical Exploration Sampling and Testing (0-0-3) 2Cr

Problems and phases of foundation investigations, Sample requirements, sampling methods and equipment, Handling, preservation and transportation of samples, Sample preparation, laboratory tests, analysis of results and interpretation, importance of in situ testing. Precautions and interpretation, Site evaluation and reporting.

GTE 7220 Deep Foundations (3-1-0) 4Cr

Unit I	Introduction of deep foundation, different types of deep foundation, requirement for deep foundation	8 lectures
Unit II	Pile foundation, classification of piles, estimation of load carrying capacity of single and pile group under various loading conditions Pile load testing (static, dynamic methods and data interpretation), negative skin friction, settlement of pile foundation, Laterally loaded piles, Code provision, Design of pile and pile cap.	14 lectures
Unit III	Well foundation, types, components, construction methods, design methods.	10 lectures
Unit IV	Structural design consideration, code provision, Design of piles and pile cap, Design methods for well foundation.	10 lectures

References:

1. Murthy,VNS,Advanced Foundations Engineering, CBS Publishers & Distributors Pvt. Ltd., 2011.
2. Saran, S,Analysis and Design of Substructures- Limit State Design, Oxford & IBH Publishing Co. Pvt. Ltd., 2013.
3. Krishna Raju, N,Design of Reinforced Concrete Structures, CBS Publishers & Distributors Pvt. Ltd., 2014.
4. Prakash S, and Sharma,H D,Pile Foundations in Engineering Practice, Wiley India Pvt. Ltd., 2013.

GTE 7222 Numerical Methods in Geotechnical Engineering (3-1-0) 4Cr

Unit I	Introduction to numerical modelling in Geotechnical Engineering, Review of basic concepts: – Stress at a point, Invariants of stress and strain, Equilibrium and Compatibility, Constitutive behaviour and its idealization, Methods of analysis.	6 lectures
Unit II	Constitutive modelling of soil- Elastic constitutive models: linear isotropic elasticity, linear anisotropic elasticity, nonlinear elasticity:K-G model, hyperbolic model; Elastic-plastic models: Essential ingredients of elastic-plastic models; Simple elastic-plastic constitutive models: Tresca model, Von Mises model, Mohr-Coulomb model, Drucker-Prager model; Development of Critical	8 lectures

	state models.	
Unit III	Introduction to FEM- historical development, advantages, general procedure of finite element analysis, displacement approach, concept of nodes, elements and boundary conditions; FE equation by direct approach for bar and truss elements.	12 lectures
Unit IV	Principle of stationary potential energy: Potential energy of an elastic body, Rayleigh-Ritz Method, Galerkin's method, Co-ordinate systems : global, local and natural co-ordinates, Shape functions for different types of elements.	6 lectures
Unit V	Finite element form of Rayleigh-Ritz method- Formulation of strain-displacement matrix and stiffness matrix; Isoparametric formulation: bar element, triangular elements (CST), consistent element nodal load vector; Numerical integration by Gauss quadrature.	10 lectures

References:

1. Atkinson JH and BrandsbyPL, Introduction to Critical State Soil Mechanics, McGraw Hill.
2. Wood, DM, Soil behaviour and Critical State Soil Mechanics, Cambridge University Press, New York
3. Potts D M and Zdravkovic L, Finite Element Analysis in Geotechnical Engineering. Thomas Telford.
4. Desai C S and Abel, JF, Introduction to the Finite Element Method: A Numerical Method for Engineering Analysis, 10thReprint, Van Nostrand Reinhold Co., New York, 1972.
5. Reddy J N, An Introduction to FEM, 3rd Ed, McGraw Hill series in Mechanical Engineering, 2006.

MA 7107 Advanced Mathematical Techniques (3-1-0) 4Cr

Unit I	Ordinary Differential Equations: Ordinary differential equation of first and second order, complementary function, particular integral, variation of parameter method.	8 lectures
Unit II	Partial Differential Equations: Basic concepts, modelling, vibration string, one dimensional wave equation, separation of variable method.	6 lectures
Unit III	Statistics: Elementary statistics, correlation, regression, random variables, probability distribution, binomial, Poisson and Normal distribution, estimation of parameters, confidence interval, hypothesis of testing, goodness of fit.	10 lectures
Unit IV	Optimization: Linear programing, graphical solution, un-constrained and constrained non-linear optimization, Lagrange multipliers.	8 lectures
Unit V	Numerical Analysis: Solution of algebraic equations by iteration method, finite differences, interpolation, numerical integration and differentiation, numerical method for ODE and PDE.	10 lectures

References:

1. Raishighania, M D,Ordinary and Partial Differential Equations, S. Chand Publications, ND, 2005.
2. Gupta,S C and Kapoor, VK,Fundamentals of Mathematical Statistics, Sultan Chand & Sons, ND, 2014**.**
3. Sastry, S S,Introductory Methods of Numerical Analysis, PHI, ND, 2005.
4. Sneddon, I N, Partial Differential Equation, Dover Edition, (First published by McGraw-Hill in 1957), 2006.
5. Coddington, E and Levinson, N, Theory of Ordinary Differential Equations,Indian Reprint, McGraw-Hill Education, 2017.

Electives

GTE7001Rock Mechanics (3-1-0) 4Cr

Unit I	Geological formation of rocks, Structural Geology, Classification of rocks, Physico-mechanical Properties of rocks.	10 lectures
Unit II	Laboratory and Field Tests, Stress-strain behaviour, Failure Criteria for intact rocks and rock masses, Fracture mechanism.	10 lectures
Unit III	Analysis and design of underground openings, Instrumentation in tunnels.	10 lectures
Unit IV	Rock Support and reinforcement, Foundations on rocks, Stability of rock slopes.	12 lectures

References:

1. Mukerjee, P K, A Text Book of Geology, World Press, 1995.
2. Brady, B H G, and Brown, E T, Rock Mechanics for Underground Mining, Chapman and Hall, London, 1993.
3. Goodman, R E, Introduction to Rock Mechanics, John Wiley and Sons, NY, 1989.
4. Bieniawski, Z T, Engineering Rock Mechanics Classification, John Wiley and Sons, NY, 1989.
5. Wyllie, D C, Foundations on Rock, 2nd Ed, E & FN Spon, London, 1992.

GTE7002Critical State Soil Mechanics (3-1-0) 4Cr

Unit I	Effective stresses, Volume change behaviour of soils, Stress-strain invariants, Isotropic/Anisotropic moduli, Modelling of drained and undrained behaviour, Role of elasticity in soil mechanics, Small strain elasticity theories.	8 lectures
Unit II	Plasticity theory, Yielding of metals, Combined loading and yield loci, Yield in sands and clays, Volume change and plastic hardening, Friction block model, Plastic potential, Normality and stability,	8 lectures
Unit III	Introduction to elasto-plastic modelling of soil, Critical state concept, Behaviour of normally/over-consolidated clays, and loose/dense sands, Critical state and constant volume, Stress-dilatancy.	8 lectures
Unit IV	Mohr Coulomb failure, Critical state line and drained/un-drained	8 lectures

	strength, Peak and residual strengths, Stress Path and Laboratory tests.	
Unit V	Introduction to Cam Clay model, Development of Cam Clay model from tri-axial test data, Application of model and critical state soil mechanics.	10 lectures

References:

1. Atkinson JH and Brandsby PL, Introduction to Critical State Soil Mechanics, McGraw Hill.
2. Wood, DM, Soil behaviour and Critical State Soil Mechanics, Cambridge University Press, New York
3. Schofield, A and Wroth, P, Critical State Soil Mechanics, Cambridge University, *www-civ.eng.cam.ac.uk/geotech_new/publications/schofield_wroth_1968.pdf*
4. Mitchell, R J, Fundamentals of Soil Behaviour, 3rd Ed, Wiley, NY, 2005.
5. Bolton, M, A Guide to Soil Mechanics, McMillan Education, NY, 1987.

GTE7003Ground Improvement Techniques (3-1-0) 4Cr

Unit I	Introduction, necessity and methods of Ground Improvement, Analysis and design of Dewatering Systems, Methods of Grouting, properties, Grouting types, Methods of Rock Reinforcement.	8 lectures
Unit II	Introduction and methods of Compaction, Factors affecting Compaction, engineering properties of Compacted Soil, Field Compaction and its control.	8 lectures
Unit III	Introduction of Soil stabilisation, Soil stabilisation using admixtures, Cement stabilisation, Lime stabilisation, Bituminous stabilisation and other chemical stabilisers, Geotechnical application.	8 lectures
Unit IV	Problematic soils- Problems, remedies and construction in problematic soils, Application of Micro pile and Sand compaction pile, Introduction of Stone column, Principle, design and method of installation of Stone column.	12 lectures
Unit V	Concept of Reinforced earth, Materials, Application and design of Reinforced earth, Principles and applications of Geotextiles in construction work	6 lectures

References:

1. Purushothama Raj,P,Ground Improvement Technique, Laxmi Publications (P) Ltd,2014.
2. Arora, K R,Soil Mechanics and Foundation Engineering, Standard Publishers Distributors, 2011.
3. Ranjan,Gopal and Rao, A S R,Basic and Applied Soil Mechanics, New Age International (P) Ltd., 2006.
4. Saran, S,Reinforced Soil and its Engineering Applications, I. K. International Publishing House Pvt. Ltd., 2013.
5. SivakumarBabu, G L,An Introduction to Soil Reinforcement &Geosynthetics, University Press, Hyderabad, 2006.

GTE7004Earthquake Geotechnical Engineering (3-1-0) 4Cr

Unit I	Introduction to Geotechnical Earthquake Engineering and Seismic Hazards, Earthquakes: Causes; Introduction to Plate Tectonics, Earthquake Magnitudes, Intensity, Types of Earthquake Waves	6 lectures
Unit II	Ground Motion: Definition and Strong motion measurement; Ground Motion Parameters	6 lectures
Unit III	Wave Propagation in Elastic rods, Elastic media and Halfspace; P, S and R waves- Characteristics and engineering significance	6 lectures
Unit IV	Dynamic Soil Properties and measurement, Dynamic Bearing Capacity	8 lectures
Unit V	Seismic Site Response Analysis; Introduction to computer codes	8 lectures
Unit VI	Introduction to Seismic Earth Pressure, and Seismic Soil- Structure Interaction	8 lectures

References:

1. Kramer, S L,Geotechnical Earthquake Engineering, 2/e, Pearson Education Inc, New Delhi, 1996.
2. Towohata, I, Geotechnical Earthquake Engineering, Springer Verlag, 2008, (e-book link: http://link.springer.com/book/10.1007%2F978-3-540-35783-4)
3. Saran,S, Analysis and Design of Foundations and Retaining Structures Subjected to Seismic Loads, I.K. International, New Delhi, 2012.

GTE7005Optimization Techniques in Geotechnical Engineering (3-1-0) 4Cr

Unit I	Introduction to Optimization, Linear and Non-Linear Programming Problems, Formulation, Graphical solutions of LP Problems.	6 lectures
Unit II	Solution of LP problems by SIMPLEX, Slack, Surplus and Artificial Variables, Two Phase SIMPLEX, Artificial Cost Function and Big M Method.	8 lectures
Unit III	Integer Programming Problems, Branch and Bound Method, Duality of LP problems.	6 lectures
Unit IV	Non-Linear Programming, Unconstrained optimization of single- and multi-variables functions, Conditions for optimality, Gradient Vector, Hessian Matrix, Quadratic form of a function, Tests on matrix of the quadratic form.	8 lectures
Unit V	Non-Linear Constrained optimization, Lagrange's Function, K-K-T conditions of optimality.	6 lectures
Unit VI	Numerical Methods of optimization, Direct Search Methods, Gradient Based Methods, Nature Inspired Methods, Example from field of Geotechnical Engineering.	8 lectures

References:

1. Arora, J S,Introduction to Optimum Design, McGraw hill Inc, New York
2. Mittal,K V and Mohan, C,Optimization Methods, New Age International Publishers, New Delhi
3. Ramamurthy, P,Operation Research, New Age International Publishers, New Delhi
4. IyengarN G R,and Gupta, Structural Design Optimization, EWP, New Delhi
5. Belegundu and Chandrapatla, Optimization Concept and Applications, Pearson Education, New Delhi
6. Recent Literature

GTE7006Geo-environmental Engineering (3-1-0) 4Cr

Unit I	Introduction, Sources & Impact of Contamination and Soil-Waste Interaction, Concepts of Integrated SWM & Geo-environmental Engineering.	6 lectures
Unit II	Soil composition and mineralogy; types and characteristics of contaminants; theory of water seepage in soil and hydraulic conductivity; theory of reactive contaminant transport in soil including molecular diffusion, mechanical dispersion and advective flow.	8 lectures
Unit III	Principles and Planning of Landfills, Liners for Landfills, Landfill Covers, Generation and Control of Leachate and Gas from Landfills,Use of Geosynthetics and geomembranes.	10 lectures
Unit IV	Stability of Slopes and Settlement of Landfills, Costs, Construction Aspects and Site Selection of Landfills	8 lectures
Unit V	Slurry Deposited Waste and their Geotechnical Properties, Planning & Design, Incremental Raisings and Failures of Slurry Ponds, Environmental Control Measures at Slurry Ponds, Geotechnical Reuse of Waste, and Remediationof contaminated sites.	10 lectures

References:

1. Daniel, DE, Geotechnical practice for waste disposal, Chapman and Hall, 1993.
2. Datta, M, Waste disposal in Engineered landfills, Narosa Publishers, 1998.
3. Qian, X, Koerner, R, and Gray, DH,Geotechnical aspects of landfill design and construction, Prentice Hall, 2002.
4. Vick, SG, Planning, analysis and design of tailings dams, John Wiley & Sons, 1990.
5. Gulhati, SK and Datta M, Geotechnical Engineering, McGraw Hill,2005.
6. Sharma, HD, and Reddy, KR, Geoenvironmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies, John Wiley & Sons, Inc. Hoboken, New Jersey, 2004 (ISBN:0-471-21599-6).

GTE7007Pavement Design (3-1-0) 4Cr

Unit I	Pavement structures, flexible, rigid and semi-rigid pavements, components, evaluation of properties of pavement and sub-grade materials.	8 lectures
Unit II	Stress in flexible pavement, homogenous and layered system, effect of total load and tyre pressure, equivalent wheel and axle loads.	8 lectures

Unit III	Design of flexible pavements, different methods, IRC specifications.	12 lectures
Unit IV	Stress in rigid pavement, relative stiffness of slabs, stresses due to bending, warping, expansion and contraction, combined stresses, IRC recommendation and design method of reinforced slabs.	8 lectures
Unit V	Joints, loads transfer at transverse joints by dowel bars, maintenance of joints, pavement distress, maintenance and strengthening of pavements.	6 lectures

References:

1. Yoder,ET, and Hitczak, MW, Principles of Pavement Design, John Wiley and Sons Inc, NY, 1975.
2. Khanna, S K,Justo,C E G,and Veeraraghavan,A,Highway Engineering, Nem Chand & Brothers, Roorkee, India, 2015.
3. Huang, Yang H. Pavement Analysis and Design, 2nd Edition, Prentice Hall, 2003.
4. Srinivasa Kumar, R,Pavement Design, Universities Press, Hyderabad India, 2013.
5. Singh,Alam,and Chowdhuri, G R,Soil Engineering in Theory and Practice Vol 1: Fundamentals and General Principles, CBS, ND, 1994.
6. IRC: 37-2012, Guidelines for the design of Flexible Pavement (Third revision). Indian Roads Congress.
7. IRC: 58-2015, Guidelines for the design of plain jointed rigid pavements for highways (fourth revision). Indian Roads Congress.

GTE7008Ground Water Hydrology (3-1-0) 4Cr

Unit I	Occurrence of ground water, ground water movement, saturated and unsaturated flow. ground water geophysics: electrical resistivity and seismic refraction method.	10 lectures
Unit II	Groundwater flow: differential equations governing groundwater flow, radial flow to wells.	8 lectures
Unit III	Evaluation of aquifer properties: Theis method, Jacob method, Chow's method.	8 lectures
Unit IV	Groundwater modeling techniques, Analog models, Mathematical models.	8 lectures
Unit V	Groundwater recharge, discharge and balance; management of groundwater: concept of basin management, conjunctive use.	8 lectures

References:

1. Todd, D K, Groundwater Hydrology, John Wiley & Sons, Singapore, 1995.
2. Freeze, R A and J A Cherry,Groundwater, Prentice Hall. Inc., NJ, 1979.
3. Raghunath, H M, Groundwater, New Age International, New Delhi,1982.
4. Karanath,Groundwater Assessment Development & Management, Tata McGraw Hill, New Delhi, 1987.
5. Bear, J, Hydraulics of Groundwater, McGraw Hill, New York, 1979.

GTE7009Finite Element Analysis (3-1-0) 4Cr

Unit I	Approximate Solution of Boundary Value Problems: Approximate solution using Rayleigh_Ritz Method and Galerkin method, Boundary conditions and general comments	5 lectures
Unit II	Basic Finite Element Concepts:Basic ideas in a finite element solution, General finite element solution procedure, Concept of nodes, elements and degree of freedom. Coordinate and shape functions. Treatment of Boundary conditions. Finite element equations using Rayleigh-Ritz method. Application to axial deformation of bars and axial spring element, Treatment of multi-freedom constraints.	10 lectures
Unit III	Analysis of Trusses: Coordinate transformation, Derivation of element stiffness matrix, calculation of internal stresses, stresses due to temperature changes.	5 lectures
Unit IV	Isoparametric Elements: Isoparametric triangular elements-Natural (or Area) coordinates for triangles, Shape functions for triangular elements, Natural coordinate mapping for triangles, Six node triangular element for general 2D BVP Isoparametric quadrilateral elements-Shape functions for rectangular elements, Isoparametric mapping for quadrilateral elements, Numerical integration for quadrilateral elements, Four node quadrilateral element for 2D BVP, Eight node serendipity element for 2D BVP.	6 lectures
Unit V	Two Dimensional Elasticity: Governing differential equations, Constant strain triangular element, Four node quadrilateral element, Eight node isoparametric element. Application of CST for analysis of plane stress problems.	8 lectures
Unit VI	Axisymmetric Elasticity Problems: Governing equations for axisymmetric elasticity, Axisymmetric linear triangular element, Axisymmetric four node isoparametric element.	8 lectures

References:

1. Reddy, J N,An Introduction to the Finite Element Method, 3rd Edition, McGraw-Hill Science/Engineering/Math, 2005.
2. Chandrupatla T R, and Belegundu, A D, Introduction to Finite Elements in Engineering, Prentice Hall, 2003.
3. Bathe, K-J, Finite Element Procedures, Prentice Hall, 1996.
4. Zienkiewicz, O C, Taylor, R L, Zhu, J Z, The Finite Element Method: Its Basis and Fundamentals, Elsevier, 2005.
5. Cook, R D, Malkus, D S, Plesha, M E, and Witt, RJ, Concepts and Applications of Finite Element Analysis, 4th Edition, Wiley-India, 2007.
6. Hughes, T J R, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications, 2000.
7. Potts D M and Zdravkovic L Finite Element Analysis in Geotechnical Engineering. Thomas Telford.
8. Desai CS, and Abel, JF, Introduction to the Finite Element Method: A Numerical Method for Engineering Analysis, Tenth Reprint.Van Nostrand Reinhold Co., New York, 1972.

GTE 7010 Soil Dynamics (3-1-0) 4Cr

Unit I	Wave Propagation: Longitudinal and torsional waves in infinitely long rod; Solution for one-dimensional and three-dimensional equations of motion; Waves in semi-infinite media; Earthquake waves – P-wave, S-wave, Rayleigh wave and Love wave; Locating earthquake's epicenter. Attenuation of stress waves – material and radiation damping; Waves in layered medium, Dispersion	10 lectures
Unit II	Stresses in soil element; Determination of dynamic soil properties; Field tests; Laboratory tests; Model tests; Stress-strain behavior of cyclically loaded soils; Estimation of shear modulus; Effect of strain level on the dynamic soil properties; Modulus reduction curve; Damping ratio; Linear, equivalent-linear and non-linear models; Ranges and applications of dynamic soil tests; Cyclic plate load test; Block Vibration Test; Measurement of seismic response of soil at low and high strain, using laboratory tests; SASW/MASW tests, cross bore hole test	14 lectures
Unit III	Liquefaction analysis: Introduction, pore pressure, liquefaction related phenomena-flow liquefaction and cyclic mobility, factors affecting liquefaction, liquefaction of cohesion-less soils and sensitive clays, liquefaction susceptibility, State criteria-CVR line, SSL, FLS, Evaluation of liquefaction potential, Characterization of earth quake loading and liquefaction resistance, cyclic stress ratio, effects of liquefaction; Cyclic triaxial and direct shear test, Vibration Table studies, Basic concept of soil improvement due to dynamic loading; Various methods; Mitigation of liquefaction.	10 lectures
Unit IV	Dynamic earth pressures; Force and displacement based analysis; Pseudo-static and Pseudo-dynamic analysis; Earth Pressure: Active and passive earth pressures; Terzaghi's passive wedge theory, numerical methods, earth pressure measurements.; Seismic design of retaining walls: types, modes of failures, static pressure, seismic response, seismic displacement, design considerations.Guidelines of various design codes.	8 lectures

References:

1. Prakash, S, Soil Dynamics, McGraw-Hill Book Company.
2. Das, B M,Principles of Soil Dynamics, PWS-KENT Publishing Company.
3. Kramer, S L,Geotechnical Earthquake Engineering, Prentice Hall Inc.
4. Barkan, D D,Dynamics of Bases and Foundations, McGraw-Hill Book Company.
5. Richart,E E,et al., Vibrations of Soils and Foundations, Prentice Hall Inc.

GTE 7011 Machine Foundations (3-1-0) 4Cr

Unit I	Overview of Soil Dynamics, Introduction to Machine Foundations, Types, Design Criteria, Methods of Analysis	4 lectures
Unit II	Method of Dynamic Subgrade Modulus (Barkan's Method); Definition of Soil Stiffness and Dynamic Elastic Constants; Block Vibration Test; Relevant IS codalrecommendations for Reciprocating, Impact and Turbo Generator Foundations	10 lectures
Unit III	Elastic Halfspace Theory; Analogs in various modes of vibration	6 lectures

Unit IV	Impedance Functions: Definition, characteristics; Computational Methods; Rigorous and Simplified models	4 lectures
Unit V	Introduction to Cone Model; Translational and Rocking cones; their static and dynamic stiffnesses; Effect of Contact Pressure distribution;	8 lectures
Unit VI	Design examples	10 lectures

References:

1. Baishya, S, Dynamic Response of Embedded Block Foundations in Layered Media, PhD Thesis, IIT Roorkee, (Chapter 2),2002.
2. Barkan, DD, Dynamics of Bases and Foundations, McGraw Hills, 1962.
3. Richart, Hall and Woods, Vibrations of Soil and Foundations, Prentice Hall, NY, 1970.
4. Saran, S, Soil Dynamics and Machine Foundations, Galgotia Publications, New Delhi,1999.
5. Wolf, J P, Foundation Vibration Analysis using Simple Physical Models, Prentice HallInc, NY,1994.
6. Wolf, JPand Deeks, A, Foundation Vibration Analysis: A Strength-of-Materials Approach, Elsevier.2004.

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Unit I		10 lectures
Unit II		10 lectures
Unit III		10 lectures
Unit IV		10 lectures
Unit V		10 lectures
Unit VI		10 lectures