DEPARTMENT OF CIVIL ENGINEERING

COURSE STRUCTURE

(1^{ST} – 4^{TH} SEMESTER)

FOR

M. TECH PROGRAMME

SPECIALISATION

IN

GEOTECHNICAL ENGINEERING

(EFFECTIVE FROM July 2019)

VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY

(FORMLY, UNIVERSITYCOLLEGE OF ENGINEERING)

BURLA – 768 018, SAMBALPUR, ODISHA

Vision

To emerge as an internationally acclaimed Civil Engineering Department for imparting futuristic technical education and creation of vibrant research enterprise to create quality civil engineers and researchers, truly world class leaders and unleash technological innovations to serve the global society and improve the quality of life.

Mission

The Department of Civil Engineering, VSSUT Burla strives to create values and ethics in its products by inculcating depth and intensity in its education standards and need based research through

- Participative learning in a cross-cultural environment that promotes the learning beyond the class room.
- Collaborative partnership with industries and academia within and outside the country in learning and research.
- Encouraging innovative research and consultancy through the active participation and involvement of all faculty members.
- Facilitating technology transfer, innovation and economic development to flow as natural results of research whereever appropriate.
- Expanding curricula to cater broader perspectives.
- Creation of service opportunities for upliftment of the society at large.

PO

- An ability to independently carry out research /investigation and development work to solve practical problems
- An ability to write and present a substantial technical report/document
- 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
- Ability to apply knowledge of mathematics, science and engineering to solve complex problems in civil engineering
- Ability to identify, formulate, and solve complex civil engineering problems using first principle of mathematics, basic science & engineering
- Ability to design and conduct complex civil engineering experiments as well as to analyze and interpret the experimental data

PEO

- To lead a successful career in industries, pursue higher studies and entrepreneurial endeavors.

- To offer techno-commercially feasible and socially acceptable solutions to real life engineering problems.

- To demonstrate effective communication skill, professional attitude and a desire to learn.

PSO

- Plan, analyse, design, prepare and execute all kinds ofStructural Engineering projects
- Apply latest construction techniques for successful completion of time bound Structural Engineering projects with optimised cost

VSS UNIVERSITY OF TECHNOLOGY BURLA ODISHA

Model Course Structure for
PG Programmes (GEOTECHNICAL ENGINEERING /CE)
To be introduced from July 2019

Semester I						
Sr. No.	**Course Type/Code**	**Course Name**	**Teaching Scheme**	**Credits**		
		Lab				
1.	MCEGT101	Advanced Soil Mechanics	3	--	--	3
2.	MCEGT102	Advanced Foundation Engineering	3	--	--	3
3.		Program Elective-I	3	--	--	3
4.		Program Elective-II	3	--	--	3
5.	MCEGT103	Geotechnical Lab-I	--	--	--	2
6.	MCEGT104	Computational Lab	--	--	-	2
7.		Research Methodology and IPR	2	--	--	3
8.		Audit course	0	0		
Total		--	14	**19**		

Semester II						
Sr. No.	**Course Type/Code**	**Course Name**	**Teaching Scheme**	**Credits**		
1.	MCEGT201	Dynamics of soils and foundations	3	--	--	3
2.	MCEGT202	Earth Retaining Structures	3	--	--	3
3.		Program Elective-III	3	--	--	3
4.		Program Elective-IV	3	--	--	3
5.	MCEGT203	Advanced Geotechnical Engg. Lab	--	--	4	2
6.	MCEGT204	Geotechnical Engineering Design	--	--	4	2
7.		Mini Project	--	--	4	2
8.		Audit course	0	0		
Total		--	**12**	**18**		

Semester III				
Sr. No.	**Course Type/Code**	**Course Name**	**Teaching Scheme**	**Credits**
1		Program Elective-IV	3	3
2		Open Electives	3	3
3		Dissertation Stage–I (to be continued next semester)		10
Total			**16**	

Semester IV				
Sr. No.	**Course Type/Code**	**Course Name**	**Teaching Scheme**	**Credits**
1		Dissertation final Stage (continued from III semester)		16
Total		**16**		

Total Credits for the programme = 19 + 18 +16 +16 = 69

Sl. No.	Course Code	Programme Elective I
1	MGTPE101	Soil Structure Interaction
2	MGTPE102	Pavement Analysis and Design
3	MGTPE103	Ground Water Flow Through Porus Media
4	MGTPE104	Numerical Methods in Engineering

Sl. No.	Course Code	Programme Elective II
1	MGTPE105	Environmental Geotechnology
2	MGTPE106	Critical Soil Mechanics
3	MGTPE107	Stability Analysis of Slopes
4	MGTPE108	Foundation on Weak Rocks

Sl. No.	Course Code	Programme Elective III
1	MGTPE201	Ground Improvement Technique
2	MGTPE202	Engineering/marine Geotechniques
3	MGTPE203	Computational Geomechanics
4	MGTPE204	Engineering rock mechanics

Sl. No.	Course Code	Programme Elective IV
1	MGTPE205	Geotechnical Earthquake Engineering
2	MGTPE206	Subsoil Exploration
3	MGTPE207	Design of Underground Excavations
4	MGTPE208	FEM in Geotechnical Engineering

Sl. No.	Course Code	Programme Elective V
1	MGTPE301	Environmental Impact Assessment
2	MGTPE302	Physical and Constitutive Modeling on Geomechanics

Sl. No.	Course Code	Open Elective I
1	MGTOE301	Business Analytics
2	MGTOE302	Industrial Safety
3	MGTOE303	Operations Research
4	MGTOE304	Cost Management of Engineering Project
5	MGTOE305	Composite Materials
6	MGTOE306	Waste to Energy

Audit course 1 & 2

Sl.No.	Course Code	Subject Name
1.	BCAC1001	English for Research Paper Writing
2.	BCAC1002	Disaster Management
3.	BCAC1003	Sanskrit for Technical Knowledge
4.	BCAC1004	Value Education
5.	BCAC2001	Constitution of India
6.	BCAC2002	Pedagogy Studies
7.	BCAC2003	Stress Management by Yoga
8.	BCAC2004	Personality Development through Life Enlightenment Skills.

Programme: M.Tech.	**Semester: 1st**
Core-I	
Subject Name: ADVANCED SOIL MECHANICS	**(3-0-0) CR-03**
Course Content	
Module-I	
Compressibility of soils: consolidation theory (one, two, and three dimensional consolidation theories), consolidation in layered soil and consolidation for time dependent loading, determination of coefficient of consolidation (Casagrande method and Taylors method)	
Module-II	
Strength behavior of soils; Mohr Circle of Stress; UU, CU, CD tests, drained and undrained behavior of sand and clay, significance of pore pressure parameters; determination of shear strength of soil; Interpretation of triaxial test results.	
Module-III	
Stress path; Drained and undrained stress path; Stress path with respect to different initial state of the soil; Stress path for different practical situations.	
Module-IV	
Elastic and plastic deformations: elastic wall; introduction to yielding and hardening; yield curve and yield surface, associated and non-associated flow rule, Failure theories and constitutive modelling.	
Module-V	
Critical state soil mechanics; Critical state parameters; Critical state for normally consolidated and over consolidated soil; Significance of Roscoe and Hvorslev state boundary surface; drained and un drained plane. Critical void ratio; effect of dilation in sands; different dilation-models.	
Reference Books:	
Atkinson, J.H. and Bransby, P.L, The Mechanics of Soils: An introduction to Critical soil mechanics, McGraw Hill, 1978. Atkinson J.H, An introduction to the Mechanics of soils and Foundation, McGraw- Hill Co., 1993. Das, B.M., Advanced Soil Mechanics, Taylor and Francis, 2nd Edition, 1997. Wood, D.M., Soil Behavior and Critical State Soil Mechanics, Cambridge University Press, 1990. Craig, R.F., Soil Mechanics, Van Nostrand Reinhold Co. Ltd., 1987. Terzaghi, K., and Peck, R.B., Soil Mechanics in Engineering Practice, John Wiley & Sons, 1967. Lambe, T.W. and Whitman, R.V., Soil Mechanics, John Wiley & Sons, 1979	
COURSE OUTCOME	
1. Use knowledge on compressibility parameters of soil mass.	
2. Select the shear strength to design different structures for different conditions of loading, drainage and failure criteria.	
3. Estimate the stress path in soil under drainage condition.	
4. Describe the mathematical models for solving different problems in soil mechanics.	
5. Illustrate the deformation behavior of soil mass.	

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	1		2
CO2	2	2		3		1
CO3	2	3		2		
CO4	3	3	1		2	3
CO5	1	2	2		3	1

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	3	2	2	3	2

Programme: M.Tech.	**Semester: 1st**
Core-II	
Subject Name: ADVANCED FOUNDATION ENGINEERING	**(3-0-0) CR-03**
Course Content	
Module-I	
Planning of soil exploration for different projects, methods of subsurface exploration, methods of borings along with various penetration tests.	
Module-II	
Shallow foundations, requirements for satisfactory performance of foundations, methods of estimating bearing capacity, settlements of footings and rafts, proportioning of foundations using field test data, IS codes.	
Module-III	
Pile foundations, methods of estimating load transfer of piles, settlements of pile foundations, pile group capacity and settlement, negative skin friction of piles, laterally loaded piles, pile load tests, analytical estimation of load- settlement behavior of piles, proportioning of pile foundations, lateral and uplift capacity of piles.	
Module-IV	
IS and IRC codal provisions, elastic theory and ultimate resistance methods	

Module-V
Foundations on problematic soils and Coffer dams: Foundations for collapsible and expansive soil, various types and analysis of coffer dams and design Foundations under uplifting loads.
Reference Books:
• Bowles. J.E., Foundation Analysis and Design, Tata McGraw-Hill International Edition, 5th Edn, 1997. • Das B.M., Shallow Foundations: Bearing capacity and settlement, CRC Press, 1999. • Tomlinson M.J., Pile design and construction Practice, Chapman and Hall Publication, 1994 • Poulos, H. G. and Davis, F. H., "Pile Foundation Analysis and Design", Wiley and Sons. 1980
COURSE OUTCOME
1. Decide the type of foundations to be recommended for construction of different engineering structures by conducting various boring and penetration tests.
2. Design different types of shallow foundations.
3. Evaluate pile resistance and deflection under lateral loads.
4. Explain in details of well foundations.
5. Assess foundations on problematic soils.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**1**	**1**	**1**
CO2	**3**	**3**	**3**	**1**	**1**	**1**
CO3	**3**	**3**	**3**	**1**	**1**	**1**
CO4	**3**	**3**	**3**	**1**	**1**	**1**
CO5	**3**	**3**	**3**	**1**	**1**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	3	3	1	1	1

Programme: M.Tech.	**Semester: 1st**
Core-III	
Subject Name: DYNAMICS OF SOILS AND FOUNDATIONS	**(3-0-0) CR-03**
Course Content	
Module-I	
Fundamentals of vibrations: single, two and multiple degree of freedom systems, vibration isolation, vibration absorbers, vibration measuring instruments.	
Module-II	
Wave propagation: elastic continuum medium, semi-infinite elastic continuum medium, soil behaviour under dynamic loading.	
Module-III	
Liquefaction of soils: liquefaction mechanism, factors affecting liquefaction, studies by dynamic tri-axial testing, oscillatory shear box, shake table and blast tests, assessment of liquefaction potential.	
Module-IV	
Dynamic elastic constants of soil: determination of dynamic elastic constants, various methods including block resonance tests, cyclic plate load tests, wave propagation tests, oscillatory shear box test.	
Module-V	
Theory of Vibration of Foundation: Vertical, sliding, torsional and rocking oscillation of footing resting on Elastic half space. Oscillation of rigid circular footing supported by an elastic layer. Introduction of bearing capacity of dynamically loaded shallow foundation.	
Reference Books:	
• Das, B.M., "Fundamentals of Soil Dynamics", Elsevier, 1983. • Steven Kramer, "Geotechnical Earthquake Engineering", Pearson, 2008. • Prakash, S., Soil Dynamics, McGraw Hill, 1981. • Kameswara Rao, N.S.V., Vibration analysis and foundation dynamics, Wheeler Publication Ltd., 1998. • Richart, F.E. Hall J.R and Woods R.D., Vibrations of Soils and Foundations, Prentice Hall Inc., 1970. • Prakash, S. and Puri, V.K., Foundation for machines: Analysis and Design, John Wiley & Sons, 1998	
COURSE OUTCOME	
Interpret theory of vibration and resonance phenomenon, dynamic amplification.	
Investigate propagation of body waves and surface waves through soil.	
Predict dynamic bearing capacity and assess liquefaction potential of any site.	
Explain different methods for estimation of dynamic soil properties required for design purpose.	
Apply theory of vibrations to design machine foundation based on dynamic soil properties and bearing capacity	

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	1	1	2
CO2		2		3		1
CO3	2			2		
CO4		3	1		2	3
CO5	1	2	2		3	1

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	1	2	1	1	1	1

Programme: M.Tech.	**Semester: 1st**
CORE- IV	
Subject Name: EARTH RETAINING STRUCTURES	**(3-0-0) CR-03**
Course Content	
Module-I	
Earth Pressure: Rankine and Coulomb theories, active, passive and pressure at rest; concentrated surcharge above the back fill, earth pressure due to uniform surcharge, earth pressure of stratified backfills, saturated and partially saturated backfill.	
Module-II	
Retaining walls and Sheet Pile wall: Proportioning of retaining walls, stability of retaining walls, mechanically stabilized retaining walls/reinforced earth retaining walls ;free earth system, fixed earth system of sheet pile wall.	
Module-III	
Bulkheads: bulkheads with free and fixed earth supports, equivalent beam method, Anchorage of bulkheads and resistance of anchor walls, spacing between bulkheads and anchor walls, resistance of anchor plates	
Module-IV	
Tunnel and Conduit: Stress distribution around tunnels, Types of conduits, Load on projecting conduits; Arching and Open Cuts: Arching in soils,	

Module-V
Work hardening plasticity theory: formulation and implementation; Applications of elasto-plastic models; Special Topics: hypo-elasticity-plasticity, disturbed state concept.
Reference Books:
Das, Braja M., "Principles of Foundation Engineering", PWS Publishing. 1998 • Bowles. J.E., Foundation Analysis and Design, Tata McGraw-Hill International Edition, 5th Edn, 1997.
COURSE OUTCOME
1. Explain earth pressures concept in soils.
2. Analyze and design of different types of retaining structures.
3. Design bulkheads.
4. Use stress distribution around tunnels.
5. Evaluate earth pressure against bracings.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**1**	**1**	**1**
CO2	**3**	**3**	**3**	**1**	**1**	**1**
CO3	**3**	**3**	**3**	**1**	**1**	**1**
CO4	**3**	**3**	**3**	**1**	**1**	**1**
CO5	**3**	**3**	**3**	**1**	**1**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	3	3	1	1	1

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-I	
Subject Name: GROUND WATER FLOW THROUGH POROUS MEDIA	**(4-0-0) CR-03**
Course Content	
Module-I	
Soil Water: Modes of occurrence of water in soils. Adsorbed water, capillary water, Capillary potential, Capillary tension and soil suction. Effective and Neutral pressures in soil ;	
Module-II	
Ground water Hydraulics:Ground water, Occurrence and movement of ground water,Origin and age of ground water, Water table in regular materials,Zones of aeration and saturation,Aquifers and their characteristics/classification, Geophysical exploration for locating water table.	
Module-III	
Flow through porous Media: Darcy's law and measurement of permeability in laboratory and field. Steady State flow solutions of LaPlace's equation, Plane problems, 3-dimensional problems,	
Module-IV	
Partial cut-offs, uplift pressure, consolidation theory –one and three dimensional consolidation Secondary consolidation	
Module-V	
Concepts and methods of artificial ground water recharge, Water withdrawal from streams, Method of ground water imageing. Pollution and quality analysis of Ground water: Sources of pollution.	
Text Book:	
D.K.Todd, *Groundwater Hydrology*, John wiley and Sons	
Reference Books:	
1. H.M. Raghunath, *Ground Water*, Willy Eastern Ltd. 2. C.Fitts, *Ground Water Science*, Elsevier Publications, U. S. A. 3. P. P. Raj, *Geotechnical Engineering*, Tata McGraw-Hill 4. A. Jumikis, *Soil Mechanics*, East West Press Pvt Ltd.	
Course Outcomes:	
▪ Explain the importance of Soil Water, Capillary tension and soil suction	

▪ Express the importance of Ground water Hydraulics
▪ Evaluate Flow through porous Media
▪ Assess the importance of consolidation
▪ Review the Concepts and methods of artificial ground water recharge

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**1**	**1**	**1**
CO2	**3**	**3**	**3**	**1**	**1**	**1**
CO3	**3**	**3**	**3**	**1**	**1**	**1**
CO4	**3**	**3**	**3**	**1**	**1**	**1**
CO5	**3**	**3**	**3**	**1**	**1**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	3	3	1	1	1

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-I	
Subject Name: SOIL STRUCTURE INTERACTIONS	**(3-0-0) CR-03**
Course Content	
Module-I	
Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behavior, Foundation behavior, Interface behavior, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behavior, Time dependent behaviour.	
Module-II	
Beam on Elastic Foundation- Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness	
Module-III	
Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.	
Module-IV	
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.	

Module-V
Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts. An introduction to soil foundation interaction under dynamic loads..
Reference Books:
• Selvadurai, A.P.S, Elastic Analysis of Soil-Foundation Interaction, Elsevier, 1979. • Poulos, H.G., and Davis, E.H., Pile Foundation Analysis and Design, John Wiley,1980. • Scott, R.F., Foundation Analysis, Prentice Hall, 1981. • Structure Soil Interaction - State of Art Report, Institution of Structural Engineers, 1978. • ACI 336. (1988), Suggested Analysis and Design Procedures for combined footings and Mats, American Concrete Institute
COURSE OUTCOME
• Review soil-foundation interaction problems.
• Analyze and Estimate beams of finite length.
• Explain Classification of finite beams in relation to their stiffness.
• Describe theoretical solutions for settlement and load distributions.
• Compute pile response for various loading condition for design purpose

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**1**	**1**	**1**
CO2	**3**	**3**	**3**	**1**	**1**	**1**
CO3	**3**	**3**	**3**	**1**	**1**	**1**
CO4	**3**	**3**	**3**	**1**	**1**	**1**
CO5	**3**	**3**	**3**	**1**	**1**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	3	3	1	1	1

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-I	
Subject Name: PAVEMENT ANALYSIS AND DESIGN	**(4-0-0) CR-03**
Course Content	
Module-I	
Factors Affecting Pavement Design: Design life, reliability, traffic, climate, road geometry, material properties, and drainage.	
Module-II	
Stresses In flexible Pavement: Vehicle-Pavement Interaction: Transient, Random & Damping	

Vibrations, Steady State of Vibration, Experiments on Vibration, Stress Inducing Factors in Flexible and Rigid pavements; Stress In Flexible Pavements: Visco-Elastic Theory and Assumptions, Layered Systems Concepts, Stress Solutions for One, Two and Three Layered Systems, Fundamental Design Concepts.
Module-III
Stresses in Rigid Pavements: Westergaard's Theory and Assumptions, Stresses due to Curling, Stresses and Deflections due to Loading, Frictional Stresses, and Stresses in Dowel Bars & Tie Bars.
Module-IV
Design of Flexible Pavements: Factors effecting Design. Deflection studies in Flexible Pavements. Present Serviceability Index. IRC guidelines for Flexible Pavements. Pavement Performance and methods- AASHTO and Asphalt Institute Method. Need for Overlays, Overlays design methods for Flexible and Rigid pavements.
Module-V
Design of Rigid Pavements: Factors affecting Design - Wheel load & its repetition, sub grade strength & proportion, strength of concrete- modulus of elasticity. Reinforcement in slab. Design of joints. Design of Dowel bars. Design of Tie bars. IRC and AASHTO methods of Rigid Pavement design.
Text book:
1. Pavement Analysis & Design, Yang H. Huang, Prentice Hall Inc. **Reference books:** 1. Design of Functional Pavements, Nai C. Yang, McGraw Hill Publications 2. Concrete Pavements, AF Stock, Elsevier, Applied Science Publishers 3. Principles of Pavement Design, Yoder.J. & Witzorac Mathew, W. John Wiley & Sons Inc 4. Pavement and Surfacing for Highway & Airports, Micheal Sargious, Applied Science Publishers Limited. 5. IRC: 37 & 58 Codes for Flexible and Rigid Pavements Design.
COURSE OUTCOME
• Review concepts of pavement stresses and performance.
• Demonstrate and apply knowledge of the principles and practices of sustainable pavement design.
• Solve complex theoretical and technical problems to design a pavement that meets given criteria and standards
• Perform advanced analyses connected to material modelling and pavement design.
• Evaluate structural condition of pavement

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**1**	**1**	**1**
CO2	**3**	**3**	**3**	**1**	**1**	**1**
CO3	**3**	**3**	**3**	**1**	**1**	**1**
CO4	**3**	**3**	**3**	**1**	**1**	**1**
CO5	**3**	**3**	**3**	**1**	**1**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	3	3	1	1	1

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-2	
Subject Name: ENVIRONMENTAL GEOTECHNOLOGY	**(3-0-0) CR-03**
Course Content	
Module-I	
Soil-environment interaction; Properties of water in relation to the porous media; Water cycle with special reference to soil medium.	
Module-II	
Soil mineralogy; significance of mineralogy in determining soil behavior; Mineralogical characterization.	
Module-III	
Mechanisms of soil-water interaction: Diffuse double layer models; Force of attraction and repulsion; Soil-water-contaminant interaction; Theories of ion exchange; Influence of organic and inorganic chemical interaction.	
Module-IV	
Concepts of waste containment; Sources, production and classification of wastes, Environmental laws and regulations, physico-chemical properties of soil, ground water flow and contaminant transport, desirable properties of soil; contaminant transport and retention; contaminated site remediation.	
Module-V	
Soil characterization techniques; volumetric water content; gas permeation in soil; electrical and thermal properties; pore-size distribution; contaminant analysis. contaminated site characterization, estimation of landfill quantities, landfill site location, design of various landfill components such as liners, covers, leachate collection and removal, gas generation and management, ground water monitoring, end users of landfill sites, slurry walls and barrier systems, design and construction, stability, compatibility and performance, remediation technologies, stabilization of contaminated soils and risk assessment approaches	
Reference Books:	
Mitchell, J.K and Soga, K., Fundamentals of Soil Behavior, John Wiley and Sons Inc., 2005. • Fang, H-Y., Introduction to Environmental Geotechnology, CRC Press,1997. • Daniel, D.E, Geotechnical Practice for Waste Disposal, Chapman and Hall, 1993. • Rowe, R.K., Quigley, R.M. and Booker, J.R., Clay Barrier Systems for Waste Disposal Facilities, E & FN Spon, 1995. • Rowe, R.K, Geotechnical and Geoenvironmental Engineering Handbook, Kluwer Academic Publishers, 2001. • Reddi, L.N. and Inyang, H.F, Geoenvironmental Engineering - Principles and Applications, Marcel Dekker Inc, 2000. • Sharma, H.D. and Lewis, S.P, Waste Containment Systems, Waste Stabilization and Landfills: Design and Evaluation, John Wiley & Sons Inc., 1994.	
COURSE OUTCOME	
1. Review soil-environment interaction.	
2. Explain soil mineralogy.	
3. Evaluate mechanisms of soil-water interaction.	

4. Describe lean ground water flow and predict contaminant transport phenomenon.
5. Apply remediation techniques for contaminated site.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**1**	**1**	**1**
CO2	**3**	**3**	**3**	**1**	**1**	**1**
CO3	**3**	**3**	**3**	**1**	**1**	**1**
CO4	**3**	**3**	**3**	**1**	**1**	**1**
CO5	**3**	**3**	**3**	**1**	**1**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	3	3	1	1	1

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-2	
Subject Name: CRITICAL SOIL MECHANICS	**(3-0-0) CR-03**

Course Content

Module-I

Soil Behavior: State of stress and strain in soils, Stress and strain paths and invariants, behavior of soils under different laboratory experiments

Module-II

The Critical state line and the Roscoe surface: Families of undrained tests, Families of drained tests, the critical state line, drained and undrained surfaces, The Roscoe surface

Module-III

Behavior of Over consolidated samples: The Hvorslev surface: Behaviour of overconsolidated samples, drained and undrained tests, The Hvorslev surface, complete State Boundary Surface, Volume changes and pore water pressure changes

Module-IV

Behaviour of Sands: The critical state line for sands, Normalized plots, the effect of dilation, Consequences of Taylor's model

Module-V

Behaviour of Soils before Failure: Elastic and plastic deformations, Plasticity theory, Development of elastic-plastic model based on critical state soil mechanics, The Cam-clay model, The modified Cam-clay model

Reference Books:

- J. H. Atkinson and P. L. Bransby, "The mechanics of soils: An introduction to critical state soil mechanics", McGraw Hill, 1978

• D. M. Wood, "Soil behaviour and critical state soil mechanics", Cambridge University Press, 1990 • B. M. Das, "Fundamental of geotechnical engineering", Cengage Learning, 2013
COURSE OUTCOME
1. Explain in detail of soil behaviour.
2. Decide the type of mathematical models to be used for analyzing the behavior of soil mass at critical state.
3. Describe the details of behavior of overconsolidated samples.
4. Review behaviour sand.
5. Evaluate various models used to study the behaviour of soil.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**1**	**1**	**1**
CO2	**3**	**3**	**3**	**1**	**1**	**1**
CO3	**3**	**3**	**3**	**1**	**1**	**1**
CO4	**3**	**3**	**3**	**1**	**1**	**1**
CO5	**3**	**3**	**3**	**1**	**1**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	3	3	1	1	1

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-2	
Subject Name: FOUNDATIONS ON WEAK ROCKS	**(3-0-0) CR-03**
Course Content	
Module-I	
Engineering properties of weak rocks, different rock mass classification systems, relative merits and demerits.	
Module-II	
Failure criteria for weak rocks, bi-linear Mohr-Coulomb failure criterion, Hoek and Brown criterion and modified Hoek and Brown failure criterion etc. Effect of structural planes on rock foundations, possible modes of failure of foundations on rocks/ rock masses, determination of in-situ shear strength of rocks and rock masses.	

Module-III
Requirements for satisfactory performance of foundations, bearing capacity of foundations on rocks and rock masses, allowable bearing pressure of rock foundations using a nonlinear failure criterion, monotonic and cyclic plate load tests.
Module-IV
Pressure-settlement characteristics, effect of layering, anisotropy, heterogeneity and in elasticity, Shallow foundations, shallow foundations on sloping ground, raft foundations, stilt foundations, foundations for suspension bridges, transmission line towers, framed buildings etc, treatment of foundations - open joints, solution cavities, weak seams.
Module-V
Piles in weak rocks, bearing capacity and settlement of piles, piles in stratified rock masses, field load tests on piles in weak rocks, behaviour of bored / driven piles in soft / weathered rocks.
Reference Books:
Wyllie Duncan C.," Foundations on Rock: Engineering Practice", E&FN Spon, Taylor and Francis. Hudson J.A. and J.P. Harrison. Engineering Rock Mechanics: an Introduction to the Principles, 1997. Elsevier, Oxford Singh, B. and Goel, R.K.,"Rock Mass Classification- A Practical Engineering Approach", Elsevier . Ramamurthy, T., "Engineering in Rocks", PHI Learning Pvt. Ltd. Hoek, E., "Practical Rock Engineering", Rock science.
COURSE OUTCOME
1. Classify different types of rock mass.
2. Design different types of foundations placed over rock mass.
3. Evaluate bearing capacity and allowable bearing pressure of foundations on rock mass.
4. Explain shallow foundations on sloping ground.
5. Use pile foundations placed over weak rock mass

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**1**	**1**	**1**
CO2	**3**	**3**	**3**	**1**	**1**	**1**
CO3	**3**	**3**	**3**	**1**	**1**	**1**
CO4	**3**	**3**	**3**	**1**	**1**	**1**
CO5	**3**	**3**	**3**	**1**	**1**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	3	3	1	1	1

Professional Elective Course-2	
Subject Name: STABILITY ANALYSIS OF SLOPES	**(3-0-0) CR-03**
Course Content	
Module-I	
Types and causes of slope failures, mechanics of slope failure, failure modes.	
Module-II	
Infinite and finite slopes with or without water pressures; concept of factor of safety, pore pressure coefficients, Mass analysis.	
Module-III	
Wedge methods, friction circle method ;Method of slices, Bishop's method, Janbu's method, Morgenstern and Price, Spencer's method.	
Module-IV	
Stability analysis in the presence of seepage: two dimensional flow – Laplace equation and it's solution, graphical method, determination of phreatic line, flow nets in homogeneous and zoned earth dams under steady seepage and draw-down conditions, seepage control in earth dams, influence of seepage on slope stability stability analysis of dam body during steady seepage.	
Module-V	
Strengthening measures: stabilization of slopes by drainage methods, surface and subsurface drainage, use of synthetic filters, retaining walls, stabilization and strengthening of slopes, shotcreting, rock bolting and rock anchoring, instrumentation and monitoring of slopes, slope movements, warning devices, maintenance of slopes.	
Reference Books:	
Chowdhary R and ChowdharyI , "Geotechnical Slope Analysis", CRC Press. Harr M.E.," Ground Water and Seepage", McGraw Hill. 1962	

COURSE OUTCOME
1. Explain the potential of failure modes of slopes.
2. Describe stability analysis of slopes.
3. Review various methods used in the stability analysis of slopes.
4. Use the stability of earthen dams, and the safety measures to be undertaken to prevent the instability of slopes, earthen dams and embankments.
5. Design to strengthen the geotechnical structures by various ground modification techniques.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**2**	**1**	**1**
CO2	**3**	**3**	**3**	**2**	**1**	**1**
CO3	**3**	**3**	**3**	**2**	**1**	**1**
CO4	**3**	**3**	**3**	**2**	**2**	**1**
CO5	**3**	**3**	**3**	**2**	**2**	**1**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	3	3	2	1	1

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-3	
Subject Name: GROUND IMPROVEMENT TECHNIQUE	**(3-0-0) CR-03**
Course Content	
Module-I	
Introduction: Situations where ground improvement becomes necessary	
Module-II	
Compaction: methods of compaction, Field compaction and control.	
Module-III	

Dynamic compaction, impact loading, compaction by blasting, vibro-compaction; pre-compression, stone columns; Hydraulic modification: dewatering systems, preloading and vertical drains, electro-kinetic dewatering

Module-IV

Chemical modification; modification by admixtures, stabilization using industrial wastes, grouting methods, Thermal modification**:** ground freezing and thawing

Module-V

Soil reinforcement and Application of Soil reinforcement:

Reinforced earth, basic mechanism, type of reinforcements, selection of stabilization/improvement of ground using Geosynthetics, design of reinforced earth retaining walls, road designs with geosynthetics.

Reference Books:

- Hausmann, M.R., Engineering Principles of Ground Modification, McGraw-Hill International Editions, 1990.
- Yonekura, R., Terashi, M. and Shibazaki, M. (Eds.), Grouting and Deep Mixing, A.A. Balkema, 1966.
- Moseley, M.P., Ground Improvement, Blackie Academic & Professional, 1993.
- Xanthakos, P.P., Abramson, L.W. and Bruce, D.A., Ground Control and Improvement, John Wiley & Sons, 1994.
- Koerner, R. M., Designing with Geosynthetics, Prentice Hall Inc. 1998.
- Shukla, S.K., Yin, Jian-Hua, "Fundamentals of Geosynthetic Engineering", Taylor & Francis

COURSE OUTCOME

1. Explain the necessity of ground modification that can be done depending upon the site condition, type and purpose of structure to be constructed.
2. Apply the appropriate ground improvement technique.
3. Describe the utilization of waste materials in the field
4. Evaluate thermal modification.
5. Design geo-synthetics and geo-cells in construction work.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-3	
Subject Name: COMPUTATIONAL GEOMECHANICS	**(3-0-0) CR-03**
Course Content	
Module-I	
Solution of Non-linear Equations and Linear Equations: Bisection, False Position, Newton-Raphson, Successive approximation method, Iterative methods, Jacobi's method, Gauss Seidal method, Successive over relaxation method.	
Module-II	
Finite Difference Method and Finite Element Method: Two point Boundary value problems – Disichlet conditions, Neumann conditions; ordinary and partial differential equations. Fundamentals, Constitutive finite element models for soils.	
Module-III	
Correlation and Regression Analysis: Correlation - Scatter diagram, Karl Pearson coefficient of correlation, Limits of correlation coefficient; Regression –Lines of regression, Regression curves, Regression coefficient, Differences between correlation and regression analysis.	
Module-IV	
One-dimensional Consolidation and Flow Through Porous Media - Theory of consolidation, Analytical procedures, Finite difference solution procedure for multilayered systems, Finite element formulation, Geotechnical aspects on flow through porous media, Numerical methods, Applications and Design analysis, Flow in jointed media.	
Module-V	
Risk assessment in Geotechnical Engg. - Probabilistic site characterization and design of foundations	
Reference Books:	
S. Chandrakant., Desai and John T. Christian, "Numerical Methods in Geotechnical	

Engineering", Mc. Graw Hill Book Company, 1977.
• M.K. Jain, S.R.K. Iyengar and R.K. Jain, "Numerical Methods for Scientific and Engineering
computations", Third edition, New Age International (P) Ltd. Publishers, New Delhi.
• D.J. Naylor and G.N. Pande, "Finite Elements in Geotechnical Engineering", Pineridge Press Ltd., UK.
• Sam Helwany, "Applied soil mechanics", John Wiley & sons, Inc

COURSE OUTCOME

1. Review various mathematical models used in non-linear and linear equations.
2. Explain FEM in geotechnical applications.
3. Distinguish between correlation and regression analysis.
4. Use different numerical and statistical tools for analyzing various geotechnical engineering problems.
5. Apply probabilistic approach for selection of design parameters and compute their impact on risk assessment

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-3	
Subject Name: ENGINEERING ROCK MECHANICS	**(3-0-0) CR-03**
Course Content	
Module-I	
Rock Rock Testing:: Formation of rocks, Physical properties, Classification of rocks and rock masses, Elastic constants of rock; Insitu stresses in rock, Laboratory and Field tests.	
Module-II	
Discontinuities in Rock Masses: Discontinuity orientation, Effect of discontinuities on strength of rock.	

Module-III
Strength Behaviour: Compression, Tension and Shear, Stress-Strain relationships, Rheological behaviour.
Module-IV
Strength/ Failure Criterion: Mohr-Coulomb, Griffith theory, Hoek and Brown, strength and other strength criteria. Stresses in rock near underground openings.
Module-V
Application of rock mechanics in Civil Engineering: Rock tunneling, rock slope stability, bolting, blasting, grouting and rock foundation design. Modern modelling techniques & analyses in rocks.
Reference Books:
Hudson J.A. and J.P. Harrison. Engineering Rock Mechanics: an Introduction to the Principles, 1997. Elsevier, Oxford • Goodman, R.E. Introduction to Rock Mechanics, John Wiley & Sons. • Ramamurthy, T., "Engineering in Rocks", PHI Learning Pvt. Ltd. • Jaeger, J.C. and Cook, N.G.W, Fundamentals of Rock Mechanics, Chapman and Hall, 1976. • Wyllie, D.C., Foundations on Rock, E & FN Spon. 2nd Edition, 1992
COURSE OUTCOME
1. Perform various laboratory tests on rock and classify rock mass.
2. Review the effect of discontinuities on strength of rock mass.
3. Evaluate the stress strain behaviour of rock mass.
4. Use strength and failure criterion of rock masses.
5. Predict strength of rock mass with respect to various Civil Engineering applications.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

Programme: M.Tech.	**Semester: 1st**
Program Elective-4	
Subject Name: SUBSURFACE EXPLORATION	**(3-0-0) CR-03**
Course Content	
Module-I	
Planning of exploration Scope and objectives, planning an exploration programme, methods of exploration, exploration for preliminary and detained design. Spacing and depth of bores, data presentation	
Module-II	
Geophysical Exploration and interpretation, seismic and electrical methods of exploration, cross bore hole, single bore hole, up bore hole and down bore hole methods.	
Module-III	
Exploration technique, methods of boring and drilling, non-displacement and displacement methods, drilling in different sub soil conditions, limitation of various drilling techniques, stabilization of bore holes, bore logs.	
Module-IV	
Sampling technique, quality of samples, factors influencing sample quality, disturbed and undisturbed samples, advanced sampling techniques, off shore sampling, shallow penetration samplers, preservation and handling of samples.	
Module-V	
Field Testing in Soil Exploration Field tests, penetration tests, Field vane shear test, Insitu shear and bore ho;e shear test, Pressure meter test, Dilatometer test, plate load test, monotonic and cyclic test, field permeability tests, block vibration test procedure, limitation, correction and data interpretation of all methods.	
Reference Books:	
• Bowles, J.E., Foundation Analysis and Design, McGraw-Hill International Edition, 1997. • Schnaid, F., "In Situ Testing in Geomechanics", Taylor and Francis	
COURSE OUTCOME	
1. Plan subsurface investigation based on the requirement of civil engineering project and site condition.	
2. Finalize depth and number of boreholes	
3. Execute different subsurface exploration tests, collect disturbed/undisturbed samples for laboratory tests and can suggest design parameters.	
4. Explain different methods for estimation of dynamic soil properties required for design purpose.	
5 Develop instrumentation scheme for monitoring of critical sites	

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-4	
Subject Name: DESIGN OF UNDERGROUND EXCAVATIONS	**(3-0-0) CR-03**
Course Content	
Module-I	
Introduction, planning of and exploration for various underground construction projects, stereographic projection method, principle and its application in underground excavation design.	
Module-II	
Elastic stress distribution around tunnels, stress distribution for different shapes and under different in-situ stress conditions, Greenspan method, design principles, multiple openings, openings in laminated rocks, elasto-plastic analysis of tunnels, Daemen's theory	
Module-III	
Application of rock mass classification systems, ground conditions in tunneling, analysis of underground openings in squeezing and swelling ground, empirical methods, estimation of elastic modulus and modulus of deformation of rocks; uniaxial jacking / plate jacking tests, radial jacking and Goodman jacking tests, long term behaviour of tunnels and caverns, New Austrian Tunneling Method (NATM), Norwegian Tunneling Method (NTM), construction dewatering.	
Module-IV	
Rock mass-tunnel support interaction analysis, ground response and support reaction curves, Ladanyi'selasto-plastic analysis of tunnels, design of various support systems including concrete and shotcrete linings, steel sets, rock bolting and rock anchoring, combined support systems, estimation of load carrying capacity of rock bolts	
Module-V	
In-situ stress, flat jack, hydraulic fracturing and over coring techniques and USBM type drill hole deformation gauge, single and multi-point bore hole extensometers, load cells, pressure cells, etc. Instrumentation and monitoring of underground excavations, during and after	

construction, various case studies.
Reference Books:
Hoek, E and and Brown, E. T.," Underground Excavations in Rocks", Institute of Mining Engineering. Obert, L. and Duvall, W.I., "Rock Mechanics and Design of Structures in Rocks", John Wiley. Singh, B. and Goel, R.K.,"Rock Mass Classification- A Practical Engineering Approach", Elsevier. Singh, B. and Goel, R.K., "Tunnelling in Weak Rocks", Elsevier
COURSE OUTCOME
1. Execute exploration for various underground construction projects.
2. Explain the use of elastic and plastic analysis in the design of underground support system.
3. Decide the mathematical models used for underground structures.
4. Design various support systems in tunnel.
5. Review about the field tests generally conducted during and after construction of under structures.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-4	
Subject Name: GEOTECHNICAL EARTHQUAKE ENGINEERING	**(3-0-0) CR-03**
Course Content	
Module-I	
Earthquake seismology – Causes of earthquake, Plate tectonics, Earthquake fault sources, Seismic waves, Elastic rebound theory, Quantification of earthquake, Intensity and magnitudes, Earthquake source models.	
Module-II	
Earthquake ground motion – Seismograph, Characteristics of ground motion, Effect of	

local site conditions on ground motions, Design earthquake, Design spectra, Development of site specification and code-based design.
Module-III
Ground response analysis – One-dimensional ground response analysis: Linear approaches, Equivalent linear approximation of non-linear approaches, Computer code "SHAKE".
Module-IV
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.
Module-V
Seismic design of foundations, Seismic slope stability analysis: Internal stability and weakening instability and Seismic design of retaining walls.
Reference Books:
Steven Kramer, "Geotechnical Earthquake Engineering", Pearson,2008. Seco e Pinto, P., Seismic behaviour of ground and Geotechnical structure, A. A. Naeim, F., The Seismic Design Handbook, Kluwer Academic Publication, 2nd Edition, 2001. Ferrito, J.M, Seismic design criteria for soil liquefaction, Tech. Report of NavalFacilities service centre, Port Hueneme, 1997
COURSE OUTCOME
1. Describe the causes and quantification of earthquake.
2. Evaluate earthquake magnitude, ground motion.
3. Analyse ground response.
4. Assess liquefaction and lateral spreading.
5. Explain the effect of earthquake and the design criterions to be followed for the design different geotechnical structures

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-4	
Subject Name: FEM IN GEOTECHNICAL ENGINEERING	**(3-0-0) CR-03**
Course Content	
Module-I	
Stress-deformation analysis: One dimensional, Two dimensional and Three-dimensional formulations.	
Module-II	
Discretization of a Continuum, Elements, Strains, Stresses, Constitutive, Relations, Hooke's Law, Formulation of Stiffness Matrix, Boundary Conditions, Solution Algorithms	
Module-III	
Principles of discretization, element stiffness and mass formulation based on direct, variational and weighted residual techniques and displacements approach, Shape functions and numerical integrations, convergence.	
Module-IV	
Displacement formulation for rectangular, triangular and isoparametric elements for two dimensional and axi-symmetric stress analysis.	
Module-V	
Settlement Analysis, 2-D elastic solutions for homogeneous, isotropic medium, Steady Seepage Analysis: Finite element solutions of Laplace's equation, Consolidation Analysis: Terzaghi consolidation problem, Choice of Soil Properties for Finite Element Analysis	
Reference Books:	
O.C. Zienkiewicz and R.L. Taylor, Finite element methods Vol I & Vol II, McGraw Hill,1989,1992. • K.J. Bathe, Finite element procedures, PHI Ltd., 1996. • David M Potts and Lidija Zdravkovic, "Finite Element Analysis in Geotechnical Engineering Theory and Application", Thomas Telford. 1999	
COURSE OUTCOME	
1. Review basic stress-strain relationship for soil and develop stress deformation techniques.	
2. Explain formulation of stiffness matrix.	
3. Describe shape functions and numerical integrations.	
4. Identify element properties and Isoparametric elements.	
5. Develop finite element formulation for different geotechnical problems including seepage and consolidation problems.	

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

Programme: M.Tech.	**Semester: 1st**
Professional Elective Course-5	
Subject Name: PHYSICAL AND CONSTITUTIVE MODELLING ON EOMECHANICS	**(3-0-0) CR-03**
Course Content	
Module-I	
Role of Constitutive Modelling; Importance of laboratory testing with relation to constitutive modelling; Elasticity: linear, quasi linear, anisotropic;	
Module-II	
Plasticity basics: yield criteria, flow rule, plastic potential, hardening/softening; Rate Independent Plasticity: Mohr-coulomb, nonlinear failure criteria, Drucker Prager, and cap models;	
Module-III	
Critical state soil mechanics: Critical state concept, cam clay models, simulation of single element test using cam clay,	
Module-IV	
Consolidation, drained and undrained triaxial test; Stress dilatancy theory;	
Module-V	
Braced excavations: Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays	
Reference Books:	
Hicher and Shao, "Constitutive Modeling of Soils and Rocks", John Wiley. 2008 • C.S. Desai and H. J. Siriwardane, "Constitutive Laws for Engineering Materials with Emphasis on Geologic Materials", Prentice-Hall, Inc., New Jersey. 1984 • David M Potts and LidijaZdravkovic, "Finite Element Analysis in Geotechnical Engineering Theory and Application", Thomas Telford. 1999 • C.S. Desai, "Mechanics of Materials and Interfaces: The Disturbed State Concept", CRC Press LLC. 2000 • A.P.S. Selvadurai, M.J. Boulon, "Mechanics of Geomaterial Interfaces, Elsevier.	
COURSE OUTCOME	
1. Review constitutive modeling.	
2. Explain theory of plasticity and various yield criteria and flow rule.	
3. Apply critical state concept in cam clay model.	
4. Evaluate critical state concept to consolidation and triaxial soil behavior.	
5. Describe the applications of elasto-plastic models.	

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

Subject Name: ENVIRONMENTAL IMPACT ASSESSMENT	**(3-0-0) CR-03**
Course Content	
Module-I	
National environmental policy act and its implementation: Terminology, Features of the National Environmental Policy Act, Screening in the EIA Process, Summary Statistical Information on EISs, EIA at the International Level, Utility of the EIA process, Expanded scope of EIA, Narrowed scope of EIA, Planning and management of impact studies: Conceptual Approach for Environmental Impact Studies, Proposal Development, Interdisciplinary Team Formations, Team Leader Selection and Duties, General Study Management, Fiscal Control	
Module-II	
Simple method for impact identification: Background Information, Interaction Matrix Methodologies, Network Methodologies, Checklist Methodologies Description of environmental setting: Conceptual Framework, Initial List of Factors, Selection Process, Documentation of Selection Process, Data Sources	
Module-III	
Environmental indices and indicators: Background Information, Environmental-Media Index-Air Quality, Environmental-Media Index—Water Quality, Environmental-Media Index—Noise Prediction and assessment of impacts on the Air environment: Basic Information on Air Quality Issues, Conceptual Approach for Addressing Air Environment Impacts	
Module-IV	
Prediction and assessment of impacts on the Surface-water environment: Basic Information on Surface-water	

Quantity and Quality, Key Federal Legislation, Conceptual Approach for Addressing Surface-Water – Environment Impacts

Prediction and assessment of impacts on the soil and ground-water environments: Background Information on the soil Environment, Background Information on Groundwater Quantity and Quality, Key Federal Legislation, Conceptual Approach for Addressing Soil and Groundwater-Environment Impacts

Module-V

Prediction and assessment of impacts on the noise environment: Basic Information on Noise, Key federal Legislation and Guidelines, Conceptual Approach for Addressing Noise-Environment Impact

Prediction and assessment of impacts on the biological Environment: Basic Information on Biological Systems, Key Federal Legislation, Conceptual Approach for Addressing Biological Impacts

Environmental laws and policies – Environmental laws for managing Air, water, land, wastewater, solid waste, hazardous waste, natural resources

Reference Books:

- Canter L., (1995), "Environmental Impact Assessment", McGraw Hill.
- Jain R.K., Urban L.V., Stacey G.S., (1977), "Environmental Impact Analysis – A New Dimension in
- Decision Making", Van Nostrand Reinhold Co.
- Rau and Wooten, (1981), "Environmental Impact Assessment Handbook". McGraw Hill.
- Environmental Law, Sengar, PHI.

COURSE OUTCOME

- Describe the environmental imbalances, indicators and explain the concept of EIA
- Explain elements to be affected by the proposed developments and/or likely to cause adverse impacts to the proposed project, including natural and man-made environment;
- Review the negative impacts and propose the provision of infrastructure or mitigation measures
- Assess the impacts of various development on environment
- Summarize the methodologies for carrying out environmental impact assessment

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	3	2

Research Methodology and IPR

Syllabus Contents:

Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: Effective literature studies approaches, analysis Plagiarism, Research ethics,

Unit 3: Effective technical writing, how to write report, Paper
Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References:

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
- Mayall , "Industrial Design", McGraw Hill, 1992.
- Niebel , "Product Design", McGraw Hill, 1974.
- Asimov , "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New

Technological Age", 2016.
T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand,

COURSE OUTCOME

1. Explain research problem formulation.
2. Describe research ethics
3. Review that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
4. Assess that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
5. Predict that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

Lab-I (Geotechnical Engg. Lab)

Lab: 3hrs/week

List of Practicals:

1. Grain Size Distribution Analysis and Hydrometer Analysis
2. Atterberg Limits (Liquid Limit, Plastic limit, Shrinkage limit)
3. Determination of field density
4. Standard and modified proctor compaction test
5. Falling head permeability test and Constant head permeability test
6. Consolidation test
7. Unconfined compression test
8. Direct shear test
9. Free Swell test
10. CBR Test (Soaking and Unsoaking)

Lab-II (Advanced Geotechnical Engg. lab)
Lab: 3hrs/week
List of Practicals:
1. Laboratory vane shear test
2. Field Vane shear test
3. Standard penetration test
4.Plate load test
5. Static cone penetration test
6. Tri-axial compression test – UU, CU, CD tests
7. Swelling Pressure Test
8. Dynamic cone penetration test
9. Pressure meter test
10. Geophysical exploration tests.

OPEN ELECTIVES
Business Analytics
Teaching scheme
Lecture: - 3 h/week
Total Number of Lectures: 48

Unit1:
Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.
Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Unit 2:
Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.
Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology
Unit 3:
Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.
Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization

Unit 4:
Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.
Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model

Unit 5:
Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Unit 6:
Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism

References:
1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education

COURSE OUTCOME
1. Demonstrate knowledge of data analytics.
2. Explain the ability of think critically in making decisions based on data and deep analytics.
3. Describe the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
4. Review the ability to translate data into clear, actionable insights
5. Use Recent Trends in Data Handling

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

.

OPEN ELECTIVES

Industrial Safety
Teaching scheme
Lecture: - 3 h/week

Unit-I: Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-II: Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit-III: Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit-IV: Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Unit-V: Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing,
cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

References:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.

2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

OPEN ELECTIVES
Operations Research
Teaching Scheme
Lectures: 3 hrs/week

Syllabus Contents:
Unit 1:
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models
Unit 2
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex
method - sensitivity analysis - parametric programming
Unit 3:
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT
Unit 4
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.
Unit 5
Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation
References:
1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

COURSE OUTCOME
1. Apply the dynamic programming to solve problems of discreet and
continuous variables.
2. Use the concept of non-linear programming
3. Evaluate sensitivity analysis
4. Explain the real world problem and simulate it.
5. Review constitutive models

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

Open Elective
Cost Management of Engineering Projects
Teaching scheme
Lecture: - 3 h/week

1 Introduction and Overview of the Strategic Cost Management Process
Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making Project: meaning,

2 Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities.

3 Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process
Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement

4 Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing

5 Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

References:

2. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi

3. Charles T. Horngren and George Foster, Advanced Management Accounting
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
5. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
6. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

Open Elective
Composite Materials
Teaching scheme
Lecture: - 3 h/week

UNIT–I: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT – II: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT – III: Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT–IV: Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.
UNIT – V: Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TEXT BOOKS:
1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.
References:
1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

Open Elective

Waste to Energy

Unit-I: Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors
Unit-II: Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.
Unit-III: Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.
Unit-IV: Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs,
Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.
Unit-V: Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification.
Biomass conversion processes - Thermo chemical conversion - Direct combustion biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion
Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production, Urban waste to energy conversion - Biomass energy programme in India.

COURSE OUTCOME
1. Interpret the use of waste as a Fuel and can learn about the conversion devices.
2. Use the term Pyrolysis
3. Describe the term Gasification
4. Design the combustors
5. Explain the terms like Biogas and Biomass conversion processes

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

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

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	2	2	1	3	2	2

AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

Syllabus:

Units	**CONTENTS**	**Hours**
1	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	4
2	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction	4
3	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	4
4	key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,	4
5	skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	4
6	useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	4

References:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht

Heidelberg London, 2011

AUDIT 1 and 2: DISASTER MANAGEMENT

Syllabus

Units	CONTENTS	Hours
1	**Introduction** Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.	4
2	**Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	4
3	**Disaster Prone Areas In India** Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics	4
4 5 6	**Disaster Preparedness And Management** Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness. **Risk Assessment** Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival. **Disaster Mitigation** Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India	4

References:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall

Of India, New Delhi.
3. Goel S. L., Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

Syllabus

Unit	*Content*	*Hours*
1	• Alphabets in Sanskrit, • Past/Present/Future Tense, • Simple Sentences	8
2	• Order • Introduction of roots • Technical information about Sanskrit Literature	8
3	• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics	8

References:

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-VempatiKutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

Course Output

Students will be able to
1. Understanding basic Sanskrit language.
2. Ancient Sanskrit literature about science & technology can be understood.
3. Being a logical language will help to develop logic in students.

AUDIT 1 and 2: VALUE EDUCATION

Syllabus

Unit	*Content*	*Hours*
1	• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. • Moral and non- moral valuation. Standards and principles. • Value judgements	4
2	• Importance of cultivation of values. • Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. • Honesty, Humanity. Power of faith, National Unity. • Patriotism.Love for nature ,Discipline	6
3	• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. • Punctuality, Love and Kindness. • Avoid fault Thinking. • Free from anger, Dignity of labour. • Universal brotherhood and religious tolerance. • True friendship.	6

4	• Happiness Vs suffering, love for truth. • Aware of self-destructive habits. • Association and Cooperation. •Doing best for saving nature • Character and Competence –Holy books vs Blind faith. • Self-management and Good health. • Science of reincarnation. • Equality, Nonviolence ,Humility, Role of Women. • All religions and same message. • Mind your Mind, Self-control. • Honesty, Studying effectively	

References:

1 Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

Course outcomes

Students will be able to

1.Knowledge of self-development

2.Learn the importance of Human values

3.Developing the overall personality

AUDIT 1 and 2: CONSTITUTION OF INDIA

Syllabus

Units	**Content**	**Hours**
1	•**History of Making of the Indian Constitution:** History Drafting Committee, (Composition & Working)	4
2	•**Philosophy of the Indian Constitution:** Preamble Salient Features	4
3	•**Contours of Constitutional Rights & Duties:** • Fundamental Rights • Right to Equality • Right to Freedom • Right against Exploitation Right to Freedom of Religion • Cultural and Educational Rights • Right to Constitutional Remedies • Directive Principles of State Policy • Fundamental Duties	4

4	•**Organs of Governance:**	4

	• Parliament • Composition • Qualifications and Disqualifications • Powers and Functions • Executive • President • Governor • Council of Ministers • Judiciary, Appointment and Transfer of Judges, Qualifications • Powers and Functions	
5	•**Local Administration:** • District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. • Pachayati raj: Introduction, PRI: ZilaPachayat. • Elected officials and their roles, CEO ZilaPachayat: Position and role. • Block level: Organizational Hierarchy (Different departments), • Village level: Role of Elected and Appointed officials, • Importance of grass root democracy	4
6	•**Election Commission:** • Election Commission: Role and Functioning. • Chief Election Commissioner and Election Commissioners. • State Election Commission: Role and Functioning. • Institute and Bodies for the welfare of SC/ST/OBC and women.	4

References:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

AUDIT 1 and 2: PEDAGOGY STUDIES

Syllabus:

Units	Content	Hours
1	• **Introduction and Methodology:**	4

	• Aims and rationale, Policy background, Conceptual framework and terminology • Theories of learning, Curriculum, Teacher education. • Conceptual framework, Research questions**.** • Overview of methodology and Searching.	
2	• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. • Curriculum, Teacher education.	2
3	• Evidence on the effectiveness of pedagogical practices • Methodology for the in depth stage: quality assessment of included studies. • How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? • Theory of change. • Strength and nature of the body of evidence for effective pedagogical practices. • Pedagogic theory and pedagogical approaches. • Teachers' attitudes and beliefs and Pedagogic strategies.	4
4	• Professional development: alignment with classroom practices and follow-up support • Peer support • Support from the head teacher and the community. • Curriculum and assessment • Barriers to learning: limited resources and large class sizes	4
5	• **Research gaps and future directions** • Research design • Contexts • Pedagogy • Teacher education • Curriculum and assessment • Dissemination and research impact.	2

References:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education.

Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Course Outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

Syllabus

Unit	*Content*	*Hours*
1	• Definitions of Eight parts of yog. (Ashtanga)	8
2	• Yam and Niyam. Do`s and Don't's in life. i) Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan	8
3	• Asan and Pranayam i) Various yog poses and their benefits for mind & body ii)Regularization of breathing techniques and its effects-Types of pranayam	8

Suggested reading

1. 'Yogic Asanas for Group Tarining-Part-I" :Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata

Course Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

Syllabus

Unit	Content	Hours
1	Neetisatakam-Holistic development of personality • Verses- 19,20,21,22 (wisdom) • Verses- 29,31,32 (pride & heroism) • Verses- 26,28,63,65 (virtue) • Verses- 52,53,59 (dont's) • Verses- 71,73,75,78 (do's)	8
2	• Approach to day to day work and duties.	8

	• Shrimad BhagwadGeeta : Chapter 2-Verses 41, 47,48, • Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35, • Chapter 18-Verses 45, 46, 48.	
3	• Statements of basic knowledge. • Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68 • Chapter 12 -Verses 13, 14, 15, 16,17, 18 • Personality of Role model. Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42, • Chapter 4-Verses 18, 38,39 • Chapter18 – Verses 37,38,63	8

References:

1. "Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

Course Outcomes

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students