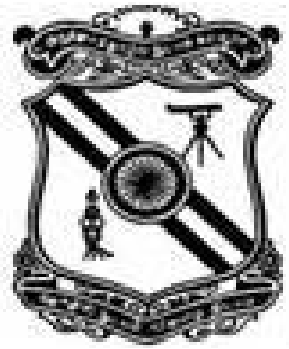
DEPARTMENT OF CIVIL ENGINEERING
GOVERNMENT COLLEGE OF TECHNOLOGY,
COIMBATORE.
(An Autonomous Institution Affiliated to Anna University, Chennai)



M.E GEOTECHNICAL ENGINEERING
2023 REGULATIONS
CURRICULUM & SYLLABI

VISION AND MISSION OF THE INSTITUTION

VISION

To emerge as a centre of excellence and eminence by imparting futuristic technical education in keeping with global standards, making our students technologically competent and ethically strong so that they can readily contribute to the rapid advancement of society and mankind.

MISSION

- To achieve academic excellence through innovative teaching and learning practices.
- To enhance employability and entrepreneurship.
- To improve the research competence to address societal needs.
- To inculcate a culture that supports and reinforces ethical, professional behaviours for a harmonious and prosperous society.

GOVERNMENT COLLEGE OF TECHNOLOGY
(An Autonomous Institution Affiliated to Anna University, Chennai) Coimbatore–641013
DEPARTMENT OF CIVIL ENGINEERING (Geotechnical Engineering)

VISION AND MISSION

VISION

To provide quality education in Civil Engineering to the societal growth in sustainable manner on par with global standards.

MISSION

* To establish the process of teaching and learning to meet the global standards for sustainable built environment.
* To make Civil Engineering department are now Ned high-tech consultancy centre.
* To carry out socially relevant and forward looking research for societal needs.
* Integrated with opportunities for team work, leadership, values, ethics and social activities.

GOVERNMENT COLLEGE OF TECHNOLOGY
(An Autonomous Institution Affiliated to Anna University, Chennai) Coimbatore–641 013
DEPARTMENT OF CIVIL ENGINEERING
(Geotechnical Engineering)

PROGRAMME OUTCOMES (POs)

Students in the Geotechnical Engineering Programme should beat the time of their graduation be in possession of the following:

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

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

PO3: Students should inculcate the capacity to develop and demonstrate Innovative ideas/techniques in the area of Geotechnical Engineering.

PO4: To prepare graduates to excel in their academic and Professional careers, tackle challenging geotechnical problems giving sustainable solutions.

PO5: To create a centre of excellence for doing advanced research and providing solutions to complex geotechnical problems.

PO6: To nurture the students in understanding the importance of Geotechnical Engineering by continual life-long learning process.

GOVERNMENT COLLEGE OF TECHNOLOGY
(An Autonomous Institution Affiliated to Anna University, Chennai) Coimbatore – 641 013
DEPARTMENT OF CIVIL ENGINEERING
(Geotechnical Engineering)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The following Programme Educational Objectives are designed based on the department mission:

PEO1: Graduates will have an advanced conceptual understanding, in depth knowledge, smart skills and awareness of their responsibilities to the society so that, they emerge themselves as globally competent Geotechnical Engineers.

PEO2: Graduates will emerge as specialist in handling investigations and testing devices to evaluate and analyses ground conditions for evolving solutions in challenging situations.

PEO3: Graduates will have an extensive knowledge of analytical and design softwares that enable them to cope with the rapid development of the construction industry.

PEO4: Graduates will be able to recognize social needs and ethical responsibilities and become a successful entrepreneur and to apply the ideas and concepts to evaluate the problems more effectively through advanced testing and measurements in order to design Geotechnical Structures.

GOVERNMENT COLLEGE OF TECHNOLOGY
(An Autonomous Institution Affiliated to Anna University, Chennai) Coimbatore–641 013
M.E. GEOTECHNICAL ENGINEERING

FIRST SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem. Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	23GEFCZ1	Research Methodology and IPR (Common to all Branches)	FC	40	60	100	3	0	0	3
2	23GEFC02	Analytical and Numerical Methods (Common to Structural & Geotechnical Engineering)	FC	40	60	100	3	0	0	3
3	23GEPC01	Strength and Deformation Characteristics of Soils	PC	40	60	100	3	0	0	3
4	23GEPC02	Advanced Foundation Engineering	PC	40	60	100	3	0	0	3
5	23GEPC03	Structural Design of Foundations and Substructures	PC	40	60	100	3	0	0	3
6	23GEPEXX	Professional Elective I	PE	40	60	100	3	0	0	3
7	23GEACXX	Audit Course-I	AC	40	60	100	2	0	0	0
PRACTICAL										
8	23GEPC04	Advanced Soil Mechanics Laboratory	PC	60	40	100	0	0	4	2
TOTAL				**340**	**460**	**800**	**20**	**0**	**4**	**20**

SECOND SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem. Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	23GEPC05	Soil Dynamics and Machine Foundations	PC	40	60	100	3	1	0	4
2	23GEPC06	Site Exploration and soil Investigation	PC	40	60	100	3	0	0	3
3	23GEPEXX	Professional Elective II	PE	40	60	100	3	0	0	3
4	23GEPEXX	Professional Elective III	PE	40	60	100	3	0	0	3
5	23GEACXX	Audit Course - II	AC	40	60	100	2	0	0	0
PRACTICAL										
6	23GEPC07	Subsoil Exploration Laboratory	PC	60	40	100	0	0	4	2
7	23GEPC08	Finite Element Analysis Laboratory	PC	60	40	100	0	0	4	2
8	23GEEE01	Mini Project	EEC	60	40	100	0	0	4	2
TOTAL				**380**	**420**	**800**	**14**	**1**	**12**	**19**

THIRD SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem. Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	23GEPEXX	Professional Elective IV	PE	40	60	100	3	0	0	3
2	23GEOEXX	Open Elective – I	OE	40	60	100	3	0	0	3
PRACTICAL										
3	23GEEE02	Internship/ Industrial Training	EEC	100	---	100	--	--	**	2
4	23GEEE03	Project - I	EEC	60	40	100	0	0	24	12
TOTAL				**240**	**160**	**400**	**6**	**0**	**24**	**20**

***Industrial Training/Internship – 4Weeks*

FOURTH SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem. Marks	Total Marks	Hours/Week			
							L	T	P	C
PRACTICAL										
1	23GEEE04	Project - II	EEC	60	40	100	-	-	*	24
TOTAL				60	40	100	-	-	*	24

Note : * Maximum number of periods 720 to earn 24 credits shall be scheduled during the maximum period of 6 months.

Total Credits - 83

SUMMARY OF CREDIT DISTRIBUTION

S.No	Course Work Subject Area	No of Credits					Percentage
		I	II	III	IV	Total	
1.	Foundation Course	6	-	-	-	6	**7.23 %**
2.	Professional Cores	11	11	-	-	22	**26.51 %**
3.	Professional Electives	3	6	3	-	12	**14.46 %**
4.	Employability Enhancement Courses	-	2	14	24	40	**48.19 %**
5.	Open Elective Courses	-	-	3	-	3	**3.61 %**
Total Credits		**20**	**19**	**20**	**24**	**83**	**100**

FOUNDATION COURSES (FC)

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem. Marks	Total Marks	Hours/Week			
							L	T	P	C
1	23GEFCZ1	Research Methodology and IPR (Common to all Branches)	FC	40	60	100	3	0	0	3
2	23GEFC02	Analytical and Numerical Methods (Common to Structural & Geotechnical Engineering)	FC	40	60	100	3	0	0	3
TOTAL				**80**	**120**	**200**	**6**	**0**	**0**	**6**

PROFESSIONAL COURSES (PC)

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem. Marks	Total Marks	Hours/Week			
							L	T	P	C
1	23GEPC01	Strength and Deformation Characteristics of Soils	PC	40	60	100	3	0	0	3
2	23GEPC02	Advanced Foundation Engineering	PC	40	60	100	3	0	0	3
3	23GEPC03	Structural Design of Foundations and Substructures	PC	40	60	100	3	0	0	3
4	23GEPC04	Advanced Soil Mechanics Laboratory	PC	60	40	100	0	0	4	2
5	23GEPC05	Soil Dynamics and Machine Foundations	PC	40	60	100	3	1	0	4
6	23GEPC06	Site Exploration and soil Investigation	PC	40	60	100	3	0	0	3
7	23GEPC07	Subsoil Exploration Laboratory	PC	60	40	100	0	0	4	2
8	23GEPC08	Finite Element Analysis Laboratory	PC	60	40	100	0	0	4	2
TOTAL				**380**	**420**	**800**	**15**	**1**	**12**	**22**

PROFESSIONAL ELECTIVES (PE)

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem. Marks	Total Marks	Hours/Week			
							L	T	P	C
1	23GEPE01	Remote Sensing and its applications in Geotechnical Engineering	PE	40	60	100	3	0	0	3
2	23GEPE02	Soil Properties and Behaviour	PE	40	60	100	3	0	0	3
3	23GEPE03	Sustainable Geotechnics	PE	40	60	100	3	0	0	3
4	23GEPE04	Reinforced Soil Structures	PE	40	60	100	3	0	0	3
5	23GEPE05	Finite Element Analysis for Geotechnical Engineering	PE	40	60	100	3	0	0	3
6	23GEPE06	Foundation in Expansive Soils	PE	40	60	100	3	0	0	3
7	23GEPE07	Soil Structure Interaction (Common to Structural & Geotechnical Engineering)	PE	40	60	100	3	0	0	3
8	23GEPE08	Forensic Geotechnical Engineering	PE	40	60	100	3	0	0	3
9	23GEPE09	Rock Mechanics in Engineering Practice	PE	40	60	100	3	0	0	3
10	23GEPE10	Geotechnical Earthquake Engineering	PE	40	60	100	3	0	0	3
11	23GEPE11	Design of Underground Excavations	PE	40	60	100	3	0	0	3
12	23GEPE12	Computational Geomechanics	PE	40	60	100	3	0	0	3
13	23GEPE13	Slope Stability and Landslides	PE	40	60	100	3	0	0	3
14	23GEPE14	Geology in Geotechnical Engineering	PE	40	60	100	3	0	0	3
15	23GEPE15	Land Reclamation	PE	40	60	100	3	0	0	3
16	23GEPE16	Environmental Geotechnology	PE	40	60	100	3	0	0	3
17	23GEPE17	Pavement Engineering	PE	40	60	100	3	0	0	3
18	23GEPE18	Theoretical Soil Mechanics	PE	40	60	100	3	0	0	3
19	23GEPE19	Earth Retaining Structures	PE	40	60	100	3	0	0	3
20	23GEPE20	Professional Practices in Design Of Geotechnical Structures	PE	40	60	100	3	0	0	3
21	23GEPE21	Ground Improvement Technique	PE	40	60	100	3	0	0	3
22	23GEPE22	Marine Geotechnical Engineering	PE	40	60	100	3	0	0	3
23	23GEPE23	Unsaturated Soil Mechanics	PE	40	60	100	3	0	0	3
24	23GEPE24	Tunnel Engineering	PE	40	60	100	3	0	0	3

OPEN ELECTIVES (OE)

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	23SEOE01	Building Bye-Laws and Codes of Practice	OE	40	60	100	3	0	0	3
2	23SEOE02	Planning of Smart Cities	OE	40	60	100	3	0	0	3
3	23SEOE03	Green Building	OE	40	60	100	3	0	0	3
4	23EEOE04	Environment Health and Safety Management	OE	40	60	100	3	0	0	3
5	23EEOE05	Climate Change and Adaptation	OE	40	60	100	3	0	0	3
6	23EEOE06	Waste to Energy	OE	40	60	100	3	0	0	3
7	23GEOE07	Energy in Built Environment	OE	40	60	100	3	0	0	3
8	23GEOE08	Earth and Its Environment	OE	40	60	100	3	0	0	3
9	23GEOE09	Natural Hazards and Mitigation	OE	40	60	100	3	0	0	3
10	23EDOE10	Business Analytics	OE	40	60	100	3	0	0	3
11	23EDOE11	Introduction to Industrial safety	OE	40	60	100	3	0	0	3
12	23EDOE12	Operations Research	OE	40	60	100	3	0	0	3
13	23MFOE13	Occupational Health and Safety	OE	40	60	100	3	0	0	3
14	23MFOE14	Cost Management of Engineering Projects	OE	40	60	100	3	0	0	3
15	23MFOE15	Composite Materials	OE	40	60	100	3	0	0	3
16	23TEOE16	Global Warming Science	OE	40	60	100	3	0	0	3
17	23TEOE17	Introduction to Nano Electronics	OE	40	60	100	3	0	0	3
18	23TEOE18	Green Supply Chain Management	OE	40	60	100	3	0	0	3
19	23PSOE19	Distribution Automation System	OE	40	60	100	3	0	0	3
20	23PSOE20	Electricity Trading & Electricity Acts	OE	40	60	100	3	0	0	3
21	23PSOE21	Modern Automotive Systems	OE	40	60	100	3	0	0	3
22	23PEOE22	Virtual Instrumentation	OE	40	60	100	3	0	0	3
23	23PEOE23	Energy Management Systems	OE	40	60	100	3	0	0	3
24	23PEOE24	Advanced Energy Storage Technology	OE	40	60	100	3	0	0	3
25	23AEOE25	Design of Digital Systems	OE	40	60	100	3	0	0	3
26	23AEOE26	Basics of Nano Electronics	OE	40	60	100	3	0	0	3
27	23AEOE27	Advanced Processor	OE	40	60	100	3	0	0	3
28	23VLOE28	HDL Programming Languages	OE	40	60	100	3	0	0	3
29	23VLOE29	CMOS VLSI Design	OE	40	60	100	3	0	0	3
30	23VLOE30	High Level Synthesis	OE	40	60	100	3	0	0	3
31	23CSOE31	Artificial Intelligence	OE	40	60	100	3	0	0	3
32	23CSOE32	Computer Network Management	OE	40	60	100	3	0	0	3
33	23CSOE33	Block Chain Technologies	OE	40	60	100	3	0	0	3

AUDIT COURSES (AC)

(Common to all Branches)

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem. Marks	Total Marks	Hours/Week			
							L	T	P	C
1	23GEACZ1	English for Research Paper writing	AC	40	60	100	2	0	0	0
2	23GEACZ2	Disaster Management	AC	40	60	100	2	0	0	0
3	23GEACZ3	Value Education	AC	40	60	100	2	0	0	0
4	23GEACZ4	Constitution of India	AC	40	60	100	2	0	0	0
5	23GEACZ5	Pedagogy Studies	AC	40	60	100	2	0	0	0
6	23GEACZ6	Stress Management by Yoga	AC	40	60	100	2	0	0	0
7	23GEACZ7	Personality Development Through life enlightenment skills	AC	40	60	100	2	0	0	0
8	23GEACZ8	Sanskrit for Technical Knowledge	AC	40	60	100	2	0	0	0

EMPLOYABILTY ENHANCEMENT COURSES (EEC)

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem. Marks	Total Marks	Hours/Week			
							L	T	P	C
1	23GEEE01	Mini Project	EEC	60	40	100	0	0	4	2
2	23GEEE02	Internship/Industrial Training	EEC	100	-	100	-	-	**	2
3	23GEEE03	Project - I	EEC	60	40	100	0	0	24	12
4	23GEEE04	Project - II	EEC	60	40	100	-	-	*	24

***Industrial Training/Internship – 4Weeks*

L: Credits for Lecture Hours
P: Credits for Practical Hours
T: Credits for Tutorial Hours
C: Total Number of Credits

23GEFCZ1	RESEARCH METHODOLOGY AND IPR (Common to all Branches)					SEMESTER I
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**FC**	**3**	**0**	**0**	**3**
Course Objective	• To impart knowledge on research methodology, Quantitative methods for problem solving, data interpretation and report writing. • To know the importance of IPR and patent rights.					
UNIT–I	**INTRODUCTION**					**9 Periods**
Definition and objectives of Research – Types of research, Various Steps in Research process, Mathematical tools for analysis, Developing a research question- Choice of a problem Literature review, Surveying, synthesizing, critical analysis, reading materials, reviewing, rethinking, critical evaluation, interpretation, Research Purposes, Ethics in research–APA Ethics code.						
UNIT–II	**QUANTITATIVE METHODS FOR PROBLEM SOLVING**					**9 Periods**
Statistical Modeling and Analysis, Time Series Analysis Probability Distributions, Fundamentals of Statistical Analysis and Inference, Multivariate methods, Concepts of Correlation and Regression, Fundamentals of Time Series Analysis and Spectral Analysis, Error Analysis, Applications of Spectral Analysis.						
UNIT–III	**DATA DESCRIPTION AND REPORT WRITING**					**9 Periods**
Tabular and graphical description of data: Tables and graphs of frequency data of one variable, Tables and graphs that show the relationship between two variables , Relation between frequency distributions and other graphs, preparing data for analysis. Structure and Components of Research Report, Types of Report, Layout of Research Report, Mechanism of Writing a research report, referencing in academic writing.						
UNIT–IV	**INTELLECTUAL PROPERTY**					**9 Periods**
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–V	**PATENT RIGHTS**					**9 Periods**
Patent Rights: Scope of Patent Rights, Licensing and transfer of technology. Patent information and databases. Geographical Indications.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*Stuart Melville and Wayne Goddard,* ***"Research methodology : an introduction",*** *Juta Academic, 2nd edition, 2014.*
2	*Donald H.Mc Burney and Theresa White,* ***"Research Methods"****, 9th Edition, Cengage Learning, 2013.*
3	*Ranjit Kumar,* ***"Research Methodology: A Step by Step Guide for Beginners",*** *5th Edition, 2019.*
4	*Dr.C. R. Kothari and Gaurav Garg,* ***"Research Methodology: Methods and Trends"****, New Age International Publishers, 4th Edition, 2018.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Formulate research question for conducting research.	K3
CO2	Analyze qualitative and quantitative data.	K4
CO3	Interpret research findings and give appropriate conclusions.	K2
CO4	Develop a structured content to write technical report.	K3
CO5	Summarize the importance of IPR and protect their research work through Intellectual property.	K2

COURSEARTICULATIONMATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	2	3	2	1	1
CO2	2	-	3	2	1	-
CO3	2	2	3	2	1	-
CO4	-	3	2	1	1	-
CO5	-	2	3	1	-	1
23GEFCZ1	2	2	3	2	1	1
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	30	20	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	30	20	-	-	100
ESE	30	30	20	20	-	-	100

23GEFC02	ANALYTICAL AND NUMERICAL METHODS *(Common to Structural & Geotechnical Engineering)*	SEMESTER I

PREREQUISITES	CATEGORY	L	T	P	C
NIL	FC	3	0	0	3

Course Objective	To familiarize the foundations of numerical methods and analysis techniques mostly used in various applications in engineering and technology.

UNIT–I	SOLUTIONS OF EQUATIONS AND EIGEN VALUE PROBLEMS	9 Periods

Error Analysis: Sources of Error in Numerical Computations, Absolute and Relative Errors, Round off and Truncation Errors. Solutions of nonlinear algebraic and transcendental equations by fixed point iteration method and Newton Raphson method. Solutions of linear system of equations by Gauss Elimination, Gauss Jordan and Gauss Seidel method. Eigen value of Matrix by Power method and Jacobi method.

UNIT–II	CURVE FITTING AND INTERPOLATION	9 Periods

Curve fitting: Fitting a straight line and parabola by method of least squares. Curves reducible to linear form. Newton's divided difference formula, Lagrange's interpolation-Newton's Forward and backward difference formula.

UNIT–III	NUMERICAL DIFFERENTIATION AND NUMERICAL INTEGRATION	9 Periods

Numerical approximation of derivatives using interpolation polynomials - Numerical integration by Trapezoidal, Simpson's one third rule and Simpson's three eight rule- Two point and three point Gaussian quadrature formula - Double integration using Trapezoidal and Simpson one third rule.

UNIT–IV	NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS	9 Periods

Taylor series method - Euler method - Modified Euler method - Fourth order Runge - Kutta method for solving first order equations – Predictor and corrector methods: Milne's and Adam Bashforth methods.

UNIT–V	NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS	9 Periods

Finite difference solutions for the second order ordinary differential equations – Finite difference solutions for one dimensional Heat Equation (Both Explicit and Implicit Methods) One dimensional wave equation - Laplace and Poisson equation.

Contact Periods:

Lecture:45 Periods **Tutorial: 0 Period** **Practical: 0 Periods** **Total: 45 Periods**

REFERENCES

1	*Steven C. Chapra, Raymond P., Canale,* ***"Numerical Methods for Engineers"****, McGraw Hill Education Pvt Ltd 8th Edition 2021.*
2	*Srimanthapal* ***"Numerical Methods, Principles, Analyses and Algorithm",*** *Oxford University Press,New Delhi, 1st Edition, 2009.*
3	*Veerarajan T and Ramachandran T* ***"Numerical Methods with Programming in C"*** *McGraw Hill Education Pvt Ltd, New Delhi, 1st Edition, Reprint,2016.*
4	*S.S.Sastry,* ***"Introduction to Methods of Numerical Analysis",*** *Prentice Hall of India, Delhi, 5th Edition, 2015.*
5	*Dr. J.S Chitode* ***"Numerical Methods"*** *Technical Publications, Pune, 2010.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the numerical solutions to algebraic, exponential, logarithmic, transcendental and linear system of simultaneous equations.	K3
CO2	Appreciate the numerical techniques of interpolation and error approximations in various intervals in real life situations.	K3
CO3	Apply the numerical techniques of finite differences to numerical differentiation and numerical integration in engineering problems.	K3
CO4	Understand the numerical solution to first order ordinary differential equations by different methods like single step and multistep.	K3
CO5	Solve second order partial differential equations with initial and boundary conditions by using certain techniques with engineering applications.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	-	2	2
CO2	3	2	3	-	2	3
CO3	3	2	3	-	2	2
CO4	3	2	2	-	2	2
CO5	3	2	3	-	2	2
23GEFC02	3	2	3	-	2	3
1–Slight,2–Moderate,3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	40	-	-	-	100
CAT2	20	40	40	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	20	40	40	-	-	-	100

23GEPC01	STRENGTH AND DEFORMATION CHARACTERISTICS OF SOILS	SEMESTER I

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objective	To impart knowledge on stress-strain characteristics of soils and its behaviour in the form of stress path and concepts of yield and failure criteria.

UNIT–I	SHEAR STRENGTH OF COHESIONLESS SOILS	9 Periods

Shear strength of granular soils– Direct shear– Triaxial Testing – Drained and undrained–Stress-strain behaviour – Dilatation – Contraction and critical states – Liquefaction and Liquefaction potential .Factors influencing–Stress-strain–Volume change behavior of soils.

UNIT–II	SHEAR STRENGTH OF COHESIVE SOILS	9 Periods

Shear strength of clays –Stress-strain behavior –Vane shear–UCC–Triaxial testing and stress path plotting– Pore pressure parameter of Skempton and Henkel–Total stress and effective stress approach –Shearstrengthofpartiallysaturatedclayintermsofstressstatevariables–Drainedandundrained–Factors influencing stress-strain and shear strength.

UNIT–III	YIELD CRITERION	9Periods

Concepts of yield and failure in soils–Yield criteria of Von Mises, Tresca,–their applicability to soils – Detailed discussion of Mohr–Coulomb failure criterion.

UNIT–IV	STRESS–STRAIN LAWS	9Periods

Stress-strain laws for soils–Hyperbolic law–Linear visco - Elastic and Elasto–Plastic laws–Yield functions, hardening law, flow rules and plastic strain computation– Cam-clay model.

UNIT–V	CRITICAL STATE SOIL MECHANICS	9Periods

Introduction to critical state soil mechanics –critical state line–Roscoe and Hvorslev's boundary Surface.

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES

1	*RobertD.Holtz., William D. Kovacs. Thomas C. Sheahan.,* ***"An introduction to geotechnical Engineering"*** *Dorling Kindersley India pvt. Ltd., Second edition,2013.*
2	*Braja,M.Das.,* ***"Advanced Soil Mechanics",*** *C R C Press, Fifth edition,2019.*
3	*Wood,D.M.,* ***"Soil behavior and Critical State Soil Mechanics",*** *Cambridge University Press, NewYork,1990*
4	*Lambe,T.W. and WhitmanR.V.,* ***Soil Mechanics in S.I. Units*** *John Wiley, India,PvtLtd.,2008.*
5	*AtkinsonJ.H. and BrandsbyP.L.* ***"Introduction to Critical State Soil Mechanics",*** *Indo American Books; Reprinted Edition, 2013.*

COURSE OUTCOMES: Upon completion of the course, the students will be able:		Bloom's Taxonomy Mapped
CO1	To evaluate the shear strength parameters of cohesionless soil and to gain knowledge about liquefaction.	K3
CO2	To obtain shear strength parameters of cohesive soil under different drainage conditions.	K3
CO3	To understand failure criteria of soils and apply models to study the time-deformation	K2

	behavior of soils.	
CO4	To understand stress strain laws of soils.	K1
CO5	To get an exposure towards critical state soil mechanics.	K1

COURSEARTICULATIONMATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	-	2	-	-
CO2	3	1	-	2	2	-
CO3	-	-	-	2	3	-
CO4	3	1	-	2	-	-
CO5	-	-	1	-	3	-
23GEPC01	3	1	1	2	3	-
1–Slight,2–Moderate,3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	40	20	-	-	-	100
CAT 2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPC02	ADVANCED FOUNDATION ENGINEERING	SEMESTER I

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objective	To learn different soil exploration techniques and to estimate load carrying capacity of different types of foundations including selection of suitable type of foundation on problematic soils.

UNIT–I	PLANNING OF SOIL EXPLORATION	9 Periods

Exploration methods for different projects - methods of borings - penetration tests - pressure meter test, field vane shear test - field permeability test-rock boring - offshore exploration- preservation, shipment and storage of samples.

UNIT–II	SHALLOW FOUNDATIONS	9 Periods

Requirements for satisfactory performance of foundations, methods of estimating bearing capacity, settlement of footing sand rafts – Proportioning of footings – Isolated, Combined and Raft foundations.

UNIT–III	PILE FOUNDATIONS	9 Periods

Methods of load carrying capacity 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, construction of Pile and Pile cap, lateral and uplift capacity of piles.

UNIT–IV	WELL FOUNDATION	9 Periods

Introduction - applications, different shapes, grip length, scour depth, forces acting on well foundation - Terzaghi and IRC methods of stability analysis – design of individual components of wells - Measures for rectification of tilts and shifts.

UNIT-V	FOUNDATIONS ON PROBLEMATIC SOILS AND COFFERDAMS	9 Periods

Problematic soils - Collapsible, soft deposits, Residual Soils, Organic soils, Dispersive and Varved Clays and expansive soil – Characterization and Engineering behavior Cofferdams –various types, analysis and design – Foundations under uplifting loads.

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES

1	*Narayan V.Nayak**, "Foundation Design Manual for Practising Engineers and Civil Engineering Students"**, Dhanpat Rai Publications Pvt. Ltd., Fourth edition(Reprint2001).*
2	*Bowles. J.E., **"Foundation Analysis and Design"**, Tata McGraw-Hill International Edition, 5th edition2001.*
3	*Das B.M., **"Shallow Foundations: Bearing capacity and Settlement"**, CRC Press,1999.*
4	*Tomlinson M.J., **"Pile design and Construction Practice"**, Chapman and Hall Publication,1994.*
5	*Braja. M.Das, **"Principles of Geotechnical Engineering"** Cengage India Private Limited, 9th Edition,2017*
6	*V.N.S.Murthy, **"Advanced Foundation Engineering"**, CBS Publishers & Distributors 1st Edition, 2017.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Identify and select suitable exploration techniques for different projects.	K2
CO2	Evaluate the bearing capacity and settlement of shallow foundations.	K3
CO3	Estimate the pile capacity and settlement of piles.	K3
CO4	Analyse the various components and forces acting on well foundation.	K3
CO5	Gain knowledge about different types of foundations in problematic soils.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	-	3	3
CO2	3	3	2	-	3	3
CO3	-	3	2	-	3	3
CO4	-	-	1	3	2	-
CO5	3	-	1	3	2	3
23GEPC02	3	3	2	3	3	3
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	25	25	50	-	-	-	100
CAT 2	20	20	60	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	25	25	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	20	20	60	-	-	-	100
ESE	20	20	60	-	-	-	100

23GEPC03	STRUCTURAL DESIGN OF FOUNDATIONS AND SUBSTRUCTURES	SEMESTER I

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objective	To impart knowledge on the structural design of shallow, deep and special type of foundations.

UNIT–I	DESIGN OF FOOTINGS	9 Periods

Introduction to Limit State Design of reinforced concrete in foundations; Soil pressure for structural design, Conventional structural design of continuous footings, individual footings – rectangular and circular, combined footings – rectangular, trapezoidal and strap.

UNIT–II	DESIGN OF RAFTS	9 Periods

Raft Foundations– Structural Design of rectangular and circular rafts and mats using conventional method of analysis, Analysis and design of rafts incorporating soil structure interaction using any FEM software.

UNIT–III	DESIGN OF PILES	9 Periods

Structural design of piles including pile caps, under - reamed piles.

UNIT–IV	DESIGN OF FOUNDATION AND COFFER DAM	9 Periods

Types of well foundation – components – structural design of well foundation – types of coffer dam – design – lateral pressure stability.

UNIT–V	DESIGN OF RETAINING WALLS	9 Periods

Structural design of retaining walls-Reinforced Concrete Cantilever retaining wall, Counterfort retaining wall, Flexible retaining Structures – Sheet Pile Wall, Anchored Bulk Heads.

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES

1	*Nainan P.Kurian **"Design of Foundation Systems: Principles and Practices"**, Narosa publish House, NewDelhi, 2005.*
2	*SwamiSaran, **"Analysis and Design of Substructures",** Oxford & IBH PublishingCo,2005.*
3	*TomlinsonM.J., **"Foundation Design and Construction",** PrenticeHal,2003l.*
4	*NainanP.Kurian **"Shell foundations: Geometry, Analysis, Design and Construction"**, Alpha Science International Ltd, 2006.*
5	*TomlinsonM.J., JohnWoodward **"Pile Design and Construction Practice",** Routledge,2008.*
6	*SomN.N., and DasS.C., **"Theory and Practice of Foundation Design",** Prentice Hall of India,2003.*
7	*Sharat Chandra Gupta, **"Raft Foundations – Design and Analysis with Practical Approach"**, New Age International Pvt. Ltd, New Delhi, 2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Design the isolated and combined footing.	K2
CO2	Carryout analysis and design of rafts	K3
CO3	Get familiarized with design of piles and pier.	K3
CO4	Carryout structural design of well foundation and cofferdam.	K3
CO5	Carryout design of retaining wall.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	2	3	-	1
CO2	1	-	2	3	1	1
CO3	1	-	2	3	1	1
CO4	1	-	2	3	1	1
CO5	1	-	2	3	1	1
23GEPC03	1	-	2	3	1	1
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	30	40	30	-	-	-	100
CAT 2	30	40	30	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	30	40	30	-	-	-	100

23GEPC04	ADVANCED SOIL MECHANICS LABORATORY	SEMESTER I

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	0	0	4	2

Course Objective	To get exposure on the characteristics of soil by performing detailed laboratory experiments and to be familiarized with the handling of Geotechnical instruments.

MODULES

TESTS ON SOIL

1. Determination of Moisture Content and Specific gravity of soil
2. Mechanical Sieve Analysis and Hydrometer Analysis
3. Atterberg's Limits (Liquid Limit, Plastic limit, Shrinkage limit)
4. Differential Free Swell Test
5. Vibration test for relative density of sand
6. Standard and modified Proctor compaction test
7. Constant head permeability test and Falling head permeability test
8. Consolidation test
9. Unconfined Compression test
10. Direct shear test
11. Tri-axial compression test – UU, CU, CD tests
12. Laboratory vane shear test
13. Swell Pressure Test

GEOTECHNICAL INSTRUMENTATION

1. Total Pressure using Earth pressure cell
2. Strain measurement using vibrating wire strain gauge
3. Depth and pressure of ground water using Piezometer
4. Water level in bore hole using Electronic water level indicator.

Contact Periods:

Lecture: 0 Period Tutorial: 0 Periods Practical: 60 Periods Total: 60 Periods

REFERENCES

1	*Shashi K Gulhati and Manoj Datta.,* ***"Geotechnical Engineering"*** *Tata McGraw Hill Company Limited, NewDelhi,2009*
2	*C.Venkatramaiah,* ***"Geotechnical Engineering"****, New Age International Publishers,2009*
3	*Gopal Ranjan, ASR Rao,* ***"Basic and Applied Soil Mechanics"****, New Age International Publishers, 2004.*
4	*Iqbal H Khan,* ***"Textbook of Geotechnical Engineering"****, PHI Learning Private limited, 2012.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Determine the physical characteristics of soils.	K3
CO2	Classify the given soils as per IS classification system.	K3
CO3	Determine the shear strength of the soil.	K3
CO4	Evaluate the compressibility and swelling characteristics of soils.	K3
CO5	Familiarize with handling of lab equipments and geotechnical instrumentation	K3

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	-	1	-	2	-	1
CO3	-	3	3	3	2	3

CO4	3	2	3	3	2	3
CO5	3	-	3	3	1	3
23GEPC04	3	1	3	3	2	3
1–Slight ,2–Moderate ,3–Substantial						

23GEPC05	SOIL DYNAMICS AND MACHINE FOUNDATIONS	SEMESTER II

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	1	0	4

Course Objective	To inculcate the fundamentals of soil dynamics and design different types of machine foundations based on the dynamic properties of soils and to get an exposure on vibration isolation techniques.

UNIT–I	THEORY OF VIBRATION	9+3 Periods

Introduction – Nature of dynamic loads – Basic definitions – Simple harmonic motion – Fundamentals of vibration – Single degree and multi degree of freedom systems – Free vibrations of spring – Mass systems – Forced vibrations – Resonance – Viscous damping – Principles of vibrations measuring systems–Effect of transient and pulsating loads.

UNIT–II	DYNAMIC SOIL PROPERTIES	9+3 Periods

Dynamic stress strain characteristics – Principles of measuring dynamic properties–Laboratory techniques – Field tests – Block vibration test – Factors affecting dynamic properties – Typical values. Mechanism of liquefaction – Influencing factors – Evaluation of liquefaction potential – Analysis from SPT test – Dynamic bearing capacity – Dynamic earth pressure.

UNIT–III	MACHINE FOUNDATIONS	9+3 Periods

Introduction – Types of machine foundations – General requirements for design of machine foundations. Design approach for machine foundation – Vibration analysis – Elastic Half Space theory – Mass – spring – dashpot model – Permissible amplitudes – Permissible bearing pressures.

UNIT–IV	DESIGN OF MACHINE FOUNDATION	9+3 Periods

Evaluation of design parameters – Types of Machines and foundations – General requirements – their importance – Analysis and design of block type and framed type machine foundations – Modes of vibration of a rigid foundation – Foundations for reciprocating machines, impact machines, Two –Cylinder vertical compressor, Double acting steam hammer – Codal recommendations. Empirical approach – Barken's method – Bulb of pressure concept – Pauw's analogy – Vibration table studies.

UNIT–V	VIBRATION ISOLATION	9+3 Periods

Vibration isolation – Types of isolation – Transmissibility – Passive and active isolation – Methods of isolation – Use of springs and damping materials – Properties of isolating materials – Vibration control of existing machine foundation.

Contact Periods:

Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 60 Periods

REFERENCES

1	*KameswaraRao,N.S.V.,* ***"Dynamics soil tests and applications"****, WheelerPublishing, NewDelhi 2000.*
2	*Moore,P.J.,* ***"Analysis and Design of Foundations for Vibrations"****, Oxford and IBH, 2006*
3	*KrammerS.L.,* ***"Geotechnical Earthquake Engineering"****, Prentice Hall, International series, Pearson Education (Singapore) Pvt Ltd, 2004.*
4	*SwamiSaran,* ***"Soil Dynamics and Machine Foundation"****, Galgotia publications Pvt. Ltd. New Delhi, 1999.*
5	*Prakash, S. and Puri, V.K.* ***"Foundations for Machines: Analysis and Design",*** *John Wiley & Sons, New York, U.S.A, 1988.*
6	*KameswaraRao,****"Vibration Analysis and Foundation Dynamics"****, Wheeler Publishing, NewDelhi, 1998.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	To solve dynamic soil problems using the knowledge acquired about theories of vibration	K2
CO2	To evaluate the dynamic properties of soil using laboratory and field tests.	K2
CO3	To acquire basic knowledge about types of machine foundations and design approach.	K2
CO4	To know and be capable of analyzing and designing machine foundations.	K3
CO5	To apply vibration isolation techniques for various field problems.	K1

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	1	-	2	-
CO2	-	-	3	2	-	-
CO3	3	-	-	2	1	-
CO4	1	-	2	-	-	-
CO5	1	-	-	-	2	-
23GEPC05	3	-	3	2	2	-
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	40	20	-	-	-	100
CAT 2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPC06	SITE EXPLORATION AND SOIL INVESTIGATION	SEMESTER II

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objective	To impart knowledge on the different exploration techniques, the samplers used for the Collection of samples and the various geotechnical instrumentation used for field monitoring.

UNIT–I	SCOPE AND OBJECTIVES OF SITE INVESTIGATION AND SUB SURFACE EXPLORATION	9 Periods

Scope and objective – Preliminary desk studies – Planning an exploration Programme – Location – Spacing – Depth of borings – Stabilization of boreholes – Soil Profile – Borelog – Data Presentation – Marine exploration and exploration reports.

UNIT–II	EXPLORATION TECHNIQUES	9 Periods

Methods of boring and drilling – Non – displacement and displacement methods – Drilling in difficult sub-soil conditions – Advantages and limitations of various drilling techniques- Geophysical exploration and interpretation Seismic refraction and electrical resistivity methods.

UNIT–III	SAMPLES AND SAMPLERS	9 Periods

Type of samples – Disturbed and undisturbed – Sample disturbance – Design features affecting sample disturbance – Area and recovery ratio – RQD – Types of samplers – Methods for preventing loss of samples – Shallow penetration samplers – Advanced sampling techniques – Offshore sampling – Preservation and handling of samples.

UNIT–IV	FIELD TESTING	9 Periods

Field tests – Importance – Penetration testing – Standard Penetration Test – Static Cone Penetration Test – Dynamic cone penetration test – Plate load test – Field Vane shear test – Pressure meter test –Dilatometer test – Data interpretation – Field Permeability test.

UNIT–V	INSTRUMENTATION	9 Periods

Instrumentation in soil Engineering – Pore pressure – Ground water table – Strain gauges – Resistance and induction type – Load cells – Earth pressure cells – Settlement and heave gauges – Piezometer sand slope indicators – Inclinometer – Case studies.

Contact Periods:
Lecture: 45 Periods Tutorial : 0 Periods Practical : 0 Periods Total: 45 Periods

REFERENCES

1	*Buert.G.,Taylor & Francis,* ***"Hand book of Geotechnical Investigation and Design Tables"*** *2nd Edition, 2019.*
2	*M. Jund H vorslev* ***"Surface exploration and sampling of soils for Civil Engineering Purposes"*** *— Waterways Experiment Station, MISSISSIPPI,1978.*
3	*E. Hunt* ***"Geotechnical Engineering Investigation Handbook"****, McGraw Hill, 2nd edition, 2019.*
4	*Winterkorn, H.F and Fang, H.Y.,* ***"Foundation Engineering Handbook"****, Nostrand Reinhold 1994.*
5	*Hanna T.H.,* ***"Field Instrumentation in Geotechnical Engineering"****, Trans Tech., 1985.*
6	*Cudoto and Donald* ***"Geotechnical Engineering Principles and Practices"****,New jersey: Pearson Higher Education, 2011.*

COURSE OUTCOMES: Upon completion of the course ,the students will be able to:		Bloom's Taxonomy Mapped
CO1	Plan for soil investigation and exploration in soil and rock.	K2
CO2	Select appropriate equipment for the exploration work for different subsoil condition.	K3
CO3	Gain the practice of recovering samples using advanced sampling techniques.	K3
CO4	Assess the importance of field testing and handling of field equipment.	K3
CO5	Implement geotechnical instrumentation in the field and evolve solutions for different soil conditions	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	3
CO2	-	3	3	-	3	3
CO3	3	3	3	-	2	3
CO4	3	2	1	1	2	3
CO5	3	2	1	1	2	3
23GEPC06	3	3	3	1	2	3
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	20	30	50	-	-	-	100
CAT 2	20	30	50	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	40	60	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	40	60	-	-	-	100
ESE	20	30	50	-	-	-	100

23GEPC07	SUBSOIL EXPLORATION LABORATORY				SEMESTER II
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**PC**	**0**	**0**	**4**	**2**

Course Objective	To impart practical exposure to subsurface exploration through different field and laboratory testing.

List of Practicals:

1. Auger boring
2. One dimensional Consolidation Test
3. Triaxial test
4. Standard Penetration test
5. Dynamic Cone Penetration test
6. Static cone penetration test
7. Light Weight Deflectometer test
8. Ring shear Apparatus
9. Electrical Resistivity meter test
10. Plate load test (Demo only)
11. Dynamic pile load test (Demo only)

Contact Periods:

Lecture: 0 Period Tutorial: 0 Periods Practical: 60 Periods Total: 60 Periods

REFERENCES

1	*J.E.Bowles,* ***"Physical and Geotechnical Properties of Soils"****, 2nd Edition, Mc.GrawHill, New York, 1984.*
2	*Das,B.M.,* ***"Soil Mechanics Laboratory Manual"****, Engineering Press, Austin, 1997.*
3	*Al-Khataji, A.W. and Anderstand,O.B.,* ***"Geotechnical Engineering & Soil Testing"****, Sounders College Publishing, FortWorth, 1992.*
4	*Alam Singh and Chowdary,G.R.,* ***"Soil Engineering in Theory and Practice (Vol.2)*** *Geotechnical Testing and Instrumentation, CBS Publishers and Distributors, NewDelhi, 2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To attain adequate knowledge in assessing compressibility and shear strength Characteristics of soils	K5
CO2	To gain knowledge in assessing the safe bearing capacity of soil through field tests.	K5
CO3	To assess the subgrade modulus of soil or design of pavement thickness.	K5
CO4	To perform geophysical exploration test and interpret the results.	K5
CO5	To attain ability for solving geotechnical problems in field.	K5

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	2	-	1	-
CO2	-	1	-	2	-	-
CO3	3	1	-	1	-	-
CO4	-	2	2	-	2	-
CO5	2	-	-	2	1	-
23GEPC07	3	1	2	2	1	-

1–Slight, 2–Moderate, 3–Substantial

23GEPC08	FINITE ELEMENT ANALYSIS LABORATORY	SEMESTER II

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	0	0	4	2

Course Objective	To acquire knowledge of software applications for various field problems and for various conditions and to demonstrate the ability to use computer-based techniques for analysis.

MODULEI

1. Shallow and deep foundations, slope stability analysis
2. Retaining walls, reinforced earth structures using geotechnical software packages.
3. Seismic hazard analysis and ground response analysis
4. Mathematical and statistical packages (MATLAB and SPSS)
5. Data processing and graphical presentation using MS EXCEL and ORIGIN.

Contact Periods:
Lecture: 0 Periods Tutorial: 0 Periods Practical: 60 Periods Total: 60 Periods

REFERENCES

1	*Rajasekaran.S, Finite Element Analysis in Engineering Design, wheeler publishing,1993*
2	*Krishnamurthy, Finite Element Analysis – Theory and Programming, second Edition, Tata Mcgraw Hill Publishing.Co, 1994*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Attain sample knowledge in analyzing the settlement of the substructure	K3
CO2	Trained to gain data in assessing the various geotechnical problems	K3
CO3	Analyzing capability for various the slope stability problems	K3
CO4	Gain knowledge in various dynamic analysis problems and analyzing various structures like raft, pile draft, embankment etc.,	K3
CO5	Gain knowledge about mathematical and statistical packages	K3

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	2	-	1
CO2	1	-	3	2	-	1
CO3	2	-	3	3	1	2
CO4	1	-	2	3	1	2
CO5	2	-	3	3	-	1
23GEPC08	1	-	3	3	1	1

1–Slight, 2–Moderate, 3–Substantial

23GEEE01	MINI PROJECT	SEMESTER II

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	0	0	4	2

Course Objective	To evaluate various methods, methodologies and to arrive solutions for various geotechnical problems.

1. Design Project will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.
2. End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution.
3. Continuous assessment of Mini Project at Mid Semester and End Semester will be monitored by the departmental committee.

Contact Periods:

Lecture: 0 Periods Tutorial: 0 Periods Practical: 60 Periods Total: 60 Periods

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify geotechnical engineering problems reviewing available literature.	K3
CO2	Study different techniques used to analyze complex Geotechnical systems.	K4
CO3	Work on the solutions given and present solution by using his/her technique Applying engineering principles	K4
CO4	Identify the methodology to analyze Geotechnical problems	K3
CO5	Preparation of reports on the project designed.	K4

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	3	-	1
CO2	1	-	3	2	-	1
CO3	2	-	2	3	1	2
CO4	1	-	2	3	1	2
CO5	2	-	2	3	-	1
23GEEE01	1	-	2	3	1	1

23GEEE02	INTERNSHIP / INDUSTRIAL TRAINING	SEMESTER III

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	-	-	-	-

Course Objective	To train the students to apply theoretical knowledge to practical problems and to make them thorough with the use various geotechnical equipments and software's to design Geotechnical structures.

MODULE

1. Students can undertake training in any reputed organization dealing Geotechnical Engineering related projects for a period of Four weeks.
2. On completion of the training programme, students have to submit detailed report on the works undertaken.
3. Evaluation will be done by the internal committee based on the report submission and on the Presentation made.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Know the field problems and relate theoretical knowledge and practical experience.	K1
CO2	Work in multi-disciplinary projects either individually or as a team.	K3
CO3	Handle real-time problems and providing solutions to complex situations.	K3
CO4	Undertake collaborative research projects meeting society demands.	K3
CO5	Submit documentation of works in the form of reports.	K3

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	3
CO2	3	-	3	2	3	2
CO3	3	-	3	3	3	2
CO4	3	-	3	2	3	2
CO5	-	3	-	-	-	1
23GEEE02	3	3	3	2	3	2

23GEEE03	PROJECT - I	SEMESTER III

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	0	0	24	12

Course Objective	To identify field problems and to develop suitable methodologies for finding solutions and to present the work in the form of report.

MODULE

1. Project works are undertaken by the students in the different areas of Geotechnical Engineering like Ground Improvement, Slope stability analysis, Environmental Geotechnology, Earthquake Engineering, Soil Dynamics, Earth Reinforcement, Pavement Engineering, Bearing capacity – settlement studies by conducting model load test etc. in the departments of that the students are capable of giving solutions to various Geotechnical problems.

2. Collection of literatures from indexed journals, thorough and detailed study of the collected literatures will help the students to identify and choose the right problem for the Phase I project.

3. In addition to problem identification, review of literatures helps the students to form alternative wide ideas, techniques, and methodologies to evolve solutions for the selected topic of research work.

4. Preliminary studies and few laboratory investigations are to be carried out in the Phase I project which will help the students to undertake a detailed study in Phase II.

Contact Periods:
Lecture: 0 Periods Tutorial: 0 Periods Practical: 360 Periods Total: 360 Periods

COURSEOUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Know the state of art in the area and will be in a position to carry the phase I Project in a systematic way.	K3
CO2	Enhance the ability to work independently on the topic using different Experimental and analytical approaches.	K3
CO3	Acquire a formulated methodology in solving any problem and to present the Solutions in a proper way.	K3

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	1	1
CO2	3	2	2	1	1	1
CO3	3	1	2	2	2	2
23GEEE03	3	3	2	1	1	1

1–Slight, 2–Moderate, 3–Substantial

23GEEE04	PROJECT - II	SEMESTER IV

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	–	–	*	24

Course Objective	To carry out extensive research on current topics and problems of societal needs, giving relevant solutions to the identified problems, and also to publish papers in referred journals.

MODULE

1. The primary objective of this course is to find the research potential in various themes of Geotechnical Engineering.

2. The students are trained to do extensive literature survey in order to get in depth knowledge and finding research gaps on the selected topics.

3. To carry out detailed experimental analysis/numerical modeling/field studies on specific research topics to give solutions to various Geotechnical Engineering related problems.

4. During the course, the students develop skills in the documentation of work, preparation of technical papers and to make technical presentations.

Contact Periods:

Lecture: 0 Period Tutorial: 0 Period Practical: 720 Periods Total: 720 Periods

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Familiarize with the laboratory and field equipments related to the research topic.	K1
CO2	Conduct numerical analysis of various Geotechnical structures	K2
CO3	Prepare detailed documentation of the research work	K3
CO4	Make presentation and publication of the research outcomes	K3
CO5	Give solutions to challenging problems in the area of Geotechnical Engineering	K3

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	-	2	3	-
CO2	3	-	-	3	3	-
CO3	1	3	3	1	-	1
CO4	1	3	3	1	2	1
CO5	3	-	-	3	3	3
23GEEE04	3	3	3	3	3	1

1–Slight, 2–Moderate, 3–Substantial

23GEPE01	REMOTE SENSING AND ITS APPLICATIONS IN GEOTECHNICAL ENGINEERING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objective	To introduce the elements of GIS applied to Geotechnical Engineering and to be familiar withthe use of GIS and GPS.

UNIT–I	INTRODUCTION	9 Periods

Remote sensing Fundamentals: Definition–Scope–Types and historical development–Ideal and real remote sensing system. Comparison of conventional survey, aerial remote sensing and satellite remote sensing–Advantages and limitation of satellite remote sensing.

EMR and Remote Sensing: Energy sources–Electro Magnetic Radiation–Spectral regions–Energy Interaction in the atmosphere–Atmospheric windows–Energy Interaction with earth surface features–Spectral reflectance patterns for different region of EMR

UNIT- II	SENSORS AND PLATFORMS	9 Periods

Land observation satellites and sensors LANDSAT-Classification of sensors and platforms LANSAT, SPOT, IRS and IKONS sensors–scanning and orbiting mechanisms–Resolution: spatial, spectral, radiometric and temporal resolution of the satellites–Classification of platforms.

UNIT–III	IMAGES INTERPRETATION AND DIGITAL IMAGE PROCESSING	9 Periods

Interpretation procedure–Elements of Photo Interpretation–Strategies of Image Interpretation–Keys of Image Interpretation–Basic equipments for Image Interpretation–Digital Signal Processing Digital analysis–Image Rectification and Restoration–Geometric correction–Image Enhancement and Image transformation

UNIT–IV	GEOGRAPHICAL INFORMATION SYSTEM (GIS)	9 Periods

Definition data input and output: Topology, Digital elevation data–Data management–Relational data model –Spatial data models–Raster and Vector data Models–GIS analysis–Classification, overlay operation.

UNIT–V	APPLICATION OF REMOTE SENSING AND GIS IN GEOTECHNICAL ENGINEERING	9 Periods

Role of Remote Sensing and GIS in terrain investigation–Digital Terrain Modeling (DTM)–Triangulated Irregular Network (TIN)–Land use and Land cover mapping–Land slide studies and seismic hazard mapping.

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES

1	*A M Chandra, S K Ghosh,* ***"Remote Sensing and Geographic information system"****, Narosa Publishing house.2016.*
2	*LillesandT.M. and Kiefer R.W.,* ***"Remote Sensing and image interpretation"****, John Wiley and Sons, NewYork.2015.*
3	*J.B.Campbell, Taylor&Francis,* ***"Introduction to remote sensing"****, London.1985.*
4	*J.R.Jensen,* ***"Introductory digital image processing"****, Prentice Hall International Ltd., London. 2009.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Study about the remote sensing system, analysis of data and the interpretation of data.	K1
CO2	Obtain knowledge about remote sensing sensors and platforms.	K2
CO3	Gain the knowledge about image interpretation and processing techniques.	K2
CO4	Gain the knowledge about data collection and management of GIS.	K1
CO5	Know the application of GIS in various fields.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	-	-	-	-
CO2	-	-	-	-	-	1
CO3	-	-	-	-	-	-
CO4	-	2	-	-	-	1
CO5	-	-	2	-	1	2
23GEPE01	1	2	2	-	1	2
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	40	30	30	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	30	40	30	-	-	-	100
ESE	35	35	30	-	-	-	100

23GEPE02	SOIL PROPERTIES AND BEHAVIOUR					
PREREQUISITES:		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To study the different clay minerals and to understand the properties of soils and also to predict soil behavior using conduction phenomenon.					
UNIT–I	**FORMATION OF SOILS AND CLAY MINERALS**					**9 Periods**
Introduction – Soil Formation – Types of soils – Geological and pedogical background –Various soil deposits and their engineering suitability – Composition and structure of clay minerals – Structure of Allophane, Kaolinite, Hallosite, Montmorillonite, Illite, Chlorite and Vermiculite minerals, mixed layer minerals-Classification and identification of clay minerals– X- ray diffraction data – electron microscopic analysis–Differential thermal analysis–Anion and cation exchange capacity of clays– Specific surface area– Bonding in clays.						
UNIT–II	**PHYSICAL AND PHYSIO-CHEMICAL BEHAVIOUR OF SOIL**					**9 Periods**
Physical and Physio-Chemical behavior of Soils–Diffused double layer theory–Computation of double layer distance–Dielectric constant–Temperature on double layer–Ion Exchange–Cation exchange capacity– Causes of cation exchange effect–Fixation of cations–Determination of cation Exchange capacity–Exchangeable cations.						
UNIT–III	**EXPANSIVE AND SHRINKING SOIL**					**9 Periods**
Introduction–Swelling and shrinking behaviour of soils–Problems associated–Characteristics affecting shrinkage – Crack formation during shrinkage – Measurements of shrinkage for samples –Identification of expansive clays.–Factors influencing swell– Shrink characteristics–Swelling pressure of soils–Swell pressure determination –Mechanism of swelling–Volume changes and Engineering problem in the field– Osmotics well pressure–Soil fabric and measurement-Pore characterization-voids distribution–Methods of fabric characterization-.						
UNIT–IV	**COMPRESSIBILITY AND COLLAPSIBLE SOIL**					**9 Periods**
Introduction–Compressibility–Permeability behaviour of soils and clays–Mechanism involved –Factors governing compressibility–Soil water–Consumption of soilwater –Capillary tube, capillary potential–Soil moisture–Methods of determination of soil moisture–Physical behavior of soil water systems–Liquefaction– Liquefaction potential–Soil suction–Determination of suction potential–Collapsible soil– identification– Effects on foundation.						
UNIT–V	**CONDUCTION PHENOMENON AND PREDICTION OF SOIL BEHAVIOUR**					**9 Periods**
Conduction in soils–Coupled flows–Electrical, Chemical, Hydraulic and Thermal flows in soils– Consolidation by Electro-osmosis–Clay mineralogy in relation to physical and engineering properties of clay minerals–Prediction of engineering behavior of soils–Empirical correlations and their applicability– Granular soil structure–Clay structure models.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*Bowles J.E.,* ***"Engineering properties of soils and their measurement"****, McGraw Hill. 4th Edition, 2012.*
2	*Mitchell J.K.,* ***"Fundamentals of Soil Behaviour"****, John Wiley, NewYork, 1993.*
3	*Knappett J.A and R.F.Craig.,* ***"Craig's Soil Mechanics"*** *Span Press, 2012.*
4	*Braja.M.Das,* ***"Principles of Foundation Engineering"****, C L Engineering, 2013.*
5	*Mc Carthy D.F.,* ***"Essentials of Soil Mechanics and Foundations"****, Prentice Hall, 2002.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Get knowledge about the structure and identification of clay minerals.	K1
CO2	Use the concept of diffuse double layer theory and the cation exchange capacity to determine the chemical behavior of soils.	K3
CO3	Analyse the mechanism and effects of swelling, shrinkage in clay soils.	K3
CO4	Assess the behavior of collapsible soil and the compressibility characteristics.	K3
CO5	Use the clay models and conduction phenomenon to predict the Engineering behavior of soils.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	1	3	3
CO2	2		1	1	2	2
CO3	2	1	3	2	3	2
CO4	3	3	3	1	3	3
CO5	2	2	1	2	3	2
23GEPE02	2	2	3	1	3	2
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	30	30	40	-	-	-	100
CAT 2	20	20	60	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	25	25	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	20	20	60	-	-	-	100
ESE	20	20	60	-	-	-	100

23GEPE03	SUSTAINABLE GEOTECHNICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objective	To learn the characterization of geomaterials, understand the interaction mechanism and to adopt suitable remediation technologies.

UNIT–I	INTRODUCTION	9 Periods

Scope - Geotechnical Engineering for sustainability – efficient and environment friendly materials in geotechnical works - Recent trends - Natural and manmade environments - Sources and types of ground contamination - pollution problem sand waste minimization – role of soiling geo- environmental applications.

UNIT–II	CHARACTERIZATION OF GEOMATERIAL	9 Periods

Need for material characterization and its types-physical, chemical, geotechnical, mineralogical, waste and recycled material – modeling and design methods of Waste Mechanics - lifecycle assessment in Geotechnical applications.

UNIT–III	ENVIRONMENTAL INTERACTION	9 Periods

Soil - Water – Environmental interaction, Soil – Contaminant Interaction, Contaminant Transport and the fate of contaminants. Monitoring of contaminated land – case studies (related to soil contamination)

UNIT–IV	REMEDIATION TECHNIQUES	9 Periods

Method of remediation – isolation and containment - on site, ex-situ soil cleaning, soil washing-Thermal desorption - soil vapour extraction - air stripping - ground freezing - soil heating - Traditional and innovative barrier technologies - Eco-friendly ground improvement techniques - monitoring of remediation (during treatment and post treatment)-case studies

UNIT–V	SUSTAINABLE DEVELOPMENT	9 Periods

Definition – components of sustainable development – climatic change and energy depletion - Bio-Geotechnology – energy Geotechnology - sustainable geotechnical design - sustainable use of underground space – utilization of geo-material for sustainable development – industrial by-products and applications – land reclamation - Case Studies

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES

1	*Slobodan B.Mickovski,* ***"Sustainable Geotechnics (Theory, Practice, and Applications)"*** *MDPI, UK.ISBN978-3-0365-1480-2(PDF)*
2	*Sanjay Kumar Shukla, Sudhir kumarV.Barai,* ***"Advances in Sustainable Construction Materials And Geotechnical Engineering",*** *Proceedings of TRACE2018.*
3	*Environmental Geotechnics, Edited by (ISSMGE) Second Edition 2006*
4	*Reddy, K.R., and Adams, J.A.,* ***"Sustainable Remediation of Contaminated Sites",*** *Momentum Press, NewYork, 2015, 160p.(ISBN:9781606505205).*
5	*HariD.Sharma ,KrishnaR.Reddy "GeoEnvironmental Engineering", John Wiley&Sons, Inc.2004*
6	*Reddy, K.R.,Cameselle, C.,andAdams,J.A., "Sustainable Engineering :Drivers, Metrics, Tools, and Applications", John Wiley & Sons, Inc., Hoboken, NewJersey, 2019, 544p(ISBN:978-1-119-49393-8).*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Gained equate knowledge on the scope and the use of environment friendly materials	K2
CO2	Characterize the geo-materials and to carryout life cycle assessment studies	K3
CO3	Study the mechanism and interaction between soil, water, air and the geo-material	K3
CO4	Assess and select appropriate remediation techniques	K3

CO5	Develop methodologies for sustainability of materials, technologies and in Geotechnical design	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	2	-	2
CO2	1	-	3	-	-	2
CO3	2	1	1	1	3	3
CO4	3	1	1	-	-	3
CO5	3	2	3	3	3	2
23GEPE03	3	2	3	3	3	2
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	30	30	40	-	-	-	100
CAT 2	30	30	40	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	20	20	60	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	20	20	60	-	-	-	100
ESE	30	30	40	-	-	-	100

23GEPE04	REINFORCED SOIL STRUCTURES					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To impart knowledge on geosynthetics, design principles, materials and mechanism of reinforced soil, soil nailing and its applications in dams, embankments, pavements and foundation structures.					
UNIT–I	**PRINCIPLES AND MECHANISMS**					**9 Periods**
Historical background – Initial and recent developments – Principles, Concepts and mechanisms of reinforced soil – Factors affecting behavior and performance of soil – Reinforcement interactions.						
UNIT–II	**MATERIALS AND MATERIAL PROPERTIES**					**9 Periods**
Materials used in reinforced soil structures – Fill materials, reinforcing materials, metal strips, Geotextile, Geogrids, Geomembranes, Geocomposites, Geojutes, Geofoam, natural fibres, coir Geotextiles – Bamboo – Timber – Facing elements – Properties – Methods of testing – Advantages and disadvantages – Preservation methods.						
UNIT–III	**DESIGN PRINCIPLES AND APPLICATIONS**					**9 Periods**
Design aspects of reinforced soil – Soil reinforcement function – Separator, Filtration, Drainage, Barrier function – Design and applications of reinforced soil of various structures – Retaining walls –Foundations – Embankments and slopes.						
UNIT–IV	**GEOSYNTHETICS AND APPLICATIONS**					**9 Periods**
Introduction – Historical background – Applications – Design criteria – Geosynthetics in roads –Design – Giroud and Noiray approach – Geosynthetics in landfills – Geosynthetic clay liner – Design of landfills – Barrier walls.						
UNIT–V	**SOIL NAILING AND CASE HISTORIES**					**9 Periods**
Soil nailing – Introduction – Overview – Soil-Nail interaction – Behaviour – Design procedure –Behaviour in seismic conditions. Performance studies of reinforced dams, embankments, Pavements, Railroads, Foundations – Case studies.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*Jewell, R.A.,* ***"Soil Reinforcement with Geotextile"****, CIRIA, London, 1996.*
2	*John, N.W.M.,* ***"Geotextiles"****, John Blackie and Sons Ltd., London, 1987.*
3	*Jones, C.J.F.P.,* ***"Earth Reinforcement and Soil Structures"****, Earthworks, London, 1982.*
4	*Koerner, R.M.,* ***"Designing with Geosynthetics"****, (Third Edition), Prentice Hall, 1997.*
5	*Proc. Conference on polymer and Reinforcement, Thomas Telford Co., London, 1984.*
6	*Gray,D.H., and Sotir, R.B.****,"Biotechnical and Soil Engineering Slope Stabilization. A Practical Guide for Erosion Control"****, John Wiley & SonInc., NewYork, 1996.*

COURSE OUTCOMES: Upon completion of the course, the students will be able:		**Bloom's Taxonomy Mapped**
CO1	To understand the soil-reinforcement interaction mechanism.	K2
CO2	To enrich their knowledge on properties, testing methods of geosynthetics in Earth reinforcement.	K1
CO3	To get detailed knowledge on soil reinforcement functions and the ability to Select suitable reinforcing material to suit the functional requirement.	K3

CO4	To understand the design criteria for use of geosynthetics in landfills, pavement, liners.	K2
CO5	To design various soil reinforcements, soil nailing major projects.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	-	-	2	-
CO2	-	-	3	3	2	2
CO3	2	-	1	-	-	-
CO4	-	-	-	-	3	-
CO5	2	-	-	-	2	1
23GEPE04	2	-	3	3	2	2
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPE05	FINITE ELEMENT ANALYSIS FOR GEOTECHNICAL ENGINEERING				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**PE**	**3**	**0**	**0**	**3**
Course Objective	To impart knowledge on elasticity concepts, finite element processes and soil applications.				
UNIT–I	**INTRODUCTION TO ELASTICITY**			**9 Periods**	
Principles of Elasticity – Elasticity Equations - Stress-strain equations – Strain-Displacement relationships in Matrix form – Equilibrium equations - Compatibility equations – Plane stress and Plane strain equations axisymmetric formulation.					
UNIT–II	**FINITE ELEMENT PROCESS**			**9 Periods**	
Historical background - Matrix approach - Principles of discretization, Classical techniques in FEM – Weighed residual method - Galerkin method - Variational approach - The Rayleigh Ritz method - Numerical integration – Gaussian Quadrature technique – Formulation of Stiffness matrix – Element stiffness matrix – Global stiffness matrix					
UNIT–III	**ELEMENT PROPERTIES AND ISOPARAMETRIC FORMULATIONS**			**9 Periods**	
Concept of an element – Various element shapes – Displacement models – Generalized coordinates – Shape Functions – Formulation of 4-noded and 8-noded isoparametric quadrilateral elements – Lagrangian elements –Serendipity elements					
UNIT–IV	**HIGHER ORDER ELEMENTS**			**9 Periods**	
Finite Element Analysis on Two-dimensional problem – CST and LST elements – formulation – Element matrices Assembly – Boundary conditions and solutions – Axisymmetric elements – Applications of the axisymmetric element – Stress distribution in thick cylinder - Boussineq's problem.					
UNIT–V	**SOIL APPLICATIONS**			**9 Periods**	
Geotechnical considerations - Choice of Soil Properties for Finite Element Analysis - Total stress analysis - pore pressure calculation - Real soil behaviour - behaviour of clay, sand and both clay and sand - Simple elasto plastic constitutive models - Tresca, Von-mises and Mohr-coulomb models - Non-linear models— Modified Newton Raphson method - Seepage and consolidation: steady state seepage - Hydraulic boundary conditions -- Permeability model sun confined seepage flow- Consolidation Analysis: settlement analysis - Terzaghi's consolidation problem –Finite Element Analysis on embankments, shallow foundations, Earth retaining structures and pile group behaviour.					
Contact periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**					

REFERENCES

1	*Krishnamurthy C.S, **"Finite Element Analysis – Theory and programming"**, Second edition, Tata McGraw Hill Publishing Co.2004*
2	*Desai C.S., **"Elementary Finite Element Method"**, Prentice Hall, INC1979*
3	*Rajasekaran S ., **"Finite Element Analysis in Engineering Design",** Wheeler publishing, 2008*
4	*Chandrapatla Tirupathi.Rand Belegundu, Ashok. D., **"Introduction to Finite Elements in Engineering,** Second edition, Prentice Hall of India, 2014*
5	*David M Potts. And Lidija, Zdravkovic, **Finite Element Analysis in Geotechnical Engineering,** Vol 1&2. Thomas Telford, London.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the various stress-strain-displacement relations.	K1
CO2	Know the concept of stiffness matrix and understand choosing boundary conditions and various classical techniques of FEA.	K2

CO3	Know the elements and its discretization to solve the problems of various element types.	K2
CO4	Learn higher order elements in finite element analysis.	K3
CO5	Attain exposure towards various concepts in geotechnical finite element analysis.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	2	2	-	1
CO2	1	-	3	2	-	1
CO3	2	-	3	3	1	2
CO4	1	-	2	3	1	2
CO5	2	-	3	3	-	1
23GEPE05						
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	30	40	30	-	-	-	100
CAT 2	30	40	30	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	30	40	30	-	-	-	100

23GEPE06	FOUNDATION IN EXPANSIVE SOILS				
PREREQUISITES:	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**PE**	**3**	**0**	**0**	**3**

Course Objective	To study the properties, the controlling techniques of swelling and to select suitable foundations in expansive soils.

UNIT–I	**GENERAL PRINCIPLES**	**9 Periods**

Origin of expansive soils – Physical properties of expansive soils – Mineralogical composition – Identification of expansive soils – simple laboratory tests – Classification of expansive soils – Field conditions that favour swelling – Consequences of swelling.

UNIT–II	**SWELLING CHARACTERISTICS**	**9 Periods**

Swelling Mechanism, Swelling measurements – factors affecting – Laboratory methods – Prediction of Swelling characteristics – Evaluation of heave.

UNIT–III	**TECHNIQUES FOR CONTROLLING SWELLING**	**9 Periods**

Horizontal moisture barriers – Vertical moisture barriers – Surface and subsurface drainage – Pre-wetting – Soil replacement – Sand cushion techniques – CNS layer technique.

UNIT–IV	**FOUNDATIONS ON EXPANSIVE SOILS**	**9 Periods**

Belled piers – Bearing capacity and skin friction – Advantages and disadvantages – Design of belled Piers – Under-reamed piles – Design and construction.

UNIT–V	**MODIFICATION OF SWELLING CHARACTERISTICS**	**9 Periods**

Lime stabilization – Mechainsms – Limitations – Lime injection – Lime columns – Mixing – Chemical stabilization – Construction.

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES

1	*Fu Hua Chen, **"Foundations on Expansive Soils"**, Elsevier Scientific Publishing Company, NewYork, 2012.*
2	*Gopal Ranjan and A.S.RRao, **"Basic and Applied Soil Mechanics"**, New Age International Publishers–NewDelhi, 2018.*
3	*Hand Book on **"Under reamed and Bored Compaction Pile Foundation"**, CBRI, Roorkee. 2001.*
4	*IS:2720 (PartXLI) –1977–Measurement of Swelling Pressure of Soils.*
5	*R.K.Katti, D.R KAtti, A.R.Katti, **"Behaviour of Saturated Expansive Soil & Control Methods",** CRC Press, 2002.*
6	*Alam Singh, **"Modern Geotechnical Engineering",** Geo-Environ Academia, Jodhapur.3rd Edition, 2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Assess the occurrence and distribution of expansive soils.	K2
CO2	Study the properties of expansive soils and the controlling techniques.	K2
CO3	Get exposure on various methods of stabilization of expansive soils.	K3
CO4	Design different types of foundations on expansive soil.	K3
CO5	Select suitable techniques and learn the mechanism of treatment of swelling soils.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	1	1	-
CO2	3	2	3	1	2	3
CO3	3	2	3	2	2	2
CO4	-	3	3	1	3	3
CO5	2	1	2	2	3	2
23GEPE06	3	2	3	1	3	3
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	30	40	30	-	-	-	100
CAT 2	30	40	30	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	20	30	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	20	30	50	-	-	-	100
ESE	30	40	30	-	-	-	100

23GEPE07	SOIL STRUCTURE INTERACTION *(Common to Structural & Geotechnical Engineering)*				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**PE**	**3**	**0**	**0**	**3**

Course Objective	To inculcate the knowledge on soil foundation interaction, soil models and elastic analysis of piles and piled raft.

UNIT–I	**SOIL – FOUNDATION INTERACTION**	**9 Periods**
Introduction to soil – Foundation interaction problems – Soil behaviour – Foundation behaviour – Interface behaviour – Scope of soil - foundation interaction analysis – Soil response models – Winkler, Elastic continuum, Two parameter elastic models, Elastic – Plastic behaviour – Time dependent behaviour.		
UNIT–II	**BEAM SON ELASTIC FOUNDATION – SOIL MODELS**	**9 Periods**
Infinite beam – Two parameters – Isotropic elastic half space – Analysis of beams of finite length – Classification of finite beams in relation to their stiffness – Analysis through application packages		
UNIT–III	**PLATE ON ELASTIC MEDIUM**	**9 Periods**
Infinite plate – Winkler, Two parameters, Isotropic elastic medium, Thin and thick plates – Analysis of finite plates – Rectangular and circular plates – Numerical analysis of finite plates – Simple solutions – Analysis of braced cuts– Application packages.		
UNIT–IV	**ELASTIC ANALYSIS OF PILE**	**9 Periods**
Elastic analysis of single pile – Theoretical solutions for settlement and load distribution – Analysis of pile group – Interaction analysis – Load distribution in groups with rigid cap – Pile raft–Application packages.		
UNIT–V	**LATERALLY LOADED PILE**	**9 Periods**
Load deflection prediction for laterally loaded piles – Subgrade reaction and elastic analysis – Interaction analysis – Pile raft system – Solutions through influence charts – Application packages		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES

1	*Saran,S., **"Analysis and design of substructures",** Taylor & Francis Publishers, 2006.*
2	*Hemsley, J.A., **"Elastic Analysis of Raft Foundations"**, Thomas Telford, 1998.*
3	*Poulos, H.G., and Davis, E.H., **"Pile Foundation Analysis and Design",** John Wiley, 2008.*
4	*Murthy, V.N.S., **"Advanced Foundation Engineering"**, CBS Publishers, NewDelhi, 2007.*
5	*McCarthy, R.N., **"Essentials of Soil Mechanics and Foundations: Basic Geotechnics"**, Sixth Edition, Prentice Hall, 2002.*
6	*Selvadurai, A.P.S., **"Elastic Analysis of Soil Foundation Interaction"**, Elsevier, 1979.*
7	*Scott, R.F., **"Foundation Analysis"**, Prentice Hall, 1981.*
8	*Structure Soil Interaction–State of Art Report, **Institution of structural Engineers, 1978.ACI336, Suggested Analysis and Design Procedures for Combined Footings and Mats,** American Concrete Institute, Delhi, 1988.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand various soil response models applicable to soil-foundation interaction analysis.	K2
CO2	Come up with elastic solutions for problems of pile, pile-raft system.	K3
CO3	Use software packages to analyze soil – foundation system including laterally loaded piles.	K3
CO4	Acquire knowledge on elastic analysis of pile and pile group.	K3

CO5	Acquire knowledge on analysis of laterally loaded piles.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	2	1	2	1
CO2	3	-	2	1	2	1
CO3	3	-	2	1	2	1
CO4	3	-	2	1	2	1
CO5	3	-	2	1	2	1
23GEPE07	3	-	2	1	2	1
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	30	40	30	-	-	-	100
CAT 2	30	40	30	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	30	40	30	-	-	-	100

23GEPE08	FORENSIC GEOTECHNICAL ENGINEERING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objective	To understand the roles and responsibilities of a forensic geotechnical engineer and to develop skill in site investigation and report preparation with gain of knowledge on settlement of structures on problematic soil conditions. Further to develop knowledge on different geotechnical problems and recommend suitable repair and rehabilitation techniques.	
UNIT–I	**INTRODUCTION**	**9 Periods**
Definition of Forensic Engineer-Types of Damage–Typical clients–Legal Process–Examples.		
UNIT–II	**ASSIGNMENT AND INVESTIGATION**	**9 Periods**
Preliminary information–Planning-Site Investigation–Documents Search–Analysis and conclusion–Report preparation.		
UNIT–III	**FORENSIC GEOTECHNICAL AND FOUNDATION INVESTIGATIONS**	**9 Periods**
Settlement of structures–Allowable Settlement–Collapsible soil–Other causes of settlement–Expansive soil–Types of Expansive soil movement–Pavements–Case Study.		
UNIT–IV	**OTHER GEOTECHNICAL AND FOUNDATION PROBLEMS**	**9 Periods**
Earthquakes, erosion, deterioration, tree roots, bearing capacity Failures, Retaining walls and Historic structures with case study.		
UNIT–V	**REPAIR AND CRACK DIAGNOSIS**	**9 Periods**
Development of repair recommendations–Repair of Surficial Slope failures–Cracks–Pavement cracks–Cracks in walls–Foundation cracks–Cracking to repaired structures.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES

1	*Robert W. Day,* ***"Forensic Geotechnical and Foundation Engineering"*** *McGraw Hill, Second Edition, 2011.*
2	*Malcolm D. Bolton,* ***"A Guide to Soil Mechanics"*** *Universities Press, 2003.*
3	*Saxena, D. S.,* ***"Technical, Ethical and Legal Issues with Forensic Geotechnical Engineering-A Case History"****, Proceedings, 13th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering, Kolkata, India, 11 December 2007.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's TaxonomyMapped
CO1	To comprehend a forensic geotechnical engineer's roles and responsibilities.	K1
CO2	To collect preliminary information, plan, adopt suitable investigating techniques available and prepare a report.	K2
CO3	To recognize settlement failures on problematic soils and identify factors causing the settlement.	K3
CO4	To identify various other geotechnical problems and understand them.	K3
CO5	To recommend repair and rehabilitation options.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	-	-	2	-
CO2	-	3	3	3	2	1
CO3	2	-	-	-	2	-
CO4	-	-	-	-	3	2
CO5	2	-	-	-	2	-
23GEPE08	2	3	3	3	2	2
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPE09	ROCK MECHANICS IN ENGINEERING PRACTICE					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To make the students understand the properties of rock, pattern of failure, evaluation of stresses and stability considerations of rock masses.					
UNIT–I	**CLASSIFICATION OF ROCKS**					**9 Periods**
Rocks of peninsular India and the Himalayas–Index properties and classification of rock masses, Competent and incompetent rock–Value of RMR and ratings in field estimations.						
UNIT–II	**STRENGTH CRITERIA OF ROCKS**					**9 Periods**
Behaviour of rock under hydrostatic compression and deviatoric loading–Modes of rock failure–Planes of weakness and joint characteristics – Joint testing, Mohr – Coulomb failure criterion and tension cut-off, Hoek and Brown Strength criteria for rocks with discontinuity set. Value of RQD rating in field estimations.						
UNIT–III	**DESIGN ASPECTS IN ROCKS**					**9 Periods**
Insitu stresses and their measurements, flat jack–Over and under coring methods–stress around underground excavations–Design aspects of openings in rocks–Case studies.						
UNIT–IV	**SLOPE STABILITY OF ROCKS**					**9 Periods**
Rock slopes–Role of discontinuities in slope failure, slope analysis and factor of safety–Remedial measures for critical slopes–Case studies.						
UNIT–V	**METHODS OF IMPROVING ROCK MASS PROPERTIES**					**9 Periods**
Rock Reinforcement–Rock bolting–Mechanism of Rock bolting and its types–Principles of design–Pressure grouting–grout curtains and consolidation grouting-Shotcreting-anchoring–Installation methods–Case studies.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*Goodman, R. E.,* ***"Introduction to Rock Mechanics"****, John Wiley and Sons, 1989.*
2	*Hool, E and Bray, J.,* ***"Rock Slope Engineering, Institute of Mining and Metallurgy"****, U.K. 1981.*
3	*Hoek, E and Brown, E. T.,* ***"Underground Excavations in Rock",*** *Institute of Mining and Metallurgy, U.K. 1981.*
4	*Obvert, L. and Duvall, W.,* ***"Rock Mechanics and the Design of Structures in Rock",*** *John Wiley, 1967.*
5	*Bazant, Z. P.,* ***"Mechanics of Geomaterials Rocks, Concrete and Soil"****, John Wiley and Sons, Chichester, 1985.*
6	*Wittke, W.,* ***"Rock Mechanics: Theory and Applications with Case Histories"****, Springerverlag, Berlin, 1990.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Know the formation and classification of rocks in India.	K1
CO2	Understand the strength of the rocks in field assessment.	K3
CO3	Understand the in-situ stresses developed and methods of measurement.	K2
CO4	Evaluate the strength parameters of rocks and adopt appropriate remedial Measures for stability of critical slopes of rocks.	K3
CO5	Give suitable remedial measures in fractured rocks	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	-	-	-	-
CO2	-	2	-	2	2	-
CO3	2	-	-	-	-	-
CO4	3	-	-	-	-	3
CO5	3	-	-	-	-	3
23GEPE09	3	2	-	2	2	3
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	30	40	30	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	35	35	30	-	-	-	100
ESE	35	35	30	-	-	-	100

23GEPE10	GEOTECHNICAL EARTHQUAKE ENGINEERING					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To understand the mechanism of earthquake, earthquake hazards and mitigation. Phenomena of Liquefaction and the seismic analysis.					
UNIT–I	**EARTHQUAKE SEISMOLOGY**					**9 Periods**
Causes of earthquake–Plate tectonics–Earthquake Fault sources–Elastic Rebound theory–Seismic waves–Elastic Rebound theory–Locating an earthquake–Quantification of earthquakes–Intensity and magnitudes – Locating an earthquake–Case studies.						
UNIT–II	**GROUND MOTION AND GROUND RESPONSE ANALYSIS**					**9 Periods**
Characteristics of ground motion–Factors influencing ground motion–Evaluation of shear wave velocity–Lab tests–Need for Ground Response Analysis–Methods of Ground Response analysis.						
UNIT–III	**LIQUEFACTION AND LATERAL SPREADING**					**9 Periods**
Liquefaction related phenomena–Liquefaction susceptibility–Evaluation of liquefaction by Cyclic Stress and Cyclic Strain approaches–Lateral deformation and spreading Criteria for mapping liquefaction hazard zones–Liquefaction computation from Lab and Field tests.						
UNIT–IV	**SEISMIC DESIGN OF FOUNDATIONS, RETAINING WALLS AND SLOPES**					**9 Periods**
Seismic design requirements of foundation–Seismic design of pile foundations–Seismic design of Retaining walls–Behaviour of reinforced slope under seismic condition Recommendations of seismic codes related to geotechnical engineering.						
UNIT–V	**SEISMIC HAZARD ANALYSIS**					**9 Periods**
Seismic hazard analysis–DSHA–PSHA–Seismic microzonation –Soil Improvement for remediation of seismic hazards.						
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**						

REFERENCES

1	*Kameswara Rao, N. S. V.,* ***"Dynamics soil tests and applications",*** *Wheller Publishing–New Delhi, 2000.*
2	*Krammer S. L.,* ***"Geotechnical Earthquake Engineering",*** *Prentice Hall, International series Pearson Education (Singapore) Pvt. Ltd., 2004. Kameswara Rao, Vibration Analysis and Foundation Dynamics, Wheeler Publishing, New Delhi, 1998.*
3	*McGuire, R. K.,* ***"Seismic Hazard and Risk Analysis, Earthquake Engineering Research Institute"****. MNo –10,ISB N0-943198-01-1, 2004.*
4	*Mahanti, N. C., Samal, S. K., Datta, P., Nag N. K.,* ***"Disaster Management****, Narosa Publishing House, New Delhi, India ISB No:81-7319-727X-2006.*
5	*Bharat Bhushan Prasad,* ***"Fundamentals of Soil Dynamics and Earthquake Engineering"****, PHI Learning Pvt. Ltd., New Delhi, 2009.*
6	*Bharat Bhushan Prasad,* ***"Advanced Soil Dynamics and Earthquake Engineering"****, PHI Learning Pvt. Ltd., New Delhi, 2011.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire knowledge about the earthquake ground motion, making familiar with code And software packages to study the ground motion.	K2
CO2	Analyze the liquefaction susceptibility of the site using laboratory and field tests.	K2
CO3	Design earthquake resistant geotechnical structures and the methods to improve the Ground for hazard resistance.	K3
CO4	Acquire knowledge about Seismic related codes in geotechnical engineering.	K3

CO5	Acquire knowledge about soil improvement for remediation of seismic hazards.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	-	2	1	1
CO2	-	-	-	2	1	1
CO3	-	-	-	2	1	1
CO4	-	1	-	2	1	1
CO5	-	1	-	2	1	1
23GEPE10	-	1	-	2	1	1
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	40	20	-	-	-	100
CAT 2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPE11	DESIGN OF UNDERGROUND EXCAVATIONS					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To get exposure to planning, analysis and design of underground support system and to learn about the various field tests conducted during and after construction of underground structures					
UNIT–I	**PLANNING AND EXPLORATION**					**9 Periods**
Introduction- planning and exploration for various underground construction projects- stereographic Projection method- principle and its application in underground excavation design.						
UNIT–II	**ANALYSIS AND DESIGN OF UNDERGROUND STRUCTURES**					**9 Periods**
Elastic stress distribution around tunnels- stress distribution for different shapes and under different in-situ stress conditions- Green span method- design principles- multiple openings-openings in laminated rocks- elasto-plastic analysis of tunnels- Daemen's theory.						
UNIT–III	**TUNNELING METHODS**					**9 Periods**
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 tests0- radial jacking and Goodman jacking tests- long term behaviour of tunnels and caverns- New Austrian Tunneling Method (NATM)- Norwegian Tunneling Method (NTM)- construction dewatering.						
UNIT–IV	**ROCK MASS**					**9 Periods**
Rock mass-tunnel support interaction analysis- ground response and support reaction curves- Ladanyi's elasto-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.						
UNIT–V	**INSTRUMENTATION**					**9 Periods**
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- Instrumentation and monitoring of underground excavations during and after construction- various case studies.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*Hoek, E and Brown , E. T., "**Underground Excavations in Rocks, Institute of Mining Engineering", 1981*
2	*Obert, L and Duvall, W. I., "**Rock Mechanics and Design of Structures in Rocks"**, John Wiley, 1967.*
3	*Singh, B and Goel, R. K., "**Rock Mass Classification-A Practical Engineering Approach"**, Elsevier, 1999.*
4	*Singh, B and Goel, R. K., "**Tunneling in Weak Rocks**", Elsevier, 2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able:		**Bloom's Taxonomy Mapped**
CO1	To understand the use of elastic and plastic analysis in the design of Underground support system.	K1
CO2	To get idea about the field tests generally conducted during and after Construction of underground structures	K1
CO3	To critically analyse the behaviour of underground structures.	K3
CO4	To understand the different methods of tunneling suited to different ground conditions.	K2

CO5	To gain knowledge about instrumentation during and after construction of Underground construction.	K1

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	3	2	-	-
CO2	-	-	3	2	2	-
CO3	2	-	2	2	1	-
CO4	-	-	-	3	2	-
CO5	-	-	1	-	3	-
23GEPE11	3	-	3	2	2	-
1–Slight,2–Moderate,3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPE12	COMPUTATIONAL GEOMECHANICS					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To get exposure on finite difference and finite element method and to learn about the various mathematical applications on geotechnical aspects.					
UNIT–I	**SOLUTION OF LINEAR AND NON – LINEAR EQUATIONS**					**9 Periods**
Bisection- False position- Newton- Raphson - successive approximation method-Iterative method. Solution of Linear Equation by Jacobi's method – Gauss Seidal method –Successive over relaxation method						
UNIT–II	**FINITE DIFFERENCE METHOD AND FINITE ELEMENT METHOD**					**9 Periods**
Two point Boundary value problems – Disichlet conditions – Neumann conditions; ordinary and partial differential equation						
UNIT–III	**FINITE ELEMENT METHOD**					**9 Periods**
Fundamentals – constitutive finite element models for soils. 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.						
UNIT–IV	**ONE DIMENSIONAL CONSOLIDATION AND FLOW THROUGH POROUS MEDIA**					**9 Periods**
Theory of consolidation – Analytical procedures – Finite difference solution procedure for multi –layered systems- Finite element formulation. Geotechnical aspects – Numerical methods – Applications and Design analysis – Flow in jointed media						
UNIT–V	**RISK ASSESSMENT IN GEOTECHNICAL ENGINEERING**					**9 Periods**
Probabilistic site characterization and design of foundation						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*S. Chandrakant Desai and John T. Christian,* ***"Numerical Methods in Geotechnical Engineering"****, Mc.Graw Hill Book Company,1977.*
2	*M. K. Jain, S. R. K. Iyengar and R.K. Jain****, "Numerical Methods for Scientific and Engineering Computation"****, Third edition, New Age International(P) Ltd. Publishers, NewDelhi-1996.*
3	*D. J. Naylorand, G. N. Pande****, "Finite Elements in Geotechnical Engineering",*** *Pine ridge press Ltd., UK- 1981.*
4	*Sam Helwany,"****Applied Soil mechanics",*** *John Wiley & sons, Inc-2007.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand different numerical and statistical tools for analyzing various geotechnical engineering problems.	K2
CO2	Apply probabilistic approach for selection of design parameters and compute their impact on risk assessment.	K3
CO3	Understand the fundamentals constitutive models for soil.	K2
CO4	Evaluate finite element solutions to consolidation and flow through porous media.	K3
CO5	Compute risk assessment both in characterization of soil and in the design.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	2	1	2	1
CO2	3	-	2	1	2	1
CO3	3	-	2	1	2	1
CO4	3	-	2	1	2	1
CO5	3	-	2	1	2	1
23GEPE12		-				
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	30	30	-	-	-	100
CAT 2	40	30	30	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	30	30	-	-	-	100

23GEPE13	SLOPE STABILITY AND LANDSLIDES				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**PE**	**3**	**0**	**0**	**3**
Course Objective	To analyze stability of finite and irregular slopes and to impart knowledge on mechanism of landslides and understand the importance of field instrumentation and remedial measures.				

UNIT–I	**STABILITY OF SLOPES**	**9 Periods**

Introduction – Importance – General characteristics – Types of failures – Causes of failures – Purpose of Stability computation – Investigation of failures – Procedure – Case studies.

UNIT–II	**STABILITY ANALYSIS**	**9 Periods**

Stability analysis – Method of slices – Friction circle method – Soils with cohesion Soils with cohesion and angle of internal friction. Critical states for design for embankments – Stability computations – Evaluation of pore water pressure.

UNIT–III	**IRREGULAR SLOPES**	**9 Periods**

Non – uniform soils – Janbu's analysis – Taylor's analysis – Bishop's analysis – Total stress and effective stress approaches – Composite surfaces of sliding – Block sliding.

UNIT–IV	**LANDSLIDES**	**9 Periods**

General Characteristics – Sources–Stability of Hill side slopes – Open cuts – Engineering problems involving the stability of slopes – Cuts in sand – Cuts in loess – Homogeneous and soft clay slopes – Sudden spreading of clay slopes – Clay flows – Clays containing pockets and sand masses – Slides in stiff clay slopes on shale – Slopes on weathered rock; talus slopes, slopes on over consolidated clays – Slides along coastal areas and tropically weathered residual soils – Long term stability of clay slopes.

UNIT–V	**FIELD OBSERVATIONS AND SLOPE STABILIZATION**	**9 Periods**

Field instrumentation – Observation studies during construction – Post construction, piezometers – Settlement plates – Inclinometer – Case histories. Compaction of new embankments – Compaction of natural masses of soil and existing fills – Compaction of deep deposits of sand – Vibroflotation – Compaction of compressible soils–Drainage as a means of stabilization–Use of Geotextiles–Soil nailing.

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES

1	*Duncan J. M., Wright S. G., and Brandon. T. L**, "Soil Strength and Slope Stability"** (2nd Edition), Wiley, 2014.*
2	*Chowdhury R, Flentje P and Bhattacharya G, **"Geotechnical Slope Analysis",** CRC Press, 2019.*
3	*McCarthy, D.F., **"Essentials of Soil Mechanics and Foundations: Basic Geotechnics"**, Sixth Edition, Prentice Hall, 2002.*
4	*Winterkorn, H.F. and Fang, H. Y., **"Foundation Engineering Handbook"**, Van No strand Reinhold, 1994.*
5	*Bramhead, E.N.,**"The Stability of Slopes"**, Blacky Academic and Professionals Publications, Glasgow1986.*
6	*Anderson, M.G., and Richards, K.S., **"Slope Stability"**, JohnWiley, 1987.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To gain knowledge about the purpose of computing slope stability.	K2
CO2	To analyse stability of slopes in cohesive and cohesionless soils.	K3
CO3	To familiarize on the analysis of irregular slopes with different approaches.	K3
CO4	To identify and report the causes of landslides in different soil conditions.	K1

CO5	To understand the use of instrumentation in the slope stability and execute suitable ground improvement techniques in the field.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	1	2	-	-
CO2	-	-	3	2	-	-
CO3	-	-	-	-	-	-
CO4	2	-	-	2	-	-
CO5	-	-	-	1	-	-
23GEPE13	3	-	3	2	-	-
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	40	20	-	-	-	100
CAT 2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPE14	GEOLOGY IN GEOTECHNICAL ENGINEERING					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To impart knowledge and skills in assessing the quality rocks in foundation to assess the aggregates and building materials derived from rocks and the geological suitability of sites for engineering projects.					
UNIT–I	**ENGINEERING PROPERTIES OF ROCKS AND SOIL FORMATION**					**9 Periods**
Geology for foundation engineering – Types of rocks, rock description-texture, structure, composition and its relation to quality and strength of rocks, engineering classification of rocks – weathering grade and its significance in engineering site – Engineering properties of rocks – Soil formation – Soil types of India.						
UNIT–II	**SUBSURFACE GEOLOGICAL INVESTIGATION**					**9 Periods**
Geotechnical Investigation – Geophysical methods of subsurface investigations– Electrical, Magnetic, gravitational, seismic, radioactive and geochemical methods – Influence of structure and texture of rocks, Engineering properties, foundation problems in igneous, sedimentary and metamorphic rocks including recent sediments – Case studies. Investigations for foundation of dams and reservoirs –Problem encountered and treatment, case studies – Investigation of canals and deep cuts – Case studies.						
UNIT–III	**LANDSLIDES AND EARTHQUAKE SEISMOLOGY**					**9 Periods**
Land Slides – Causes – Preventive and control measures – Engineering problems related to earthquakes, case studies – seismic zones in India, earthquake mechanism and causes – Elastic Rebound theory.						
UNIT–IV	**GEOTECHNICAL INVESTIGATIONS FOR GROUNDWATER**					**9 Periods**
Ground Water problems – Location of water tables, composition of groundwater – Groundwater Surveys – Conservation of groundwater – Scope of groundwater investigation in Civil Engineering						
UNIT–V	**STRUCTURAL GEOLOGY INVESTIGATION FOR FOUNDATION**					**9 Periods**
Altitude of beds, Dip and Strike, Characteristics, Types, Causes and mechanism of folding, Classification, Causes and mechanism of faults–Field evidences and Recognition of faults. Joint systems – Classification and its types, Difference between faults and joints. Definition, importance and field Recognition of unconformity.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*RoyE.Hunt**,"Geotechnical Engineering Investigation Handbook"**,CRC Press,2005.*
2	*Varghese P.C.**,"Engineering Geology for Civil Engineers"**, PHI learning Pvt.Ltd.NewDelhi,2012.*
3	*Krynine and Judd, **"Principles of Engineering Geology and Geotechnics"**, CBS Publishers and Distributors Pvt ltd.,ebook edition,2008.*
4	*Parbin Singh, **Engineering and General Geology"**, 8th revised edition S.K. Kataria & Sons Publishers, 2015.*
5	*Blyth,**"Geology for Engineering"**,ELBS1995.*
6	*Legget **"Geology and Engineering"**, McGraw Hill Book Company, 1998.*
7	*Krynine and Judd**,"Principles of Engineering Geology and Geotechniques"**,1998.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the soil types and its historical background of formation.	K2
CO2	Identify mineral content, texture and structural behaviour of rocks using microscopic study.	K1
CO3	Carryout investigation for foundations of massive structures, handle situations	K2

	of earthquake and landslide.	
CO4	Do groundwater survey and understand groundwater investigation studies.	K2
CO5	Gain knowledge about structural problems and recognition of field and give the suitable remedial measures.	K3

COURSEARTICULATIONMATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	1	-	-	-	-
CO2	-	-	-	2	-	-
CO3	-	-	-	-	-	3
CO4	2	-	-	-	1	-
CO5	-	-	-	2	-	-
23GEPE14	2	1	-	2	-	3
1–Slight,2–Moderate,3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	40	40	20	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	40	40	20	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPE15	LAND RECLAMATION					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To get an idea of characteristic of waste, processes and remediation techniques and to impart knowledge on the needs, techniques, classification, design and operation of landfills.					
UNIT–I	**INTRODUCTION**					**9 Periods**
Soil around us, Soil Water Characteristics, Soil Erosion, Soil and Pollution, Water resources, Irrigation and Wetlands, Soil Pollution Management, Nuclear Waste Management, Solid Waste Management.						
UNIT–II	**TRANSPORTATION OF WASTES**					**9 Periods**
Handling and segregation of wastes at source-storage and collection of municipal solid wastes-Analysis of collection systems- Need for transfer and transport- Transfer stations Optimizing Waste allocation-compactability, storage, labeling and handling of hazardous wastes-hazardous waste manifests and transport.						
UNIT–III	**TREATMENTOFWASTES**					**9 Periods**
Objectives of waste processing- material separation and processing technologies-biological and chemical conversion technologies- method and controls of composting-thermal conversion technologies and energy recovery-incineration-solidification and stabilization of hazardous wastes-treatment of Biomedical wastes.						
UNIT–IV	**LANDFILLS**					**9 Periods**
Waste disposal options- Disposal in landfills- Landfill Classification, types and methods- site selection-design and operation of sanitary landfills, secure landfills and landfill bioreactors- leachate and landfill gas management-landfill closure and environmental monitoring-closure of landfills-landfill remediation.						
UNIT–V	**WASTEMANAGEMENTANDBIOREMEDIATION**					**9 Periods**
Types and Sources of solid and hazardous wastes-Need for solid and hazardous waste management-Elements of integrated waste management and roles of stakeholders-Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical Wastes-Bioremediation-techniques-field applications.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total:45 Periods**						

REFERENCES

1	*George Tchobanoglous, Hilary Theisen and Samuel A, Vigil* ***"Integrated Solid Waste Management"****, McGraw-Hill International edition, New York, 1993.*
2	*CPHEEO* ***"Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organization"****, Government of India, NewDelhi,2000.*
3	*MicheaelD.Lagrega, Philip L Buckingham, Jeffrey C.Evans* ***"Environmental Resources Management, Hazardous waste Management"****, McGraw-Hill International edition, Newyork, 2001.*
4	*VesilindP.A.,Worrell Wand Reinhart,* ***"Solid Waste Engineering"****, Thomson Learning Inc.,Singapore, 2002.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To understand the fundamentals of solid and hazardous wastes and also the types, need and sources of solid and hazardous wastes.	K2
CO2	To understand the methods of waste characterization and source reduction and to study the various methods of generation of wastes.	K3
CO3	To understand in detail about the storage, collection handling, segregation and transport of wastes.	K3
CO4	To gain the knowledge on the waste processing techniques which includes	K2

	incineration, solidification and stabilization of hazardous wastes.	
CO5	To know the basics of various waste disposal methods.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	-	3	3	-
CO2	3	-	-	-	3	-
CO3	3	-	3	2	-	2
CO4	1	-	-	-	2	-
CO5	1	-	-	-	2	-
23GEPE15	1	-	3	3	3	2
1–Slight,2–Moderate,3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	40	20	-	-	-	100
CAT 2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPE16	ENVIRONMENTAL GEOTECHNOLOGY					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To acquire knowledge on the interaction mechanism of pollutants, contaminant transport and remediation of contaminated sites.					

UNIT–I	**SOIL POLLUTION AND INTERACTION**	**9 Periods**

Introduction to Geo-environmental engineering–Environmental cycle–Sources, production and classification of waste – Causes of soil pollution – Classification, identification and characterization of contaminated soils-Factors governing soil–Pollutant interaction–Failures of foundations due to Pollutants–Environmental Geotechnical problems-Case studies.

UNIT–II	**SITE SELECTION AND SAFE DISPOSAL OF WASTE**	**9 Periods**

Safe disposal of waste–Site selection for landfills– Characterization of landfill sites– Risk assessment–Stability of landfills–Current practice of waste disposal–Design of landfill –Monitoring facilities–Passive containment system–Leachate contamination-Hydrological consideration in landfill design–Application of geosynthetics in solid waste management–Rigid and Flexible liners–Design.

UNIT–III	**TRANSPORT OF CONTAMINANTS**	**9 Periods**

Contaminant transport in sub surface – Advection – Diffusion – Dispersion – Governing equations – Contaminant transformation – Sorption – Biodegradation – Ion exchange – Precipitation – Ground water pollution – Bearing capacity of compacted fills – Foundation for waste fill ground – Pollution of Aquifers by mixing of liquid waste – Protection of aquifers.

UNIT–IV	**WASTE STABILIZATION AND DISPOSAL**	**9 Periods**

Hazardous waste control and storage system–Stabilization/Solidification of wastes–Micro and Macro encapsulation–Absorption, adsorption, precipitation–Detoxification–Mechanism of stabilization–Organic and inorganic stabilization–Utilization of solid waste for soil improvement–Case studies.

UNIT–V	**REMEDIATION OF CONTAMINATED SOILS**	**9 Periods**

Rational approach to evaluate and remediate contaminated sites–Monitored natural attenuation–Ex-situ and in-situ remediation–Solidification, Bio-remediation, incineration, soil washing, electro-kinetics, soil heating, vitrification, bio-venting–Groundwater remediation–Pump and treat, air sparing, reactive-well–Case studies.

Contact Periods:

Lecture: 45 Periods Tutorial:0 Periods Practical: 0 Periods Total:45 Periods

REFERENCES

1	*Daniel, D.E.,* ***"Geotechnical Practice for waste disposal"****, Chapman and Hall, London, 1993.*
2	*Westlake, K.,* ***"Landfill Waste pollution and Control"****, Albion Publishing Ltd., England,1995.*
3	*Lagrega ,M.D., Buckingham, P.L., and Evans, J.C.,* ***"Hazardous Waste Management"****, McGraw Hill,Inc. Singapore, 1994.*
4	*Jo Strange and Nick Langdon,* ***"Contaminated Land: Investigation, Assessment and Remediation – Design and Practice Guides"****, ICE, 2008.*
5	*Yue Rong,* ***"Fundamentals of Environmental Site Assessment and Remediation"****, CRC Press, 2018.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Learn about soil contamination and soil pollutant interaction	K2
CO2	Select suitable sites for safe disposal of wastes	K3
CO3	Assess different mechanisms of transport of contaminants	K3

CO4	Adopt appropriate waste stabilization techniques	K3
CO5	Remediate contaminated soils using different methods	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	3	1	3	3
CO2	3	-	2	2	-	-
CO3	2	-	3	-	3	3
CO4	3	-	-	3	2	-
CO5	3	-	2	3	2	-
23GEPE16	3	-	3	3	3	3
1–Slight,2–Moderate,3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analysing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	20	40	40	-	-	-	100
CAT 2	20	40	40	-	-	-	100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project1	10	50	40	-	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2 / Project 2	10	50	40	-	-	-	100
ESE	20	40	40	-	-	-	100

23GEPE17	PAVEMENT ENGINEERING					
PREREQUISITES:		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To design flexible and rigid pavements as per IRC codes, evaluate pavements for distress and to adopt suitable rehabilitation techniques.					

UNIT–I	**BASIC CONCEPTS**	**9 Periods**

Pavement–types–Historical developments–Approaches to pavement design–Vehicle and traffic considerations– Behaviour of road materials under repeated loading–Stresses and deflections in Layered systems.

UNIT–II	**FLEXIBLE PAVEMENT**	**9 Periods**

Factors affecting flexible pavements–Types of stresses and causes–Material characterization for Analytical pavement design–CBR and stabilometer tests–Resilient modulus–Fatigue subsystem–Failure criteria for bituminous pavements–IRC design guidelines

UNIT–III	**RIGID PAVEMENT**	**9 Periods**

Factors affecting rigid pavements–Types of stresses and causes–Design procedures for rigid pavement–IRC guidelines–Design of joints, reinforcements, tie bars, dowel bars-Airfield pavements–CRC pavements.

UNIT–IV	**PAVEMENT EVALUATION AND REHABILITATION**	**9 Periods**

Pavement evaluation and rehabilitation, condition and evaluation surveys–Evaluation by Non-destructive tests- FWD- Benkelman Beam Deflection Test- Wave Propagation Test–PSI models–Serviceability index of rural roads–Overlays and design-pavements maintenance management and Construction.

UNIT–V	**STABILIZATION OF SOILS FOR ROAD CONSTRUCTIONS**	**9 Periods**

Need for a stabilized soil–Design criteria and choice of stabilizers–Testing and field control–
Stabilization for rural roads–Pavement recycling–Use of recycled materials–geosynthetics in road construction– Case studies.

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical:0 Periods Total:45 Periods

REFERENCES

1	*Wright, P.H., **"Highway Engineers"**, John wiley & Sons,Inc. NewYork,2009.*
2	*Yoder, R.J and Witchak, M.W., **"Principles of Pavment Design"**, John wiley, 2000.*
3	*Khanna, S.Kand Justo C.E.G., **"Highway Engineering"**, New Chand and Brothers, Roorkee,1998.*
4	***"Design and specification of Rural Roads (Manual")**, Ministry of rural roads, Government of India, NewDelhi, 2001.*
5	***"Guidelines for the Design of Flexible Pavements"**, IRC:37–2012,The Indian Roads Congress, NewDelhi.*
6	***"Guidelines for the Design of Rigid Pavements"**, IRC:58–2012,The Indian Roads Congress, NewDelhi.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Learn loading conditions and corresponding stresses and deformation developed.	K2
CO2	Carryout material characterization and the design of flexible pavement.	K3
CO3	Design of rigid pavement as per IRC guidelines.	K3
CO4	Evaluate pavement and to select appropriate rehabilitation technique.	K3
CO5	Select suitable stabilizers and their applicability in pavements.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	3	1	3	3
CO2	3	-	2	2	-	-
CO3	2	-	3	-	3	3
CO4	3	-	-	3	2	-
CO5	3	-	2	3	2	-
23GEPE17	3	-	3	3	3	3
1–Slight,2–Moderate,3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analysing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	40	50	-	-	-	100
CAT2	10	40	50	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	20	40	40	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	20	40	40	-	-	-	100
ESE	10	40	50	-	-	-	100

23GEPE18	THEORETICAL SOIL MECHANICS				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**PE**	**3**	**0**	**0**	**3**

Course Objective	To learn the material behaviour and basics of stress fields in soil based on theory of elasticity and plasticity.

UNIT–I	**THEORY OF ELASTICITY**	**9 Periods**

Introduction – Material behaviour – Idealistic behaviour – Elastic, viscous and plastic – Elasticity and stability problems, concept of stress and strain–Plane stress, plane strain and axisymmetric problems– Equation of equilibrium and compatibility– Stress functions

UNIT–II	**STRESSES AND DISPLACEMENTS (ELASTIC SOLUTIONS)**	**9 Periods**

Stresses in elastic half-space medium by external loads–Fundamental solutions–Boussinesq, Flamant, Kelvin and Mindlin solution– Applications of fundamental solutions–Anisotropic and non-homogeneous linear continuum–Influence charts–Elastic displacement.

UNIT–III	**LIMIT EQUILIBRIUM ANALYSIS**	**9 Periods**

Limit equilibrium analysis– Perfectly plastic material–Stress-strain relationship–Stress and displacement field calculations – Slip line solutions for undrained and drained loading – Dimensional similitude.

UNIT–IV	**LIMIT ANALYSIS**	**9 Periods**

Limit analysis – Principles of virtual work – Theorems of plastic collapse – Mechanism for plane plastic collapse – Simple solutions for drained and undrained loading – Stability of slopes, cuts and retaining structures. Centrifuge model– Principles and scale effects, practical considerations.

UNIT–V	**FLOW THROUGH POROUS MEDIA**	**9 Periods**

Flow through porous media – Darcy's law – General equation of flow – Steady state condition –Solution by flow net – Fully saturated conditions – Flow net in anisotropic soils – construction of flow net for different cases.

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES

1	*Aysen,A.,"**Soil Mechanics**: **Basic concepts and Engineering Application"**,A.A.Balkema Publishers, 2002.*
2	*Ulrich Smoltc,Y.K, "**Geotechnical Engineering Handbook(Vol.1)",**Ernot & Sohn,2002.*
3	*Aysen,A.,"**Problem Solving in Soil Mechanics"**,A.A.Balkema Publisher,2003.*
4	*Davis,R.O., and Selvadurai, A.P.S.,"**Elasticity and Geomechanics"**,Cambridge University Press, 1996.*
5	*Taylor,R.N.,"**Geotechnical Centrifuge Technology"**, Blackie Academic and Professional 1995.*
6	*Wai-FahChen, and Liu, X.L., **Limit Analysis in Soil Mechanics**", Elsevier Science Ltd., 1991.*
7	*MuniBudhu,"**Soil Mechanics and Foundations"**, John Wiley and Sons,Inc,Network, 2000.*
8	*Atkinson, J.H., **"Foundations and Slopes"**, McGrawHill, 1981.*
9	*Harr,M.E., **"Foundations of Theoretical Soil Mechanics"**, McGrawHill,1966.*
10	*Cedergren, H.R., **"Seepage Drainage and Flownets"**, JohnWiley,1997.*
11	*Winterkorn,H.F.,andFang,H.Y.**,"Foundation Engineering Handbook",** Galgottia, Book source, 2000.*
12	*Karl Terzaghi,**"Theoritical Soil Mechanics"**, John Wiley & Sons Publications.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Apply theories of elasticity and plasticity to characterize the stress-strain behaviour of soil.	K3
CO2	Imparting knowledge required for calculating stress and settlement at any depth in semi-infinite elastics oil medium, anisotropic and layered medium due to external loads.	K2
CO3	Acquiring knowledge on slip line solutions on drained and undrained condition.	K3
CO4	Arrive at solutions for drained and undrained loading conditions for analysis of slopes, cuts and retaining structures for their stability using theorem of plastic collapse.	K3
CO5	Understand the concept of flow through soil media and to construct flow nets for different cases.	K2

COURSEARTICULATIONMATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	2	2	-	1
CO2	1	-	2	2	-	1
CO3	3	-	3	3	1	1
CO4	3	-	3	3	1	1
CO5	2	-	3	2	1	1
23GEPE18	3	-	3	2	1	1
1–Slight,2–Moderate,3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	30	30	-	-	-	100
CAT 2	40	30	30	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	30	30				100

23GEPE19	EARTH RETAINING STRUCTURES					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To impart knowledge on earth pressure theories, design of retaining walls, sheet pile walls, concepts of braced excavation and understand the concepts and mechanisms of reinforced earth retaining wall.					
UNIT–I	**EARTH PRESSURE THEORIES**					**9 Periods**
Introduction – State of stress in retained soil mass – Classical earth pressure theories – Active and Passive earth pressures – Earth pressure at rest – Earth pressure due to external loads – Empirical methods–Wall movements and complex geometry–Graphical method of computing earth pressure–Rehbann's and Culmann's approach.						
UNIT–II	**RETAINING WALLS**					**9 Periods**
Retaining walls – Uses and types – Forces on retaining walls – Design of retaining walls by limit state method – General principles – Design and construction details – Design of solid gravity walls, Semi – gravity walls, cantilever walls, counterfort walls–Stability of retaining walls–Drainage arrangements and its influence.						
UNIT–III	**SHEET PILE WALLS**					**9 Periods**
Earth retaining structures– Selection of soil parameters–Analysis and design of cantilever and anchored sheet pile walls– Dead man and continuous anchor–Diaphragm and bored pile walls–Design requirements.						
UNIT–IV	**BRACED EXCAVATION**					**9 Periods**
Braced cuts in sand and clay–Lateral pressure on sheeting in Braced excavation– Stability against Piping and bottom heaving–Procedure for computation of lateral earth pressure for braced cuts and Flexible Bulk heads– Soil anchors– Soil nailing– Soil pinning– Methods of design.						
UNIT–V	**REINFORCED EARTH RETAINING WALL**					**9 Periods**
Reinforced earth retaining wall–General principles, Concepts and Mechanism of reinforced earth–Design consideration of reinforced earth– Geotextile, geogrids, metal strips and facing elements–Construction– Selection of type of retaining structures– Construction practice– Field observations.						
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**						

REFERENCES

1	*WinterkornH.F. and FangH.Y.,* ***"Foundation Engineering Handbook"*** *,Galgotia Book source, 2000.*
2	*RoweR.K.,* ***"Geotechnical and Geo environmental Engineering Hand Book"****, Kluwer Academic Publishers, 2001.*
3	*Militisky.Jand WoodsR.* ***"Earth and earth retaining structures"****, Routledge, 1992.*
4	*DasB.M****., "Principles of Geotechnical Engineering (Fourth edition)",*** *The PWS series in Civil Engineering, 1998.*
5	*Clayton C.R.I .Militisky,J and WoodsR****.,"Earth pressure and earth retaining structures(second Edition)",*** *Survey University Press, 1993.*
6	*McCarthyD.F.,* ***"Essentials of soil Mechanics and foundations",*** *Basic Geotechnics (sixth Edition) PrenticeHall,2002*

COURSE OUTCOMES: Upon completion of the course, the students will be able:		**Bloom's Taxonomy Mapped**
CO1	To understand earth pressure theories and computation of earth pressure.	K2
CO2	To calculate the forces on retaining walls and design the retaining walls.	K3
CO3	To carry out analysis and design of sheet pile walls.	K3
CO4	To design braced excavations, soil nailing, pinning, and anchoring on stability considerations.	K3
CO5	To apply concepts of reinforcement in earth retaining structures.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	-	2	-	-
CO2	-	-	3	-	2	-
CO3	3	-	-	-	1	-
CO4	2	-	2	-	3	-
CO5	2	-	-	3	1	-
23GEPE19	3	-	3	3	1	-
1–Slight,2–Moderate,3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPE20	PROFESSIONAL PRACTICES IN DESIGN OF GEOTECHNICAL STRUCTURES				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**PE**	**3**	**0**	**0**	**3**

Course Objective	To gain exposure on practical aspects of designs relating to substructure elements using software, Geotechnical construction practices, and field execution of the works.

UNIT–I	**CONSTRUCTION TECHNIQUES**	**9 Periods**

Project planning – Geotechnical engineering practices – Soil profile – Bore log – Report review and preparation – Geotechnical Plant and Machinery – Safety aspects at site– Construction management – Quality control–Quality management–Geosynthetics–Geomembrane.

UNIT–II	**RETAINING STRUCTURES**	**9 Periods**

Design of retaining wall–Design of culvert–Design of deep excavations–Sheet pile–diaphragm walls–Shoring system–Design of Caisson.

UNIT–III	**SUBSTRUCTURES**	**9 Periods**

Design of Tower Foundation–Design of Floating foundation–Design of Pile and Pile group –Design of under reamed pile – Design of abutment – Design of Pier – Design of mat foundation – Design of pile draft foundation.

UNIT–IV	**DYNAMIC RESPONSE OF FOUNDATIONS**	**9 Periods**

Soil behaviour – Dynamic properties of soil– Seismic performance analysis – Calculation of seismic loads in foundation–Design procedure for earthquake resistant foundation –Soil structure interaction–Retrofitting.

UNIT–V	**FINITE ELEMENT ANALYSES AND SOFTWARE APPLICATION**	**9 Periods**

Finite Element Analysis applied to Geotechnical Engineering–ANSYS–Modelling–Applications–Oasys–PLAXIS.

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES

1	*Helmsley,* ***"Design Applications of Raft Foundations".***
2	*Michael John Tomlinson, R. Boorman,* ***"Foundation Design &Construction"****, Prentice Hall PTR,2001.*
3	*George paaswell* ***"Retaining Walls: Design & Construction"****, Bibliobazaar,2009.*
4	***"Design & Construction of bridge approaches"****, Transportation Research Board,1990*
5	*Davies and Poulos****,"Analysis and design of pile foundation"****, John Wiley and Sons,1980*
6	*Potts and Zdravkovic****,"Finite Element Analyse Applied to Geotechnical Engineering"****, Vol.1 (Theory) and Vol.2 Applications*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To know the field practices in investigations, safety, and quality on Substructure components.	K2
CO2	To design foundations for special structures using softwares.	K3
CO3	To evaluate dynamic properties of soils and design earthquake resistant foundations.	K3
CO4	To know about various substructure retrofitting techniques	K3
CO5	To acquire knowledge about the use of finite element based softwares to analyse geotechnical engineering structures.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	3	-	-	-
CO2	-	-	3	-	-	-
CO3	-	-	3	2	-	3
CO4	1	-	3	-	-	-
CO5	1	-	3	-	-	2
23GEPE20	1	-	3	2	-	3
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	40	20	-	-	-	100
CAT 2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPE21	GROUND IMPROVEMENT TECHNIQUES					
PREREQUISITES:		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To impart knowledge on the various improvement techniques for cohesionless and cohesive soils.					
UNIT – I	**DEWATERING**					**9 Periods**
Introduction–Necessity of ground improvement–Current status and scope in Indian context-New Technologies–Basic concepts–Drainage methods–Ground water lowering by well points– Deep well, Vacuum and Electro–Osmosis methods.						
UNIT – II	**COMPACTION AND SAND DRAINS**					**9 Periods**
In-situ compaction of cohesionless and cohesive soils – Shallow and deep compaction –Vibration methods– Vibro-compaction, Blasting, Vibrating probe, Vibratory rollers, Vibro-displacement compaction, Vibro flotation – Concept, Factors influencing compaction– Heavy Tamping–Vertical drains–Preloading with sand drains, Fabric drains, Wick drains–Design of sand drains–Relative Merits of different methods – limitations.						
UNIT – III	**STONE COLUMN AND EARTH REINFORCEMENT**					**9 Periods**
Pre-compression and consolidation –Dynamic consolidation –Electro-osmotic consolidation–Stone column – Functions – Methods of installation – Design estimation of load carrying capacity of stone column– Settlement of stone column–Lime piles–Earth reinforcement–Soil Nailing and Rock Bolting –Types of reinforcement material–Applications.						
UNIT– IV	**STABILIZATION**					**9 Periods**
Introduction–Stabilization methods– Mechanical, Cement, Lime, Bitumen, Chemical stabilization– Electrical stabilization–Stabilization by Thermal and Freezing techniques–Ground improvement by excavating and replacing –Stabilization of expansive clays– Prewetting.						
UNIT–V	**GROUTING**					**9 Periods**
Introduction–Applications–Functions–Characteristics of grouts–Types of grout–Suspension and solution routs–Basic requirements of grout–Displacement–Compaction grouting, displacement –Soil fracture grouting, Jet–Displacement grouting, and Permeation grouting–Grouting equipment–Injection methods– Grout monitoring - Deep vertical cut-stability considerations – Case studies.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*Moseley M.D., **"Ground Treatment"**, Blackie Academic and Professional, 1998.*
2	*Koerner,R.M., **"Designing with Geosynthetics"** (fourth edition), Prentice Hall, NewJersey,1999.*
3	*Purushothama Raj P., **"Ground Improvement Techniques"**, Laxmi Publications(P)Ltd., NewDelhi, 2005*
4	*Shroff, A.V., **"Grouting Technology in Tunnelling and Dam"**, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2009.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Ascertain the parameters of weak soil and the techniques used for treating such soils.	K2
CO2	Select various shallow and deep compaction techniques.	K3
CO3	Design stone column and learn the consolidation processes.	K3
CO4	Choose various types of stabilizers and stabilizing techniques.	K3
CO5	Gain knowledge for application of grouting methods in the field.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	3	3	2
CO2	3	1	2	3	-	-
CO3	2	3	3	3	-	3
CO4	3	-	2	2	3	-
CO5	3	-	2	2	-	2
23GEPE21	3	3	3	3	3	2
1 – Slight, 2 – Moderate , 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	30	30	40	-	-	-	100
CAT 2	30	30	40	-	-	-	100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project1	20	40	40	-	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2 / Project 2	20	40	40	-	-	-	100
ESE	30	30	40	-	-	-	100

23GEPE22	MARINE GEOTECHNICAL ENGINEERING					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To impart knowledge on marine environment, dynamic loading on soils and different foundations on marine deposits.					
UNIT – I	**MARINE SOIL DEPOSITS**					**9 Periods**
Offshore environment- Offshore structures and foundations- Specific problems related to marine soil deposits- Physical and engineering properties of marine soils.						
UNIT – II	**BEHAVIOUR OF SOILS SUBJECTED TO DYNAMIC LOADING**					**9 Periods**
Effect of wave loading on offshore foundations- Behaviour of sands and clays under cyclic loading - Laboratory experiments including repeated loading- Cyclic behaviour of soils based on fundamental theory of mechanics- Approximate engineering methods - practical cases.						
UNIT – III	**SITE INVESTIGATION IN MARINE SOIL DEPOSITS**					**9 Periods**
Challenges of site investigation in marine environment- Different site investigation techniques- sampling techniques -Geophysical methods- recent advancements in site investigation - sampling used for marine soil deposits.						
UNIT – IV	**FOUNDATIONS IN MARINE SOIL DEPOSITS**					**9 Periods**
Different offshore and near shore foundations-Gravity platforms-Jack-uprigs- pile foundations- Cassions-spudcans.						
UNIT–V	**NUMERICAL MODELING OF MARINE FOUNDATIONS**					**9 Periods**
Numerical modeling of cyclic behaviour of soils- empirical models- elastic-plastic models- FEM analysis of marine foundations subjected to wave loading.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Period Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*George P T sinker**, "Port Engineering planning, construction, maintenance and security"**, John Wiley & Sons, Inc.2004.*
2	*M J Tomlinson**, "Pile design and construction practice"**, View point Publications , Palladian Publications Limited,1987.*
3	*H.G.Poulos,**"Marine Geotechnics"**, Prentice Hall Inc.,1988.*
4	*Ben C Gerwick,jr., **"Construction of marine and offshore structures"**, CRC Press, Taylor and Francis Group.2012.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand marine environment related problems.	K2
CO2	Acquire knowledge about effect of dynamic loading on soils.	K3
CO3	Familiarize about various Site investigation techniques.	K1
CO4	Apply the knowledge of marine platforms for various geotechnical applications.	K3
CO5	Perform numerical modeling on marine foundations.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	3	1	1
CO2	2	-	2	3	1	1
CO3	2	-	2	3	1	1
CO4	2	-	2	3	1	1
CO5	2	-	2	3	1	1
23GEPE22	2	-	2	3	1	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	40	20	-	-	-	100
CAT 2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEPE23	UNSATURATED SOIL MECHANICS					
PREREQUISITES:		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To understand the properties of unsaturated soils, the stress state variables and the modeling techniques.					
UNIT–I	**STATE OF UNSATURATED SOIL**					**9 Periods**
Definition- Interdisciplinary nature of unsaturated soil- soil classification – Nature and practice – stress profiles, stress state variables – material variables constitutive law –suction potential of soil water.						
UNIT–II	**PHYSICS OF SOIL WATER SYSTEM**					**9 Periods**
Physical properties of air and water – partial pressure and relative humidity- density of moist air-surface tension - cavitation of water. Solubility of air in water - air water solid interface - vapour pressure lowering - soil water characteristic curve. Capillary tube model - contacting sphere model. Young Laplace equation-Height of capillary rise-Rate of capillary rise- capillary pore size distribution-Theoretical basis-determination-laboratory method.						
UNIT–III	**STRESS STATE VARIABLES AND SHEAR STRENGTH**					**9 Periods**
Effective stress-stress between two spherical particles - Hysteresis in SWCC - stress parameter, stress tensor-stress control by axis translation analytical representation of stress-volume change characteristics -Extended Mohr-Coulomb criterion-shear strength parameters-Interpretation of Direct shear test results and Triaxial test results-unified representation of failure envelope-Influence of suction in earth pressure distribution.						
UNIT–IV	**STEADY AND TRANSIENT FLOWS**					**9 Periods**
Driving mechanism- Permeability and Hydraulic conductivity- capillary barriers-steady infiltration and evaporation-Vapor flow-Air diffusion in water-Principles for pore liquid flow-Rate of infiltration, Transient suction and moisture profiles-Principles for Pore Gas flow- Barometric pumping analysis.						
UNIT–V	**MATERIAL VARIABLE MEASUREMENT AND MODELLING**					**9 Periods**
Measurement of total suction -psychrometers- Filter paper measurement of matric suction-High air entry disks-Direct measurements- Tensiometers- Air-translation technique-Indirect measurements Thermal conductivity sensors-measurement of osmotic suction-squeezing technique-soil water Characteristic curves and Hydraulic conductivity models.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*Fredlund,D.G. .Rahardjo,H. and Fredlund,M.D.* ***"Unsaturated Soil Mechanics in Engineering Practice"****, John Wiley & Sons,INC,NewJersey,2012.*
2	*Ning Luand William, J.Likes,****"Unsaturated Soil Mechanics"*** *,John Wiley & sons, INC.NewJersey,2004*
3	*NgCharles,Ww Menzies Bruce,* ***"Advanced unsaturated Soil Mechanism and Engineering"****, Taylor & Francis Group,2007.*
4	*NingLu, LaureanoR. Hoyes and Lakshmi Reddi,****"Advances in unsaturated soil, seepage and Environmental Geotechnics"****,ASCE,Geotechnical special publication No.148.*
5	*Jean-Louis Briaud.,****"Geotechnical Engineering: Unsaturated and Saturated soils"****,John Wiley & Sons,INC, NewJersey,2013.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Gain knowledge on stress state variables, material variables and constitutive law of Unsaturated soil.	K2
CO2	Study the physics of soil –water mechanism, relationship of models.	K2
CO3	Determine soil-water characteristic curve and the shear strength of unsaturated soil.	K3

CO4	Learn the principles of vapour flow, air diffusion, pore liquid flow and rate of Infiltration in unsaturated soil.	K1
CO5	Measure the material variables and select the suitable soil models.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	1	-	-	3	3
CO2	2	1	3	2	2	3
CO3	3	-	3	3	2	2
CO4	1	1	-	2	2	3
CO5	3	-	2	3	3	2
23GEPE23	3	1	3	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	30	30	40	-	-	-	100
CAT 2	30	30	40	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	20	40	40	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	20	40	40	-	-	-	100
ESE	30	30	40	-	-	-	100

23GEPE24	TUNNEL ENGINEERING					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objective	To understand the fundamentals, different techniques of tunneling and gain knowledge on the hazards related to tunneling.					

UNIT–I	**INTRODUCTION**	**9 Periods**
Scope and application, historical developments, art of tunneling, tunnel engineering, future tunneling considerations- Types of Underground Excavations: Tunnel, adit, decline, shaft; parameters influencing location, shape and size; geological aspects; planning and site investigations.		
UNIT–II	**TUNNELING METHODS**	**9 Periods**
Types and purpose of tunnels; factors affecting choice of excavation technique; Methods-soft ground tunneling, hard rock tunneling, shallow tunneling, deep tunneling; Shallow tunnels – cut and cover, cover and cut, pipe jacking, jacked box excavation techniques, methods of muck disposal, supporting, problems encountered and remedial measures.		
UNIT–III	**TUNNELING BY DRILLING AND BLASTING**	**9 Periods**
Unit operations in conventional tunneling; Drilling - drilling principles, drilling equipment, drilling tools, drill selection, specific drilling, rock drill ability factors; Blasting-explosives, initiators, blasting mechanics, blast holes nomenclature; types of cuts- fan, wedge and others; blast design, tunnel blast performance-powder factor, parameters influencing, models for prediction; mucking and transportation equipment selection.		
UNIT–IV	**GROUND TREATMENT IN TUNNELING**	**9 Periods**
Adverse ground conditions and its effect on tunneling; introduction to ground control.		
UNIT–V	**TUNNELING HAZARDS**	**9 Periods**
Explosion, flooding, chimney formation, squeezing ground.		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Period Total: 45 Periods

REFERENCES

1	*Ratan Raj Tatiya**, "Surface and underground Excavation"**, Second Edition,2005.*
2	*David Chapman, Nicole Metje and Alfred Stark, **"Introduction to Tunnel Construction",** Spon Press, Second edition,2010.*
3	*Hoek and Brown**, "Underground excavation in rock"**, Revised First Edition,2003*
4	*Palmström and Stille**, "Rock Engineering"**, Second Edition,2014*

COURSE OUTCOMES: Upon completion of the course, the students will be able:		**Bloom's Taxonomy Mapped**
CO1	To apply the fundamentals of tunnel engineering.	K2
CO2	To identify and evaluate different tunneling methods.	K3
CO3	To apply knowledge on drilling and blasting tunneling techniques.	K2
CO4	To identify and deal with different ground conditions during tunneling.	K2
CO5	To anticipate tunneling hazards and apply safety measures.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	1	2	-	-
CO2	-	-	3	2	-	-
CO3	1	-	-	2	1	-
CO4	2	-	-	2	-	-
CO5	-	-	-	1	-	-
23GEPE24	3	-	3	2	1	-
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	40	20	-	-	-	100
CAT 2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	50	50	-	-	-	-	100
ESE	40	40	20	-	-	-	100

23SEOE01	BUILDING BYE-LAWS AND CODES OF PRACTICE (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	To impart knowledge on the building bye –laws and to emphasize the significance of codes of practice in construction sector.	
UNIT – I	**INTRODUCTION TO BUILDING BYE-LAWS**	**9 Periods**
Introduction to Building Bye Laws and regulation, their need and relevance, General definitions such as building height, building line, FAR, Ground Coverage, set back line. Introduction to Master Plan and understanding various land uses like institutional, residential etc. - Terminologies of Building bye-laws.		
UNIT – II	**ROLE OF STATUTORY BODIES**	**9 Periods**
Role of various statutory bodies governing building works like development authorities, municipal corporations etc. Local Planning Authority, Town and Country planning organisation, Ministry of urban development.		
UNIT – III	**APPLICATION OF BUILDING BYE-LAWS**	**9 Periods**
Interpretation of information given in bye laws including ongoing changes as shown in various annexure and appendices. Application of Bye-laws like structural safety, fire safety, earthquake safety, basement, electricity, water, and communication lines in various building types.		
UNIT – IV	**INTRODUCTION TO CODES OF PRACTICE**	**9 Periods**
Introduction to various building codes in professional practice - Codes, regulations to protect public health, safety and welfare - Codes , regulations to ensure compliance with the local authority.		
UNIT – V	**APPLICATION OF CODES OF PRACTICE**	**9 Periods**
Applications of various codes as per various building types. Bureau of Indian Standards, Eurocode – Introduction to other international codes.		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES :

1	***"National Building Code of India 2016 – SP 7",*** *NBC 2016, Bureau of Indian Standards.*
2	***"Model Building Bye-Laws (MBBL) – 2016",*** *Town and Country Planning Organization, Ministry of Housing and Urban Affairs, Government of India.*
3	***"Unified Building Bye-laws for Delhi 2016",*** *Nabhi Publications, 2017.*
4	Mukesh *Mittal,* ***"Building Bye Laws",*** *Graphicart publishers, Jaipur, 2013.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the building bye-laws in planning, design and construction works.	K3
CO2	Familiarize with the role of various statutory bodies.	K2
CO3	Execute safety related work practices in the construction sector.	K3
CO4	Ensure compliance with the rules and regulations in design and construction practices.	K3
CO5	Perform design and construction practices based on national and international codal provisions.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	3	1	1	2	3
CO2	1	3	1	1	2	3
CO3	1	3	1	1	2	3
CO4	2	3	1	1	2	3
CO5	2	3	1	1	2	3
23SEOE01	2	3	1	1	2	3
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	40	40	20	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	40	40	20	-	-	-	100
ESE	40	40	20	-	-	-	100

23SEOE02	PLANNING OF SMART CITIES (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	To have an exposure on planning of smart cities with consideration of the recent challenges and to address the importance of sustainable development of urban area.	
UNIT – I	**SMART CITIES DEVELOPMENT POTENTIALS AND CHALLENGES**	**9 Periods**
Perspectives of Smart Cities: Introduction and Overview - Implementation Challenges - Methodological issues - Spatial distribution of startup cities – Re imagining postindustrial cities - Implementation Challenges for Establishing Smart Urban Information and Knowledge Management System.		
UNIT – II	**SUSTAINABLE URBAN PLANNING**	**9 Periods**
Optimising Green Spaces for Sustainable Urban Planning - 3D City Models for Extracting Urban Environmental Quality Indicators - Assessing the Rainwater Harvesting Potential - The Strategic Role of Green Spaces - Monitoring Urban Expansion.		
UNIT – III	**ENERGY MANAGEMENT AND SUSTAINABLE DEVELOPMENT**	**9 Periods**
Alternatives for Energy Stressed Cities - Social Acceptability of Energy - Efficient Lighting - Energy Management - Urban Dynamics and Resource Consumption - Issues and Challenges of Sustainable Tourism - Green Buildings: Eco-friendly Technique for Modern Cities.		
UNIT – IV	**MULTIFARIOUS MANAGEMENT FOR SMART CITIES**	**9 Periods**
Assessment of Domestic Water Use Practices - Issue of Governance in Urban Water Supply - Assessment of Water Consumption at Urban Household Level - Water Sustainability - Socio-economic Determinants and Reproductive Healthcare System - Problems and Development of Slums.		
UNIT – V	**INTELLIGENT TRANSPORT SYSTEM**	**9 Periods**
Introduction to Intelligent Transport Systems (ITS) - The Range of ITS Applications -Network Optimization - Sensing Traffic using Virtual Detectors - Vehicle Routing and Personal route information - The Smart Car - Commercial Routing and Delivery - Electronic Toll Collection - The Smart Card - Dynamic Assignment - Traffic Enforcement. Urban Mobility and Economic Development.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES

1	*Poonam Sharma, Swati Rajput,* ***"Sustainable Smart Cities In India Challenges And Future Perspectives"****, Springer 2017 Co.(P) Ltd. 2013.*
2	*Ivan Nunes Da Silva,* ***"Rogerio Andrade Flauzino-Smart Cities Technologies-Exli4eva"****, 2016.*
3	*Stan McClellan, Jesus A. Jimenez, George Koutitas* ***"Smart Cities_ Applications, Technologies, Standards"****, and Driving Factors-Springer International Publishing, 2018.*
4	*Stan Geertman, Joseph Ferreira, Jr., Robert Goodspeed, John Stillwell,* ***"Planning Support Systems And Smart Cities"****, Springer, 2015.*
5	*Pradip Kumar Sarkar and Amit Kumar Jain* ***"Intelligent Transport Systems"****, PHI Learning, 2018.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Indicate the potential challenges in smart city development.	K2
CO2	Select the different tools for sustainable urban planning.	K3
CO3	Choose appropriate energy conservation system for smart cities.	K3
CO4	Identify the proper method of water management system.	K3

CO5	Apply Intelligent Transport System concepts in planning of smart city.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	2	3	1	1
CO2	1	1	1	3	2	1
CO3	1	1	-	2	2	1
CO4	1	-	1	2	1	1
CO5	1	-	1	3	1	-
23SEOE02	1	1	2	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	45	30	-	-	-	100
CAT2	25	45	30	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	15	40	45	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	10	45	45	-	-	-	100
ESE	20	40	40	-	-	-	100

23SEOE03	GREEN BUILDING (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	To introduce the different concepts of energy efficient buildings, indoor environmental quality management, green buildings and its design.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Life cycle impacts of materials and products – sustainable design concepts – strategies of design for the Environment -The sun-earth relationship and the energy balance on the earth's surface, climate, wind – Solar radiation and solar temperature – Sun shading and solar radiation on surfaces – Energy impact on the shape and orientation of buildings – Thermal properties of building materials.		
UNIT – II	**ENERGY EFFICIENT BUILDINGS**	**9 Periods**
Passive cooling and day lighting – Active solar and photovoltaic- Building energy analysis methods- Building energy simulation- Building energy efficiency standards-Lighting system design- Lighting economics and aesthetics- Impacts of lighting efficiency – Energy audit and energy targeting- Technological options for energy management.		
UNIT – III	**INDOOR ENVIRONMENTAL QUALITY MANAGEMENT**	**9 Periods**
Psychrometry- Comfort conditions- Thermal comfort- Ventilation and air quality-Air conditioning requirement- Visual perception- Illumination requirement- Auditory requirement- Energy management options- Air conditioning systems- Energy conservation in pumps- Fans and blowers- Refrigerating machines- Heat rejection equipment- Energy efficient motors- Insulation.		
UNIT – IV	**GREEN BUILDING CONCEPTS**	**9 Periods**
Green building concept- Green building rating tools- Leeds and IGBC codes. – Material selection Embodied energy- Operating energy- Façade systems- Ventilation systems-Transportation- Water treatment systems- Water efficiency- Building economics		
UNIT – V	**GREEN BUILDING DESIGN - CASE STUDY**	**9 Periods**
Case studies - Building form, orientation and site considerations; conservation measures; energy modeling; heating system and fuel choices; renewable energy systems; material choices - construction budget		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES :

1	*Sam Kubba* ***"Handbook of Green Building Design and Construction: LEED, BREEAM, and Green Globes",*** *, Elsevier Science, 2012.*
2	*Yudelson, Jerry, McGraw-Hill,* ***"Greening existing buildings",*** *New York, 2010*
3	*Charles J. Kibert, John Wiley & Sons,* ***"Sustainable Construction: Green Building Design and Delivery****", 3rd Edition, 2012*
4	*R.S. Means, John Wiley & Sons,* ***"Green Building: Project Planning & Cost Estimating",*** *2010.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the concepts of sustainable design in building construction.	K3
CO2	Execute green building techniques including energy efficiency management in the building design.	K3
CO3	Establish indoor environmental quality in green building.	K3
CO4	Perform the green building rating using various tools.	K3
CO5	Create drawings and models of green buildings.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	3	3	3
CO2	3	3	2	3	3	3
CO3	2	2	2	2	3	3
CO4	2	3	1	3	3	3
CO5	3	3	1	3	3	3
23SEOE03	3	3	2	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	40	40	20	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	40	40	20	-	-	-	100
ESE	40	40	20	-	-	-	100

23EEOE04	ENVIRONMENT HEALTH AND SAFETY MANAGEMENT (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objectives	To impart knowledge on occupational health hazards, safety measures at work place, accident prevention, safety management and safety measures in industries.					
UNIT – I	**OCCUPATIONAL HEALTH HAZARDS**				**9 Periods**	
Occupation, Health and Hazards - Safety Health and Management: Occupational Health Hazards - Ergonomics - Importance of Industrial Safety - Radiation and Industrial Hazards: Types and effects - Vibration - Industrial Hygiene - Different air pollutants in industries and their effects - Electrical, fire and Other Hazards.						
UNIT – II	**SAFETY AT WORKPLACE**				**9 Periods**	
Safety at Workplace - Safe use of Machines and Tools: Safety in use of different types of unit operations - Ergonomics of Machine guarding - working in different workplaces - Operation, Inspection and maintenance - Housekeeping, Industrial lighting, Vibration and Noise.						
UNIT – III	**ACCIDENT PREVENTION**				**9 Periods**	
Accident Prevention Techniques - Principles of accident prevention - Hazard identification and analysis, Event tree analysis, Hazop studies, Job safety analysis - Theories and Principles of Accident causation - First Aid: Body structure and functions - Fracture and Dislocation, Injuries to various body parts.						
UNIT – IV	**SAFETY MANAGEMENT**				**9 Periods**	
Safety Management System and Law - Legislative measures in Industrial Safety - Occupational safety, Health and Environment Management, Bureau of Indian Standards on Health and Safety, IS 14489 standards - OSHA, Process safety management (PSM) and its principles - EPA standards						
UNIT – V	**GENERAL SAFETY MEASURES**				**9 Periods**	
Plant Layout for Safety - design and location, distance between hazardous units, lighting, colour coding, pilot plant studies, Housekeeping - Accidents Related with Maintenance of Machines - Work Permit System - Significance of Documentation - Case studies involving implementation of health and safety measures in Industries.						
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**						

REFERENCES:

1	***"Physical Hazards of the Workplace"**, Barry Spurlock, CRC Press, 2017.*
2	***"Handbook of Occupational Safety and Health",** S. Z. Mansdorf, Wiley Publications,2019*
3	***"Safety, Health, and Environment"**, NAPTA, 2nd Edition, Pearson Publications, 2019.*
4	*"**Occupational Health and Hygiene in Industries**", Raja Sekhar Mamillapalli, Visweswara Rao , PharmaMed Press, 1st edition, 2021.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the occupational health hazards.	K3
CO2	Execute various safety measures at workplace.	K3
CO3	Analyze and execute accident prevention techniques.	K3
CO4	Implement safety management as per various standards.	K3
CO5	Develop awareness on safety measures in Industries.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	2	2	3	2
CO2	2	2	2	1	2	2
CO3	2	3	2	1	2	2
CO4	1	1	1	2	2	2
CO5	1	1	1	1	1	2

23EEOE04	1	2	2	1	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	25	35	20	10	5	5	100
CAT2	25	35	20	10	5	5	100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project 1	20	40	30	10	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2/ Project 2	20	40	30	10	-	-	100
ESE	25	35	20	10	5	5	100

23EEOE05	CLIMATE CHANGE AND ADAPTATION (Common to all Branches)

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To understand the Earth's climate system, changes and their effects on the earth, identifying the impacts, adaptation, mitigation of climate change and for gaining knowledge on clean technology, carbon trading and alternate energy sources.

UNIT – I	EARTH'S CLIMATE SYSTEM	9 Periods

Introduction-Climate in the spotlight - The Earth's Climate Machine – Climate Classification- Global Wind Systems – Trade Winds and the Hadley Cell – The Westerlies – Cloud Formation and Monsoon Rains – Storms and Hurricanes - The Hydrological Cycle – Global Ocean Circulation – El Nino and its Effect - Solar Radiation – The Earth's Natural Green House Effect – Green House Gases and Global Warming – Carbon Cycle.

UNIT – II	OBSERVED CHANGES AND ITS CAUSES	9 Periods

Observation of Climate Change – Changes in patterns of temperature, precipitation and sea level rise – Observed effects of Climate Changes – Patterns of Large-Scale Variability –Drivers of Climate Change – Climate Sensitivity and Feedbacks – The Montreal Protocol –UNFCCC – IPCC – Evidences of Changes in Climate and Environment – on a Global Scale and in India – climate change modeling.

UNIT – III	IMPACTS OF CLIMATE CHANGE	9 Periods

Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem – Water Resources – Human Health – Industry, Settlement and Society – Methods and Scenarios –Projected Impacts for Different Regions – Uncertainties in the Projected Impacts of Climate Change – Risk of Irreversible Changes.

UNIT – IV	CLIMATE CHANGE ADAPTATION AND MITIGATION MEASURES	9 Periods

Adaptation Strategy/Options in various sectors – Water – Agriculture –- Infrastructure and Settlement including coastal zones – Human Health – Tourism – Transport – Energy – Key Mitigation Technologies and Practices – Energy Supply – Transport – Buildings – Industry –Agriculture – Forestry - Carbon sequestration – Carbon capture and storage (CCS) – Waste (MSW & Bio waste, Biomedical, Industrial waste – International and Regional cooperation.

UNIT – V	CLEAN TECHNOLOGY AND ENERGY	9 Periods

Clean Development Mechanism – Carbon Trading - examples of future Clean Technology –Biodiesel – Natural Compost – Eco- Friendly Plastic – Alternate Energy – Hydrogen – Biofuels– Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding.

Contact Periods:
Lecture: 45 Periods **Tutorial: 0Periods** **Practical: 0 Periods** **Total:45 Periods**

REFERENCES

1	***"Impacts of Climate Change and Climate Variability on Hydrological Regimes",*** *Jan C. Van Dam, Cambridge University Press, 2003.*
2	*IPCC fourth assessment report - The AR4 synthesis report, 2007*
3	*IPCC fourth assessment report –Working Group I Report****, "The physical sciencebasis",****2007*
4	*IPCC fourth assessment report - Working Group II Report,* ***"Impacts, Adaptation and Vulnerability",*** *2007*
5	*IPCC fourth assessment report – Working Group III Report****" Mitigation of Climate Change",*** *2007*
6	***"Climate Change and Water". Technical Paper of the Intergovernmental Panel on Climate Change,*** *Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., IPCC Secretariat, Geneva, 2008.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Classify the Earths climatic system and factors causing climate change and global warming.	K2
CO2	Relate the Changes in patterns of temperature, precipitation and sea level rise and Observed effects of Climate Changes	K2
CO3	Illustrate the uncertainty and impact of climate change and risk of reversible changes.	K3
CO4	Articulate the strategies for adaptation and mitigation of climatic changes.	K3

CO5	Discover clean technologies and alternate energy source for sustainable growth.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	2	3	1
CO2	3	2	2	2	3	2
CO3	2	2	2	2	3	2
CO4	3	2	2	2	2	2
CO5	3	3	2	3	3	3
23EEOE05	3	3	3	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	30	35	10	-	-	100
CAT2	25	30	35	10	-	-	100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project 1	20	30	40	10	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2/ Project 2	20	30	40	10	-	-	100
ESE	25	30	35	10	-	-	100

23EEOE06	WASTE TO ENERGY (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objectives	To classify waste as fuel, introduce conversion devices, gain knowledge about Biomass Pyrolysis, demonstrate methods, factors for biomass gasification, and acquire knowledge about biogas and its development in India.					
UNIT – I	**INTRODUCTION**					**9 Periods**
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**					**9 Periods**
Biomass Pyrolysis: Pyrolysis -Types, Slow Pyrolysis, Fast Pyrolysis – Manufacture of charcoal – Methods – Yields and Applications – Manufacture of Pyrolytic oils and gases, Yields and Applications.						
UNIT – III	**BIOMASS GASIFICATION**					**9 Periods**
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 Considerations in gasifier operation.						
UNIT – IV	**BIOMASS COMBUSTION**					**9 Periods**
Biomass Combustion – Biomass Stoves – Improved Chullahs, types, some exotic designs, Fixed bed combustors, types – Inclined grate combustors – Fluidized bed combustors, design, construction and operation of all the above biomass combustors.						
UNIT – V	**BIOENERGY SYSTEM**					**9 Periods**
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.						
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**						

REFERENCES:

1	***"Energy Recovery from Municipal Solid Waste by Thermal Conversion Technologies",*** *P Jayaram Reddy, Taylor and Francis Publications, 2016.*
2	***"Waste – to – Energy: Technologies and project Implementations",*** *Marc J Rogoff, Francois Screve,ELSEVIER Publications, Third Edition, 2019.*
3	***"Biogas Technology and Principles"****, Brad Hill, NY RESEARCH PRESS Publications, Illustrated Edition, 2015.*
4	***"Biomass Gasification and Pyrolysis Practical Design and Theory",***Prabir*ELSEVIER Publication 2010.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Investigate solid waste management techniques.	K2
CO2	Get knowledge about biomass pyrolysis.	K3
CO3	Demonstrate methods and factors considered for biomass gasification.	K3
CO4	Identify the features of different facilities available for biomass combustion.	K4
CO5	Analyze the potential of different Bioenergy systems with respect to Indian condition.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	3	2	3	1
CO2	3	2	2	2	3	1
CO3	3	3	2	3	2	1
CO4	3	2	2	3	3	1
CO5	2	3	3	3	2	1
23EEOE06	3	3	3	3	3	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	20	20	25	15	10	100
CAT2	10	25	20	10	25	10	100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project 1	-	15	35	50	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2/ Project 2	-	10	40	50	-	-	100
ESE	10	25	25	20	10	10	100

23GEOE07	ENERGY IN BUILT ENVIRONMENT (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objective	To understand constructional energy requirements of buildings, energy audit methods and conservation of energy.					
UNIT–I	**INTRODUCTION**					**9 Periods**
Indoor activities and environmental control - Internal and external factors on energy use –Characteristics of energy use and its management -Macro aspect of energy use in dwellings and its implications – Thermal comfort-Ventilation and air quality-Air-conditioning requirement-Visual perception-Illumination requirement-Auditory requirement.						
UNIT–II	**LIGHTING REQUIREMENTS IN BUILDING**					**9 Periods**
The sun-earth relationship - Climate, wind, solar radiation and temperature - Sun shading and solar radiation on surfaces-Energy impact on the shape and orientation of buildings–Lighting and day lighting :Characteristics and estimation, methods of day-lighting–Architectural considerations for day-lighting.						
UNIT–III	**ENERGY REQUIREMENTS IN BUILDING**					**9 Periods**
Steady and unsteady heat transfer through wall and glazed window-Standards for thermal performance of building envelope- Evaluation of the overall thermal transfer- Thermal gain and net heat gain-End-Use energy requirements-Status of energy use in buildings-Estimation of energy use in a building.						
UNIT–IV	**ENERGY AUDIT**					**9 Periods**
Energy audit and energy targeting-Technological options for energy management-Natural and forced ventilation–Indoor environment and air quality-Air flow and air pressure on buildings-Flow due to Stack effect.						
UNIT–V	**COOLING IN BUILT ENVIRONMENT**					**9 Periods**
Passive building architecture – Radiative cooling-Solar cooling techniques - Solar desiccant dehumidification for ventilation-Natural and active cooling with adaptive comfort–Evaporative cooling – Zero energy building concept.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*J.Krieder and A.Rabl**, "Heating and Cooling of Buildings**: **Design for Efficiency"**, McGraw-Hill, 2000.*
2	*S.M.Guinnes and Reynolds, "**Mechanical and Electrical Equipment for Buildings"**,Wiley, 1989.*
3	*A.Shaw, "**Energy Design for Architects"**, AEE Energy Books, 1991.*
4	*ASHRAE,"**Hand book of Fundamentals"**,ASHRAE,Atlanta,GA.,2001.*
5	*Reference Manuals of DOE-2 (1990), Orlando Lawrence-Berkeley Laboratory, University of California, and Blast, University of Illinois ,USA.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand energy and its usage	K2
CO2	Know lighting to be given to a building	K1
CO3	Analyse the energy requirements in a building	K3
CO4	Apply the energy audit concepts.	K3

CO5	Study architectural specifications of a building	K1

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	3	1	2	1
CO2	2	-	3	1	2	1
CO3	2	-	3	1	2	1
CO4	2	-	3	1	2	1
CO5	2	-	3	1	2	1
23GEOE07	2	-	3	1	2	1
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Rememberi ng (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	40	20	-	-	-	100
CAT 2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	50	50	-	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEOE08	EARTH AND ITS ENVIRONMENT (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objective	To know about the planet earth, the geosystems and the resources like ground water and air and to learn about the Environmental Assessment and sustainability.					
UNIT–I	**EVOLUTION OF EARTH**					**9 Periods**
Evolution of earth as habitable planet-Evolution of continents-oceans and landforms-evolution of life through geological times - Exploring the earth's interior - thermal and chemical structure - origin of gravitational and magnetic fields.						
UNIT–II	**GEOSYSTEMS**					**9 Periods**
Plate tectonics - working and shaping the earth - Internal geosystems – earthquakes – volcanoes -climatic excursions through time - Basic Geological processes - igneous, sedimentation – metamorphic processes.						
UNIT–III	**GROUND WATER GEOLOGY**					**9 Periods**
Geology of ground water occurrence –recharge process-Ground water movement-Ground water discharge and catchment hydrology – Ground water as a resource - Natural ground water quality and contamination-Modelling and managing ground water systems.						
UNIT–IV	**ENVIRONMENTAL ASSESMENT AND SUSTAINABILITY**					**9 Periods**
Engineering and sustainable development - population and urbanization - toxic chemicals and finite resources - water scarcity and conflict - Environmental risk - risk assessment and characterization –hazard assessment-exposure assessment.						
UNIT–V	**AIR AND SOLIDWASTE**					**9 Periods**
Air resources engineering-introduction to atmospheric composition–behaviour-atmospheric photo chemistry-Solid waste management–characterization-management concepts.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*John Grotzinger and Thomas H.Jordan, "**Understanding Earth",** Sixth Edition, W.H.Freeman, 2010.*
2	*Younger,P.L., "**Ground water in the Environment: An introduction",** Blackwell Publishing,2007.*
3	*Mihelcic, J. R., Zimmerman, J. B., "**Environmental Engineering:Fundamentals, Sustainability and Design",**Wiley,NJ, 2010.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To know about evolution of earth and the structure of the earth.	K2
CO2	To understand the internal geosystems like earthquakes and volcanoes and the Various geological processes.	K2
CO3	To able to find the geological process of occurrence and movement of Ground water and the modeling systems.	K3
CO4	To assess the Environmental risks and the sustainability developments.	K3
CO5	To learn about the photochemistry of atmosphere and the solid waste Management concepts.	K1

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	-	2	2	-
CO2	3	-	3	3	-	3
CO3	2	-	-	-	-	-
CO4	-	2	-	-	1	-
CO5	2	2	-	1	-	-
23GEOE08	2	2	3	3	2	3
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	40	20	-	-	-	100
CAT 2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23GEOE09	NATURAL HAZARDS AND MITIGATION (Common to all Branches)					
PREREQUISITES:		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objective	To get idea on the causes, effects and mitigation measures of different types of hazards with case studies.					
UNIT–I	**EARTH QUAKES**					**9 Periods**
Definitions and basic concepts-different kinds of hazards–causes-Geologic Hazards–Earthquakes-causes of earthquakes–effects-plate tectonics-seismic waves-measures of size of earthquakes-earthquake resistant design concepts.						
UNIT–II	**SLOPE STABILITY**					**9 Periods**
Slope stability and landslides-causes of landslides–principles of stability analysis-remedial and corrective measures for slope stabilization.						
UNIT–III	**FLOODS**					**9 Periods**
Climatic Hazards–Floods-causes of flooding-regional flood frequency analysis–flood control measures-flood routing-flood forecasting-warning systems.						
UNIT–IV	**DROUGHTS**					**9 Periods**
Droughts –causes - types of droughts –effects of drought -hazard assessment – decision making-Use of GIS in natural hazard assessment–mitigation-management.						
UNIT–V	**TSUNAMI**					**9 Periods**
Tsunami–causes–effects–under sea earthquakes–landslides–volcanic eruptions–impact of sea meteorite–remedial measures–precautions–case studies.						
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Period** **Practical: 0 Periods** **Total: 45 Periods**						

REFERENCES

1	*Donald Hyndman and David Hyndman,* ***"Natural Hazards and Disasters",*** *Brooks/Cole Cengage Learning, 2008.*
2	*Edward Bryant,* ***"Natural Hazards"****, Cambridge University Press,2005.*
3	*J Michael Duncan and Stephan G Wright,* ***"Soil Strength and Slope Stability"****, John Wiley & Sons, Inc,2005.*
4	*AmrS.Elnashai and Luigi Di Sarno,****"Fundamentals of Earthquake Engineering"****, John Wiley & Sons,Inc,2008*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Learn the basic concepts of earthquakes and the design concepts of earthquake Resistant buildings.	K2
CO2	Acquire knowledge on the causes and remedial measures of slope stabilization.	K3
CO3	As certain the causes and control measures of flood.	K3
CO4	Know the types, causes and mitigation of droughts.	K2
CO5	Study the causes, effects and precautionary measures of Tsunami.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	-	3	2	3
CO2	3	1	2	3	3	3
CO3	3	2	3	-	-	3
CO4	3	-	-	3	2	3
CO5	3	-	2	2	-	3
23GEOE09	3	1	2	3	2	3
1–Slight, 2–Moderate, 3–Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT 1	40	40	20	-	-	-	100
CAT 2	40	40	20	-	-	-	100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

23EDOE10	BUSINESS ANALYTICS (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives

- To apprehend the fundamentals of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To study modeling for uncertainty and statistical inference.
- To apprehend analytics the usage of Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT – I	**BUSINESS ANALYTICS AND PROCESS**	**9 Periods**

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, 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 – II	**REGRESSION ANALYSIS**	**9 Periods**

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 – III	**STRUCTURE OF BUSINESS ANALYTICS**	**9 Periods**

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 – IV	**FORECASTING TECHNIQUES**	**9 Periods**

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 – V	**DECISION ANALYSIS AND RECENT TRENDS IN BUSINESS ANALYTICS**	**9 Periods**

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Recent Trends: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0Periods** **Total:45 Periods**

REFERENCES

1	*VigneshPrajapati,* ***"Big Data Analytics with R and Hadoop",****Packt Publishing, 2013.*
2	*Umesh R Hodeghatta, UmeshaNayak****, "Business Analytics Using R – A Practical Approach",*** *Apress, 2017.*
3	*AnandRajaraman, Jeffrey David Ullman,* ***"Mining of Massive Datasets",*** *Cambridge University Press, 2012.*
4	*Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson,* ***"Essentials of Business Analytics",*** *Cengage Learning, second Edition, 2016.*
5	*U. Dinesh Kumar,* ***"Business Analytics: TheScience of Data-Driven Decision Making",*** *Wiley, 2017.*
6	*Rui Miguel Forte,* ***"Mastering Predictive Analytics with R",*** *Packt Publication, 2015.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Identify the real world business problems and model with analytical solutions.	K4
CO2	Solve analytical problem with relevant mathematics background knowledge.	K4
CO3	Convert any real world decision making problem to hypothesis and apply suitable statistical testing.	K4
CO4	Write and Demonstrate simple applications involving analytics using Hadoop and Map Reduce	K4
CO5	Use open source frameworks for modeling and storing data.	K4

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	2	1	2	1
CO2	1	1	1	2	1
CO3	2	2	1	1	-
CO4	2	2	1	-	-
CO5	1	2	-	-	-
23EDOE10	1	2	1	2	1
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	25	25	25	25			100
CAT2	20	25	25	30			100
Assignment 1	25	30	25	20			100
Assignment 2	30	20	30	20			100
ESE	20	30	20	30			100

23EDOE11	INTRODUCTION TO INDUSTRIAL SAFETY (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	• Summarize basics of industrial safety. • Describe fundamentals of maintenance engineering. • Explain wear and corrosion. • Illustrate fault tracing. • Identify preventive and periodic maintenance.

UNIT – I	**INTRODUCTION**	**9 Periods**

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**	**9 Periods**

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**	**9 Periods**

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**	**9 Periods**

Fault tracing-concept and importance, decision tree concept, 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**	**9 Periods**

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

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical:0Periods** **Total:45 Periods**

REFERENCES

1	*Hans F. Winterkorn,* ***"Foundation Engineering Handbook",*** *Chapman & Hall London, 2013.*
2	***"Maintenance Engineering"*** *by Dr. Siddhartha Ray, New Age International (P) Ltd., Publishers, 2017*
3	***"Industrial Safety Management",*** *McGraw Hill Education; New edition (1 July 2017)*
4	***"Industrial Engineering And Production Management",*** *S. Chand Publishing; Third edition ,2018*
5	***"Industrial Safety and Maintenance Engineering",*** *Parth B. Shah, 2021.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Ability to summarize basics of industrial safety	K4
CO2	Ability to describe fundamentals of maintenance engineering	K4
CO3	Ability to explain wear and corrosion	K4
CO4	Ability to illustrate fault tracing	K4

CO5	Ability to identify preventive and periodic maintenance	K4

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	1	1	-	-
CO2	2	2	1	-	1
CO3	1	2	1	1	1
CO4	2	1	1	1	1
CO5	2	1	2	1	1
23EDOE11	2	1	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	25	25	25			100
CAT2	20	25	25	30			100
Assignment 1	25	30	25	20			100
Assignment 2	30	20	30	20			100
ESE	20	30	20	30			100

23EDOE12	OPERATIONS RESEARCH (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	• Solve linear programming problem and solve using graphical method. • Solve LPP using simplex method. • Solve transportation, assignment problems. • Solve project management problems. • Solve scheduling problems.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models		
UNIT – II	**LINEAR PROGRAMMING PROBLEM**	**9 Periods**
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming		
UNIT – III	**NON-LINEAR PROGRAMMING PROBLEM**	**9 Periods**
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT		
UNIT – IV	**SEQUENCING AND INVENTORY MODEL**	**9 Periods**
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.		
UNIT – V	**GAME THEORY**	**9 Periods**
Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical:0Periods Total:45 Periods**		

REFERENCES

1	*H.A. Taha**"Operations Research, An Introduction",** PHI, 2017.*
2	***"Industrial Engineering and Management",** O. P. Khanna, 2017.*
3	***"Operations Research",** S.K. Patel, 2017.*
4	***"Operation Research",**AnupGoel, RuchiAgarwal, Technical Publications, Jan 2021.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Formulate linear programming problem and solve using graphical method.	K4
CO2	Solve LPP using simplex method.	K4
CO3	Formulate and solve transportation, assignment problems.	K4
CO4	Solve project management problems.	K4
CO5	Solve scheduling problems	K4

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	1	1	-	-
CO2	2	2	1	-	-
CO3	1	1	2	1	1
CO4	1	1	-	-	-
CO5	2	1	-	-	-
23EDOE12	2	1	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	25	25	25	25			100
CAT2	20	25	25	30			100
Assignment 1	25	30	25	20			100
Assignment 2	30	20	30	20			100
ESE	20	30	20	30			100

23MFOE13	OCCUPATIONAL HEALTH AND SAFETY (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objectives	• To gain knowledge about occupational health hazard and safety measures at work place. • To learn about accident prevention and safety management. • To learn about general safety measures in industries.					
UNIT – I	**OCCUPATIONAL HEALTH AND HAZARDS**					**9 Periods**
Safety- History and development, National Safety Policy- Occupational Health Hazards - Ergonomics - Importance of Industrial Safety Radiation and Industrial Hazards- Machine Guards and its types, Automation.						
UNIT – II	**SAFETY AT WORKPLACE**					**9 Periods**
Safety at Workplace - Safe use of Machines and Tools: Safety in use of different types of unit operations - Ergonomics of Machine guarding - working in different workplaces - Operation, Inspection and maintenance, Plant Design and Housekeeping, Industrial lighting, Vibration and Noise Case studies.						
UNIT – III	**ACCIDENT PREVENTION**					**9 Periods**
Accident Prevention Techniques - Principles of accident prevention - Definitions, Theories, Principles – Hazard identification and analysis, Event tree analysis, Hazop studies, Job safety analysis - Theories and Principles of Accident causation - First Aid : Body structure and functions - Fracture and Dislocation, Injuries to various body parts.						
UNIT – IV	**SAFETY MANAGEMENT**					**9 Periods**
Safety Management System and Law - Legislative measures in Industrial Safety: Various acts involved in Detail- Occupational safety, Health and Environment Management: Bureau of Indian Standards on Health and Safety, 14489, 15001 - OSHA, Process safety management (PSM) and its principles - EPA standards- Safety Management: Organisational & Safety Committee - its structure and functions.						
UNIT – V	**GENERAL SAFETY MEASURES**					**9 Periods**
Plant Layout for Safety -design and location, distance between hazardous units, lighting, colour coding, pilot plant studies, Housekeeping - Accidents Related with Maintenance of Machines - Work Permit System: Significance of Documentation Directing Safety, Leadership -Case studies involving implementation of health and safety measures in Industries.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical:0 Periods Total:45 Periods**						

REFERENCES

1	*Benjamin O.Alli,* ***Fundamental Principles of Occupational Health and Safety*** *ILO 2008.*
2	*Danuta Koradecka,* ***Handbook of Occupational Health and Safety****, CRC, 2010.*
3	*Dr. Siddhartha Ray,* ***Maintenance Engineering,*** *New Age International (P) Ltd., Publishers, 2017*
4	*Deshmukh. L.M.,* ***Industrial Safety Management****, 3rd Edition, Tata McGraw Hill, NewDelhi, 2008.*
5	*https://nptel.ac.in/courses/110105094*
6	*https://archive.nptel.ac.in/courses/110/105/110105094/*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Gain the knowledge about occupational health hazard and safety measures at work place.	K3
CO2	Learn about accident prevention and safety management.	K2
CO3	Understand occupational health hazards and general safety measures in industries.	K3
CO4	Know various laws, standards and legislations.	K2

CO5	Implement safety and proper management of industries.	K4

COURSE ARTICULATION MATRIX:					
Cos/Pos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	1	1	1	1
CO2	2	2	1	1	1
CO3	1	2	1	1	1
CO4	2	1	1	1	1
CO5	2	1	2	1	1
23MFOE13	**2**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1		50	50				100
CAT2		50	30	20			100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project1		50	50				100
Individual Assessment 2/ Case Study 2/ Seminar 2 / Project 2		50	30	20			100
ESE		40	40	20			100

23MFOE14	COST MANAGEMENT OF ENGINEERING PROJECTS (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	• To understand the costing concepts and their role in decision making. • To acquire the project management concepts and their various aspects in selection. • To gain the knowledge in costing concepts with project execution. • To develop knowledge of costing techniques in service sector and various budgetary control techniques. • To familiarize with quantitative techniques in cost management.

UNIT – I	**INTRODUCTION TO COSTING CONCEPTS**	**9 Periods**

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.

UNIT – II	**PROJECT PLANNING ACTIVITIES**	**9 Periods**

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

UNIT – III	**COST ANALYSIS**	**9 Periods**

Cost Behaviour 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.

UNIT – IV	**PRICING STRATEGIES AND BUDGETORY CONTROL**	**9 Periods**

Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing, Costing of service sector, Just-in - time approach, Material Requirement Planning, Enterprise Resource Planning. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

UNIT – V	**TQM AND OPERATIONS REASEARCH TOOLS**	**9 Periods**

Total Quality Management and Theory of constraints, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

REFERENCES:

1	*Charles T. Horngren and George Foster, **Advanced Management Accounting**, 2018.*
2	*John M. Nicholas,**Project Management for Engineering, Business and Technology**, Taylor &Francis, 2016*
3	*Nigel J, **Engineering Project Management**, John Wiley and Sons Ltd, Smith 2015.*
4	*Charles T. Horngren and George Foster **Cost Accounting a Managerial Emphasis**, Prentice Hall of India, New Delhi, 2011.*
5	*https://archive.nptel.ac.in/courses/110/104/110104073/*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Apply the costing concepts and their role in decision making.	K3
CO2	Apply the project management concepts and analyze their various aspects in selection.	K4
CO3	Interpret costing concepts with project execution.	K4
CO4	Gain knowledge of costing techniques in service sector and various budgetary control techniques.	K2
CO5	Become familiar with quantitative techniques in cost management.	K3

COURSE ARTICULATION MATRIX:					
COs/Pos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	1	2	1	1
CO2	2	1	1	1	-
CO3	2	2	2	-	-
CO4	1	1	1	1	1
CO5	1	2	1	1	-
23MFOE14	1	1	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1			40	60			100
CAT2		30	30	40			100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1			40	60			100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2		30	30	40			100
ESE		20	40	40			100

23MFOE15	COMPOSITE MATERIALS (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	• To summarize the characteristics of composite materials and effect of reinforcement in composite materials. • To identify the various reinforcements used in composite materials. • To compare the manufacturing process of metal matrix composites. • To understand the manufacturing processes of polymer matrix composites. • To analyze the strength of composite materials.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement on overall composite performance.		
UNIT – II	**REINFORCEMENT**	**9 Periods**
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 Isosteresconditions.		
UNIT – III	**MANUFACTURING OF METAL MATRIX COMPOSITES**	**9 Periods**
Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing- 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 COMPOSITE**	**9 Periods**
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 ANALYSIS OF COMPOSITES**	**9 Periods**
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.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

REFERENCES:

1	*Chawla K.K., **Composite Materials**, Springer, 2013.*
2	*Lubin.G, **Hand Book of Composite Materials**, Springer New York, 2013.*
3	*Deborah D.L. Chung, **Composite Materials Science and Applications**, Springer, 2011.*
4	*uLektz, **Composite Materials and Mechanics**, uLektz Learning Solutions Private Limited, Lektz, 2013.*
5	*https://nptel.ac.in/courses/112104168*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Know the characteristics of composite materials and effect of reinforcement in composite materials.	K2
CO2	Know the various reinforcements used in composite materials.	K2
CO3	Understand and apply the manufacturing processes of metal matrix composites	K3
CO4	Understand and apply the manufacturing processes of polymer matrix composites.	K3
CO5	Analyze the strength of composite materials.	K4

COURSE ARTICULATION MATRIX:					
COs/Pos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	2	1	1	1
CO2	2	2	1	1	2
CO3	2	1	2	1	1
CO4	1	2	2	2	1
CO5	1	2	1	1	1
23MFOE15	1	2	2	1	1
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1		60	40				100
CAT2			60	40			100
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1		60	40				100
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2			60	40			100
ESE		40	40	20			100

23TEOE16	GLOBAL WARMING SCIENCE (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	To make the students learn about the material consequences of climate change, sea level change due to increase in the emission of greenhouse gases and to examine the science behind mitigation and adaptation proposals.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Terminology relating to atmospheric particles – Aerosols - Types, characteristics, measurements – Particle mass spectrometry - Anthropogenic-sources, effects on humans.		
UNIT – II	**CLIMATE MODELS**	**9 Periods**
General climate modeling- Atmospheric general circulation model - Oceanic general circulation model, sea ice model, land model concept, paleo-climate - Weather prediction by numerical process. Impacts of climate change - Climate Sensitivity - Forcing and feedback.		
UNIT – III	**EARTH CARBON CYCLE AND FORECAST**	**9 Periods**
Carbon cycle-process, importance, advantages - Carbon on earth - Global carbon reservoirs - Interactions between human activities and carbon cycle - Geologic time scales - Fossil fuels and energy - Perturbed carbon cycle.		
UNIT – IV	**GREENHOUSE GASES**	**9 Periods**
Blackbody radiation - Layer model - Earth's atmospheric composition and Green house gases effects on weather and climate - Radioactive equilibrium - Earth's energy balance.		
UNIT – V	**GEO ENGINEERING**	**9 Periods**
Solar mitigation - Strategies – Carbon dioxide removal - Solar radiation management - Recent observed trends in global warming for sea level rise, drought, glacier extent.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0Periods** **Practical: 0 Periods** **Total: 45 Periods**		

REFERENCES:

1	*Eli Tziperman,* ***"Global Warming Science: A Quantitative Introduction to Climate Change and Its Consequences"****, Princeton University Press, 1st Edition, 2022.*
2	*John Houghton,* ***"Global warming: The Complete Briefing"****, Cambridge University Press, 5th Edition, 2015.*
3	*David Archer,* ***"Global warming: Understanding the Forecast"****, Wiley, 2nd Edition, 2011.*
4	*David S.K. Ting, Jacqueline A Stagner,* ***"Climate Change Science: Causes, Effects and Solutions for Global Warming"****, Elsevier, 1st Edition, 2021.*
5	*Frances Drake,* ***"Global Warming: The Science of Climate Change"****,Routledge, 1st edition, 2000.*
6	*Dickinson,* ***"Climate Engineering-A review of aerosol approaches to changing the global energybalance"****, Springer, 1996.*
7	*Andreas Schmittner,* ***"Introduction to Climate Science"****, Oregon State University, 2018.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the global warming in relation to climate changes throughout the earth.	K2
CO2	Assess the best predictions of current climate models.	K4
CO3	Understand the importance of carbon cycle and its implication on fossil fuels.	K2
CO4	Know about current issues, including impact from society, environment, economy as well as ecology related to greenhouse gases.	K4
CO5	Know the safety measures and precautions regarding global warming.	K5

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	2	1	1	2
CO2	1	1	2	1	1	1
CO3	1	2	1	1	1	2
CO4	1	1	1	1	1	2
CO5	2	1	2	1	1	2
23TEOE16	1	1	1	1	1	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	35	35	10	-	-	100
CAT2	15	25	25	20	15	-	100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project 1	25	20	20	35	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2/ Project 2	20	20	35	15	10	-	100
ESE	25	20	25	20	10	-	100

23TEOE17	INTRODUCTION TO NANO ELECTRONICS (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
ENGINEERING PHYSICS		**OE**	**3**	**0**	**0**	**3**
Course Objectives	To make the students provide strong, essential, important methods and foundations of quantum mechanics and apply quantum mechanics on engineering fields.					
UNIT – I	**INTRODUCTION**					**9 Periods**
Particles and Waves - Operators in quantum mechanics - The Postulates of quantum mechanics - The Schrodinger equation values and wave packet Solutions - Ehrenfest's Theorem.						
UNIT – II	**ELECTRONIC STRUCTURE AND MOTION**					**9 Periods**
Atoms- The Hydrogen Atom - Many-Electron Atoms – Pseudopotentials, Nuclear Structure, Molecules, Crystals - Translational motion – Penetration through barriers – Particle in a box - Two terminal quantum dot devices - Two terminal quantum wire devices.						
UNIT – III	**SCATTERING THEORY**					**9 Periods**
The formulation of scattering events - Scattering cross section - Stationary scattering state - Partial wave stationary scattering events - multi-channel scattering - Solution for Schrodinger equation- Radial and wave equation - Greens' function.						
UNIT – IV	**CLASSICAL STATISTICS**					**9 Periods**
Probabilities and microscopic behaviours - Kinetic theory and transport processes in gases - Magnetic properties of materials - The partition function.						
UNIT – V	**QUANTUM STATISTICS**					**9 Periods**
Statistical mechanics - Basic Concepts - Statistical models applied to metals and semiconductors - The thermal properties of solids- The electrical properties of materials - Black body radiation - Low temperatures and degenerate systems.						
Contact Periods: **Lecture:45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total:45 Periods**						

REFERENCES:

1	*Vladimi V.Mitin, Viatcheslav A. Kochelap and Michael A.Stroscio,* ***"Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications"****, Cambridge University Press, 1st Edition, 2007.*
2	*Vinod Kumar Khanna,* ***"Introductory Nanoelectronics: Physical Theory and Device Analysis"****, Routledge, 1st Edition, 2020.*
3	*George W. Hanson,* ***"Fundamentals of Nanoelectronics"****, Pearson Publishers, United States Edition, 2007.*
4	*Marc Baldo,* ***"Introduction to Nanoelectronics"****, MIT Open Courseware Publication, 2011.*
5	*Vladimi V.Mitin,* ***"Introduction to Nanoelectronics"****, Cambridge University Press, South Asian Edition, 2009.*
6	*Peter L. Hagelstein, Stephen D. Senturia and Terry P. Orlando, "****Introductory Applied Quantum Statistical Mechanics"****, Wiley, 2004.*
7	*A. F. J. Levi,* ***"Applied Quantum Mechanics"****, 2nd Edition, Cambridge, 2012.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the postulates of quantum mechanics.	K2
CO2	Know about nano electronic systems and building blocks.	K2
CO3	Solve the Schrodinger equation in 1D, 2D and 3Ddifferent applications.	K4
CO4	Learn the concepts involved in kinetic theory of gases.	K2

CO5	Know about statistical models applies to metals and semiconductor.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	1	1	1	1
CO2	2	2	1	1	1	1
CO3	2	2	2	1	1	1
CO4	1	1	1	1	1	1
CO5	1	1	1	1	1	1
23TEOE17	1	1	1	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	20	20	-	-	100
CAT2	30	30	20	20	-	-	100
Individual Assessment 1/ Case Study 1/ Seminar 1/ Project 1	35	25	20	20	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2/ Project 2	30	25	20	25	-	-	100
ESE	20	30	30	20	-	-	100

23TEOE18	GREEN SUPPLY CHAIN MANAGEMENT (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	To make the students learn and focus on the fundamental strategies, tools and techniques required to analyze and design environmentally sustainable supply chain systems.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Intro to SCM – complexity in SCM, Facility location - Logistics – Aim, activities, importance, progress, current trends - Integrating logistics with an organization.		
UNIT – II	**ESSENTIALS OF SUPPLY CHAIN MANAGEMENT**	**9 Periods**
Basic concepts of supply chain management - Supply chain operations – Planning and sourcing - Making and delivering - Supply chain coordination and use of technology - Developing supply chain systems.		
UNIT – III	**PLANNING THE SUPPLY CHAIN**	**9 Periods**
Types of decisions – strategic, tactical, operational - Logistics strategies, implementing the strategy - Planning resources – types, capacity, schedule, controlling material flow, measuring and improving performance.		
UNIT – IV	**ACTIVITIES IN THE SUPPLY CHAIN**	**9 Periods**
Procurement – cycle, types of purchase – Framework of e-procurement - Inventory management – EOQ, uncertain demand and safety stock, stock control - Material handling – Purpose of warehouse and ownership, layout, packaging - Transport – mode, ownership, vehicle routing and scheduling models- Travelling salesman problems - Exact and heuristic methods.		
UNIT – V	**SUPPLY CHAIN MANAGEMENT STRATEGIES**	**9 Periods**
Five key configuration components - Four criteria of good supply chain strategies - Next generation strategies- New roles for end-to-end supply chain management - Evolution of supply chain organization – International issues in SCM – Regional differences in logistics.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

REFERENCES:

1	*Charisios Achillas, Dionysis D. Bochtis, Dimitrios Aidonis and Dimitris Folinas,* ***"Green Supply Chain Management"****, Routledge, 1st Edition, 2019.*
2	*Hsiao-Fan Wang and Surendra M.Gupta,* ***"Green Supply Chain Management: Product Life Cycle Approach"****,McGraw-Hill Education, 1st Edition, 2011.*
3	*Joseph Sarkis and Yijie Dou,* ***"Green Supply Chain Management"****, Routledge, 1st Edition, 2017.*
4	*Arunachalam Rajagopal,* ***"Green Supply Chain Management: A Practical Approach"****, Replica, 2021.*
5	*Mehmood Khan, Matloub Hussain and Mian M. Ajmal,* ***"Green Supply Chain Management for Sustainable Business Practice"****, IGI Global, 1st Edition, 2016.*
6	*S Emmett,* ***"Green Supply Chains: An Action Manifesto"****, John Wiley & Sons Inc, 2010.*
7	*Joseph Sarkis and Yijie Dou,* ***"Green Supply Chain Management: A Concise Introduction"****, Routledge, 1st Edition, 2017.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Integrate logistics with an organization.	K2
CO2	Evaluate complex qualitative and quantitative data to support strategic and operational decisions.	K5
CO3	Develop self-leadership strategies to enhance personal and professional effectiveness.	K3
CO4	Analyze inventory management models and dynamics of supply chain.	K4

CO5	Identify issues in international supply chain management and outsources strategies.	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	1	1	1	3
CO2	2	2	1	1	1	1
CO3	2	1	2	1	1	1
CO4	2	2	1	1	2	2
CO5	1	1	2	1	1	3
23TEOE18	2	1	1	1	1	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	25	30	10	10	-	100
CAT2	30	40	20	10	-	-	100
Individual Assessment 1/ Case Study 1/ Seminar 1/ Project 1	30	20	25	15	10	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2/ Project 2	35	30	25	10	-	-	100
ESE	30	30	20	10	10	-	100

23PSOE19	DISTRIBUTION AUTOMATION SYSTEM (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	To study about the distributed automation and economic evaluation schemes of power network	
UNIT – I	**INTRODUCTION**	**9 Periods**
Introduction to Distribution Automation (DA) - Control system interfaces- Control and data requirements- Centralized (vs) decentralized control- DA system-DA hardware-DAS software.		
UNIT – II	**DISTRIBUTION AUTOMATION FUNCTIONS**	**9 Periods**
DA capabilities - Automation system computer facilities- Management processes- Information management- System reliability management- System efficiency management- Voltage management- Load management.		
UNIT – III	**COMMUNICATION SYSTEMS**	**9 Periods**
Communication requirements - reliability- Cost effectiveness- Data requirements- Two way capability- Communication during outages and faults - Ease of operation and maintenance- Conforming to the architecture of flow. Distribution line carrier- Ripple control-Zero crossing technique- Telephone, cableTV, radio, AM broadcast, FM SCA,VHF radio, microwave satellite, fiber optics-Hybrid communication systems used in field tests.		
UNIT – IV	**ECONOMIC EVALUATION METHODS**	**9 Periods**
Development and evaluation of alternate plans- select study area – Select study period- Project load growth- Develop alternatives- Calculate operating and maintenance costs-Evaluate alternatives.		
UNIT – V	**ECONOMIC COMPARISON**	**9 Periods**
Economic comparison of alternate plans-Classification of expenses - capital expenditures-Comparison of revenue requirements of alternative plans-Book life and continuing plant analysis- Year by year revenue requirement analysis, Short term analysis- End of study adjustment-Break even analysis, sensitivity analysis - Computational aids.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES

1	*M.K. Khedkar, G.M. Dhole,* ***"A Textbook of Electric Power Distribution Automation"****, Laxmi Publications, Ltd., 2010.*
2	*Maurizio Di Paolo Emilio,* ***"Data Acquisition Systems: From Fundamentals to Applied Design"****, Springer Science & Business Media, 21-Mar-2013*
3	*IEEE Tutorial course* ***"Distribution Automation"****, IEEE Working Group on Distribution Automation, IEEE Power Engineering Society. Power Engineering Education Committee, IEEE Power Engineering Society. Transmission and Distribution Committee, Institute of Electrical and Electronics Engineers, 1988*
4	*Taub,* ***"Principles Of Communication Systems",*** *Tata McGraw-Hill Education, 07-Sep-2008*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyse the requirements of distributed automation	K1
CO2	Know the functions of distributed automation	K2
CO3	Perform detailed analysis of communication systems for distributed automation.	K3
CO4	Study the economic evaluation method	K4
CO5	Understand the comparison of alternate plans	K5

COURSE ARTICULATION MATRIX				
COs/Pos	**PO1**	**PO2**	**PO3**	**PO4**
CO1	2	-	1	3
CO2	3	-	3	2
CO3	3	-	3	2
CO4	3	-	3	1
CO5	2	-	1	2
23PSOE19	3	-	3	2
1 – Slight, 2 – Moderate, 3 – Substantial				

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20%	30%	20%	10%	20%	-	100%
CAT2	20%	20%	20%	20%	20%	-	100%
Individual Assessment1/ Case study1/ Seminar 1/ Project1	20%	10%	30%	20%	20%	-	100%
Individual Assessment2/ Case study2/ Seminar 2 / Project2	20%	30%	10%	20%	20%	-	100%
ESE	30%	20%	20%	20%	10%	-	100%

23PSOE20	ELECTRICITY TRADING AND ELECTRICITY ACTS (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objectives	To acquire expertise on Electric supply and demand of Indian Grid, gain exposure on energy trading in the Indian market and infer the electricity acts and regulatory authorities.					
UNIT – I	**ENERGY DEMAND**					**9 Periods**
Basic concepts in Economics - Descriptive Analysis of Energy Demand - Decomposition Analysis and Parametric Approach - Demand Side Management - Load Management - Demand Side Management - Energy Efficiency - Rebound Effect						
UNIT – II	**ENERGY SUPPLY**					**9 Periods**
Supply Behavior of a Producer - Energy Investment - Economics of Non-renewable Resources - Economics of Renewable Energy Supply Setting the context - Economics of Renewable Energy Supply - Economics of Electricity Supply						
UNIT – III	**ENERGY MARKET**					**9 Periods**
Perfect Competition as a Market Form - Why is the Energy Market not Perfectly Competitive? - Market Failure and Monopoly - Oil Market: Pre OPEC Era I - Oil Market: Pre OPEC Era II - Oil Market: OPEC						
UNIT – IV	**LAW ON ELECTRICITY**					**9 Periods**
Introduction of the Electricity Law; Constitutional Design - Evolution of Laws on Electricity Salient Features of Electricity Act, 2003 - Evolution of Laws on Electricity - Salient Features of the Electricity Act 2003						
UNIT – V	**REGULATORY COMMISSIONS FOR ELECTRICITY ACT**					**9 Periods**
Regulatory Commissions - Appellate Tribunal - Other Institutions under the Act - Electricity (Amendment) Bill 2020/2021. A Critical Comment - Renewable Energy - Role of Civil Society; Comments on Draft Renewable Energy Act, 2015						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*Bhattacharyya, Subhes. C. (2011).* ***"Energy Economics: Concepts, Issues, Markets and Governance"****. Springer.London, UK*
2	*Stevens, P. (2000).* ***"An Introduction to Energy Economics. In Stevens, P.(ed.) The Economics of Energy"****, Vol.1, Edward Elgar, Cheltenham, UK.*
3	*Nausir Bharucha,* ***"Guide to the Electricity Laws"****, LexisNexis, 2018*
4	*Mohammad Naseem,* ***"Energy Laws in India"****, Kluwer Law International, 3rd Edn, The Netherlands, 2017.*
5	*Alok Kumar & Sushanta K Chaterjee,* ***"Electricity Sector in India: Policy and Regulation"****, OUP, 2012.*
6	*Benjamin K Sovacool & Michael H Dowrkin,* ***"Global Energy Justice: Problems, Principles and Practices"****, Cambridge Univesity Press, 2014.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Describe electric supply and demand of power grid	K1
CO2	Summarize various energy trading strategies	K2
CO3	Relate the electricity acts practically	K3
CO4	Cite the electricity regulatory authorities	K2
CO5	Analyze/check the existing power grid for its technical and economical sustainability	K4

COURSE ARTICULATION MATRIX				
COs/Pos	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	-	3	3
CO2	3	-	1	1
CO3	3	-	2	2
CO4	3	-	1	2
CO5	3	-	3	3
23PSOE20	3	-	2	2
1 – Slight, 2 – Moderate, 3 – Substantial				

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20%	30%	20%	30%	-	-	100%
CAT2	20%	20%	20%	20%	20%	-	100%
Individual Assessment1/ Case study1/ Seminar 1/ Project1	20%	30%	30%	20%	-	-	100%
Individual Assessment2/ Case study2/ Seminar 2 / Project2	20%	30%	-	20%	-	40%	100%
ESE	30%	30%	-	20%	20%	-	100%

23PSOE21	MODERN AUTOMOTIVE SYSTEMS (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objectives	To expose the students with theory and applications of Automotive Electrical and Electronic Systems.					
UNIT – I	**INTRODUCTION TO MODERN AUTOMOTIVE ELECTRONICS**					**9 Periods**
Introduction to modern automotive systems and need for electronics in automobiles- Role of electronics and microcontrollers- Sensors and actuators- Possibilities and challenges in automotive industry- Enabling technologies and industry trends.						
UNIT – II	**SENSORS AND ACTUATORS**					**9 Periods**
Introduction- basic sensor arrangement- Types of sensors- Oxygen sensor, engine crankshaft angular position sensor – Engine cooling water temperature sensor- Engine oil pressure sensor- Fuel metering- vehicle speed sensor and detonation sensor- Pressure Sensor- Linear and angle sensors- Flow sensor- Temperature and humidity sensors- Gas sensor- Speed and Acceleration sensors- Knock sensor- Torque sensor- Yaw rate sensor- Tyre Pressure sensor- Actuators - Stepper motors – Relays.						
UNIT – III	**POWERTRAIN CONTROL SYSTEMS IN AUTOMOBILE**					**9 Periods**
Electronic Transmission Control - Digital engine control system: Open loop and close loop control systems- Engine cooling and warm up control- Acceleration- Detonation and idle speed control - Exhaust emission control engineering- Onboard diagnostics- Future automotive powertrain systems.						
UNIT – IV	**SAFETY, COMFORT AND CONVENIENCE SYSTEMS**					**9 Periods**
Cruise Control- Anti-lock Braking Control- Traction and Stability control- Airbag control system- Suspension control- Steering control- HVAC Control.						
UNIT – V	**ELECTRONIC CONTROL UNITS (ECU)**					**9 Periods**
Introduction to Energy Sources for ECU, Need for ECUs- Advances in ECUs for automotives - Design complexities of ECUs- V-Model for Automotive ECU's- Architecture of an advanced microcontroller (XC166 Family, 32-bit Tricore) used in the design of automobile ECUs- On chip peripherals, protocol interfaces, analog and digital interfaces.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES

1	*Enrique Acha, Manuel Madrigal,* ***"Power System Harmonics: Computer Modeling and Analysis****", John Wiley and Sons, 2001.*
2	*M. H. J. Bollen,* ***"Understanding Power Quality Problems, Voltage Sag and Interruptions",*** *IEEE Press, series on Power Engineering, 2000.*
3	*Roger C. Dugan, Mark F. McGranaghan, Surya Santoso and Wayne Beaty H.,* ***"Electrical Power SystemQuality"****, Second Edition, McGraw Hill Publication Co., 2008.*
4	*G.T.Heydt,* ***"Electric Power Quality",*** *Stars in a Circle Publications, 1994(2nd edition).*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire knowledge about conventional automotive control units and devices.	K1
CO2	Recognize the practical issues in the automotive control systems	K2

CO3	Analyze the impact of modern automotive techniques in various Engineering applications	K4
CO4	Develop modern automotive control system for electrical and electronics systems	K6
CO5	Understand the function of sensors and actuators	K2

COURSE ARTICULATION MATRIX				
COs/Pos	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	-	1	3
CO2	3	-	3	2
CO3	3	-	3	2
CO4	2	-	3	1
CO5	2	-	1	2
23PSOE21	3	-	2	2
1 – Slight, 2 – Moderate, 3 – Substantial				

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20%	30%	20%	30%	-	-	100%
CAT2	20%	20%	20%	20%	20%	-	100%
Individual Assessment1/ Case study1/ Seminar 1/ Project1	20%	30%	-	20%	-	30%	100%
Individual Assessment2/ Case study2/ Seminar 2 / Project2	20%	30%	-	20%	-	40%	100%
ESE	30%	30%	20%	20%	-	-	100%

23PEOE22	VIRTUAL INSTRUMENTATION (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	To comprehend the Virtual instrumentation programming concepts towards measurements and control and to instill knowledge on DAQ, signal conditioning and its associated software tools	
UNIT – I	**INTRODUCTION**	**7 Periods**
Introduction - advantages - Block diagram and architecture of a virtual instrument - Conventional Instruments versus Traditional Instruments - Data-flow techniques, graphical programming in data flow, comparison with conventional programming.		
UNIT – II	**GRAPHICAL PROGRAMMING AND LabVIEW**	**9 Periods**
Concepts of graphical programming - LabVIEW software - Concept of VIs and sub VI - Display types - Digital - Analog - Chart and Graphs. Loops - structures - Arrays – Clusters- Local and global variables – String - Timers and dialog controls.		
UNIT – III	**MANAGING FILES & DESIGN PATTERNS**	**11 Periods**
High-level and low-level file I/O functions available in LabVIEW – Implementing File I/O functions to read and write data to files – Binary Files – TDMS – sequential programming – State machine programming – Communication between parallel loops –Race conditions – Notifiers & Queues – Producer Consumer design patterns		
UNIT – IV	**PC BASED DATA ACQUISITION**	**9 Periods**
Introduction to data acquisition on PC, Sampling fundamentals, ADCs, DACs, Calibration, Resolution, - analog inputs and outputs - Single-ended and differential inputs - Digital I/O, counters and timers, DMA, Data acquisition interface requirements - Issues involved in selection of Data acquisition cards - Use of timer-counter and analog outputs on the universal DAQ card.		
UNIT – V	**DATA ACQUISITION AND SIGNAL CONDITIONING**	**9 Periods**
Components of a DAQ system, Bus, Signal and accuracy consideration when choosing DAQ hardware – Measurement of analog signal with Finite and continuous buffered acquisition- analog output generation – Signal conditioning systems – Synchronizing measurements in single & multiple devices – Power quality analysis using Electrical Power Measurement tool kit.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

REFERENCES :

1	*Jeffrey Travis, Jim Kring,* ***"LabVIEW for Everyone: Graphical Programming Made Easy and Fun" (3rd Edition),*** *Prentice Hall, 2006.*
2	*Jovitha Jerome,* ***"Virtual Instrumentation using LabVIEW",*** *PHI, 2010*
3	*Gary W. Johnson, Richard Jennings,* ***"LabVIEW Graphical Programming"****, McGraw Hill Professional Publishing, 2019*
4	*Robert H. Bishop,* ***"Learning with LabVIEW"****, Prentice Hall, 2013.*
5	*Kevin James, "****PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control"****, Newness, 2000*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Describe the graphical programming techniques using LabVIEW software.	K2
CO2	Explore the basics of programming and interfacing using related hardware.	K4
CO3	Analyse the aspects and utilization of PC based data acquisition and Instrument interfaces.	K4
CO4	Create programs and Select proper instrument interface for a specific application.	K6

CO5	Familiarize and experiment with DAQ and Signal Conditioning	K3

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3	-	3	2	1
CO2	3	-	3	2	1
CO3	3	-	2	2	2
CO4	3	1	3	3	1
CO5	3	1	3	3	2
23PEOE22	3	1	3	2	1

1 – Slight, 2 – Moderate, 3 – Substantial

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	40	15	15	-	-	100
CAT2	15	10	25	30	20	-	100
Individual Assessment1/ Case study1/ Seminar 1/ Project1	10	10	20	30	20	10	100
Individual Assessment2/ Case study2/ Seminar 2 / Project2	25	40	20	15	-	-	100
ESE	30	25	15	20	5	5	100

23PEOE23	ENERGY MANAGEMENT SYSTEMS (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objectives	To Comprehend energy management schemes, perform energy audit and execute economic analysis and load management in electrical systems.					
UNIT – I	**GENERAL ASPECTS OF ENERGY AUDIT AND MANAGEMENT**					**9 Periods**
Energy Conservation Act 2001 and policies – Eight National Missions - Basics of Energy and its forms (Thermal and Electrical) - Energy Management and Audit - Energy Managers and Auditors - Types and Methodology Audit Report - Material and energy balance diagrams - .Energy Monitoring and Targeting.						
UNIT – II	**STUDY OF BOILERS, FURNACES AND COGENERATION**					**9 Periods**
Boiler Systems - Types - Performance Evaluation of boilers - Energy Conservation Opportunity - Steam Distribution - Efficient Steam Utilisation - Furnaces:types and classification - Performance evaluation of a typical fuel fired furnace. Cogeneration: Need - Principle - Technical options - classification - Technical parameters and factors influencing cogeneration choice - Prime Movers - Trigeneration.						
UNIT – III	**ENERGY STUDY OF ELECTRICAL SYSTEMS**					**9 Periods**
Electricity Billing – Electricity load management - Maximum Demand Control - Power Factor improvement and its benefits - pf controllers - capacitors - Energy efficient transformers and Induction motors - rewinding and other factors influencing energy efficiency - Standards and labeling programme of distribution transformers and IM - Analysis of distribution losses - demand side management - harmonics - filters - VFD and its selection.						
UNIT – IV	**STUDY OF ELECTRICAL UTILITIES**					**9 Periods**
Compressor types - Performance - Air system components - Efficient operation of compressed air systems- Compressor capacity assessment - HVAC: psychrometrics and air-conditioning processes - Types of refrigeration system - Compressor types and applications - Performance assessment of refrigeration plants - Lighting Systems: Energy efficient lighting controls - design of interior lighting - Case study.						
UNIT – V	**PERFORMANCE ASSESSMENT FOR EQUIPMENT**					**9 Periods**
Performing Financial analysis: Fixed and variable costs – Payback period – ROI - methods – factors affecting analysis. Energy Performance Assessment: Heat exchangers - Fans and Blowers - Pumps. Energy Conservation in buildings and ECBC.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES:

1	*Murphy W.R. and G.Mckay Butter worth , "**Energy Management**", Heinemann Publications, 2007*
2	*Albert Thumann, Terry Niehus, William J. Younger, "**Handbook of Energy Audits"**, Ninth Edition, River Publishers, 2012.*
3	*Dr. Subhash Gadhave Anup Goel Siddu S. Laxmikant D. Jathar, **"Energy Audit & Management"**, Second edition, Technical Publications, 2019.*
4	*S. M. Chaudhari, S. A. Asarkar, M. A. Chaudhari, **"Energy Conservation and Audit"**, Second Edition, Nirali Prakashan Publications, 2021.*
5	www.em-ea.org/gbook1.asp

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyze the feature of energy audit methodology and documentation of report.	K3
CO2	Perform action plan and financial analysis	K4
CO3	Familiarize with thermal utilities.	K4
CO4	Familiarize with electrical utilities.	K4

CO5	Perform assessment of different systems.	K5

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	1	1
CO2	3	2	2	1	1
CO3	3	2	2	1	1
CO4	3	2	2	1	1
CO5	3	2	2	1	1
23PEOE23	3	2	2	1	1

1 – Slight, 2 – Moderate, 3 – Substantial

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	10	30	30	20	10	-	100
CAT2	10	30	30	20	10	-	100
Individual Assessment1/ Case study1/ Seminar 1/ Project1	-	30	30	20	20	-	100
Individual Assessment2/ Case study2/ Seminar 2 / Project2	-	30	30	20	20	-	100
ESE	10	30	30	20	10	-	100

23PEOE24	ADVANCED ENERGY STORAGE TECHNOLOGY (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	To explore the fundamentals, technologies and applications of energy storage	
UNIT – I	**ENERGY STORAGE: HISTORICAL PERSPECTIVE, INTRODUCTION AND CHANGES**	**9 Periods**

Storage Needs- Variations in Energy Demand- Variations in Energy Supply- Interruptions in Energy Supply- Transmission Congestion - Demand for Portable Energy-Demand and scale requirements - Environmental and sustainability issues-conventional energy storage methods: battery-types.

UNIT – II	**TECHNICAL METHODS OF STORAGE**	**9 Periods**

Introduction: Energy and Energy Transformations, Potential energy (pumped hydro, compressed air, springs)- Kinetic energy (mechanical flywheels)- Thermal energy without phase change passive (adobe) and active (water)-Thermal energy with phase change (ice, molten salts, steam)- Chemical energy (hydrogen, methane, gasoline, coal, oil)- Electrochemical energy (batteries, fuel cells)- Electrostatic energy (capacitors), Electromagnetic energy (superconducting magnets)- Different Types of Energy Storage Systems.

UNIT – III	**PERFORMANCE FACTORS OF ENERGY STORAGE SYSTEMS**	**9 Periods**

Energy capture rate and efficiency- Discharge rate and efficiency- Dispatch ability and load flowing characteristics, scale flexibility, durability – Cycle lifetime, mass and safety – Risks of fire, explosion, toxicity- Ease of materials, recycling and recovery- Environmental consideration and recycling , Merits and demerits of different types of Storage.

UNIT – IV	**APPLICATION CONSIDERATION**	**9 Periods**

Comparing Storage Technologies- Technology options- Performance factors and metrics- Efficiency of Energy Systems- Energy Recovery - Battery Storage System: Introduction with focus on Lead Acid and Lithium- Chemistry of Battery Operation, Power storage calculations, Reversible reactions, Charging patterns, Battery Management systems, System Performance, Areas of Application of Energy Storage: Waste heat recovery, Solar energy storage, Green house heating, Power plant applications, Drying and heating for process industries, energy storage in automotive applications in hybrid and electric vehicles.

UNIT – V	**HYDROGEN FUEL CELLS AND FLOW BATTERIES**	**9 Periods**

Hydrogen Economy and Generation Techniques, Storage of Hydrogen, Energy generation - Super capacitors: properties, power calculations – Operation and Design methods - Hybrid Energy Storage: Managing peak and Continuous power needs, options - Level 1: (Hybrid Power generation) Bacitor "Battery + Capacitor" Combinations: need, operation and Merits; Level 2: (Hybrid Power Generation) Bacitor + Fuel Cell or Flow Battery operation-Applications: Storage for Hybrid Electric Vehicles, Regenerative Power, capturing methods.

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES :

1	*DetlefStolten, "**Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications**", Wiley, 2010.*
2	*Jiujun Zhang, Lei Zhang, Hansan Liu, Andy Sun, Ru-Shi Liu, "**Electrochemical Technologies for Energy Storage and Conversion**", John Wiley and Sons, 2012.*
3	*Francois Beguin and ElzbietaFrackowiak, "**Super capacitors**", Wiley, 2013.*
4	*Doughty Liaw, Narayan and Srinivasan, "**Batteries for Renewable Energy Storage**", The Electrochemical Society, New Jersy, 2010.*

COURSE OUTCOMES: upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Recollect the historical perspective and technical methods of energy storage.	K1
CO2	Explain the basics of different storage methods.	K2
CO3	Determine the performance factors of energy storage systems.	K2
CO4	Identify applications for renewable energy systems.	K4
CO5	Outline the basics of Hydrogen cell and flow batteries.	K2

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	1	3	3	3
CO2	3	1	3	3	3
CO3	3	1	3	3	3
CO4	3	1	3	3	3
CO5	3	1	3	3	3
23PEOE24	3	1	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	30	20	10	-	100
CAT2	10	30	30	20	10	-	100
Individual Assessment1/ Case study1/ Seminar 1/ Project1	-	30	30	20	10	10	100
Individual Assessment2/ Case study2/ Seminar 2 / Project2	-	30	30	20	20	-	100
ESE	10	30	30	20	10	-	100

23AEOE25	DESIGN OF DIGITAL SYSTEMS (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	To gain knowledge in the design and VHDL programming of synchronous and asynchronous sequential circuits, PLD's and the basic concepts of testing in VLSI circuits	
UNIT–	**I SYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN**	**9 Periods**
Analysis of Clocked Synchronous Sequential Circuits - Modeling, state table reduction, state assignment, Design of Synchronous Sequential circuits, Design of iterative circuits- ASM chart –ASM realization.		
UNIT–II	**ASYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN**	**9 Periods**
Analysis of Asynchronous Sequential Circuits - Races in ASC – Primitive Flow Table - Flow Table Reduction Techniques, State Assignment Problem and the Transition Table – Design of ASC – Static and Dynamic Hazards – Essential Hazards– Data Synchronizers.		
UNIT–III	**SYSTEM DESIGN USING PLDS**	**9 Periods**
Basic concepts – Programming Technologies - Programmable Logic Element (PLE) – Programmable Array Logic (PLA)-Programmable Array Logic (PAL) –Design of combinational and sequential circuits using PLDs– Complex PLDs (CPLDs).		
UNIT– IV	**INTRODUCTION TO VHDL**	**9 Periods**
Design flow -Software tools – VHDL: Data Objects-Data types – Operators –Entities and Architectures Components and Configurations – Signal Assignment – Concurrent and Sequential statements —Behavioral, Dataflow and Structural modeling– Transport and Inertial delays –Delta delays-Attributes - Generics–Packages and Libraries.		
UNIT–V	**LOGIC CIRCUIT TESTING AND TESTABLE DESIGN**	**9 Periods**
Digital logic circuit testing - Fault models - Combinational logic circuit testing - Sequential logic circuit testing- Design for Testability - Built-in Self-test, Board and System Level Boundary Scan - Case Study: Traffic Light Controller.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

REFERENCES:

1	*Donald G.Givone, "**Digital principles and Design**", TataMcGrawHill, 2002.*
2	*Nelson, V.P., Nagale, H.T., Carroll, B.D., and Irwin, J.D., "**Digital Logic Circuit Analysis and Design**", Prentice Hall International, Inc., NewJersey, 1995.*
3	*VolneiA.Pedroni,"**Circuit Design withVHDL**", PHILearning,2011.*
4	*ParagK Lala,"**Digital Circuit Testing and Testability**", AcademicPress,1997.*
5	*CharlesHRoth,"**Digital Systems Design Using VHDL",** Cencage 2nd Edition2012.*
6	*NripendraN.Biswas,"**Logic Design Theory**" Prentice Hal l of India,2001.*

COURSEOUTCOMES: Upon completion of the course ,students will be able to/have:		**Bloom's Taxonomy Mapped**
CO1	To design synchronous sequential circuits based on specifications.	K3
CO2	To design asynchronous sequential circuits based on specifications	K3
CO3	Ability to illustrate digital design implementation using PLDs.	K2
CO4	To develop algorithm and VHDL code for design of digital circuits.	K3
CO5	Understand the different testing methods for combinational and sequential circuits.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	2	-	-	1
CO2	3	-	2	-	-	1
CO3	3	-	2	-	-	1
CO4	3	-	2	-	-	1
CO5	3	-	2	-	-	1
23AEOE25	3	-	2	-	-	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40%	40%	20%				100%
CAT2	40%	40%	20%				100%
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1		50%	50%				100%
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2		50%	50%				100%
ESE	20%	45%	35%				100%

23AEOE26	BASICS OF NANO ELECTRONICS (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objective	The students will be able to acquire knowledge about nano device fabrication technology, nano structures, nano technology for memory devices and applications of nano electronics in data transmission.

UNIT – I	**TECHNOLOGY AND ANALYSIS**	**9 Periods**

Fundamentals : Dielectric, Ferroelectric and Optical properties - Film Deposition Methods – Lithography Material removing techniques - Etching and Chemical Mechanical Polishing - Scanning ProbeTechniques.

UNIT – II	**CARBON NANO STRUCTURES**	**9 Periods**

Principles and concepts of Carbon Nano tubes - Fabrication - Electrical, Mechanical and VibrationProperties - Applications of Carbon Nano tubes.

UNIT – III	**LOGIC DEVICES**	**9 Periods**

Silicon MOSFET's: Novel materials and alternative concepts - Single electron devices for logic applications - Super conductor digital electronics - Carbon Nano tubes for data processing.

UNIT – IV	**MEMORY DEVICES AND MASS STORAGE DEVICES**	**9 Periods**

Flash memories - Capacitor based Random Access Memories - Magnetic Random Access Memories - Information storage based on phase change materials - Resistive Random Access Memories - HolographicData storage.

UNIT – V	**DATA TRANSMISSION AND INTERFACING DISPLAYS**	**9 Periods**

Photonic Networks - RF and Microwave Communication System - Liquid Crystal Displays - Organic Light emitting diodes.

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES:

1	*Rainer Waser,* ***"Nano Electronics and Information Technology, Advanced Electronicmaterials and novel devices"****, 3rd Edition, Wiley VCH, 2012.*
2	*T. Pradeep,* ***"Nano: The essentials"****, Tata McGraw Hill, 2007.*
3	*Charles Poole,* ***"Introduction to Nano Technology"****, Wiley Interscience, 2003*
4	*Vladimir V.Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio,* ***"Introduction to Nano Electronics Science, Nanotechnology, Engineering and Applications"****, Cambridge University Press, 2011.*
5	*C.Wasshuber Simon,* ***"Simulation of Nano Structures Computational Single-Electronics"****,Springer, 2001.*
6	*Mark Reed and Takhee Lee,* ***"Molecular Nano Electronics, American Scientific Publisher,California"****, 2003.*

COURSE OUTCOMES: Upon completion of the course, students will be able to/have:		**Bloom's Taxonomy Mapped**
CO1	Explain principles of nano device fabrication technology.	K2
CO2	Describe the concept of Nano tube and Nano structure.	K2
CO3	Explain the function and application of various nano devices	K3
CO4	Reproduce the concepts of advanced memory technologies.	K2
CO5	Emphasize the need for data transmission and display systems.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	2	-	-	1
CO2	3	-	2	-	-	1
CO3	3	-	2	-	-	1
CO4	3	-	2	-	-	1
CO5	3	-	2	-	-	1
22AEOE26	3	-	2	-	-	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50%	25%	25%				100%
CAT2	50%	25%	25%				100%
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project1	50%	25%	25%				100%
Individual Assessment 2/ Case Study 2/ Seminar 2 / Project 2	50%	25%	25%				100%
ESE	50%	25%	25%				100%

23AEOE27	ADVANCED PROCESSOR (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objective	The students will be able to acquire knowledge about the high performance RISC, CISC and special purpose processors.	
UNIT – I	**MICROPROCESSOR ARCHITECTURE**	**9 Periods**
Instruction set – Data formats – Instruction formats – Addressing modes – Memory hierarchy – registerfile – Cache – Virtual memory and paging – Segmentation – Pipelining – The instruction pipeline – pipeline hazards – Instruction level parallelism – reduced instruction set – Computer principles – RISCversus CISC – RISC properties – RISC evaluation.		
UNIT – II	**HIGH PERFORMANCE CISC ARCHITECTURE –PENTIUM**	**9 Periods**
The software model – functional description – CPU pin descriptions – Addressing modes – Processor flags – Instruction set – Bus operations – Super scalar architecture – Pipe lining – Branch prediction – The instruction and caches – Floating point unit– Programming the Pentium processor.		
UNIT – III	**HIGH PERFORMANCE CISC ARCHITECTURE – PENTIUM INTERFACE**	**9 Periods**
Protected mode operation – Segmentation – paging – Protection – multitasking – Exception and interrupts- Input /Output – Virtual 8086 model – Interrupt processing.		
UNIT – IV	**HIGH PERFORMANCE RISC ARCHITECTURE: ARM**	**9 Periods**
ARM architecture – ARM assembly language program – ARM organization and implementation – ARM instruction set - Thumb instruction set.		
UNIT – V	**SPECIAL PURPOSE PROCESSORS**	**9 Periods**
Altera Cyclone Processor – Audio codec – Video codec design – Platforms – General purpose processor –Digital signal processor – Embedded processor – Media Processor – Video signal Processor – Custom Hardware – Co-Processor.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

REFERENCES:

1	*Daniel Tabak, "**Advanced Microprocessors**", McGraw Hill Inc., 2011.*
2	*James L. Antonakos, "**The Pentium Microprocessor**", Pearson Education, 1997.*
3	*Steve Furber, "**ARM System –On –Chip architecture**", Addison Wesley, 2009.*
4	*Gene. H. Miller, "**Micro Computer Engineering**", Pearson Education, 2003.*
5	*Barry. B. Brey, "**The Intel Microprocessors Architecture, Programming and Interfacing**", PHI, 2008.*
6	*Valvano, **"Embedded Microcomputer Systems"** Cencage Learing India Pvt Ltd, 2011.*
7	*Iain E.G. Richardson, "**Video codec design**", John Wiley & sons Ltd, U.K, 2002.*

COURSE OUTCOMES: Upon completion of the course, students will be able to		**Bloom's Taxonomy Mapped**
CO1	Describe the fundamentals of various processor architecture.	K2
CO2	Interpret and understand the high performance features in CISC architecture.	K2
CO3	Describe the concepts of Exception and interrupt processing.	K2
CO4	Develop programming skill for ARM processor.	K3
CO5	Explain various special purpose processor	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	2	-	-	1
CO2	3	-	2	-	-	1
CO3	3	-	2	-	-	1
CO4	3	-	2	-	-	1
CO5	3	-	2	-	-	1
22AEOE27	3	-	2	-	-	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40%	40%	20%				100%
CAT2	40%	40%	20%				100%
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1		50%	50%				100%
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2		50%	50%				100%
ESE	30%	40%	30%				100%

23VLOE28	HDL PROGRAMMING LANGUAGES (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	OE	**3**	**0**	**0**	**3**
Course Objective	To code and simulate any digital function in Verilog HDL and understand the difference between synthesizable and non-synthesizable codes.				
UNIT – I	**VERILOG INTRODUCTION AND MODELING**				**9 Periods**
Introduction to Verilog HDL, Language Constructs and Conventions, Gate Level Modeling, Modeling at Dataflow Level, Behavioral Modeling, Switch Level Modeling, System Tasks, Functions and Compiler Directives.					
UNIT – II	**SEQUENTIAL MODELING AND TESTING**				**9 Periods**
Sequential Models - Feedback Model, Capacitive Model, Implicit Model, Basic Memory Components, Functional Register, Static Machine Coding, Sequential Synthesis. Test Bench - Combinational Circuits Testing, Sequential Circuit Testing, Test Bench Techniques, Design Verification, Assertion Verification.					
UNIT – III	**SYSTEM VERILOG**				**9 Periods**
Introduction, System Verilog declaration spaces, System Verilog Literal Values and Built-in Data Types, System Verilog User-Defined and Enumerated Types, system Verilog Arrays, Structures and Unions, system verilog Procedural Blocks, Tasks and Functions.					
UNIT – IV	**SYSTEM VERILOG MODELING**				**9 Periods**
System Verilog Procedural Statements, Modeling Finite State Machines with System Verilog, System Verilog Design Hierarchy.					
UNIT – V	**INTERFACES AND DESIGN MODEL**				**9 Periods**
System Verilog Interfaces, A Complete Design Modeled with System Verilog, Behavioral and Transaction Level Modeling.					
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**					

REFERENCES:

1	*T.R.Padmanabhan, B Bala Tripura Sundari, "**Design through Verilog HDL",** Wiley 2009.*
2	*Stuart Sutherland, Simon Davidmann ,Peter Flake , Foreword by Phil Moorby, "**System Verilog For Design Second Edition A Guide to Using System Verilog for Hardware Design and Modelling",** Springer 2006.*
3	*Samir Palnitkar, "**Verilog HDL**", 2nd Edition, Pearson Education, 2009.*
4	*ZainalabdienNavabi,"**Verilog Digital System Design",**TMH,2ndEdition,2005.*
5	*System Verilog 3.1a, Language Reference Manual, Accellera, 2004*
6	*Dr.SRamachandran, "**Digital VLSI Systems Design: A Design Manual for Implementation of Projects on FPGAs and ASICs Using Verilog",** Springer, 2007.*
7	*Chris Spear, "**System verilog for verification a guide to learning the test bench Language Features**", Springer 2006.*
6	*Stuart Sutherland, Simon Davidmann, Peter Flake, "**System Verilog For Design: A Guide to Using System Verilog for Hardware Design and Modeling**" 1st Edition, 2003*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the verilog coding and simulate any digital function using Verilog HDL	K2
CO2	Develop sequential modeling based Verilog HDL code and develop the test bench for the modeling	K3
CO3	Explain the system verilog modeling	K2
CO4	Differentiate the synthesizable and non-synthesizable code	K3
CO5	Apply good coding techniques on system verilog interfaces and complete design model	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3		2		2
CO2	3	3		2		2
CO3	3	3		2		2
CO4	3	3		2		2
CO5	3	3		2		2
23VLOE28	3	3		2		2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40%	40%	20%	-	-	-	100%
CAT2	40%	40%	20%	-	-	-	100%
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	-	50%	50%	-	-	-	100%
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	-	50%	50%	-	-	-	100%
ESE	40%	40%	20%	-	-	-	100%

23VLOE29	CMOS VLSI DESIGN (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	OE	**3**	**0**	**0**	**3**
Course Objective	To gain knowledge on CMOS Circuits with its characterization and to design CMOS logic and sub-system with low power				
UNIT – I	**INTRODUCTION TO MOS CIRCUITS**				**9 Periods**
MOS Transistor Theory -Introduction MOS Device Design Equations -MOS Transistor as a Switches - Pass Transistor - CMOS Transmission Gate -Complementary CMOS Inverter - Static Load MOS Inverters - Inverters with NMOS loads - Differential Inverter - Tri State Inverter - BiCMOS Inverter.					
UNIT – II	**CIRCUIT CHARACTERIZATION AND PERFORMANCE ESTIMATION**				**9 Periods**
Delay Estimation, Logical Effort and Transistor Sizing, Power Dissipation, Sizing Routing Conductors, Charge Sharing, Design Margin and Reliability.					
UNIT – III	**CMOS CIRCUIT AND LOGIC DESIGN**				**9 Periods**
CMOS Logic Gate Design, Physical Design of CMOS Gate, Designing with Transmission Gates, CMOS Logic Structures, Clocking Strategies, I/O Structures.					
UNIT – IV	**CMOS SUBSYSTEM DESIGN**				**9 Periods**
DataPath Operations-Addition/Subtraction, Parity Generators, Comparators, Zero/One Detectors, Binary Counters, ALUs, Multipliers, Shifters, Memory Elements, Control-FSM, Control Logic Implementation.					
UNIT – V	**LOWPOWERCMOS VLSIDESIGN**				**9 Periods**
Introduction to Low Power Design, Power Dissipation in FET Devices, Power Dissipation in CMOS, Low-Power Design through Voltage Scaling – VTCMOS Circuits, MTCMOS Circuits, Architectural Level Approach – Pipelining and Parallel Processing Approaches, Low Power Basics CMOS Gate and Adder Design.					
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**					

REFERENCES:

1	*Sung Mo Kang,Yusuf Lablebici,**"CMOS Digital Integrated Circuits:Analysis & Design"**, Tata Mc-Graw Hill, 2011.*
2	*N.Weste and K.Eshranghian, **"Principles of CMOS VLSI Design"**, AddisonWesley,1998.*
3	*Neil H. E. Weste, David Harris, Ayan Banerjee, **"CMOS VLSI Design: A Circuits and Systems Perspective"**, Pearson Education 2013.*
4	*Kiat-Seng Yeo,Kaushik Roy,**"Low-Voltage, Low-Power VLSI Subsystems",** McGraw-Hill Professional, 2004.*
5	*Gary K.Yeap, **"Practical Low Power Digital VLSI Design"**, Kluwer Academic Press, 2002.*
6	*Jan M .Rabaey,**"Digital Integrated Circuits: A Design Perspective"**, Pearson Education, 2003.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the MOS circuits and Transmission gates	K2
CO2	Illustrate the CMOS Circuits with its characterization	K2
CO3	Design CMOS logic circuits	K3
CO4	Design CMOS sub-system	K3
CO5	Discuss low power CMOS VLSI Design	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	-	2	-	3
CO2	2	1	-	2	-	3
CO3	2	1	-	2	-	3
CO4	3	1	-	2	-	3
CO5	3	1	-	2	-	3
23VLOE29	**3**	**1**	**-**	**2**	**-**	**3**
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40%	40%	20%	-	-	-	100%
CAT2	40%	40%	20%	-	-	-	100%
Individual Assessment 1/ Case Study 1/ Seminar 1/ Project1	-	50%	50%	-	-	-	100%
Individual Assessment 2 / Case Study 2/ Seminar 2/ Project 2	-	50%	50%	-	-	-	100%
ESE	40%	40%	20%	-	-	-	100%

23VLOE30	HIGH LEVEL SYNTHESIS (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		OE	**3**	**0**	**0**	**3**
Course Objective	To provide students with foundations in High level synthesis, verification and CAD Tools					
UNIT – I	**HIGH-LEVEL SYNTHESIS (HLS) FUNDAMENTALS**					**9 Periods**
Overview HLS flow, Scheduling Techniques, Resource sharing and Binding Techniques, Data-path and Controller Generation Techniques.						
UNIT – II	**HIGH LEVEL SYNTHESIS**					**9 Periods**
Introduction to HDL, HDL to DFG, operation scheduling: constrained and unconstrained scheduling, ASAP, ALAP, List scheduling, Force directed Scheduling, operator binding, Static Timing Analysis: Delay models, setup time, hold time, cycle time, critical paths, Topological mvs. Logical timing analysis, False paths, Arrival time (AT), Required arrival Time (RAT), Slacks.						
UNIT – III	**HIGH-LEVEL SYNTHESIS VERIFICATION**					**9 Periods**
Simulation based verification - Formal Verification of digital systems- BDD based approaches, functional equivalence, finite state automata, ω-automata, FSM verification.						
UNIT – IV	**CAD TOOLS FOR SYNTHESIS**					**9 Periods**
CAD tools for synthesis, optimization, simulation and verification of design at various levels as well as for special realizations and structures such as microprogrammes, PLAs, gate arrays etc. Technology mapping for FPGAs. Low power issues in high level synthesis and logic synthesis.						
UNIT – V	**ADVANCED TOPICS**					**9 Periods**
Relative Scheduling, IO scheduling modes - cycle fixed scheduling modes, super-fixed scheduling modes, free-floating scheduling mode, Pipelining, Handshaking, System Design, High-Level Synthesis for FPGA.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES :

1	*Philippe Coussy and Adam Morawiec, "**High-level Synthesis from Algorithm to Digital Circuit**", Springer, 2008.*
2	*Sherwani, N., "**Algorithms for VLSI Physicsl Design Automation**", Springer, 3rd ed., 2005.*
3	*D. Micheli,"**Synthesis and optimization of digital systems**", Mc Graw Hill, 2005.*
4	*Dutt, N. D. and Gajski, D. D., "**High level synthesis**", Kluwer, 2000.*
5	*Gerez S.H., "**Algorithms for VLSI Design Automation**", John Wiley (1998)*
6	*David. C. Ku and G. De Micheli, "**High-level Syntehsis of ASICs Under Timing and Synchronization Constraints**", Kluwer Academic Publishers, 1992.*
7	*K. Parhi, "**VLSI Digital Signal Processing Systems: Design and Implementation**", Jan 1999, Wiley.*
8	*Egon Boerger and Robert Staerk "**Abstract State Machines: A Method for High-Level System Design and Analysis**", Springer,2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the fundamentals of High level synthesis	K2
CO2	Synthesis the HDL for operation scheduling	K2
CO3	Simulate and verify any digital systems	K2
CO4	Apply CAD tools for synthesis	K2

CO5	Have knowledge on various scheduling modes	K2

COURSE ARTICULATION MATRIX:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	-	2	2	-
CO2	2	2	-	2	2	-
CO3	2	2	-	2	2	-
CO4	2	2	-	2	2	-
CO5	2	2	-	2	2	-
23VLOE30	**2**	**2**	**-**	**2**	**2**	**-**

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Rememberin g (K1) %	Understandin g (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluati ng (K5) %	Creatin g (K6) %	Total %
CAT1	50%	50%		-	-	-	100%
CAT2	50%	50%		-	-	-	100%
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project1	-	50%	50%	-	-	-	100%
Individual Assessment 2/ Case Study 2/ Seminar 2/ Project 2	-	50%	50%	-	-	-	100%
ESE	50%	50%		-	-	-	100%

23CSOE31	ARTIFICIAL INTELLIGENCE (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objectives	Identify and apply AI techniques in the design of systems that act intelligently, making automatic decisions and learn from experience.					
UNIT – I	**SEARCH STRATEGIES**					**9 Periods**
Uninformed Strategies – BFS, DFS, Djisktra, Informed Strategies – A* search, Heuristic functions, Hill Climbing, Adversarial Search – Min-max algorithm, Alpha-beta Pruning						
UNIT – II	**PLANNING AND REASONING**					**9 Periods**
State Space search, Planning Graphs, Partial order planning, Uncertain Reasoning – Probabilistic Reasoning, Bayesian Networks, Dempster Shafer Theory, Fuzzy logic						
UNIT – III	**PROBABILISTIC REASONING**					**9 Periods**
Probabilistic Reasoning over Time - Hidden Markov Models, Kalman Filters, Dynamic Bayesian Networks. Knowledge Representations – Ontological Engineering, Semantic Networks and description logics.						
UNIT – IV	**DECISION MAKING**					**9 Periods**
Utility Theory, Utility Functions, Decision Networks – Sequential Decision Problems – Partially Observable MDPs – Game Theory.						
UNIT – V	**REINFORCEMENT LEARNING**					**9 Periods**
Reinforcement Learning - Passive and active reinforcement learning - Generations in Reinforcement Learning - Policy Search – Deep Reinforcement Learning.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

REFERENCES :

1	*Deepak Khemani,* ***"A First Course in Artificial Intelligence",*** *Tata Mc Graw Hill Education 2013*
2	*Yang Q,* ***" Intelligent Planning: A decomposition and Abstraction based Approach",*** *Springer, 2006*
3	*Russell and Norvig,* ***"Artificial Intelligence, A Modern Approach****", 3rd edition, Pearson Prentice Hall,2010.*
4	*Elaine Rich,Kevin Knight,Shivashankar B. Nair,* ***"Artificial Intelligence",*** *3rd edition, TataMcGraw Hill, 2009.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Use search techniques to solve AI problems	K2
CO2	Reason facts by constructing plans and understand uncertainty efficiently.	K3
CO3	Examine data using statistical codes and solve complex AI problems	K6
CO4	Apply techniques to make apt decisions.	K4
CO5	Use deep reinforcement learning to solve complex AI problems	K6

COURSE ARTICULATION MATRIX						
COs/ POs	**PO 1**	**PO2**	**PO 3**	**PO 4**	**PO5**	**PO6**
CO1	3		2		3	3
CO2	3		2		3	3
CO3	3		3		3	3
CO4	3		3		3	3
CO5	3		3		3	3
23CSOE31	3		3		3	3

1 – Slight, 2 – Moderate, 3 – Substantial

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1		20	40	20	20		100
CAT2		10	20	40	10	20	100
Individual Assessment 1/ Case study 1/ Seminar 1/ Project 1					50	50	100
Individual Assessment 2/ Case study 2/ Seminar 2/ Project 2					50	50	100
ESE	30	30	40				100

23CSOE32	COMPUTER NETWORK MANAGEMENT (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	After the completion of the course, the students will be able to understand the concept of layering in networks, functions of protocols of each layer of TCP/IP protocol suite, concepts related to network addressing and routing and build simple LANs, perform basic configurations for routers and switches, and implement IPv4 and IPv6 addressing schemes using Cisco Packet Tracer.

UNIT – I	**INTRODUCTION AND APPLICATION LAYER**	**9 Periods**

Building network – Network Edge and Core – Layered Architecture – OSI Model – Internet Architecture (TCP/IP) Networking Devices: Hubs, Bridges, Switches, Routers, and Gateways – Performance Metrics - Ethernet Networking – Introduction to Sockets – Application Layer protocols – HTTP – FTP Email Protocols – DNS.

UNIT – II	**TRANSPORT LAYER AND ROUTING**	**9 Periods**

Transport Layer functions –User Datagram Protocol – Transmission Control Protocol – Flow Control – Retransmission Strategies – Congestion Control - Routing Principles – Distance Vector Routing – Link State Routing – RIP – OSPF – BGP – Introduction to Quality of Service (QoS).Case Study: Configuring RIP, OSPF BGP using Packet tracer

UNIT – III	**NETWORK LAYER**	**9 Periods**

Network Layer: Switching concepts – Internet Protocol – IPV4 Packet Format – IP Addressing – Subnetting – Classless Inter Domain Routing (CIDR) – Variable Length Subnet Mask (VLSM) – DHCP – ARP – Network Address Translation (NAT) – ICMP – Concept of SDN.Case Study: Configuring VLAN, DHCP, NAT using Packet tracer

UNIT – IV	**INTERNETWORK MANAGEMENT**	**9 Periods**

Introduction to the Cisco IOS - Router User Interface – CLI - Router and Switch Administrative Functions - Router Interfaces - Viewing, Saving, and Erasing Configurations - Switching Services - Configuring Switches - Managing Configuration Registers - Backing Up and Restoring IOS - Backing Up and Restoring the Configuration - Using Discovery Protocol (CDP) - Checking Network Connectivity

UNIT – V	**TRAFFIC MANAGEMENT AND WAN PROTOCOLS**	**9 Periods**

Managing Traffic with Access Lists: Introduction to Access Lists - Standard Access Lists - Extended Access Lists - Named Access Lists - Monitoring Access Lists - Wide Area Networking Protocols: Introduction to Wide Area Networks - Cabling the Wide Area Network - High-Level Data-Link Control (HDLC) Protocol - Point-to-Point Protocol (PPP) - Frame Relay: Frame Relay Implementation and Monitoring - Integrated Services Digital Network (ISDN) - Dial-on-Demand Routing (DDR): Configuring DDR

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCES :

1	*James F. Kurose, Keith W. Ross,* ***"Computer Networking: A Top-Down Approach",*** *Seventh Edition, Pearson Education, 2017.*
2	*William Stallings,* ***"Data and Computer Communications",*** *Tenth Edition, Pearson Education, 2014*
3	*Larry L. Peterson, Bruce S. Davie,* ***"Computer Networks: A Systems Approach",*** *Fifth Edition, Morgan Kaufmann Publishers Inc., 2011.*
4	*Todd Lammle,* ***"CCNA™: Cisco® Certified Network Associate Study Guide",*** *5th Edition, Sybex, 2003*
5	*Ying-Dar Lin, Ren-Hung Hwang, Fred Baker,* ***"Computer Networks: An Open Source Approach",*** *McGraw Hill, 2012.*
6	*Ron Gilster, Jeff Bienvenu, and Kevin Ulstad,* ***"CCNA for Dummies",*** *IDG Books Worldwide, 2000*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Highlight the significance of the functions of each layer in the network.	K1
CO2	Identify the devices and protocols to design a network and implement it.	K4
CO3	Apply addressing principles such as subnetting and VLSM for efficient routing.	K3
CO4	Build simple LANs, perform basic configurations for routers and switches	K6
CO5	Illustrate various WAN protocols	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3		3		2	1
CO2	3		3		2	2
CO3	3		3		3	2
CO4	3		3		3	3
CO5	3		3		3	3
23CSOE32	3		3		3	2
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY (Times New Roman, Size 11)							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	20	20			100
CAT2		30	20	30	10	10	100
Individual Assessment 1/ Case Study 1/ Seminar 1/ Project 1	10	30	20	20	20		100
Individual Assessment 2/ Case Study 2/ Seminar 2/ Project 2		20	20	20	20	20	100
ESE	20	40	40				100

23CSOE33	BLOCKCHAIN TECHNOLOGIES (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**
Course Objectives	The objective of the course is to explore basics of block chain technology and its application in various domaiin					
UNIT – I	**INTRODUCTION OF CRYPTOGRAPHY AND BLOCKCHAIN**					**9 Periods**
History of Blockchain - Types of blockchain- CAP theorem and blockchain – benefits and Limitations of Blockchain – Decentalization using blockchain – Blockchain implementations- Block chain in practical use - Legal and Governance Use Cases						
UNIT – II	**BITCOIN AND CRYPTOCURRENCY**					**9 Periods**
Introduction to Bitcoin, The Bitcoin Network, The Bitcoin Mining Process, Mining Developments, Bitcoin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Blockchain and Digital Currency, Transactional Blocks, Impact of Blockchain Technology on Cryptocurrency						
UNIT – III	**ETHEREUM**					**9 Periods**
Introduction to Ethereum, Consensus Mechanisms, Metamask Setup, Ethereum Accounts, , Transactions, Receiving Ethers, Smart Contracts						
UNIT – IV	**HYPERLEDGER AND SOLIDITY PROGRAMMING**					**9 Periods**
Introduction to Hyperledger, Distributed Ledger Technology & its Challenges, Hyperledger & Distributed Ledger Technology, Hyperledger Fabric, Hyperledger Composer. Solidity – Programming with solidity						
UNIT – V	**BLOCKCHAIN APPLICATIONS**					**9 Periods**
Ten Steps to build your Blockchain application – Application: Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins						
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**						

REFERENCES:

1	*Imran Bashir,* ***"Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained"****, Second Edition, Packt Publishing, 2018.*
2	*Joseph J. Bambara Paul R. Allen,* ***"Blockchain A Practical Guide to Developing Business, Law, and Technology Solutions"****,McGraw Hill Education ,2018.*
3	*Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder,* ***"Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction"*** *Princeton University Press, 2016.*
4	*Manav Gupta* ***"Blockchain for Dummies",*** *IBM Limited Edition 2017.*
5	*Antonopoulos and G. Wood,* ***"Mastering Ethereum: Building Smart Contracts and Dapps",*** *O'Reilly Publishing, 2018*
6	***NPTEL Course : Blockchain and its applications*** *https://archive.nptel.ac.in/courses/106/105/106105235/*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Comprehend the working of Blockchain technology	K2
CO2	Narrate working principle of smart contracts and create them using solidity for given scenario.	K3
CO3	Comprehend the working of Hyperledger in an real time application	K2
CO4	Apply the learning of solidity to build de-centralized apps on Ethereum	K3
CO5	Develop applications on Blockchain	K3

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2		3	2		3
CO2	2	3	3	3	2	3
CO3	3		3	2		3
CO4	3	3	3	3	2	3
CO5	3	3	3	3	2	3
23CSOE33	**3**	**3**	**3**	**3**	**2**	**3**
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	40				100
CAT2	20	30	50				100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project1		30	70				100
Individual Assessment 2/ Case Study 2/ Seminar 2 / Project 2		40	60				100
ESE	10	60	30				100

23GEACZ1	ENGLISH FOR RESEARCH PAPER WRITING (Common to all Branches)					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**AC**	**2**	**0**	**0**	**0**
Course Objectives	The objective of the course is to make the learners understand the format and intricacies involved in writing a research paper.					
UNIT – I	**PLANNING AND PREPARATION**					**6 Periods**
Need for publishing articles, Choosing the journal, Identifying a model journal paper, Creation of files for each section, Expectations of Referees, Online Resources.						
UNIT – II	**SENTENCES AND PARAGRAPHS**					**6 Periods**
Basic word in English, Word order in English and Vernacular, placing nouns, Verbs, Adjectives, and Adverb suitably in a sentence, Using Short Sentences, Discourse Markers and Punctuations- Structure of a Paragraph, Breaking up lengthy Paragraphs.						
UNIT – III	**ACCURACY, BREVITY AND CLARITY (ABC) OF WRITING**					**6 Periods**
Accuracy, Brevity and Clarity in Writing, Reducing the linking words, Avoiding redundancy, Appropriate use of Relative and Reflexive Pronouns, Monologophobia, verifying the journal style, Logical Connections between others author's findings and yours.						
UNIT – IV	**HIGHLIGHTING FINDINGS, HEDGING AND PARAPHRASING**					**6 Periods**
Making your findings stand out, Using bullet points headings, Tables and Graphs- Availing non-experts opinions, Hedging, Toning Down Verbs, Adjectives, Not over hedging, Limitations of your research.						
UNIT – V	**SECTIONS OF A PAPER**					**6 Periods**
Titles, Abstracts, Introduction, Review of Literature, Methods, Results, Discussion, Conclusions, References.						
Contact Periods: **Lecture: 30 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 30 Periods**						

REFERENCES :

1	*Goldbort R* ***, "Writing for Science", Yale University Press*** *(available on GoogleBooks),2006*
2	*Day R ,* ***How to Write and Publish a Scientific Paper****, Cambridge University Press, 2006.*
3	*Highman N,* ***"Handbook of Writing for the Mathematical Sciences"****, SIAM. Highman's book, 1998.*
4	*Adrian Wallwork,"* ***English for Writing Research Papers"****, Springer New York Dordrecht Heidelberg London, 2011.*

COURSE OUTCOMES : Upon completion of this course the learners will be able to		**Bloom's Taxonomy Mapped**
CO1	**U**nderstand the need for writing good research paper.	K2
CO2	Practice the appropriate word order, sentence structure and paragraph writing.	K4
CO3	Practice unambiguous writing.	K3
CO4	Avoid wordiness in writing.	K2
CO5	Exercise the elements involved in writing journal paper.	K3

COURSE ARTICULATION MATRIX :						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	1	1	1	1
CO2	3	3	1	1	1	1
CO3	3	3	1	1	1	1
CO4	3	3	1	1	1	1
CO5	3	3	1	1	1	1
23GEACZ1	3	3	1	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1/ Case Study 1/ Seminar 1/ Project 1	-	50	50	-	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2/ Project 2	-	50	50	-	-	-	100
ESE	30	30	40	-	-	-	100

23GEACZ2	DISASTER MANAGEMENT (Common to all Branches)	
Course Objectives	• To become familiar in key concepts and consequences about hazards, disaster and area of occurrence. • To know the various steps in disaster planning. • To create awareness on disaster preparedness and management.	
UNIT – I	**INTRODUCTION**	**6 Periods**
Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude. Areas proneto ,EarthquakesFloods , Droughts, Landslides ,Avalanches ,Cyclone and Coastal Hazards with Special Reference to Tsunami.		
UNIT – II	**REPERCUSSIONS OF DISASTERS AND HAZARDS**	**6 Periods**
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.		
UNIT – III	**DISASTER PLANNING**	**6 Periods**
Disaster Planning-Disaster Response Personnel roles and duties, Community Mitigation Goals, Pre-Disaster Mitigation Plan, Personnel Training, Comprehensive Emergency Management, Early Warning Systems.		
UNIT – IV	**DISASTER PREPAREDNESS AND MANAGEMENT**	**6 Periods**
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.		
UNIT – V	**RISK ASSESSMENT**	**6 Periods**
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.		
Contact Periods: **Lecture:30 Periods Tutorial: 0 Periods Practical: 0Periods Total: 30 Periods**		

REFERENCES:

1	*R. Nishith, Singh AK,* ***"Disaster Management In India: Perspectives, Issues And Strategies"****, New Royal book Company, 2007.*
2	*Sahni, PardeepEt.Al. (Eds.),* ***"Disaster Mitigation Experiences And Reflections"****, Prentice Hall Of India, New Delhi, 2010*
3	*Goel S. L,* ***"Disaster Administration And Management Text And Case Studies"****, Deep &Deep Publication Pvt. Ltd., New Delhi, 2008.*
4	*Jagbir Singh,* ***"Disaster Management: Future Challenges And Opportunities"****, I.K. International Publishing House Pvt. Ltd., New Delhi, 2007.*
5	*Damon Coppola* ***"Introduction To International Disaster Management"****, Butterworth-Heinemann, 2015*
6	*Ryan Lanclos* ***"Dealing With Disasters: Gis For Emergency Management"****, ESRI Press 2021.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Differentiate hazard and disaster with their significance.	K4
CO2	Analyse the causes and impact of natural and manmade disaster.	K4
CO3	Execute the steps involved in disaster planning.	K4
CO4	Predict vulnerability of disaster and to prevent, mitigate their impact.	K4

CO5	Prepare risk assessment strategy for national and global disaster.	K4

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	1	1	2	2
CO2	1	2	1	1	1
CO3	1	1	1	2	2
CO4	1	1	1	2	2
CO5	2	1	1	2	2
23GEACZ2	1	1	1	2	2
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	50					100
CAT2			100				100
Individual Assessment 1/ Case Study 1/ Seminar 1/ Project 1	50	50					100
Individual Assessment 2 / Case Study 2/ Seminar 2/ Project 2			100				100
ESE	25	25	50				100

23GEACZ3	VALUE EDUCATION (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**AC**	**2**	**0**	**0**	**0**

Course Objectives	• Value of education and self- development • Requirements of good values in students • Importance of character	
UNIT – I	**ETHICS AND SELF-DEVELOPMENT**	**6 Periods**
Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements.		
UNIT – II	**PERSONALITY AND BEHAVIOR DEVELOPMENT**	**6 Periods**
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.		
UNIT – III	**VALUES IN HUMAN LIFE**	**6 Periods**
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.		
UNIT – IV	**VALUES IN SOCIETY**	**6 Periods**
True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association andCooperation. Doing best for saving nature.		
UNIT – V	**POSITIVE VALUES**	**6 Periods**
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.		
Contact Periods: **Lecture: 30 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 30 Periods**		

REFERENCES :

1	*Chakroborty, S.K.* ***"Values and Ethics for organizations Theory and practice"****, Oxford University Press, New Delhi,1998*
2	*Dr. Yogesh Kumar Singh,* ***"Value Education"****, A.P.H Publishing Corporation, New Delhi,2010*
3	*R.P Shukla,* ***"Value Education and Human Rights"****, Sarup and Sons, NewDelhi,2004*
4	*https://nptel.ac.in/courses/109104068/36*

COURSE OUTCOMES : Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Know the values and work ethics.	K3
CO2	Enhance personality and 157ehavior development.	K3
CO3	Apply the values in human life.	K3
CO4	Gain Knowledge of values in society.	K3
CO5	Learn the importance of positive values in human life.	K3

COURSE ARTICULATION MATRIX						
Cos/Pos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	3	-	-	1
CO2	-	-	3	-	-	1
CO3	-	-	3	-	-	1
CO4	-	-	3	-	-	1
CO5	-	-	3	-	-	1
23GEACZ3	-	-	3	-	-	1
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20%	50%	30%	-	-	-	100%
CAT2	20%	50%	30%	-	-	-	100%
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	20%	50%	30%	-	-	-	100%
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	20%	50%	30%	-	-	-	100%
ESE	20%	50%	30%	-	-	-	100%

23GEACZ4	CONSTITUTION OF INDIA (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**AC**	**2**	**0**	**0**	**0**

Course Objectives	• To address the importance of constitutional rights and duties • To familiarize about Indian governance and local administration. • To know about the functions of election commission.	
UNIT – I	**INDIAN CONSTITUTION**	**6 Periods**
History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working) - Philosophy of the Indian Constitution: Preamble Salient Features.		
UNIT – II	**CONSTITUTIONAL RIGHTS & DUTIES**	**6 Periods**
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.		
UNIT – III	**ORGANS OF GOVERNANCE**	**6 Periods**
Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.		
UNIT – IV	**LOCAL ADMINISTRATION**	**6 Periods**
Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Panchayat raj: Introduction, PRI: Zila Panchayat. Elected officials and their roles, CEO Zila Panchayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.		
UNIT – V	**ELECTION COMMISSION**	**6 Periods**
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.		
Contact Periods: **Lecture: 30 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 30 Periods**		

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: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Discuss the growth of the demand for civil rights in India.	K2
CO2	Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.	K2
CO3	Understand the various organs of Indian governance.	K2
CO4	Familiarize with the various levels of local administration.	K2
CO5	Gain knowledge on election commission of india.	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	1	1	1	1
CO2	-	-	1	1	1	2
CO3	-	-	1	1	2	1
CO4	-	-	1	1	1	1
CO5	-	-	1	1	1	1
23GEACZ4	**-**	**-**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial						

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20%	50%	30%	-	-	-	100%
CAT2	20%	50%	30%	-	-	-	100%
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	20%	50%	30%	-	-	-	100%
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	20%	50%	30%	-	-	-	100%
ESE	20%	50%	30%	-	-	-	100%

23GEACZ5	PEDAGOGY STUDIES (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**AC**	**2**	**0**	**0**	**0**

Course Objectives	• To understand of various theories of learning, prevailing pedagogical practices and design of curriculum in engineering studies. • Application of knowledge in modification of curriculum, its assessment and introduction of innovation in teaching methodology.

UNIT – I	**INTRODUCTION**	**6 Periods**

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and Searching.

UNIT – II	**PEDAGOGICAL PRACTICES**	**6 Periods**

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education. Evidence on the effectiveness of pedagogical practices Methodology for the in depth stage: quality assessment of included studies.

UNIT – III	**PEDAGOGICAL APPROACHES**	**6 Periods**

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. Teacher's attitudes and beliefs and Pedagogic strategies.

UNIT – IV	**PROFESSIONAL DEVELOPMENT**	**6 Periods**

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.

UNIT – V	**CURRICULUM AND ASSESSMENT**	**6 Periods**

Research gaps and future directions Research design Contexts Pedagogy Teacher education Curriculum and assessment Dissemination and research impact.

Contact Periods:
Lecture: 30 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 30 Periods

REFERENCES:

1	*Ackers J, Hardman F , **Classroom interaction in Kenyan primary schools, Compare**, 31 (2): 245-261, 2001.*
2	*Alexander RJ , **Culture and pedagogy: International comparisons in primary education**. Oxford and Boston: Blackwell, 2001*
3	*Akyeampong K, Lussier K, Pryor J, Westbrook J, **Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count?** International Journal Educational Development, 33 (3): 272–282, 2013.*
4	*Agrawal M ,**Curricular reform in schools: The importance of evaluation**, Journal of Curriculum Studies, 36 (3): 361-379, 2004*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the concept of curriculum, formal and informal education systems and teacher education.	K3

CO2	Explain the present pedagogical practices and the changes occurring in pedagogical approaches	K3
CO3	Understand the relation between teacher and community, support from various levels of teachers to students and limitation in resources and size of the class.	K3
CO4	Perform research in design a problem in pedagogy and curriculum development.	K3

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	1	1	2	1
CO2	-	-	1	1	1	2
CO3	-	-	1	1	2	1
CO4	-	-	1	1	2	1
23GEACZ5	**-**	**-**	**1**	**1**	**2**	**1**

1 – Slight, 2 – Moderate, 3 – Substantial

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20%	50%	30%	-	-	-	100%
CAT2	20%	50%	30%	-	-	-	100%
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	20%	50%	30%	-	-	-	100%
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	20%	50%	30%	-	-	-	100%
ESE	20%	50%	30%	-	-	-	100%

23GEACZ6	STRESS MANAGEMENT BY YOGA (Common to all Branches)				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	AC	2	0	0	0

Course Objectives	• To create awareness on the benefits of yoga and meditation. • To understand the significance of Asana and Pranayama.

UNIT – I	**PHYSICAL STRUCTURE AND ITS FUNCTIONS**	**6 Periods**

Yoga - Physical structure, Importance of physical exercise, Rules and regulation of simplified physical exercises, hand exercise, leg exercise, breathing exercise, eye exercise, kapalapathy, maharasana, body massage, acupressure, body relaxation.

UNIT – II	**YOGA TERMINOLOGIES**	**6 Periods**

Yamas - Ahimsa, satya, astheya, bramhacharya, aparigraha
Niyamas- Saucha, santosha, tapas, svadhyaya, Ishvara pranidhana.

UNIT – III	**ASANA**	**6 Periods**

Asana - Rules & Regulations – Types & Benefits

UNIT – IV	**PRANAYAMA**	**6 Periods**

Regularization of breathing techniques and its effects-Types of pranayama

UNIT – V	**MIND**	**6 Periods**

Bio magnetism& mind - imprinting & magnifying – eight essential factors of living beings, Mental frequency and ten stages of mind, benefits of meditation, such as perspicacity, magnanimity, receptivity, adaptability, creativity.

Contact Periods:
Lecture: 30 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 30 Periods**

REFERENCES :

1	*Janardan Swami Yogabhyasi Mandal , **"Yogic Asanas for Group Training-Part-I"**, Nagpur.*
2	*Swami Vivekananda, **"Rajayoga or conquering the Internal Nature"**, Advaita Ashrama (Publication Department), Kolkata.*
3	*Pandit Shambu Nath, **"Speaking of Stress Management Through Yoga and Meditation"**, New Dawn Press, New Delhi, 2016.*
4	*K. N. Udupa, **"Stress and its management by Yoga",** Motilal Banarsidass Publishers, New Delhi, 2007.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Practice physical exercises and maintain good health.	K3
CO2	Attain knowledge on the various concepts of Yoga.	K2
CO3	Perform various asanas with an understanding on their benefits.	K3
CO4	Practice breathing techniques in a precise manner.	K3
CO5	Attain emotional stability and higher level of consciousness.	K2

COURSE ARTICULATION MATRIX					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	-	-	-	-	2
CO2	-	-	-	-	3
CO3	-	-	-	-	2
CO4	-	-	-	-	1
CO5	-	-	-	-	1
23GEACZ6	-	-	-	-	2
1 – Slight, 2 – Moderate, 3 – Substantial					

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40%	30%	30%	-	-	-	100%
CAT2	30%	40%	30%	-	-	-	100%
Individual Assessment1/ Case study1/ Seminar 1/ Project1	40%	40%	20%	-	-	-	100%
Individual Assessment2/ Case study2/ Seminar 2 / Project2	30%	30%	40%	-	-	-	100%
ESE	30%	30%	40%	-	-	-	100%

23GEACZ7	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS (Common to all Branches)				
PREREQUISITES :	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	AC	**2**	**0**	**0**	**0**

Course Objectives	• To familiar with Techniques to achieve the highest goal in life. • To become a person with stable mind, pleasing personality and determination.	
UNIT – I		**6 Periods**
Neetisatakam-Holistic development of personality-Verses- 19,20,21,22 (wisdom)-Verses29,31,32 (pride & heroism)-Verses- 26,28,6.		
UNIT – II		**6 Periods**
Verses- 52,53,59 (dont's)-Verses- 71,73,75,78 (do's). - Approach to day to day work and duties.- Shrimad BhagwadGeeta - Chapter 2-Verses 41, 47,48,		
UNIT – III		**6 Periods**
Shrimad BhagwadGeeta -Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,- Chapter 18-Verses 45, 46, 48.		
UNIT – IV		**6 Periods**
Statements of basic knowledge.-Shrimad BhagwadGeeta: -Chapter2-Verses 56, 62, 68 -Chapter 12 -Verses 13, 14, 15, 16,17, 18-Personality of Role model.		
UNIT – V		**6 Periods**
Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42, Chapter 4-Verses 18, 38,39-Chapter18 – Verses 37,38,63.		
Contact Periods: **Lecture: 30 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 30 Periods**		

REFERENCES :

1	*Swami SwarupanandaAdvaita Ashram "**Srimad Bhagavad Gita**",AdvaitaAshrama, Kolkata,2016*
2	*P.Gopinath, Rashtriya Sanskrit Sansthanam "**Bhartrihari's Three Satakam**" (Niti-sringar-vairagya), New Delhi, 1986.*
3	*Swami Mukundananda, JagadguruKripalujiYog "**Bhagavad Gita: The Song Of God**", USA,2019*
4	*A.C. Bhaktivedanta Swami Prabhupada "**Bhagavad-Gita As It Is**",Bhaktivedanta Book Trust Publications,2001*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the Holistic development in life	K4
CO2	Effective Planning of day to day work and duties	K4
CO3	Identify mankind to peace and prosperity	K4
CO4	Develop versatile personality.	K4
CO5	Awakening wisdom in life	K4

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	1	-	-	-
CO2	-	-	1	-	-	-
CO3	-	-	1	-	-	-
CO4	-	-	1	-	-	-
CO5	-	-	1	-	-	-
23GEACZ7	**-**	**-**	**1**	**-**	**-**	**-**

1 – Slight, 2 – Moderate, 3 – Substantial

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20%	50%	30%	-	-	-	100%
CAT2	20%	50%	30%	-	-	-	100%
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	20%	50%	30%	-	-	-	100%
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	20%	50%	30%	-	-	-	100%
ESE	20%	50%	30%	-	-	-	100%

23GEACZ8	SANSKRIT FOR TECHNICAL KNOWLEDGE (Common to all Branches)				
PREREQUISITES:	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**AC**	**2**	**0**	**0**	**0**

Course Objectives	• To get a working knowledge in illustrious Sanskrit, the scientific language in the world. • Learning of Sanskrit to improve brain functioning. • Enhancing the memory power. • Learning of Sanskrit to develop the logic in mathematics, science & other subjects.	
UNIT – I	**BASICS OF SANSKRIT**	**6 Periods**
Alphabets in Sanskrit, Past/Present/Future Tense.		
UNIT – II	**SENTENCES AND ROOTS**	**6 Periods**
Simple Sentences - Order, Introduction of roots		
UNIT – III	**SANSKRIT LITERATURE**	**6 Periods**
Technical information about Sanskrit Literature		
UNIT – IV	**TECHNICAL CONCEPTS -1**	**6 Periods**
Technical concepts of Engineering-Electrical, Mechanical		
UNIT – V	**TECHNICAL CONCEPTS -2**	**6 Periods**
Technical concepts of Engineering-Architecture, Mathematics		
Contact Periods: **Lecture: 30 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 30 Periods**		

REFERENCES:

1	*Dr.Vishwas, "**Abhyaspustakam",** Samskrita -Bharti Publication, New Delhi, 2020.*
2	*Prathama Deeksha Vempati Kutumbshastri, "**Teach Yourself Sanskrit**", Rashtriya Sanskrit Sansthanam, New Delhi, Publication, 2009.*
3	*Suresh Soni, **"India's Glorious Scientific Tradition**" , Ocean books (P) Ltd., New Delhi,2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Recognize ancient literature and their basics	K3
CO2	Formulate the sentences with order and understand the roots of Sanskrit	K2
CO3	Acquire familiarity of the major traditions of literatures written in Sanskrit	K3
CO4	Distinguish the Technical concepts of Electrical & Mechanical Engineering	K2
CO5	Categorize the Technical concepts of Architecture & Mathematics	K2

COURSE ARTICULATION MATRIX						
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	-	1	2	1
CO2	-	-	-	1	2	-
CO3	-	-	-	1	1	1
CO4	-	-	-	2	1	1
CO5	-	-	-	1	2	1
23GEACZ8	**-**	**-**	**-**	**1**	**2**	**1**

1 – Slight, 2 – Moderate, 3 – Substantial

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20%	50%	30%	-	-	-	100%
CAT2	20%	50%	30%	-	-	-	100%
Individual Assessment 1 / Case Study 1/ Seminar 1 / Project1	20%	50%	30%	-	-	-	100%
Individual Assessment 2 / Case Study 2/ Seminar 2 / Project 2	20%	50%	30%	-	-	-	100%
ESE	20%	50%	30%	-	-	-	100%