Scheme of Instruction, Evaluation

and

Syllabi of

M.E. (CIVIL)

with specialization in

GEOTECHNICAL ENGINEERING
Regular & CEEP

With effect from Academic Year 2023-24

DEPARTMENT OF CIVIL ENGINEERING

UNIVERSITY COLLEGE OF ENGINEERING

(Autonomous)

Osmania University

Hyderabad – 500 007, TS, INDIA

Estd. 1917

Estd. 1929

INSTITUTION

The University College of Engineering is established in the prestigious Osmania University, Hyderabad in the year 1929 having the distinction of being the 6th oldest Engineering College in the then British India. The college become autonomous in the year 1994. Over the decades, the UCE(A), OU has produced several illustrious alumni who brought laurels to the nation at world forums. The college is offering BE in eight branches viz., AI&ML, BME, CE, CSE, EEE, ECE, ME and Mining Engineering; ME in 22 specialisations with majority of them receiving NBA Accreditation. The college offers Ph.D. in all ME specialisations.

The college has well established laboratories and research facilities and is well placed in NIRF Rankings. The faculty members are well qualified and several of them received Best Teacher Award from Government of Telangana state. They are serving as expert members on several professional bodies, state and national level committees. The faculty members authored several research publications, text/reference books and extend consultancy services.

Vision

The Vision of the institute is to generate and disseminate knowledge through harmonious blending of science, engineering and technology. To serve the society by developing a modern technology in students' heightened intellectual, cultural, ethical and humane sensitivities, fostering a scientific temper and promoting professional and technological expertise.

Mission

- To achieve excellence in Teaching and Research
- To generate , disseminate and preserve knowledge
- To enable empowerment through knowledge and information
- Advancement of knowledge in Engineering, Science and Technology
- Promote learning in free thinking and innovative environment
- Cultivate skills, attitudes to promote knowledge creation
- Rendering socially relevant technical services to the community
- To impart new skills of technology development
- To inculcate entrepreneurial talents and technology appreciation programmes
- Technology transfer and incubation

DEPARTMENT

The Department of Civil Engineering was established in the year 1929 and was the first Department to commence the undergraduate programme at University college of Engineering, Osmania University. Over the years, the Department grew from strength to strength in terms of its academic achievements and infrastructure development. The Department has produced many All India GATE 1st Rankers / Toppers in Indian Civil Services / IES / State Public Service Commission Tests and those who got admitted in to IITs/IISc./Top Universities in the world for higher studies. The renowned alumni of this Department include several successful Engineers in Government Departments / Consultants / Contractors / Academicians who made positive contribution to the development of State and Nation.

Currently, the Department offers BE in Civil Engineering; ME in Structural Engineering, Geotechnical Engineering, Water Resources Engineering and Transportation Engineering specializations and Ph.D. programs. The Department also has the distinction of enrolling large number of foreign students both at UG and PG level. The Department provides research and consultancy services to various organizations. Several faculty members have received prestigious awards including the Best Teacher awards of the State Government and the Best Publication awards reflecting high standards in teaching and research. Many of the faculty members are listed in several national and international biographical directories. Many of them are serving in Panel of Experts in the State and National level committees. The faculty members have published over 1500 papers in various international and national journals and conferences besides text books and professional books.

Vision

To be as a leading academic department on pace with global standards and contribute to the development of economic, technically viable and useful to societal problems and challenges of civil engineering profession and also contribute to the regional and country's developmental activities.

Mission

- To produce highly competent and capable professionals to face the challenges and provide viable solutions to Civil Engineering problems
- Integration of their knowledge and skills to excel in the profession through continuous learning and contribute to the well being of the society.
- To enhance the technical knowledge, research aptitude to serve the society in highly competent manner.

Programme Educational Objectives (PEO):

PEO 1 : Enrich the core competencies in Geotechnical Engineering specialization through well designed curriculum.

PEO 2: Enhance the expertise in Laboratory Evaluation, analysis and design of Geotechnical Applications.

PEO 3: Develop skill for modelling field challenges in to research proposals and ability to carry out innovative research in core and multidisciplinary areas leading to meaningful solutions.

PEO 4 : Prepare a professional who can deal with the professional challenges, demonstrate leadership, exhibit ethics contribute to the sustainable development of the society and to excel at global standards.

Programme Outcomes (PO):

On completion of the programme, the student is expected to

PO-1 Acquire Strong theoretical base that enhances analytical capabilities
PO-2 Develop greater capability for laboratory experimentation and field evaluation of geotechnical behavior of soils / Rocks
PO-3 Gain competence to apply engineering knowledge, analyze, design and develop solution to complex geotechnical engineering problems
PO-4 Acquire ability to independently carry out research /investigation and development work to solve practical challenges together with an ability to write and present a substantial technical report/document
PO-5 Demonstrate a degree of mastery over the Geotechnical Engineering specialization at a level higher than that acquired in preceding bachelor program

MAPPING OF PEOs WITH POs

PROGRAMME EDUCATIONAL OBJECTIVES	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**
PEO-1	3	--	--	--	2
PEO-2	--	3	--	2	2
PEO-3	2	2	3	1	2
PEO-4	2	2	2	2	3

Rubrix

1 : Weakly mapped
2 : Moderately mapped
3 : Strongly mapped

SCHEME OF INSTRUCTION & EVALUATION
M.E CIVIL (Geo-Technical Engineering) - REGULAR

S. No.	Course Code	Course Name	Contact hours per week		Scheme of Examination		Credits
			L	P	CIE	SEE	
		SEMESTER-I					
1.	CE301	Advanced Soil Mechanics	3	---	40	60	3
2.	CE302	Deep Foundation Engineering	3	---	40	60	3
3.	CE303	Sub-surface Investigations and Instrumentation	3		40	60	3
4.	CE311	Expansive Soil Engineering	3	---	40	60	3
	CE312	Soil Structure Interaction					
	CE313	Tunneling and underground space Technology					
5.	CE314	Advanced Engineering Geology	3	---	40	60	3
	CE315	Environmental Geo-technology					
	CE316	Earth and Rock fill Dams					
6.	CE317	Earth Retaining Structures	3	---	40	60	3
	CE411	Statistical Techniques					
	CE102	Theory of Elasticity					
7.	CE351	GTE Laboratory – I	0	2	50	-	1
8.	CE361	Seminar	0	2	50	-	1
		TOTAL	**18**	**4**	**340**	**360**	**20**

		SEMESTER-II					
1.	CE 304	Dynamics of Soils and Foundations	3	---	40	60	3
2.	CE305	Ground Improvement Techniques	3	---	40	60	3

3.	CE306	Engineering Rock Mechanics	3	---	40	60	3
4.	CE317	Design of Geo-synthetic Applications	3	---	40	60	3
	CE318	Offshore Geotechnical Engineering	3	---	40	60	3
	CE104	Finite Element Method					
5.	CE319	Geotechnical Earthquake Engineering	3	---	40	60	3
	CE120	Advanced Concrete Technology					
	CE422	Pavement Evaluation, Maintenance & Management					
6.	OE 941 CE	Green Building Technology	3	---	40	60	3
	OE 942 CE	Cost Management of Engineering Projects					
	OE 941 ME	Operation Research					
	OE 942 ME	Composite Materials					
	OE 943 ME	Industrial Safety					
	OE 941 CS	Business Analytics					
	OE 941 EE	Waste to Energy					
	OE 942 EE	Power Plant Control & Instrumentation					
	OE 941 EC	Elements of Embedded Systems					
	OE 941 BM	Medical Assistive Devices					
	OE 942 BM	Medical Imaging Techniques					
	OE 941 LA	Intellectual Property Rights					
7.	CE371	Mini Project	---	4	50	---	2
8.	CE352	GTE Laboratory – II (including Advanced Computational Lab.)	---	2	50	---	1
9.	CE 353	Rock Mechanics Laboratory	---	2	50	---	1
		TOTAL	**18**	**8**	**390**	**360**	**22**
		SEMESTER-III					
1.		**Audi Course-I (Online)**					
	AC030	Engineering Research	2	---	40	60	0

		Methodology					
2.		**Audi Course-II (Online)**					
	AC 031	Disaster Mitigation & Management	2	---	40	60	0
	AC 032	English for Research Paper Writing					
	AC 033	Sanskrit for Technical Education					
	AC 034	Value Education					
	AC 035	Stress Management by Yoga					
	AC 036	Personality Development					
	AC 037	Constitution of India					
	AC 038	Pedagogy Studies					
3.		Dissertation-I	---	20*	100	---	10
		TOTAL	**4**	**20**	**180**	**120**	**10**
		SEMESTER-IV					
1.		Dissertation-II	---	32*	100	100	16
		GRAND TOTAL	**40**	**64**	**1010**	**940**	**68**

Note:

i. Dissertation-II has two parts, CIE - I and CIE - II, at the end of 8th week and 16th week respectively for evaluation of 50 marks each.

ii. Audit Course will be offered in ONLINE/OFFLINE/HYBRID mode and SEE will be conducted in Computer Based Test Mode.

iii. Research Methodology and IPR will be offered as an Audit Course for all PG Programs.

iv. Engineering Research Methodology workshop will be conducted for one week to the Ph.D scholars.

***The student has to work a minimum of 20 hours/week and 32 hours/week at Dissertation - I and II.**

SCHEME OF INSTRUCTION & EVALUATION
M.E CIVIL (Geo-Technical Engineering) – Part time - CEEP

S. No.	Course Code	Course Name	Contact hours per week		Scheme of Examination		Credits
			L	P	CIE	SEE	
		SEMESTER-I					
1.	CE301	Advanced Soil Mechanics	3	---	40	60	3
2.	CE302	Advanced Foundation Engineering	3	---	40	60	3
3.	CE311	Expansive Soil Engineering	3	---	40	60	3
	CE312	Soil Structure Interaction					
	CE313	Tunneling and underground space Technology					
4.	CE351	GTE Laboratory – I	0	2	50	-	1
		TOTAL	**9**	**2**	**170**	**180**	**10**

		SEMESTER-II (CEEP)					
1.	CE 304	Dynamics of Soils and Foundations	3	---	40	60	3
2.	CE305	Ground Improvement Techniques	3	---	40	60	3
3.	CE306	Design of Geo-synthetic Applications	3	---	40	60	3
	CE318	Offshore Geotechnical Engineering	3	---	40	60	3
	CE104	Finite Element Method					
4.	CE352	GTE Laboratory – II (including Advanced Computational Lab.)	---	2	50	---	1
		TOTAL	**9**	**2**	**170**	**180**	**10**

S. No.	Course Code	Course Name	Contact hours per week		Scheme of Examination		Credits
			L	P	CIE	SEE	
		SEMESTER-III (CEEP)					
1.	CE303	Sub-surface Investigations and Instrumentation	3		40	60	3
2.	CE313	Advanced Engineering Geology	3	---	40	60	3
	CE314	Environmental Geo-technology					
	CE315	Earth and Rock fill Dams					
3.	CE316	Earth Retaining Structures	3	---	40	60	3
	CE411	Statistical Techniques					
	CE102	Theory of Elasticity					
4.	CE361	Seminar	0	2	50	-	1
		TOTAL	**9**	**2**	**170**	**180**	**10**

		SEMESTER-IV (CEEP)					
1.	CE306	Engineering Rock Mechanics	3	---	40	60	3
2.	CE319	Geotechnical Earthquake Engineering	3	---	40	60	3
	CE120	Advanced Concrete Technology					
	CE422	Pavement Evaluation, Maintenance & Management					
3.	OE 941 CE	Green Building Technology	3	---	40	60	3
	OE 942 CE	Cost Management of Engineering Projects					
	OE 941 ME	Operational Research					
	OE 942 ME	Composite Materials					
	OE 943 ME	Industrial Safety					
	OE 941 CS	Business Analytics					
	OE 941 EE	Waste to Energy					
	OE 942 EE	Power Plant Control & Instrumentation					
	OE 941 EC	Elements of Embedded Systems					
	OE 941 BM	Medical Assistive Devices					
	OE 942 BM	Medical Imaging Techniques					
	OE 941 LA	Intellectual Property Rights					
5.	CE371	Mini Project	---	4	50	---	2
6.	CE 353	Rock Mechanics Laboratory	---	2	50	---	1
		TOTAL	**9**	**6**	**220**	**180**	**12**

		SEMESTER-IV (CEEP)					
1.		**Audi Course-I (Online)**					
	AC030	Engineering Research Methodology	2	---	40	60	0
2.		**Audi Course-II (Online)**					
	AC 031	Disaster Mitigation & Management	2	---	40	60	0
	AC 032	English for Research Paper Writing					
	AC 033	Sanskrit for Technical Education					
	AC 034	Value Education					
	AC 035	Stress Management by Yoga					
	AC 036	Personality Development					
	AC 037	Constitution of India					
	AC 038	Pedagogy Studies					
3.		Dissertation-I	---	20*	100	---	10
		TOTAL	**4**	**20**	**180**	**120**	**10**
		SEMESTER-IV					
1.		Dissertation-II	---	32*	100	100	16
		GRAND TOTAL	**40**	**64**	**1010**	**940**	**68**

Note:

1. Dissertation-II has two parts, CIE - I and CIE - II, at the end of 8th week and 16th week respectively for evaluation of 50 marks each.
2. Audit Course will be offered in ONLINE/OFFLINE/HYBRID mode and SEE will be conducted in Computer Based Test Mode.
3. Research Methodology and IPR will be offered as an Audit Course for all PG Programs.
4. Engineering Research Methodology workshop will be conducted for one week to the Ph.D scholars.

***The student has to work a minimum of 20 hours/week and 32 hours/week at Dissertation - I and II.**

CE 301	**ADVANCED SOIL MECHANICS**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To understand the Seepage analysis and related applications*
2	*To learn the mechanisms contributing to shear strength of soils, factors affecting and procedures for determination of shear parameters in laboratory*
3	*To gain knowledge in the settlement analysis, earth pressure computation*
4	*To understand the soil mechanics associated with analysis, design and construction of Embankments and Earthen Dams*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Understanding the mechanics of Seepage and competence to take up seepage analysis.*
CO-2	*Ability to perform laboratory tests and to find the shear strength parameters of the soil simulating the different field conditions.*
CO-3	*Competence in performing the settlement analysis*
CO-4	*Ability to compute earth pressure and perform stability analysis of earth retaining systems*
CO-5	*Core competence in analysis & design of Embankments and Earthen Dams*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	3		2	2	1	
CO-2	2	3	2	2	1	
CO-3	2	1	3			
CO-4	2		3			
CO-5	2		1	2	3	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Soil water hydraulics: Seepage - mathematical Analysis-finite element formulation of steady state and transient flow of water through soils- Quick Condition – analysis – measures to mitigate – case studies. Flow nets - construction of flow nets below and through the body of the earthen dams.

UNIT - II
Shear strength of soils: Review of conventional laboratory tests for determination of shear strength parameters - Factors affecting shear strength of soils – pore pressure in soils- pore pressure measurement in triaxial compression test and field measurements- total and effective shear stress parameters- stress path – Hvorslave shear parameters – shear strength, thixotrophy and liquefaction of soils.

UNIT - III
Consolidation of Clayey Soils : one, two and three dimensional consolidation theories – primary, secondary consolidation process-finite difference formulations of consolidation equations – radial consolidation – sand drains and other techniques to accelerate consolidation process- estimation of settlements.

UNIT - IV
Review of Limit equilibrium (Rankine, Coulomb) Earth pressure theories - Computation of earth pressure using theory of plasticity for cohesive and cohesionless soils- soil tension effects- rupture zones- reliability of solutions- Earth pressure computations- soil properties to be used- graphical and computer aided solutions.

UNIT - V
Earthen dams and highway embankments- type of embankments, factors influencing design of embankments- control of pore pressure, slope stability analysis of embankments – critical study of failures- embankments settlements – Earthen Dams : Types - seepage analysis- seepage control methods- filters and their use- impervious zones- cut off walls- slope protection methods.

Suggested Reading :

1	Karl Terzaghi, Ralph B Peck, and Gholamreza Mesri, "Soil Mechanics in Engineering Practice", 3rd Edition, Wiley, 2009
2	R.D. Holtz, W.D. Kovacs and T.C. Sheahan, "An Introduction to Geotechnical Engineering" – 2nd Edition – Prentice – Hall India, 2010.
3	Lambe, T.W. and Whitman, R.V.(2012), *Soil Mechanics*, John Wiley and Sons.
4	Alam Singh, *Soil Engineering in Theory and Practice(1981)*, Asia Publishing House.
5	Braja M Das, Principles of Geotechnical Engineering – 5th Edition, Thomson – Brooks & Cole, 2004.

CED 302	**DEEP FOUNDATION ENGINEERING**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To understand the estimation of allowable bearing capacity of shallow foundations using theories and field tests.*
2	*To learn the necessity of deep foundations, types and their suitability, evaluation of their capacity.*
3	*To learn the mechanics governing the stability of deep excavations*
4	*To learn different methods of geotechnical investigations required for selection and design of shallow foundations.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Comprehensive understanding about bearing capacity of shallow foundations (Isolated & Spread footings) and the analysis and design associated with it*
CO-2	*Competence in the analysis and geotechnical design of Pile foundations.*
CO-3	*Ability to perform geotechnical design of Pier foundations.*
CO-4	*Understanding of the design and construction of Caissons.*
CO-5	*Knowledge of foundation construction related aspects such as deep excavations, Sheet pile walls, cofferdams*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	2	1	3	1	1	
CO-2	2	1	3	1	1	
CO-3	2	1	3	1	1	
CO-4	2	1	3	1	1	
CO-5	1		1		3	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I
General : Functions and necessity of Foundation – Types and suitability – Necessity of Geotechnical Investigations in the geotechnical design of foundations-Review of foundation design principles.
Shallow Foundations : Bearing capacity of Shallow foundations on Soils - review of existing methods- additional considerations for development of bearing capacity of equations (Terazaghi, Meyerhoff, Vesic, Brinch Hansen etc.) - effect of water table, layered soils,

foundation on slopes, uplift pressure- consideration from field test (PLT, SPT, CPT etc.). Settlement analysis and estimation of allowable bearing capacity. Bearing capacity of Shallow foundations on rocks - safety factors in foundation design.

UNIT - II
Pile Foundations : Types of piles- necessity and use of pile foundation - review of principles of design by conventional and finite element methods determination of pile capacities for vertical and horizontal loads - single pile and group of pile - for loads - tension piles - batter piles and anchor piles - settlement of pile foundations - negative skin fiction, design of pile caps - polygon of forces - pile load tests.

UNIT - III
Pier foundations - types - their necessity - construction methods - determination of ultimate load capacity for vertical and lateral loads- settlement - pier inspection methods.

UNIT - IV
Well foundations (Caissons) types of caissons - their necessity- principles of design – review of IS and IRC codes- determination of grip length in cohesive and cohesionless soils - settlements - scour depths - thickness of straining - case studies.

UNIT - V
Walls for deep excavations of foundations : Necessity for deep excavation (>6m deep) various methods and techniques adopted- braced type wall supports- estimation of soil pressures – ground loss around excavations- instability due to heave and piping of bottom of excavations and other causes of instability.
Sheet pile walls - necessity of using the piles - types of piles - principles of design consideration of sheet piles and their components - cantilevered, anchored, - review of convensional design methods and finite elements methods.
Coffer dams - different types and their utility- principles of design and construction of methods - review of conventional methods.

Suggested Reading :

1	Joseph Bowels (2018), *Foundation Analysis and Design*, Mc Graw Hill.
2	Tomlinson, "Foundation Design and Construction", Pearson Publications, 2001
3	H.Y.Fang .(1997). *Foundations Engineering Hand Book* , CBS Publications
4	B.M.Das, (2019), Advanced Foundation Engineering, Cengage Publications.
5	P.C.Verghese (2000), Foundation Engineering, PHI Publishers.

CED 303	**SUB-SURFACE INVESTIGATIONS AND INSTRUMENTATION**

Pre-requisites		**L**	**T**	**P**	**C**
		3	-	-	3
Evaluation	**SEE** 60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To understand the objectives, necessity and scope of sub-soil exploration methods*
2	*To learn the field and laboratory components of a geotechnical investigation*
3	*To gain competence in interpretation of the investigation data*
4	*To learn the methods of reporting including the recommendations*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Ability to understand the requirement of geotechnical investigations, select suitable method of investigation and planning*
CO-2	*Competence in the investigation methods including collection of samples*
CO-3	*Acquire knowledge to perform different field tests, to take observations, to analyse and interpret the results.*
CO-4	*Competence to prepare Geotechnical Investigation report to suit the requirements of a project including necessary recommendations*
CO-5	*Acquire knowledge about different instruments used in GTE practice*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	2	2	3	2	2	
CO-2	1	2	3	1	2	
CO-3	2	3	1	1	1	
CO-4	1	1	3		1	
CO-5	2	3	2		2	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
General considerations – Delineation of objectives of site investigation, reconnaissance, preliminary and detail investigations - methods and types of investigations – spacing of bore holes – geophysical methods – planning of exploration methods.

UNIT – II
Methods of direct investigations, review of existing methods including for marine conditions, drilling in soils and rock, description of soils and rock during exploration, methods of sampling and preservations - ground water observations.

UNIT – III
Insitu tests(field) : static and dynamic tests – SPT, CPT, Dutch cone, vane shear, PMT, DMT, BST, permeability, KO, Plate load test, deformation modulus, tests on rocks RQD, chemical tests on water - recording of the tests and their interpretation – determination of dynamic properties of soils and rock for machine foundation designs – C_u, shear G, natural frequency, resonance, amplitude and damping ,etc.

UNIT – IV
Preparation of geotechnical investigation reports – geotechnical documentation – preparation of geotechnical features – generalized characteristics properties of soils – statistics methods, graphical correlations and factor of safety values. Final recommendation to evaluate the bearing capacities and settlement characteristics of soils and for use of proper selection of type of foundations.

UNIT – V
Geotechnical Instrumentation – Necessity and use – Displacement measuring Devices – Pore pressure measuring devices – Earth pressure measuring devices – Vibration measuring devices – Advances in instrumentation.

Suggested Reading : (five for BE and up to seven for ME)

1	J.E. Bowles.(2017) – *Foundation Design & Analysis*. McGraw-Hill Edition.
2	Roy E.Hunt (2020) – *Geotechnical Investigation Methods – A field guide to Geotechnical Engineers,* Taylor & Francis, CRC Publications.
3	Clayton C. R., Matthews M. C and Simons N. E., "Site Investigation", Blackwell Science, 2005.
4	Lourie, W.(1997) - *Fundamentals of Geophysics*, Cambridge University press.
5	Hanna T.W. (2017) *Foundation Instrumentations*, Transtech Pub., Switzerland.

CED 311	**EXPANSIVE SOIL ENGINEERING**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	gain comprehensive understanding about identification and characterization of expansive soils
2	learn the laboratory test procedures for evaluation of expansiveness
3	learn the swell control measures

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Ability to understand the Engineering behavior of Expansive Soils, their presence and identification
CO-2	Acquiring knowledge about Clay mineralogy responsible for expansive behaviour
CO-3	Competence in laboratory and field evaluation of swell potential of expansive soils
CO-4	Appraisal of problems posed by expansive soils on Foundations and competence in providing remediation
CO-5	Understanding about open excavations in expansive soils and the remedial measures to be taken.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	2		1	1	1	
CO-2	3			1	1	
CO-3	2	3		1	1	
CO-4	1		1		3	
CO-5	2		1		1	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
General: Necessity of study and importance. Spread of expansive soils in India and other countries. Various problems encountered for structural safety of structures, remedial measures.

UNIT – II
Clay mineralogy: study of physic- chemical properties of clay mineral including their micro structures, their identification by thermal, x-ray diffraction, Electron Microscopic methods engineering properties.

UNIT – III
Determination of swell and swell potential of soil water systems- laboratory and field estimates of heave. Study of moisture movements- swelling and shrinkage behaviors- cyclic swells- multidimensional swells. Shear strength, consolidation and earth pressure (Characteristic) properties of swelling clays.

UNIT – IV
Problems and remedial measures: Problems encountered in shallow, deep foundations in swelling sub- soil strata- design considerations- study of case histories, methods of alteration or modification of swell properties. Use of under reamed piles and their design criteria – Reliability analysis of foundations on expansive soils- settlement characteristics- hysteresis of deformations of swelling soils- Inter swelling. Safety factors.

UNIT – V
Open and underground excavations in swelling and shrinkage soils- construction techniques to be adopted. Remedial measures- stabilization methods use of chemical grouts etc.

Suggested Reading :

1	J. D. Nelson et. al., Foundation Engineering for Expansive Soils, 2015, John Wiley & Sons Inc.
2	Jphn S. McCartney and L.R. Hoyos (Edts.), Recent Advancements on Expansive Soils, 2019, ISSMGE Conference Proceedings, Springer Publications.
3	F.H.Chen, Foundations on Expansive Soils, 2012, Springer Publications.
4	J.D.Nelson & D.J.Miller, Expansive Soils: Problems and Practice in Foundation and Pavement Engineering, 1997, John Wiley & Sons Inc.

CED 312	**SOIL-STRUCTURE INTERACTION**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the engineering behavior of the structure, soil and their interaction
2	To learn the methods to model the soil behavior associated with Isolated, Combined, Raft and pile foundations.
3	To study the effect of structure on the soil-structure interaction

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Gain knowledge about the engineering behavior of the soil-structure interaction.
CO-2	Competence to model the soil behavior associated with shallow isolated / combined footing.
CO-3	Ability to model the soil-structure interaction associated with a raft foundation.
CO-4	Competence to model the interaction of a pile foundation with the soil
CO-5	Understanding about the effect of Structure on the soil behavior.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	3			2	2	
CO-2	1		3	2	2	
CO-3	1		3	2	2	
CO-4	1		3	2	2	
CO-5	1		3	1	2	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elasto-plastic behaviour, Time dependent behaviour.

UNIT – II
Beams on Elastic Foundation- Soil Models: Infinite beam, Two-parameters models, Isotropic elastic half space model, Analysis of beams of finite length, combined footings.

UNIT – III
Plates on Elastic Continuum: Thin and thick rafts, Analysis of finite plates, Numerical analysis of finite plates.

UNIT – IV
Analysis of Axially and Laterally Loaded Piles and Pile Groups: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap, Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system.

UNIT – V
Ground-Foundation-Structure Interaction: Effect of structure on ground-foundation interaction, Static and dynamic loads.

Suggested Reading :

1	Rolando P. Orense, Nawawi Chouw & Michael J. Pender (2010)- *Soil-Foundation-Structure Interaction*, CRC Press, Taylor & Francis Group, London, UK.
2	*Soil Structure Interaction – The real behaviour of structures*, the institution of structural engineers, London, 1989.
3	Selvadurai, A. P. S.(2013) - *Elastic Analysis of Soil-Foundation Interaction*.
4	Poulos, H. G., and Davis, E. H.(1980) - *Pile Foundation Analysis and Design*.
5	Das, B. M.(2019), *Principles of Foundation Engineering* 5th Edition Nelson Engineering

CE 313	**TUNNELLING AND UNDERGROUND SPACE TECHNOLOGY**

Pre-requisites		**L**	**T**	**P**	**C**
		3	-	-	3
Evaluation	**SEE** 60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To study various design methods of tunnels, underground spaces and their supports*
2	*To study various methods of driving tunnels, underground spaces and their surveying related*
3	*To study about various machinery used in driving tunnels and underground spaces.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*The students will acquire knowledge relating to design of underground tunnels and spaces including their supports*
CO-2	*Competence in selection of suitable method of driving tnnnels and underground spaces.*
CO-3	*Gain knowledge of machinery used in underground tunnelling and spaces.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	3			2	2	
CO-2			3		2	
CO-3	3			2	2	
CO-4						
CO-5						

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I

INTRODUCTION

Congestion in cities and its impact on development of social infrastructure for transport, water and power supply, separation of pedestrian and motorized vehicles and its movements, storage of materials, defence facilities including civil shelters. Parameters influencing location, shape and size; geological aspects; planning and site investigations. Natural caves, archaeological caves and their construction; Scope and application, historical developments, art of tunnelling, tunnel engineering, Tunnels for various purposes like road, rail, hydropower tunnels and caverns, Underground storage for LPG and crude oil, Nuclear waste disposal, Metro tunnels, future tunnelling considerations. Planning and design, Assessment of behaviour of tunnelling media, deformation modulus and rock pressure assessment; determination of appropriate size and shape; Design of openings in rocks with the help of field data; Instrumentation and monitoring; Numerical modelling to assess the stability.

UNIT – II
TUNNELLING METHODS
Types and purpose of tunnels; factors affecting choice of excavation techniques; soil and rock sampling and testing, Methods - soft ground tunnelling, hard rock tunnelling, shallow tunnelling, deep tunnelling; 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
TUNNELLING BY DRILLING AND BLASTING
Unit operations in conventional tunnelling; Drilling - drilling principles, drilling equipment, drilling tools, drill selection, specific drilling, rock drillability 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
TUNNELLING BY ROAD HEADERS, IMPACT HAMMERS AND TUNNEL BORING MACHINE
Cutting principles, method of excavation, selection, performance, limitations and problems. Boring principles, method of excavation, selection, performance, limitations and problems; Road headers, Impact Hammers, Tunnel Boring Machines and applications.

UNIT – V
TUNNEL SURVEYING, SUPPORTS AND SERVICES
Surveying in Tunnels: Topographic and geological survey, Methods of surveying and different instruments used for surveying in tunnels, Supports in Tunnels: Principal types of supports, their design and applicability. Steel supports, rock bolts, shotcrete, wire mesh, chain link fabric and fibre reinforced shotcrete and other ground consolidation/grouting techniques. Ground Treatment in Tunnelling: Adverse ground conditions and its effect on tunnelling; introduction to ground control. Supports in Metro tunnels, Tunnel Services and Hazards: Ventilation, drainage and pumping. Explosion, flooding, chimney formation, squeezing ground.

Suggested Reading :

1	Hudson, J.A., *Rock Engineering Systems Theory and Practice*, Ellis Horwood, England.
2	Clark G.B., (1987), *Principles of Rock Fragmentation*, John Wiley and Sons, New York.

References:

1	Lohanson, John and Mathiesen, C.F.(2000), *Modern trends in Tunnelling and Blast Design*, AA Balkima, 154 P.
2	Bickel J.O., Kuesel T.R. and King E.H., *Tunnel Engineering Hand Book*, 2nd addition, Chapmen & Hill Inc., New York and CBS Publishers, New Delhi.

CE 314	**ADVANCED ENGENEERING GEOLOGY**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To understand the formation of Soils / Rock and its influence on their Engineering behavior.*
2	*To learn Classification and characterization using advanced techniques such as Geophysical methods, RS, GIS etc.*
3	*To gain comprehensive understanding about geological factors influencing the ground water hydraulics*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Ability to characterize the soil and rock based on their formation*
CO-2	*Knowledge of RS & GIS in Engineering Geology*
CO-3	*Competence in application of Geophysical methods for investigation of soils and rock*
CO-4	*Understanding the Geological aspects on Ground water*
CO-5	*Competence for accounting the geological aspects in the selection, investigation of ground for major civil engineering structures.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	2		3		2	
CO-2	2		3	1	2	
CO-3	2	3	2	1	2	
CO-4	1		2		3	
CO-5	1	2	3			

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Geology of soils: evolution, classification, characteristics, features, mechanical behavior and engineering uses of soils. Important clay minerals and their importance in soils.
Engineering geomorphology: evolution of different land forms ,(erosional and depositional) characteristic features and their suitability or response to various engineering works.

UNIT – II
Photogeology & remote sensing: Different types of aerial photographs, stereography, principles and uses of aerial photographs in the engineering practice. Infra red line scan(IRLS)and side looking airborne radar (SLAR) thermal properties of geological materials, sensors. Interpretation of landsat images and use of satellite images in civil engineering practice

UNIT – III
Engineering geophysics: principles, theory, instruments, filed methods, data collection and data interpretation of electrical and seismic refraction methods. application in engineering practice.

UNIT – IV
Ground water: artificial recharge of ground water, fluctuations in ground water levels due to various causes and management of ground water.
Environmental geology: effects of withdrawal of excessive ground water, disposal of solid and liquid wastes, environmental impact of water impoundment.

UNIT – V
Case histories: Engineering geology of most important dams and funnels of India.

References :

1	Attewel and Farmer.(1976) *Principles of Geology,* Chapman and Publications.
2	Bell, F.G.(1983), *Fundamentals of Engineering Geology,* Butterworth Publications.
3	Bell, F.G.(1980), *Engineering Geology and Geotechnics*, Butterworth Publications.

CE 315	**ENVIRONMENTAL GEOTECHNOLOGY**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To understand the necessity and scope of safe waste disposal systems*
2	*To gain comprehensive understanding about the planning and design of waste disposal systems*
3	*To learn the analysis and design of applications of Geosynthetics in Geo-environmental applications.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Understanding about characterization of different types of wastes*
CO-2	*Comprehensive Understanding about the Waste Disposal Facilities and Barrier Systems*
CO-3	*Knowledge of modification and re-use of waste materials*
CO-4	*Understanding about the soil erosion mechanics and measures to control*
CO-5	*Ability to analyse and design the Geo-environmental application of geosynthetics*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	3			1	2	
CO-2	3			1	2	
CO-3	3		2		2	
CO-4	2		3		2	
CO-5	2		3		2	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Wastes: source, production and classification of wastes, soil pollution processes, waste characterization

UNIT – II
Waste disposal facilities such as landfills and impoundments, slurry walls, landfill planning and design.

Barrier systems – basic concepts, design and construction, stability, compatibility and performance contaminant transformation and transport in subsurface.

UNIT – III
Monitoring surface contamination, stabilization, and modification of wastes.
Reuse of waste materials, contaminated site remediation. Case studies in waste handling.

UNIT – IV
Soil erosion and conservations – causes of soil erosions, factors contributing to erosion – climatic factors, topographical factors, vegetation factors. Erosion control – cropping systems, gullies, check dams, contouring, wind striping, ridging, bank protection.

UNIT – V
Application of Geosynthetics : Introduction – Classification & Functions of Geosythetics – Over view of Geotextiles, Geogrids, Geonets, Geomembranes and Geocomposites.
Geosynthetics in Geo-environmental Engineering : Capping & Lining – Design requirements – Case studies.

Suggested Reading :

1	Daniel, D. E.(1993) *Geotechnical practice for waste disposal*, Chapman and Hall, London.
2	Rowe, R. K., Quigley, R. M. and Booker.(1995), *Clay barrier systems for waste disposal facilities*, J.R., E & FN Spon, London.
3	Reddi, L. N., and Inyang, H. F.(2000) *Geoenvironmental Engineering – principles and applications*, Marcel Dekker.
4	Bagchi, A.(1995) *Design, construction and monitoring of landfills*, John Wiley & Sons, New York.
5	Sharma, H. D. and Lewis, S. P.(1994), *Waste containment systems, Waste stabilization and landfills: Design and evaluation* John Wiley & Sons, New York.
6	Koener, R.M. (2012), "*Designing with Geosynthetics, Vol.1 & 2,* Xlibriss Corporation LLC

CE 316	**EARTH AND ROCK FILL DAMS**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understand different types of dams and their suitability
2	gain knowledge of seepage through earth and rockfill dams
3	Learn design aspects of earth and rockfill dams

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Select suitable site and materials for the construction of earth / rockfill dams
CO-2	Analyse seepage through a given earth / rockfill dam section and propose suitable seepage control measures
CO-3	Analyse the earth/rock fill dams for different stability conditions
CO-4	Plan and decide the construction procedure of earth and rockfill dams.
CO-5	Design the earth and rockfill dams

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	3		1		1	
CO-2	2		2		2	
CO-3	2			1	2	
CO-4	2		2		2	
CO-5	2		3		2	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Introduction: Classification of dams, Selection of site, Preliminary section, Types of earth dams, Basic design requirements.

UNIT – II
Seepage Through Dam Section and Its Control: Fundamentals of seepage flow, Flownets, Seepage control through dam section, Design of filters, Impervious core, Drains.

Control of Seepage Through Dam Foundations: Types of foundations trench cut off, Upstream impervious blanket, Horizontal drainage blanket, Relief wells, Drainage trenches, Cut off walls, Downstream loading berm.

UNIT – III

Stability Analysis: Fundamentals of slope failures, Critical slip surfaces, Test conditions, Strength parameters, Pore pressures, Methods of stability analysis.

UNIT – IV

Construction of Earth Dams: Construction equipment, Procedures for construction, Construction supervision, Treatment of foundations - core contact treatment, grouting, foundation excavation.

Failures and Damages of Earth Dams: Nature of failures - piping, settlement cracks, slides, earthquake & miscellaneous damages – case studies.

for thermal performance of building envelope - Evaluation of the overall thermal transfer.

UNIT – V

Rock Fill Dams: General characteristics, Types of rockfill dams, Rockfill materials, Foundation, Construction, Deformations.

Design of Rockfill Dams: Design of Rockfill dam sections, Concrete face and earth core, Nature of failures and damages, Case studies.

Suggested Reading :

1	Engineering for Embankment Dams, B. Singh and R. S. Varshney, A.A. Balkema, 1995.
2	Embankment Dams, H.D. Sharma, Oxford and IBH Publishing Co., 1991.
3	Irrigation Engineering and Hydraulic Structures, S.K. Garg, Khanna Publishers, 2006.
4	Earth and Rockfill Dams, Christian Kutzner, A.A. Balkema, 1997
5	Earth and Earth Rock Dams, J. L. Sherard, John Wiley & Sons Inc, 1963.

CE 319	**EARTH RETAINING STRUCTURES**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To gain comprehensive understanding earth pressure and its computation
2	To learn the stability analysis of retaining walls, sheet pile walls, bulk heads and braced excavations

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Ability to compute earth pressure using theories
CO-2	Competence in stability analysis of conventional and reinforced earth retaining systems
CO-3	Ability to analyze the stability of sheet pile walls

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	2		3		2	
CO-2	2		3	1	2	
CO-3	2	1	3		3	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Earth Pressure: Rankine and Coulomb theories, active, passive and pressure at rest; concentrated surcharge above the back fill, earth pressure due to uniform surcharge, earth pressure of stratified backfills, saturated and partially saturated backfill.

UNIT – II
Retaining walls: Proportioning of retaining walls, stability of retaining walls, mechanically stabilized retaining walls/reinforced earth retaining walls

UNIT – III
Sheet Pile wall: free earth system, fixed earth system

UNIT – IV
Bulkheads: bulkheads with free and fixed earth supports, equivalent beam method, Anchorage of bulkheads and resistance of anchor walls, spacing between bulkheads and anchor walls, resistance of anchor plates

UNIT – V
Braced excavations: Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays

Suggested Reading :

1	Das, Braja M.(1998),*Principles of Foundation Engineering*, PWS Publishing.
2	Bowles. J.E.(1997), *Foundation Analysis and Design*, 5th Edtn. Tata McGraw-Hill International Edition.
3	Gulhati, K.Shashi and M.Datta, Geootechnical engineering",Mc.GrawHill bookcompany,2005.
4	Chris R.I.Clayton (2014), Earth Pressure and Earth Retaining Structures", CRS Press.
5	H. Brooks (2018), Basics of Retaining Wall Design", HBA Publications.

CE 416	**STATISTICAL TECHNIQUES**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To introduce fundamental knowledge of sampling technique.
2	To describe basic statistical techniques such as statistical distributions and correlation methods.
3	To impart knowledge on exact sampling distributions and the tests of significance.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Use sampling techniques for conducting various surveys related to transportation Engineering
CO-2	Apply the statistical distributions to traffic problems
CO-3	Decide best fit and develop the regression equations for the given variables
CO-4	Apply multi-variant data distributions.
CO-5	Applications of sampling distributions in Highway and Traffic Engineering problems.

Course outcome	**Program Outcome**				
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**
CO-1	3	3	3	3	3
CO-2	2	2	2	2	2
CO-3	2	2	2	2	2
CO-4	1	0	0	2	0
CO-5	0	0	0	1	1

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I
Introduction: Frequency distribution; Measures of central tendency; Measures of dispersion; Standard error, Moments (about mean, arbitrary numbers and origin); Skewness; Kurtosis; Sampling-Definitions and Applications; Simple random sampling; Stratified sampling; Systematic sampling; Sample size determination; Applications in Highway and Traffic Engineering

UNIT - II
Statistical Distribution; Probability, Bayes' Theorem; Binomial, Poisson, Exponential and Normal distributions; Fitting of distributions; Mean and variance; Chi-square test of goodness-of-fit; Applications in Highway and traffic Engineering. Mathematical expectation.

UNIT - III
Regression and Correlation: Linear regression and correlation; Multiple correlation; Multiple correlation coefficient; Standard error of estimate; Analysis of variance; Curvilinear regression; Applications in Transportation Engineering.

UNIT - IV
Multi Variate Data Distributions; Types of data; Basic vectors and matrices; Simple estimate of centroid, Standard deviation Variance and covariance; Correlation matrices; Principal component analysis; Time series analysis. Estimation-Point Estimation interval Estimation, Box Plot, Maximum likelihood estimation, Biased & Non-Biased Estimation.
Topics to be taught by Industry Subject Expert: Types of data; Basic vectors and matrices; Simple estimate of centroid, Standard deviation Variance and covariance

UNIT - V
Exact Sampling Distributions and Tests of Significance; Chi-square distribution; students t-distribution; Snedectors F-distribution. Large sample and small sample tests; Tests for single mean. Means of two samples, Proportions, two variances, two observed correlation coefficients, paired T-tests, Applications. Intervals for mean, variance and regression Coefficients; Applications in Highway and Traffic Engineering Problems.
Topics to be taught by Industry Subject Expert: Chi-square distribution; students t-distribution; Snedectors F-distribution. Large sample and small sample tests; Tests for single mean. Means of two samples, Proportions, two variances

Suggested Reading:

1	Basic Statistics - Simpson and Kafks; Oxford and IBH Calcutta,1969.
2	Fundamentals of Mathematical Statistics - Gupta, S.C. and Kapoor, K. V. Sultanchand
3	Multivariate Data Analysis – Cootey W.W &Cochens P.R; John Wiley & Sons

CE 102	**THEORY OF ELASTICITY**					
Pre-requisites	Strength of Materials		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understand the concepts of elasticity and equip them with the knowledge to independently handle the problems of elasticity.
2	Enhance the competency level and develop the self-confidence through quality assignments in theory of elasticity.
3	Inculcate the habit of researching and practicing in the field of elasticity.

Course Outcomes :	
On completion of this course, the student will be able to do :	
CO-1	Solve the problems of 3-D elasticity with confidence.
CO-2	Acquire the knowledge of principle stresses and principle strains
CO-3	Work independently with the problems of 2-D elasticity in Cartesian coordinates
CO-4	Familiarize with the use of Airy‟s stress function in 2-D problems of elasticity in polar coordinates.
CO-5	Equip with the knowledge of various theories of torsion of prismatic bars of various cross sections and can solve the problems of torsion.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3		1	1		
CO-2	3		1	1		
CO-3	3		1	1		
CO-4	3		1	1		
CO-5	3		1	1		

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

Unit - I
Introduction: Definition and notation for forces and stresses, components of stress and strain, Generalized Hooke‟s law, Stress-strain relations in three directions, Plane stress and plane strain, Equations of equilibrium and compatibility in two and three dimensions, Stress components on an oblique plane, Transformation of stress components under change of co-ordinate system.

Unit - II
Principal stresses and principal planes: Stress invariants, Mean and Deviator stress, Strain energy per unit volume, Distortion strain energy per unit volume, Octahedral shear stress, Strain of a line element. Principal strains, Strain invariants, Volume strain, Principle of superposition, reciprocal theorem.

Unit - III
Two dimensional problems in Cartesian co-ordinates: Solution by polynomials, St. Venant‟s Principle, Uniqueness of solution, Stress components in terms of Airy‟s stress function. Applications to Cantilever, simply supported and fixed beams with simple loading.

Unit - IV
Two dimensional problems in Polar co-ordinates: Stress-strain components, Equilibrium equations, Compatibility equations, Applications using Airy‟s strain functions in polar co-ordinates for stress distributions symmetric about an axis, Effect of hole on stress distribution in a plate in tension, Stress due to load at a point on a semi-infinite straight boundary, Stresses in a circular disc under diametrical loading.

Unit - V
Torsion: Torsion of various shapes of bars, Stress function method of solution applied to circular and elliptical bars, Torsion of rectangular bars, Solution of Torsional problems by energy method, use of soap films in solving torsion problems, Prandtl‟s membrane analogy. Solution of torsion of bars by Finite difference method.

Suggested Reading:

1	Timoshenko.S, Goodier.N (2017), Theory of Elasticity, Mc Graw Hill.
2	Sadhu Singh (2012), Theory of Elasticity, Khanna Publishers.
3	Ukad Gaonkar (2015), Theory of Elasticity and Fracture Mechanics, ,PHI Learning Private Limited
4	Chandramouli , P.N.(2017), Theory of Elasticity ,Yesdee Publishing Pvt.Ltd.
5	Landau, L D, Pitaevskii, L. P., Kosevich, A. M.(1984) , Lifshitz,E.M., Theory of Elasticity, Butterworth-Heinemann
6	Jane Helena,H(2017), Theory of Elasticity and Plasticity , PHI Learning

CE 351	**GEOTECHNICAL ENGINEERNIG LAB-I**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	1.5
Evaluation	**SEE**	-- Marks	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Expose the students to different types of soils*
2	*Experience the concepts of soil mass, soil solids, and soil structure.*
3	*Understand the laboratory test procedures and appreciate the suitability of each test.*
4	*Make the students to relate theoretical concepts in doing lab tests.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Competence in performing the laboratory experiments for determination of Index properties and for classification of soils*
CO-2	*Ability to determine the compaction characteristics in the laboratory as well as in the field as part of field compaction quality control*
CO-3	*Hands on experience in finding the shear strength parameters of soils*
CO-4	*Ability to find out the subgrade characteristics and hence ability to design the pavements*
CO-5	*Competence in determination of permeability characteristics of soils*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	2	3	2	1	2	
CO-2	2	3	2	1	2	
CO-3	2	3	2	1	2	
CO-4	1	2	3		2	
CO-5	1	3	2		2	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

List of Experiments :

1. **Critical Evaluation of Specific Gravity**
   a. Comparison of specific gravity determined by using density bottle and Pycnometer
   b. Evaluation of Specific gravity of Clays by density bottle using distilled water and Kerosene

c. Correction of Specific gravity for temperature

2. Comparison of **Water content** determined by Pycnometer with Oven drying method
3. **Particle Size Analysis**
   a. Comparison of Dry and Wet sieve analysis
   b. Hydrometer analysis
   c. Gradation of soils

4. **Consistency of Clays**
   a. Determination of Liquid and Plastic Limit
   b. Critical comparison of Liquid Limit determined using Standard Casagrande's apparatus with Cone Penetration method
   c. Determination of Shrinkage Limit
   d. Determination of DFSI

5. **Classification of soils** using IS:1498-1970

6. **Compaction Characteristics**
   a. Evaluation of effect of compaction effort on compaction characteristics by performing IS Light and Heavy compaction tests
   b. Calibration of Proctor Needle
   c. Field compaction quality control – determination of FBD by Sand Replacement & Core Cutter methods – determination of FMC by Calcium Carbide method

7. **Shear Strength Characteristics**
   a. Evaluation of effect of dry density on shear parameters
   b. Evaluation of effect of submergence on shear parameters
   c. Evaluation of effect of water content on shear strength of clays by performing Vane Shear tests

8. **CBR Characteristics**
   a. Effect of soaking on CBR Value of Sands and Clays
   b. Practice of initial correction and finding CBR value

9. **Permeability Characteristics**
   a. Comparison of the coefficient of permeability using Constant and Variable head Permeability test
   b. Effect of dry density on the k-value
   c. Effect of Temperature on the k-value

Suggested Reading : (five for BE and up to seven for ME)

1	IS:2720 – Relevant Parts.
2	Lambe, T.W.(1969), "*Soil Testing for Engineers*", Wiley Eastern Ltd., New Delhi.

CE 361	**SEMINAR**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	1.5
Evaluation	**SEE**	-- Marks	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To get exposure to the latest innovations / developments in the field of Geotechnical Engineering which are currently outside the syllabus*
2	*To develop abilities to collect the relevant literature, skill to organise and prepare a report and a PPT*
3	*To gain confidence in oral presentation of the seminar and answer the questions raised*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Ability to identify and select an appropriate topic.*
CO-2	*Ability to take up review of literature, collect relevant technical content*
CO-3	*Skill to organize the content in to a technical seminar report*
CO-4	*Competence to prepare a PPT, present and answer the questions*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	1		3		2	
CO-2	2		2		2	
CO-3	1		3		2	
CO-4			2		3	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Identify appropriate topic of relevance. The topic must be relevant to the field of specialisation and must be the latest developments that are yet to be included in the syllabus. It should include latest research findings, innovative field practices, latest demonstration of instrumentation / software; that enable value addition to the knowledge of the peers /classmates / audience.

UNIT – II

Update literature on technical articles of selected topic and develop comprehension. The literature from authentic sources only should be consulted. The review of literature must include review articles published in top 20 standard SCOPUS indexed Journals / Key note lectures by eminent researchers delivered during International / National Conferences / Symposiums. The information should be collected with permission where ever applicable and should be acknowledged under the references.

UNIT – III
Prepare a technical report of about 50 pages and submit in quadruplicate (one for Faculty Advisor, Supervisor, two examiners). The report should essentially consist of standard thesis format with Cover page / Certificate / Abstract / Contents / Introduction / Body of the Seminar consisting of Technical Analysis, design, case study, physical / software simulation / application / Concluding remarks / References.

UNIT – IV
Prepare a PPT in standard format and deliver presentation within stipulated time. The PPT should essentially consist of Title slide consisting of Title of the Seminar, Presenters details followed by Supervisor details. The second slide should indicate outline of the presentation. The body of the seminar should be systematically arranged such that connectivity and central theme are not missed. After the concluding remarks, references followed by Acknowledgments should be presented. The slides in PPT should be numbered. The content in the slides should be in bullet form consisting of limited words not exceeding in three sentences. It should never be in bulk paragraphs.

UNIT – V
Answer the questions raised after the presentation is given in scheduled time. The ultimate objective of the seminar should be fulfilled.

SEMISTER - II

CE 304	**DYNAMICS OF SOILS AND FOUNDATIONS**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To understand Theory of Vibrations and its application to the design of machine foundations*
2	*To learn the laboratory and field test procedures for determination of dynamic properties of soils*
3	*To gain knowledge of the dynamic earth pressure, dynamic bearing capacity of soils*
4	*To learn the essentials of design of machine foundations*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Competence in application of theory of vibrations in modeling and analysis of machine foundations*
CO-2	*Competence in determination of dynamic properties of soils*
CO-3	*Ability to compute the dynamic earth pressure, dynamic bearing capacity of soils*
CO-4	*Acquiring comprehensive understanding about Liquefaction, ability to assess liquefaction potential and to recommend remediation*
CO-5	*Competence in the standard design of Machine foundations*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	3		1	2	2	
CO-2	1	3		1	1	
CO-3	1		3		2	
CO-4	1		3		1	
CO-5	1		2		3	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Theory of vibration, wave propagation in elastic, homogenous and isotropic medium - single degree of freedom - spring - dashpot, free and forced vibration – without and with damping – Magnification factor – Vibration Isolation – Transmissibility ratio - description and methods of use of vibration measuring equipment.

UNIT – II
Determination of dynamics soil properties - Laboratory methods – Resonant column test – Cyclic simple shear test – Cyclic torsional shear test – Cyclic triaxial compression test – Field tests – Vertical and Horizontal Block resonance test – Ultrasonic pulse velocity test – Seismic tests – Cyclic plate load test – Standard Penetration test- limitations and suitability.

UNIT – III
Determination of dynamic earth pressure – pseudo-static approach- Mononobe-Okabe's theory – determination of dynamic bearing capacity – Triandafilidis – Francis – Chummar's theory.

UNIT – IV
Liquefaction – necessary conditions – mechanism – initial, final liquefaction – Cyclic mobility – Factors affecting liquefaction – Classical studies of Lee & Seed ; Peacock & Seed – Evaluation of liquefaction potential – Remediation methods – Case studies – overview of recent research studies.

UNIT – V
General principles of machine foundation design - vibration isolation and screening methods. Earthquake resistant design of structures - stipulation of IS:1893 - Case studies

Suggested Reading :

1	D D Barkan.(1970). *Dynamics of Bases and Foundations*, 2nd edition, McGraw Hill publications.
2	E E Rihcart(1970) ,*Vibrations of Soils and Foundations*, International series in Applied Mathematics.
3	S.Prakash and V. K.Puri, "Analysis and Design of Machine Foundations", McGraw Hill Book Co., NewYork, 1993.
4	Swami Saran,(2016). *Soil Dynamics and Machine Foundations*, 3rd edition, Golgotia Publications.
5	Prasad.B.B,(2011). *Advance Soil Dynamics and Earthquake Engineering*, 1st Edition,

	Prentice Hall.
6	P.Srinivasulu, S.Vaidyanathan,(2017).*Hand Book of Machine Foundations,* SERC Publications.

CE 305	**GROUND IMPROVEMENT TECHNIQUES**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To understand the objectives, necessity and scope of ground improvement techniques*
2	*To learn different methods of insitu densification of cohesive, cohesionless soils*
3	*To learn the classification, functions and applications of Geosynthetics in ground improvement*
4	*To learn the process of identification of necessity for ground improvement, finding alternative methods and recommendation of the ideal technique through case studies*

Course Outcomes :	
On completion of this course, the student will be able to acquire :	
CO-1	*Ability to understand the necessity of ground improvement and evaluation of potential of a ground for improvement*
CO-2	*comprehensive understanding about the improvement of in-situ Cohesion less soils*
CO-3	*Competence to plan, design the in-situ densification of cohesive soils*
CO-4	*Knowledge of Grouting, soil stabilization methods, application of Geo synthetics and competence to apply them for ground improvement*
CO-5	*Competence to analyse an in-situ ground, identification of ground improvement techniques feasible, selection of the ideal method, its implementation and evaluation of improvement level*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	3	1	2		1	
CO-2	3	1	2	1	2	
CO-3			3		1	
CO-4	3		2	1	2	
CO-5			2		3	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I

Introduction : Objectives and necessity of Ground Improvement – Formation of Rock and soils – Alteration of ground after its formation – Reclaimed soils – , Types and distribution of Soils in India - marine, black cotton soils (expansive), lateritic, alluvial, desert, peaty Soils etc - Ground improvement potential – Geotechnical processes.

UNIT - II
Surface Compaction methods: Compaction Mechanism - moisture density relationship – Factors affecting compaction – Laboratory evaluation of Compaction Characteristics – Field Surface Compaction Methods – Compaction procedure – Specification – Quality Control aspects.
In-situ Densification of Cohesionless Soils : Necessity for Deep compaction – Vibration methods – Vibro-compaction methods (Blasting, Vibratory probe, Dynamic compaction / heavy tamping), Vibro-displacement Methods (Displacement Piles, Sand Compaction Piles), vibro-replacement cum displacement methods (Vibro-floatation, Stone Columns).

UNIT - III
In-situ Densification of Cohesive Soils:
Drainage methods – Methods of dewatering systems - selection of pumps and accessories
Pre-compression methods – Concept & benefit of pre-compression -consolidation of Clayey soils – Pre-loading technique – consolidation acceleration methods - consolidation aided with vertical drains – Sand Drains - Pre-fabricated vertical drains, Consolidation by Electro-osmosis and vacuum compression methods - Compression monitoring.

UNIT - IV
Grouting: Aspects of grouting – Types of grout materials – Classification based on Groutability Ratio - grouting procedure – Applications of grouting in ground improvement.
Soil Stabilisation: Types and suitability of stabilization methods - Mechanical, Cementing methods – Aggregants and dispersants – Stabilization procedure – quality control in Soil Stablization.

UNIT - V
Geo-Synthetics: Classification of Geosynthetics – Functions and applications – Concept of design by function.
Reinforced Soil Walls – Components of a RSW – Types of facia – Types of Reinforcement & factors influencing the selection - Design of RSW – construction procedure - Gabions.

Suggested Reading :

1	H.R. Hausmann, (2013), *Principles of Ground Modification,* Mc-Graw Hill Publications.
2	P.Nicholson, (2015), *Soil Improvement and Ground Modification Methods,* Butterworth-Heinemann Ltd
3	Purushotham Raj, (2016), *Ground Improvement Techniques,* Laxmi Publications.
4	R.M.Koerner, (2012), *Designing with Geosynthetics Vol-1&2*, Prentice Hall Inc.
5	Indrarathna, Chu, Cholachat, (2015), *Ground Improvement Case Histories,* Butterworth-

	Heinemann Publications.

CE 306	**ENGINEERING ROCK MECHANICS**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To understand the formation of Rock, Classification, characterization, discontinuity analysis etc.*
2	*To gain comprehensive understanding about state of stress in Rock mass and its measurement*
3	*To learn the essentials of dynamic behavior of Rock Mass*
4	*To learn analysis and design of Rock Slopes*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Competence in Rock Mass Characterization*
CO-2	*Acquire knowledge about analysis of rock discontinuity, performing Laboratory and Field tests*
CO-3	*Ability to assess stress in rocks and its application in Tunnels and shafts*
CO-4	*Competence for analysis and design of Rock Slopes*
CO-5	*Gain understanding of determining dynamic rock properties*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	1		2		3	
CO-2	3		1		1	
CO-3	2		3	2	2	
CO-4	2		3	1	2	
CO-5	2	3			2	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I

Introduction : Rock as an Engineering material. review of rockmass classification systems.
Friction of Rocks: Phenomena with smooth surfaces, stiff stin slip oscillations. Elasticity and strength of Rock: Stress, strain curve for different rocks under classical and modern strength criteria.

UNIT - II
Rock Discontnuity Analysis: Planes of weakness in rocks and their influnence on engineering works. Recording and plotting of discontinuity data.
Rock Testing: Laboratory and field testing of intact rocks masses as per standard practices.

UNIT - III
Initial stresses in rock and their Measurement: Infulence of the primary or virgin rock stresses on engineering works. Techniques for measurement of insitu stresses. Hydraulic fracturing the flat jack method and overcoring. Tunnels and Shafts: Secondary stress distribution around tunnels and shafts in elastic and plastic rocks. Methods of stabilization of tension zones.

UNIT - IV
Rock Slopes: Modes of failures, analysis of slopes, stabilization techniques.

UNIT - V
Rock Dynamics: Dynamic properties of rocks and their determination in the laboratory and field, rock blastering, rock bursts.

Suggested Reading :

1	Jaeger, J.C. and Cook, N.G.W.(1976), *Fundamentals of Rock Mechanics*", Chapman and Hall.
2	Goodman, R.E.(1989). *Introduction to Rock Mechanics*, John Wiley and Sons.
3	Vutukuri, V.S., Lama, R.D. and Saluja, S.S.(1974)., *Handbook on mechanical properties of rocks*, Transtech Pub.

CE 317	**DESIGNING WITH GEOSYNTHETICS**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To understanding the necessity and scope of Geosynthetics in Ground Improvement*
2	*To gain comprehensive understanding about different types of Geosynthetic Products their functions, application and suitability*
3	*To learn the analysis and design of Reinforced Soil Walls*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Acquiring knowledge about genesis and classification of Geosynthetic products*
CO-2	*Ability to analyse and design the application of geotextiles*
CO-3	*Competence in the design of applications of Geogrids and Geonets*
CO-4	*Gain knowledge about design of applications of Geomembrane*
CO-5	*Comprehensive understanding about the applications of Geocomposites and the construction practices*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	3		1		1	
CO-2	2	1	3	1	2	
CO-3	2	1	3	1	2	
CO-4	2	1	3		2	
CO-5	2	1	2	1	3	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
An overview of Geosythetics : Introduction – Classification & basic description of Geosythetics – manufacturing process – Over view of Geotextiles, Geogrids, Geonets, Geomembranes and Geocomposites.
Design methods – Design by cost & availability – Design by specification – Design by function.

UNIT – II
Geotextile Properties and Test methods – Physical, Mechanical, Hydraulic, Endurance and Degradation properties.
Designing with Geotextiles : Geotextile functions and mechanisms – Designing for separation – Designing for reinforcement – Designing for stabilization – Designing for filtration – Designing for drainage – designing for multi functions.

UNIT – III
Geogrid Properties and Test methods – Physical, Mechanical, Endurance and Environmental properties.
Designing with Geogrids : Designing for geogrid reinforcement
Geonets Properties and Test methods – Physical, Mechanical, Hydraulic, Endurance and Environmental properties.
Designing with Geonets : Designing for geonet drainage

UNIT – IV
Geomembrane Properties and Test methods – Physical, Mechanical, chemical, biological, thermal and Identification properties.
Designing with Geomembranes – Liquid containment liners – Covers for reservoirs – Canal liners – Landfill liners – Caps & closures – Underground storage tanks etc.

UNIT – V
Designing with Geocomposites – Geocomposites for separation – reinforcement – filtration – drainage – liquid/ vapour barriers.
Construction methods & techniques using Geosynthetics.

Suggested Reading :

1	Hausman, M. R. (1990). " *Engineering Principles of Ground Modification*" McGraw-Hills
2	Moseley, M.P. (1193), "*Ground Improvemen*." Champman and Hall.
3	Koener, R.M. (2012), "*Designing with Geosynthetics, Vol.1 & 2,* Xlibriss Corporation LLC.
4	Rao, G.V. and Raju, G.V.S.S. (1995). " *Engineering with Geosynthetics*", Tata McGraw Hills.
5	Purushothama Raj, P. (2014). "*Ground Improvement Techniques*". Lami Publishers (P), Ltd. New Delhi

6	Fang, H.Y. (1191). "*Foundation Engineering Hand Book*", Second Edition, CBS Publications, New Delhi.

CE 318	**OFFSHORE GEOTECHNICAL ENGINEERING**					
PROGRAM ELECTIVE - III						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To learn the soil mechanics of seabed and the forces acting on an offshore structure foundation.*
2	*To gain comprehensive understanding about Dynamics of Offshore structures and the geotechnical response of offshore structure foundations.*
3	*To learn the geotechnical analysis and design of offshore structure foundations.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Knowledge of the forces acting on an offshore structure*
CO-2	*Ability to understand the Soil Mechanics of Seabed*
CO-3	*Acquiring knowledge about geotechnical response of offshore structure foundations*
CO-4	*Comprehensive understanding about Dynamics of Offshore structures*
CO-5	*ability to evaluate the risk associated with design of offshore structure foundation*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	3		1		1	
CO-2	3	1	1		1	
CO-3	2		3	1	2	
CO-4	2	1	3		2	
CO-5	2		1		3	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
General: Nature of magnitude of loads on foundation of offshore structures – design

consideration in relation to environment wave action on large offshore structures.

UNIT – II
Soil mechanics of seabed: Geotechnical studies of sea floor sediments – stability – bearing – capacity – features of foundation of gravity structures – bearing capacity and settlement under dynamic loads – immediate and long term behavior liquefaction under cyclic loads.

UNIT – III
Concrete structures and buried structures: dynamic stresses in pile driving – pile behavior, p-y curves – analysis of single and pile groups – long term performance of concrete in marine environment.
General appraisal offshore structure – sea bed foundation considerations for gravity structures – finite element methods for inter active analysis using linear, nonlinear foundation response – geotechnical aspects of anchor and submarine pipe lines – coastal structures – ports and harbors.

UNIT – IV
Dynamics of offshore structures – Waves and wave action – wave induced loading on dynamic structures, offshore platform.

UNIT – V
Risk factors – assessment of the accuracy of design process – problems areas in design calculation and classified offshore structures – general research problems – state of art for long term experience and maintenance and operations of the offshore structure drilling and production platforms for the oil industry.

Suggested Reading :

1	H. G. Poulos.(1988) *Marine Geotechnics,* Unwin Hyman Ltd, London, UK.
2	D. V. Reddy and M. Arockiasamy,(1991). *Offshore Structures, Volume: 1,* R.E. Kreiger Pub and Co.,
3	D. Thomson and D. J. Beasley,(2012). *Handbook of Marine Geotechnical Engineering*, US Navy.

CE 104	**FINITE ELEMENT ANALYSIS**					
PROGRAM ELECTIVE – IV						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Learn the rudiments of finite element analysis.*
2	*Study the fundamentals of domain discretization, interpolation, application of boundary conditions, assembly of global matrices, and solution of the resulting algebraic systems.*
3	*Explain the core concepts of variational and weighted residual methods in FEM.*
4	*Derive the element stiffness matrix for 1-D, 2-D and 3-D problems.*
5	*Formulate the simple structural problems in to finite elements.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Build and analyse the FEA models for various engineering problems*
CO-2	*Identify the information requirements and sources for analysis, design and evaluation.*
CO-3	*Use the standard finite element software to solve the structural engineering problems.*
CO-4	*Interpret the results obtained from FEA software, not only in terms of conclusions but also awareness of limitations,*
CO-5	*To solve problems of non linear finite element*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	2		3		2	
CO-2	1	1	2	1	3	
CO-3			2	1	3	
CO-4	2	1	2	1	3	
CO-5	1		3	1	2	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Introduction to FEM: Types of Problems – Types of Materials – Elastic / Inelastic situations – Types of forces: Body forces / Surface Traction / Point loads – Deformable bodies – Types of Deformations – Homogeneous / Non homogeneous Problems – Equations of equilibrium for elastic 2-D / 3-D continua - Equilibrium equations for 2-D / 3-D boundary elements – Boundary conditions – Strain-displacement relation for 2-D / 3-D – Stress-strain relation for 2-D / 3-D – Plane stress / Plane strain problems.
Virtual Work Formulation: Application to problems of plane trusses with static indeterminacy not exceeding three.
Finite Difference Method with Central Differences: Solving ODE's and PDE's with central differences. Application to beam and plate bending problems of simple geometry.

UNIT – II
Variational Formulation: Finite Element Formulation - Stationarity of Functional – Given the Functional or Differential equation – Number of elements limited to two.
1-D Elements: Strain-displacement relation matrix / stiffness matrix / Minimum Potential Energy Approach / Rayleigh-Ritz Method / introduction to natural coordinates / stiffness matrix of second order bar element / Axial bar subjected to point loads, body forces and surface traction forces / Problems with kinematic indeterminacy not exceeding two. **2-D Triangular Elements:** Displacement models / criterion for convergence / geometric invariance / conforming and non-conforming elements - 3-node triangular elements (CST) / determination of strain-displacement matrix / area coordinates-shape functions / determination of element stiffness and load matrices, assembling global stiffness and load matrices / Problems with kinematic indeterminacy not exceeding three. **2nd Order triangular elements:** Shape functions – degradation technique / strain-displacement matrix / Expression for stiffness matrix / Load matrices due to body forces and surface traction.

UNIT – III
Iso-parametric elements:
Quadrilateral elements: Construction of shape functions using natural coordinates/Strain-displacement matrices/Load matrices for body force and surface traction/ Expressions for stiffness matrix, load matrices for 4-noded quadrilateral elements/ Gauss Quadrature of numerical integration / Problems with rectangular elements, kinematic indeterminacy not exceeding three.
2nd Order Quadrilateral elements: - Determination of shape functions for 2nd order quadrilateral elements and for elements of with serendipity / Strain-displacement matrices / Load matrices for body force and surface traction.

UNIT – IV
Method of Weighted Residuals:
Galerkin's Method of Weighted Residuals – Application to problems of mathematics /

structural engineering, number of trial functions not exceeding two. **Galerkin's Finite Element Method** – Weak form of Trial Function - Application to problems of mathematics / structural engineering, number of elements limited to two.
Axi-symmetric Problems: Strain-displacement relationship/stress-strain relationship / determination of stiffness matrix for 3-noded ring element and load matrices for body force and surface traction/ Problems with kinematic indeterminacy not exceeding three for 3-noded ring elements only.

UNIT – V
Tetrahedron elements: Volume coordinates, Strain-displacement matrix, stiffness matrix, load matrices due to body force and surface traction/ introduction to Hexahedron (brick) elements.
Non-linear Finite element analysis: Introduction – problems with material non-linearity – problems with geometric non-linearity – problems with both material and geometric non-linearity.
Introduction to MSC Nastran: Illustration on different modules of Nastran / Structural engineering applications of the package/Creation of a simple 1-D model, 2-D model and a 3-D model/ analysis and post processing of the results.

Suggested Reading :

1	Cook, R. D. (1981). ―*Concepts and Application of Finite Element Analysis-I,* John Wiley andSons
2	Zienkiewicz, O. C. And Taylor, R. L, (1989). ―*The Finite Element Method*‖, Vol.1, McGraw Hill Company Limited, London.
3	Reddy, J. N, (1993). ―*An Introduction to the Finite Element Method*‖, McGraw Hill, NewYork.
4	Chandrupatla, T. R. And Belegundu, A. D, (2001). ―*Introduction to Finite Elements in Engineering*‖, Prentice Hall of India, New Delhi.
5	Seshu. P, (2003). ―*Finite Element Analysis*‖, Prentice Hall of India Private Limited, NewDelhi.
6	David V. Hutton, (2005). ―*Fundamentals of Finite Element Analysis*‖, Tata McGraw-Hill Publishing Company Limited, New Delhi.
7	Bathe, K. J, (2006). ―*Finite Element Procedures*‖, Prentice Hall of India, New Delhi.

CE 321	**GEOTECHNICAL EARTHQUAKE ENGINEERING**					
PROGRAM ELECTIVE - V						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To learn the causes and effects of Earth quakes on soils.*
2	*To gain comprehensive understanding about the earth quake ground motion and its response including liquefaction*
3	*To learn the analysis and design of earth quake resistant geo-structures*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	knowledge about causes and effects of earth quakes
CO-2	Ability to understand the earth quake ground motion and to provide code based design
CO-3	Competence in evaluating the earth quake ground response
CO-4	Comprehensive understanding about the liquefaction and its remediation measure
CO-5	Competence in the preliminary design of earth quake resistant foundations and other geo-structures

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	3				1	
CO-2	2	1	3		2	
CO-3	2		3	1	2	
CO-4	2	1	2	1	3	
CO-5	2		2	1	3	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I
Earthquake Seismology – Causes of earthquake, Plate tectonics, Earthquake fault sources, Seismic waves, Elastic rebound theory, Earthquake, Intensity and magnitudes, Effects of earthquake, Modified Mercalis intensity scale and seismic instruments.

UNIT - II
Earthquake Ground Motion – Characteristics of ground motion, Effect of local site conditions on ground motions, Design earthquake, Design spectra, Development of site specification and code-based design

UNIT - III
Ground Response Analysis – One-dimensional ground response analysis: Linear approach, Nonlinear approach, Comparison of one dimensional ground response analyses. Two-dimensional ground response analysis: Equivalent linear approach, Nonlinear approach, Comparison of two dimensional ground response analyses.

UNIT - IV
Liquefaction and Lateral Spreading - Liquefaction related phenomena, Liquefaction susceptibility: Historical, Geological, Compositional and State criteria. Evaluation of liquefaction by cyclic stress and cyclic strain approaches, Lateral deformation and spreading, Soil improvement for remediation of seismic hazards.

UNIT - V
Seismic Design of Foundations, Retaining Walls & Slopes - Seismic design requirements for foundation, Seismic bearing capacity, Seismic settlement, Design loads. Seismic slope stability analysis - Internal stability and weakening instability, Seismic design of retaining walls: Dynamic response of retaining walls, Seismic displacement of retaining walls.

References :

1	Kramer S. L (2003)- *Geotechnical Earthquake Engineering*, Prentice Hall.
2	Bharat Bushan Prasad,(2011). *Advanced Soil Dynamics and Earthquake Engineering*, PHI Learning Pvt. Ltd., New Delhi.
3	Kamalesh Kumar,(2008). *Basic Geotechnical Earthquake Engineering* – 1st Edition, New Age International Publishers.
4	IS(Indian Standards). 2002. *Criteria for Earthquake Resistance Design of Structures, Part-1, General Provision of Buildings,* IS 1893 (Part-1).
5	R. W. Day(2002). *Geotechnical Earthquake Engineering Handbook*, McGraw-Hill.
6	Bolt, B. A.(1999). Earthquakes, , 4th Edition, W. H. Freeman and Company.

CE 120	**ADVANCED CONCRETE TECHNOLOGY**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Learn the characterization of constituents of concrete.*
2	*Design concrete mix by various methods as per different codes.*
3	*Study the different types of admixtures, mix design, properties and applications of special concretes.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Learn hydration of cement and tests on properties of cement and aggregates.*
CO-2	*Comprehend the properties and testing of concrete in fresh and hardened state.*
CO-3	*Understand the shrinkage and creep mechanisms, curing and durability of concrete.*
CO-4	*Design concrete mixes by various methods.*
CO-5	*Familiarize with the types of admixtures, and applications of special concretes.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	3			1	1	
CO-2		3		1	1	
CO-3	2		2		1	
CO-4	2		2		3	
CO-5	3		2		2	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT – I
Cement: Types of cement and their composition - Manufacture of Portland cement - Hydration of cement and hydration product - Structure of hydrated cement - Heat of hydration - Gel theories - Review of tests on properties of cement.
Aggregate: Classification of aggregates - Particle shape and texture - Bond and strength of aggregate and its influence on strength of concrete - Porosity - Absorption and moisture content and their influence - Soundness of aggregate - Alkali aggregate reaction - Sieve analysis and grading of aggregate - Review of tests on properties of aggregate.

UNIT – II
Properties of Concrete: Mixing and batching - Workability - Factors affecting workability - Measurements of workability - Various tests and procedures - Segregation and bleeding - Vibration of concrete - Types of vibrators and their influence on composition - Analysis of fresh concrete - Strength of concrete - Water-cement ratio - Gel space ratio - Effective water in the mix - Mechanical properties of concrete - Tests and procedure - Influence of various parameters on strength of concrete - Relationship between various mechanical strengths of concrete.

UNIT – III
Shrinkage and creep of concrete: Types of shrinkage - Mechanism of shrinkage - Fctors affecting shrinkage - Creep mechanism - Factors influencing creep - Rheological model - Effects of creep.
Curing of Concrete: Methods of curing - Maturity concept - Influence of temperature on strength of concrete.
Durability of Concrete: Permeability of concrete - Chemical attack of concrete - Tests on sulphate resistance - Effect of frost - Concreting in cold weather - Hot weather concreting and air entrained concrete.

UNIT – IV
Mix design of concrete: Basic considerations - Process of mix design - Factors in the choice of mix proportions and their influence - Quality control - Various methods of mix design - IS code method - British and ACI methods.

UNIT – V
Admixtures: Classification of admixtures - Chemical and mineral admixtures - Influence of various admixtures on properties of concrete and their applications. Fly ash concrete: Mix design - Properties and its applications. High strength concrete: Mix design - Properties and its applications. Fiber reinforced concrete: Mix design - Properties and its applications. Ferro cement - Lightweight concrete - High-density concrete - Recycled aggregate concrete and their applications.

Suggested Reading :

1	A.M. Neville,(1988). *Properties of Concrete*, English Language Book Society-Longman

	Publications.
2	P.K. Mehta and J.M.M. Paulo,(1997) *Concrete – Microstructure – Properties and Material*, McGraw-Hill, New York.
3	N. Krishna Raju,(1985) *Design of Concrete Mix*, CBS Publications, New Delhi.

CE 422	**PAVEMENT EVALUATION, MAINTENANCE AND MANAGEMENT**					
PROGRAM ELECTIVE - V						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Understand the basic working principles of various NDT equipment used for pavement evaluation*
2	*Describe design aspects of overlay thickness of pavements*
3	*Impart knowledge regarding the different types of distresses, PMS and LCCA of pavements*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Apply and acquainted with the fundamental principles of Pavement and understand functional evaluate by using different equipment*
CO-2	*Awareness about various NDT equipment used for structural pavement evaluation of flexible and rigid pavements*
CO-3	*Evaluating the distress condition of pavements through surface condition surveys and learn possible alternative treatments*
CO-4	*Understanding the basic components of pavement management systems and Capacity to perform and apply LCCA to optimize funding expenditures*
CO-5	*Understand the maintenance needs and propensity for application of knowledge towards of flexible and rigid pavements by using different type of layers*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	2		1		1	
CO-2		2	2		1	
CO-3	1	2	2	1	1	
CO-4			2		2	

CO-5	1	2	2		2	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I
Introduction to Pavement Inventories and Functional Evaluation: Purposes, Classification of pavement evaluation, Basic concept of pavement evaluation and management; functional Evaluation: AASHTO Serviceability concept, International Road Roughness Experiment, Methods of Measuring Roughness: World Bank Roughness Measurement Systems, Response type & Profile type; IRI: Quarter Car Model, Classification of equipment used for Measurement : MERLIN, Bump Integrator, Dipstick and High speed laser-profiler. Riding Number; Pavement Safety Evaluation: Skid Resistance, measurement of skid, skid resistance, Change of Skid resistance with time, traffic and climate; Control of Skid Resistance.

UNIT - II
Structural Evaluation: Purpose, Destructive Structural Evaluation, Non-destructive structural evaluation, Pavement Deflection: Different Methods of NDT(Working Principles): Benkelman Beam and limitations of BB, LaCroix Deflectometer, Dynaflect, Road Ratar, Rolling Dynamic Deflectometer, Loadman, Different Types of Falling Weight Deflectometers (FWD) for evaluation of rigid and flexible pavements; Working principle of Geophone, Factors influencing deflections. Overlay design as per IRC:81; Back-calculation of Pavement Layer Moduli and detection of loss of bonding of cement concrete pavements using FWD data.

UNIT - III
Distress/failures Surveys: Distress, definitions, significance of distress measurement, Categorisation of distresses in asphalt pavement: identification, causes and measurement of distresses of Bituminous and Concrete pavements; Visual Rating and severity levels; symbols of distresses observed, PSI, PCI, Distress modes; Distresses and the possible options of repairs to treat distortion, deformation, deterioration disintegration of bituminous and concrete pavements.

UNIT - IV
Pavement Maintenance Management: Purpose of PMS, Uses of PMS, Basic terminology used in PMS, Components of PMS and related activities, Major steps in implementing PMS -Network and project level analysis, Pavement performance prediction models , Budgeting; Prioritization Techniques; Feedback system, Pavement Preservation, Decision tree, Methods of Priority Ranking, Basic approaches of PMS, Pavement Life Cycle Cost Analysis (LCCA): Cost Components, Basic steps in LCCA, Solution of LCCA – with typical Components involved.

UNIT - V
Highway Maintenance and Treatments: Need of Highway maintenance, Types of maintenance for flexible and rigid pavement layers; WBM, WMM, Bituminous and Cement Concrete pavements; Surface texturing practices, Details of overlay and seal coats: Slurry seal (IRC:SP:81), Open Graded Friction Course, Fibre-stabilized Stone Matrix Asphalt (IRC:SP:79), Microsurfacing, Surface dressing, Semi-Dense Bituminous Concrete, Dense Bituminous Concrete and Bituminous

Concrete.

Suggested Reading :

1	Haas and Hudson W.R. *Pavement Management Systems* - McGraw Hill publications
2	Srinivasa Kumar R,(2014). *Pavement Evaluation Maintenance and Management*, Universities Press.
3	Rober F.Baker, Editor, L.G Byrd D.Grarit Mikle,(1975). *Hand Book of Highway Engineering*, Associate Edotor, Van Nostrand Reinhold Company.
4	Shahin M.Y. 1994 - *Pavement Management for airports, roads and parking lots*.
5	Relevant IRC/Morth Codes and manuals

CE371	**MINI PROJECT**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	__ Marks	**CIE**		50 Marks	

Each student will be attached to a faculty member, (Guide) for project seminar during third semester. The student will carry out the project which may be development of Software/Hardware/Simulation. Studies/ Design/ Analysis/Experimental related to his/her specialization: The work will be monitored regularly by the guide. At the end of semester, student will write the report on the work done and submit to the guide. Student has to present his/her work before two faculty members (one guide and other to be appointed by Chairman BOS) on a fixed day during last week of the semester in which the project seminar is offered. The sessional marks will be awarded jointly by these two examiners based on report, the presentation and viva voice.

CE 352	**GEOTECHNICAL ENGINEERNIG LAB-II**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	1.5
Evaluation	**SEE**	-- Marks	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To learn advanced laboratory tests for evaluation of Ground Improvement, Vibration characteristics*
2	*To understand the application and use of advanced instrumentation.*
3	*To practice the geotechnical investigation methods.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Competence in performing the advanced laboratory tests*
CO-2	*Greater insight in to the soil behavior and hence enhanced understanding of Soil-Structure interaction*
CO-3	*Acquire confidence in ground improvement mechanisms through the laboratory model tests*
CO-4	*Experience the dynamic behavior of soils*
CO-5	*Ability to plan, organize and conduct of advanced tests and application of the results to address geotechnical challenge*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	2	3			1	
CO-2	3	2		1	1	
CO-3	1		3		2	
CO-4	2	2	2	1	2	
CO-5	1		2		3	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

1. Tri-axial Compression Test
   (a) Determination of Shear strength parameters using Tri-axial Compression test under different drainage conditions
   (b) Comparison of TCT with DST and verification of error in DST due to an imposed horizontal failure plane

2. Electro-osmosis method

3. Consolidometer Test

4. Swell Pressure Test

5. North Dakota Test

6. Laboratory model plate load test
   a. Monotonic model plate load test
   b. Cyclic model plate load test
   c. Uplift resistance of model footing in Cohesionless soils
   d. Uplift resistance of model footing in Cohesive soils

7. Model block resonance test

8. Ground Improvement
   a. Mechanical stabilization by blending
   b. Lime stabilization of Clays
   c. Cement stabilization of Clays
   d. Randomly distributed Fiber reinforced Sand
   e. Improvement in Bearing Capacity using Geosynthetics

9. Cyclic Triaxial Compression Test (Demonstration)

10. Advanced Computational Laboratory
    (Hands on exposure to Geo.5 and other softwares available)

Suggested Reading :

1	IS:2720 – Relevant Parts.
2	Lambe, T.W.(1969), "*Soil Testing for Engineers*", Wiley Eastern Ltd., New Delhi.

CE 353	**ROCK MECHANICS LABORATORY**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	1.5
Evaluation	**SEE**	-- Marks	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To learn characterization of rock*
2	*To learn performing the engineering tests on rock*
3	*To gain knowledge of estimation of bearing capacity of shallow foundations on rock*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Competence in finding CRR, RQD, RMR and to characterize the rock mass*
CO-2	*Ability to prepare the rock core specimen for laboratory tests*
CO-3	*Competence to perform strength tests on rock specimen*
CO-4	*Acquire knowledge of finding elastic properties of the rock specimen*
CO-5	*Ability to apply the rock specimen results to the rock mass and compute Bearing Capacity of shallow foundations laid on rock mass*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1	1	3	2		2	
CO-2	1	3	1		1	
CO-3	1	3	1		1	
CO-4	2	2	1	1	1	
CO-5	2		3		2	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

1. Determination of Core Recovery Ratio (CRR) and Rock Quality Designation (RQD)
2. Determination of Rock Mass Rating (RMR)
3. Rock specimen preparation- Core drilling, cutting and grinding
4. Determination of density, porosity and water absorption
5. Determination of Uni-axial Compressive Strength
6. Brazilian Test on Rock cores
7. Determination of Modulus of elasticity and Poisson's ratio
8. Demonstration of direct shear test on Rock specimen
9. Demonstration of True Tri-axial Compression Test on Rock specimen
10. Estimation of bearing capacity of shallow foundations on rock

Suggested Reading :

1	Relevant Indian Standard Codes of practice
2	Jaeger, J.C. and Cook, N.G.W.(1976), *Fundamentals of Rock Mechanics*", Chapman and Hall,
3	Goodman, R.E.(1989) *Introduction to Rock Mechanics*, John Wiley and Sons.

SEMISTER – III

OPEN ELECTIVES

OE 941 BM	**MEDICAL ASSISTIVE DEVICES**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To extend knowledge of the amputee, of lost and remaining functions affecting locomotion, and to collect information on the best possible medical treatment.
2	To improve fitting techniques and practices, including training, so that existing devices might be used with greater comfort and function.
3	To develop improved lower-extremity devices

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Apply fundamental knowledge of engineering in rehabilitation
CO-2	Apply analytical skills to assess and evaluate the need of the end-user
CO-3	Develop self-learning initiatives and integrate learned knowledge for problem solving
CO-4	Understand the basics of robotics and apply their principles in developing prosthetics
CO-5	Apply the knowledge of computers in solving rehabilitation problems

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Introduction to Rehabilitation Engineering, Measurement and analysis of human movement, Disability associated with aging in the workplace and their solutions, clinical practice of rehabilitation engineering.

Unit – II
Assistive Technology, Seating Biomechanics and systems. Wheeled Mobility: Categories of Wheelchairs. Wheelchair Structure and Component Design. Ergonomics of Wheel chair propulsion. Power Wheelchair Electrical Systems. Control. Personal Transportation. Auxiliary devices and systems.

Unit – III
Sensory augmentation and substitution: Visual system: Visual augmentation. Tactual vision substitution, Auditory vision substitution; Auditory system: Auditory augmentation. Cochlear implantation, Visual auditory substitution, Tactual auditory substitution, Tactual system: Tactual augmentation. Tactual substitution. Measurement tools and processes: fundamental principles, structure, function; performance and behavior. Subjective and objective measurement methods.

Unit – IV
Rehabilitation Robotics, Major Limb Prosthetic Devices, Orthotic Devices, Types of orthotics and prosthetics, Intelligent prosthetic Knee, Prosthetic Hand, Controlled orthotics and prosthetics FES system, Restoration of Hand function, Restoration of standing and walking, Myo-electric Hand.

Unit – V
Augmentative and Alternative communication technology, Computer applications in Rehabilitation Engineering, telecommunications, and Web Accessibility.

Suggested Reading:

1	Robinson C.J., *Rehabilitation Engineering*, CRC Press, 1995.
2	Ballabio E., et al., *Rehabilitation Technology*, IOS Press, 1993.
3	Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, *Series in medical physis and biomedical engineering: An introduction to rehabilitation engineering*, Taylor and Francis Group, London, 2007.
4	Joseph D. Bronzino *The biomedical engineering handbook -biomedical engineering fundamentals*, 3rd Ed., CRC Press, Taylor & Francis Group, London, 2006.

OE 942 BM	**MEDICAL IMAGING TECHNIQUES**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To familiarize the students with various medical imaging modalities.
2	To make learners understand the principles, detectors and operating procedures of X-ray, CT, MRI, ultrasound, PET and SPECT.
3	To make the students learn the advantages, disadvantages and hazards of various medical imaging equipment.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Interpret the working principle and operating procedure and applications of X-ray equipment.
CO-2	Understand the image reconstruction techniques and applications of CT.
CO-3	Summarize the image acquisition and reconstruction techniques in MRI.
CO-4	Comprehend the working principle, modes and medical applications of ultrasound imaging.
CO-5	Examine the operation and applications of PET, SPECT and radio nuclide instrumentation.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

X ray Imaging: Electromagnetic spectrum, Production of X-rays, X-ray tubes- Stationary and Rotating Anode types, Block diagram of an X-Ray Machine, Collimators and Grids, Timing and Exposure controls. X-Ray Image visualization-Films, Fluorescent screens, Image Intensifiers.

Dental X-Ray machines, Portable and mobile X-Ray units, Mammographic X-Ray equipment, Digital Radiography and flat panel detectors.

Radiation safety, ALARA principle, Dose units and dose limits, Radiation dosimeters and detectors.

Unit – II

Computed Tomography: Basic principles, CT number scale, CT Generations. Major sub

systems- Scanning system, processing unit, viewing unit, storage unit. Need and Principle of sectional imaging, 2D image reconstruction techniques - Iteration and Fourier methods. Applications of CT - Angio, Osteo, Dental, Perfusion (Body & Neuro), Virtual Endoscopy, Coronary Angiography.

Unit – III

Magnetic Resonance Imaging: Principles of NMR imaging systems, Image reconstruction techniques-Relaxation processes, imaging/ pulse sequences. Sub systems of an NMR imaging system, NMR detection system, types of coils, biological effects and advantages of NMR imaging.
Functional MRI - The BOLD effect, intra and extra vascular field offsets, source of T2* effects, Creating BOLD contrast sequence optimization sources and dependences of physiological noise in fMRI.

Unit – IV

Ultrasound Imaging: - Principles of image formation -Imaging principles and instrumentation of A-mode, B-Mode, Gating Mode, Transmission mode and M-mode. Basics of multi-element linear array scanners, Digital scan conversion.
Doppler Ultrasound and Colour Doppler imaging, Image artifacts, Biological effects, Ultrasound applications in diagnosis, therapy and surgery.

Unit – V

Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation detectors, Pulse height analyzer, Rectilinear scanner, Gamma camera.
Emission Computed Tomography (ECT), Principle and instrumentation of Single Photon Emission Computed Tomography(SPECT) and Positron Emission Tomography (PET).
Comparison of SPECT, PET and combined PET/ X-ray CT.

Suggested Reading:

1	Khandpur R.S., *Handbook of Biomedical Instrumentation*, Tata McGraw Hill, 2016.
2	S Webb, "*The Physics of Medical Imaging*", Adam Highler, Bristol Published by CRC Press, 1988.
3	A C Kak, "*Principle of Computed Tomography*", IEEE Press New York, 1988.
4	Hykes, Heorick, Starchman, *Ultrasound physics and Instrumentation* MOSBY year book, 2nd Ed. 1992.
5	Stewart C. Bushong, *Magnetic Resonance Imaging- physical and biological principles*, MOSBY, 2nd Ed., 1995.

OE 941 CE	**GREEN BUILDING TECHNOLOGY**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Exposure to the green building technologies and their significance.
2	Understand the judicial use of energy and its management.
3	Educate about the Sun-earth relationship and its effect on climate.
4	Enhance awareness of end-use energy requirements in the society.
5	Develop suitable technologies for energy management

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamentals of energy use and energy processes in building.
CO-2	Identify the energy requirement and its management.
CO-3	Know the Sun-earth relationship vis-a-vis its effect on climate.
CO-4	Be acquainted with the end-use energy requirements.
CO-5	Be familiar with the audit procedures of energy

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	3	3	2	1	2
CO-2	3	2	3	2	1	1
CO-3	3	2	3	2	1	2
CO-4	3	2	3	2	1	2
CO-5	3	2	3	2	1	1

Unit – I
Overview of the significance of energy use and energy processes in building - Indoor activities and environmental control - Internal and external factors on energy use and the attributes of the factors - Characteristics of energy use and its management - Macro aspect of energy use in dwellings and its implications.

Unit – II
Indoor environmental requirement and management - Thermal comfort - Ventilation and air quality – Air-conditioning requirement - Visual perception - Illumination requirement - Auditory requirement.

Unit – III
Climate, solar radiation and their influences - Sun-earth relationship and the energy balance on the earth's surface - Climate, wind, solar radiation, and temperature - Sun shading and solar radiation on surfaces - Energy impact on the shape and orientation of buildings.

Unit – IV
End-use, energy utilization and requirements - Lighting and day lighting - End-use energy requirements - Status of energy use in buildings Estimation of energy use in a building. Heat gain and thermal performance of building envelope - Steady and non-steady heat transfer through the glazed window and the wall - Standards for thermal performance of building envelope - Evaluation of the overall thermal transfer.

Unit – V
Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation Energy management options - Energy audit and energy targeting - Technological options for energy management.

Suggested Reading:

1	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.
2	Carter, W. Nick, (1991): Disaster Management, Asian Development Bank, Manila.
3	Sahni, Pardeep et.al. (eds.) (2002), Disaster Mitigation Experiences and Reflections, Prentice Hall of India, New Delhi.
4	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.

OE 942 CE	**COST MANAGEMENT OF ENGINEERING PROJECTS**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Introduce the concepts of cost management
2	Fundamentals of cost overruns
3	Introduce the concepts of Quantitative techniques for cost management Linear Programming, PERT/CPM.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understanding of strategic cost management process, control of cost and decision making based on the cost of the project.
CO-2	Ability to appreciative detailed engineering activities of the project and execution of projects
CO-3	Preparation of project report and network diagram
CO-4	Able to plan Cost Behavior , Profit Planning , Enterprise Resource Planning, Total Quality Management.
CO-5	Applications of various quantitative techniques for cost management

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
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: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning- Project execution as conglomeration of technical and non- technical activities- Detailed Engineering activities.

Unit – III
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 – IV
Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems- Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector- Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints- Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets- Performance budgets- Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Unit – V
Quantitative techniques for cost management, Linear Programming, PERT/CPM,- Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Suggested Reading:

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

OE 941 CS	**BUSINESS ANALYTICS**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understanding the basic concepts of business analytics and applications
2	Study various business analytics methods including predictive, prescriptive and prescriptive analytics
3	Prepare the students to model business data using various data mining, decision making methods

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	To understand the basic concepts of business analytics
CO-2	Identify the application of business analytics and use tools to analyze business data
CO-3	Become familiar with various metrics, measures used in business analytics
CO-4	Illustrate various descriptive, predictive and prescriptive methods and techniques
CO-5	Model the business data using various business analytical methods and techniques

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Introduction to Business Analytics: Introduction to Business Analytics, need and science of data driven (DD) decision making, Descriptive, predictive, prescriptive analytics and techniques, Big data analytics, Web and Social media analytics, Machine Learning algorithms, framework for decision making, challenges in DD decision making and future.

Unit – II
Descriptive Analytics: Introduction, data types and scales, types of measurement scales, population and samples, measures of central tendency, percentile, decile and quadrille, measures of variation, measures of shape-skewness, data visualization.

Unit – III
Forecasting Techniques: Introduction, time-series data and components, forecasting accuracy,

moving average method, single exponential smoothing, Holt's method, Holt-Winter model, Croston's forecasting method, regression model for forecasting, Auto regression models, auto-regressive moving process, ARIMA, Theil's coefficient

Unit – IV
Decision Trees: CHAID, Classification and Regression tree, splitting criteria, Ensemble and method and random forest. **Clustering**: Distance and similarity measures used in clustering, Clustering algorithms, K-Means and Hierarchical algorithms, **Prescriptive Analytics**- Linear Programming(LP) and LP model building.

Unit – V
Six Sigma: Introduction, introduction, origin, 3-Sigma Vs Six-Sigma process, cost of poor quality, sigma score, industry applications, six sigma measures, DPMO, yield, sigma score, DMAIC methodology, Six Sigma toolbox.

Suggested Reading:

1	U Dinesh Kumar, "Data Analytics", Wiley Publications, 1st Edition, 2017
2	Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, "Business analytics Principles, Concepts, and Applications with SAS", Associate Publishers, 2015
3	S. Christian Albright, Wayne L. Winston, "Business Analytics - Data Analysis and Decision Making", 5th Edition, Cengage, 2015

Web Resources:

1	https://onlinecourses.nptel.ac.in/noc18-mg11/preview
2	https://nptel.ac.in/courses/110105089/

OE 941 EC	**ELEMENTS OF EMBEDDED SYSTEMS**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understanding various Embedded Design strategies
2	Designing Micro controller based Embedded Systems
3	Designing FPGA Based Embedded Systems

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand Embedded Design Strategies and architecture of Arduino Board
CO-2	Program using various onboard components of Arduino
CO-3	Design real time interfacing with Arduino
CO-4	Understand Design Flow of FPGA, programming FPGA using Verilog HDL
CO-5	Implement combinational and sequential circuits using verilog HDL

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Embedded Systems Design Strategies: Micro Controller, DSP, FPGA, Introduction to Arduino (Micro controller Board), Components of Arduino, Architecture and Pin Configuration of ATMega328, Ports of ATMega328.

Unit – II
Interfacing: Interfacing Switches, LEDs, Analog to Digital Converter, Digital to Analog Converter, Interfacing and Programming I2C, SPI

Unit – III
Real Time Programming: Interfacing Key Pad, 7-segment display, LCD, Interfacing Sensors, Interfacing Stepper Motor**,** USB programming

Unit – IV
FPGA Based Embedded Design: FPGA Design flow, Introduction to Verilog HDL**,** Basic

building blocks, Data types of Verolog HDL, Behavioral Modelling, Data Flow Modelling, Structural Modelling, Hierarchal Structural Modelling, Case Studies on Verilog HDL descriptions of Basic Circuits

Unit – V
Modelling of Circuits: Verilog HDL Implementation of Combinational MSI Circuits, Verilog HDL Implementation of Sequential MSI Circuits, Finite Sate Machine Design, Tasks and Functions, Introduction to Test Benches

Suggested Reading:

1	Ming-Bo Lin, Digital System Designs and Practices Using Verilog HDL and FPGAs, Wiley India, 2008
2	Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Pearson Education, 2005
3	Simon Monk, Programming Arduino: Getting Started with sketches, Mc.Hill, 2016

Web Resources:

1	www.arduino.cc
2	www.learn.sparkfun.com/tutorials/arduino

OE 941 EE	**WASTE TO ENERGY**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To know the various forms of waste
2	To understand the processes of Biomass Pyrolysis.
3	To learn the technique of Biomass Combustion.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of conservation of waste
CO-2	Identify the different forms of wastage.
CO-3	Chose the best way for conservation to produce energy from waste.
CO-4	Explore the ways and means of combustion of biomass.
CO-5	Develop a healthy environment for the mankind.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	-	3	2	3	1
CO-2	3	-	3	2	3	1
CO-3	3	-	3	2	3	1
CO-4	3	-	3	2	3	1
CO-5	3	-	3	2	3	1

Unit – I
Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit – II
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit – III
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal

heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit – IV
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit – V
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Suggested Reading:

1	Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2	Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3	Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4	Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

OE 942 EE	**POWER PLANT CONTROL AND INSTRUMENTATION**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	The operation of different types of power plants.
2	The basic working principle of instruments for measurement of electrical and non-electrical quantities like Temperature Pressure flow level measurements.
3	The instrumentation and protection systems applied in thermal power plant.
4	The control techniques employed for the operation of modern power generation plant

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Explain the different methods of power generation. Along with Piping and Instrumentation diagram of boiler.
CO-2	Select various measurements involved in power generation for measuring electrical and non-electrical parameters.
CO-3	Identify the different types of analyzers used for scrutinizing boiler steam and water.
CO-4	Model different types of controls and control loops in boilers.
CO-5	Illustrate the methods of monitoring and control of different parameters like speed, vibration of turbines

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	1	-	-	-	2
CO-2	3	1	-	-	-	2
CO-3	3	1	-	-	-	2
CO-4	3	1	-	-	-	2
CO-5	3	1	-	-	-	2

Unit – I
Brief survey of methods of power generation, hydro, thermal, nuclear, solar and wind power, importance of instrumentation in power generation, thermal power plants, block diagram, details of boiler processes, Piping and Instrumentation diagram of boiler, cogeneration.

Unit – II
Electrical measurements, current, voltage, power, frequency, power factor etc, non-electrical parameters, flow of feed water, fuel, air and steam with correction factor for temperature, steam pressure and steam temperature, drum level measurement, radiation detector, smoke density measurement, dust monitor.

Unit – III
Flue gas oxygen analyzer: Analysis of impurities in feed water and steam, dissolved oxygen analyzer. Chromatography, pH meter, fuel analyzer, pollution monitoring instruments.

Unit – IV
Combustion control, air / fuel ratio control, furnace draft control, drum level control, main steam and reheat steam temperature control, super heater control, air temperature, distributed control system in power plants, interlocks in boiler operation.

Unit – V
Speed, vibration, shell temperature monitoring and control, steam pressure control, lubricant oil temperature control, cooling system.

Suggested Reading:

1	Sam G. Dukelow, The Control of Boilers, Instrument Society of America, 2nd Edition, 2010.
2	P.K. Nag, „Power Plant Engineering", Tata McGraw-Hill, 1st Edition, 2001.
3	S.M. Elonka and A.L. Kohal, "Standard Boiler Operations", Tata McGraw-Hill, 1st Edition, 1994.
4	R K Jain, "Mechanical and Industrial Measurements", Khanna Publishers, 1st Edition, 1995.
5	E Al Wakil, "Power Plant Engineering", Tata McGraw-Hill, 1st Edition, 1984.

OE 941 ME	**OPERATION RESEARCH**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the dynamic programming to solve problems of discrete and continuous variables
2	To apply the concept of non-linear programming and carry out sensitivity analysis
3	To understand deterministic and probabilistic inventory control models.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	To understand the basics of OR, including mathematical modeling, feasible solutions and optimization.
CO-2	Able to carry out sensitivity analysis.
CO-3	Apply PERT/CPM in project management.
CO-4	Select appropriate inventory control model.
CO-5	Able to apply dynamic programming and understand the concept of non-linear programming.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I
Development, Different Phases, Characteristics, Operations Research models and applications. Linear Programming Problem: Introduction, Basic Assumptions, Formulation, graphical method, simplex method: Big M and Two Phase method.

Unit – II
DUALITY: Duality theory, primal-dual relationships, Economic interpretation, Dual simplex method, Post optimal or sensitivity analysis.

Unit – III
Project Management: Introduction to PERT and CPM, critical Path calculation, float calculation and its importance. Cost reduction by Crashing of activity.

Inventory models – Economic order quantity models – Quantity discount models – Stochastic inventory models – Multi product models – Inventory control models in practice.

Unit – IV
Sequencing Models: Introduction, General assumptions, processing n jobs through 2 machines, processing 'n' jobs through m machines. **Game Theory**: Introduction, Characteristics of Game Theory, Dominance theory, Mixed strategies (2 x 2, m x 2), Algebraic and graphical methods. **Nonlinear programming problem:** - Kuhn-Tucker conditions.

Unit – V
Queuing models - Queuing systems and structures – Notation parameter – Single server and multi server models – Poisson arrivals – Exponential service times – with finite population – Infinite population. Dynamic Programming: Characteristics, principle of optimality, deterministic problems.

Suggested Reading:

1	H.A. Taha, Operations Research, An Introduction, PHI, 2008
2	H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3	J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008.
4	Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5	Pannerselvam, Operations Research: Prentice Hall of India 2010.
6	Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.

OE 942 ME	**COMPOSITE MATERIALS**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Study the concepts of composite construction.*
2	*Learn analysis and designs of composite beams, floors, columns and trusses as per the recommendations of IS codes of practice.*
3	*Apply the concepts for design of multi-storey composite buildings.*
4	*Scope of analysis is restricted to skeletal structures subjected to prescribed dynamic loads.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Understand the fundamentals of composite construction, and analysis and designs of composite beams.*
CO-2	*Analyse and design the composite floors*
CO-3	*Select suitable materials for composite columns,*
CO-4	*Analyse composite trusses and understand connection details.*
CO-5	*Analyse and design the multi-storey composite buildings*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Introduction of composite constructions: Benefits of composite construction - Introduction to IS - BS and Euro codal provisions. Composite beams: Elastic behaviour of composite beams - No and full interaction cases - Shear connectors - Ultimate load behaviour - Serviceability limits - Effective breadth of flange - Interaction between shear and moment - Basic design consideration and design of composite beams.

Unit – II
Composite floors: Structural elements - Profiled sheet decking - Bending resistance - Shear resistance - Serviceability criterion - Analysis for internal forces and moments - Design of composite floors.

Unit – III
Composite columns: Materials - Concrete filled circular tubular sections - Non-dimensional slenderness - Local buckling of steel sections - Effective elastic flexural stiffness - Resistance of members to axial compressions - Composite column design - Fire resistance.

Unit – IV
Composite trusses: Design of truss - Configuration - Truss members - Analysis and design of composite trusses and connection details.

Unit – V
Design of multi-storey composite buildings: Design basis - Load calculations - Design of composite slabs with profile decks - Composite beam design - Design for compression members - Vertical cross bracings - Design of foundation.

Suggested Reading:

1	R.P. Johnson, "Composite Structures of Steel and Concrete - Beams, Slabs, Columns and Frames in Buildings", Blackwell Publishing, Malden, USA, 2004.
2	"INSDAG Teaching Resources for Structural Steel Design", Vol-2, Institute for Steel Development and Growth Publishers, Calcutta, India.
3	"INSDAG Handbook on Composite Construction – Multi-Storey Buildings", Institute for Steel Development and Growth Publishers, Calcutta, India.
4	"INSDAG Design of Composite Truss for Building", Institute for Steel Development and Growth Publishers, Calcutta, India.
5	"INSDAG Handbook on Composite Construction – Bridges and Flyovers", Institute for Steel Development and Growth Publishers, Calcutta, India.
6	IS: 11384-1985, "Code of Practice for Composite Construction in Structural Steel and Concrete", Bureau of Indian Standards, New Delhi, 1985.

OE 943 ME	**INDUSTRIAL SAFETY**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Causes for industrial accidents and preventive steps to be taken.
2	Fundamental concepts of Maintenance Engineering.
3	About wear and corrosion along with preventive steps to be taken
4	The basic concepts and importance of fault tracing.
5	The steps involved in carrying out periodic and preventive maintenance of various equipments used in industry

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Identify the causes for industrial accidents and suggest preventive measures.
CO-2	Identify the basic tools and requirements of different maintenance procedures.
CO-3	Apply different techniques to reduce and prevent Wear and corrosion in Industry.
CO-4	Identify different types of faults present in various equipments like machine tools, IC Engines, boilers etc.
CO-5	Apply periodic and preventive maintenance techniques as required for industrial equipments like motors, pumps and air compressors and machine tools etc

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

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

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

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

Unit – IV
Fault Tracing: 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, any one machine tool, Pump, Air compressor, Internal combustion engine, Boiler, Electrical motors, Types of faults in machine tools and their general causes.

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

Suggested Reading:

1	H. P. Garg, "Maintenance Engineering", S. Chand and Company
2	Audels, "Pump-hydraulic Compressors", Mcgraw Hill Publication
3	Higgins & Morrow, "Maintenance Engineering Handbook", Da Information Services.
4	Winterkorn, Hans, "Foundation Engineering Handbook", Chapman & Hall London

OE 941 LA	**INTELLECTUAL PROPERTY RIGHTS**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Acquaint the students with basics of intellectual property rights with special reference to Indian Laws and its practices.
2	Compare and contrast the different forms of intellectual property protection in terms of their key differences and similarities.
3	Provide an overview of the statutory, procedural, and case law underlining these processes and their interplay with litigation.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of intellectual property rights.
CO-2	Develop proficiency in trademarks and acquisition of trade mark rights.
CO-3	Understand the skill of acquiring the copy rights, ownership rights and transfer.
CO-4	Able to protect trade secrets, liability for misappropriations of trade secrets.
CO-5	Apply the patents and demonstration of case studies.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

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 – II
Trade Marks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

Unit – III
Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law. Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer**.**

Unit – IV
Trade Secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation. Unfair competition: Misappropriation right of publicity, false advertising.

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

Suggested Reading:

1	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
2	“Mayall, “Industrial Design”, McGraw Hill,1992
3	“Niebel, “Product Design”, McGraw Hill,1974.
4	“Asimov, “Introduction to Design”, Prentice Hall,1962.
5	“Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”,2016.
6	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand,2008

CE 381	**MAJOR PROJECT PHASE-I**					
Pre-requisites			**L**	**T**	**P**	**C**
			6	-	-	10
Evaluation	**SEE**	-- Marks	**CIE**		100 Marks	

Course Objectives :	
1	*Identification of the research problem*
2	*Discussion of literature survey*.

Course Outcomes :	
CO-1	*Identification of the objectives of the Research Problem*
CO-2	*Ability to update the latest literature in chosen area of research & establishment of the scope of work*
CO-3	*Development of the methodology for the chosen research problem and perform basic theoretical /experiment studies*

Each student will be attached to a faculty member/guide for project. The student will carry out the project which may be development of Software / Hardware / Simulation studies / Design analysis / Experimental related to his/her specialization. The work will be monitored regularly by the guide. At the end of the semester student will write the report on the work done and submit to the guide. Student has to present his/her work before two faculty members (one guide and other to be appointed by chairman BOS) on a fixed day during last week of the semester in which project is offered. The sessional marks will be awarded jointly by these examiners based on the report, presentation and viva voice

SEMESTER - IV

AUDIT COURSES

AC131CE	**DISASTER MITIGATION & MANAGEMENT**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives : (3 to 5)	
The course is taught with the objectives of enabling the student to:	
1	Introduction of various types of disasters and its effect on structures.
2	Educate different types of repair, strengthening, rehabilitation and retrofitting techniques.
3	Awareness about flood characteristics and flood forecasting systems
4	
Course Outcomes : (5)	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamentals of disaster and different types of disasters
CO-2	Assessment of flood characteristics and methods of forecasting
CO-3	Appropriate mitigation and rehabilitation of structures due to disasters.
CO-4	Adaptation of Regulations to control disasters for vulnerable structures
CO-5	Ability to understand to disaster preparedness and rehabilitation of Civil Engineering structures

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO6**
CO-1	2	1	1	1	1	1
CO-2	2	2	2	2	1	1
CO-3	2	2	1	1	1	1
CO-4	2	2	1	1	1	0
CO-5	2	2	1	1	1	1

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I
Disaster: Classifications - Causes - Impacts including social, economic, political, environmental, health, psychosocial, etc. Hazard, Vulnerability, Resilience, Risks.-Disaster- Different types of cold wave-heat wave- droughts- floods-Effect of climate change on Processes.
Natural and Manmade disasters- *Impact of drought, review of past disasters and drought in India, its classification and characteristics. Classification of drought, causes*

UNIT - II
Flood characteristics and forecasting: Measureable features of a flood (Elevation, discharge, volume, and duration), flood forecasting (unit hydrograph method, meteorological and snow data, and snow field air temperatures), operation of flood forecasting systems- CWC Recommendations on Floods on reservoir.

UNIT - III
Flood Mitigation and Rehabilitation: Flood mitigation reservoirs (purpose, location, size and operation) levees and flood walls (location, maintenance and flood fighting), flood ways, channel improvements, evacuation and flood proofing, land management, flood plain management, estimating benefits of flood mitigation- National Disaster Management Authority- objectives and Provisions of NDMA –Disaster Management Act- 2005

UNIT - IV
Disaster Risk and Mitigation Strategies: - Introduction of Risk, Problems on computation of risk, significance of and objectives of mitigation, types and strategies guidelines for mitigation of natural disasters like floods, earthquake, fire hazards, mitigation plans based on causes and effects.
Topics to be taught by Industry Subject Expert :

UNIT - V
Disaster preparedness and Management: Steps in disaster preparedness- strengthening of community based disaster preparedness- Developing Action plan- Repair of materials, Common types of repairs – Repairs of underwater structures- Gunting- shortcrete-techniques in Civil Engineering- Repair in concrete structures – Repair of structures distressed due to corrosion, fire, Leakage, earthquake, Retrofitting techniques.
Topics to be taught by Industry Subject Expert :

Suggested Reading : (five for BE and up to seven for ME)

1	Ven Te Chow (1964), 'Hand Book of Applied Hydrology', McGraw-Hill Publishers, New York.
2	Barry A. Richardson (1991) "*Defects and Deterioration in Buildings*", E &FN Spon Press, London, 1991
3	Varshney, R. S. (1979), 'Engineering Hydrology', Nem Chand Publishers, Roorkee.
4	Bungey, J.H (1989) "*Testing of Concrete in Structures*", Chapman and Hall, New Delhi
5	A.R. Santakumar (2006) "*Concrete Technology*", Oxford University Press,New Delhi.6.
6	Gupta Anil K, and Sreeja S. Nair. (2011). *Environmental Knowledge for Disaster Risk Management,* NIDM, New Delhi.

AC 032	**ENGLISH FOR RESEARCH PAPER WRITING**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives : (3 to 5)	
The course is taught with the objectives of enabling the student to:	
1	Understand that how to improve your writing skills and level of readability
2	Learn about what to write in each section
3	Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission
4	
Course Outcomes : (5)	
On completion of this course, the student will be able to :	
CO-1	Able to plan and prepare paragraphs
CO-2	Writing of abstracts
CO-3	Providing of critical and thorough review of literature
CO-4	Able to exhibit key skills for writing titles
CO-5	Able to show key and necessary skills for paper writing

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO6**
CO-1						
CO-2						
CO-3						
CO-4						
CO-5						

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT - II
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

UNIT - III
Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT - IV
Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature
Topics to be taught by Industry Subject Expert :

UNIT - V
Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions -Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission
Topics to be taught by Industry Subject Expert :

Suggested Reading : (five for BE and up to seven for ME)

1	Goldbort R , *Writing for Science*, Yale University Press (available on Google Books), 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'sbook. 1998
4	Adrian Wallwork *English for Writing Research Papers*, Springer New York Dordrecht Heidelberg London. 2011.

AC033	**SANSKRIT FOR TECHNICAL KNOWLEDGE**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives : (3 to 5)	
The course is taught with the objectives of enabling the student to: (use the phrases such as, learn, understand, know, enhance/ improve knowledge etc.)	
1	To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2	Learning of Sanskrit to improve brain functioning
3	Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4	The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Course Outcomes : (5)	
On completion of this course, the student will be able to : (use the phrases such as, describe / differentiate / perform / analyze / design / demonstrate etc.,)	
CO-1	Understanding basic Sanskrit language
CO-2	Ancient Sanskrit literature about science & technology can be understood
CO-3	Being a logical language will help to develop logic in students
CO-4	
CO-5	

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO6**
CO-1						
CO-2						
CO-3						
CO-4						
CO-5						

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I
Alphabets in Sanskrit,Past/Present/Future Tense, Simple Sentences

UNIT - II
Order Introduction of roots Technical information about Sanskrit Literature

UNIT - III
Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

UNIT - IV
Topics to be taught by Industry Subject Expert :

UNIT - V
Topics to be taught by Industry Subject Expert :

Suggested Reading : (five for BE and up to seven for ME)

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

AC034	**VALUE EDUCATION**					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives : (3 to 5)	
The course is taught with the objectives of enabling the student to:	
1	Understand value of education and self- development
2	Imbibe good values in students
3	Let the should know about the importance of character
4	

Course Outcomes : (5)	
On completion of this course, the student will be able to :	
CO-1	Knowledge of self-development
CO-2	Learn the importance of Human values
CO-3	Developing the overall personality
CO-4	
CO-5	

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO6**
CO-1						
CO-2						
CO-3						
CO-4						
CO-5						

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I
Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism-Moral and non- moral valuation. Standards and principles-Value judgements

UNIT - II
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 - III
Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. • Punctuality, Love and Kindness. • Avoid fault Thinking-Free from anger, Dignity of labour-Universal brotherhood and religious tolerance-True friendship. • Happiness Vs suffering, love for truth-Aware of self-destructive habits-Association and Cooperation-• Doing best for saving nature

UNIT - IV
Character and Competence –Holy books vs Blind faith.-Self-management and Good health-Science of reincarnation-Equality, Non-violence, Humility, Role of Women-All religions and same message-Mind your Mind, Self-control-• Honesty, Studying effectively

Suggested Reading : (five for BE and up to seven for ME)

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

AC 035	**STRESS MANAGEMENT BY YOGA**					
(AUDIT COURSE - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Creating awareness about different types of stress and the role of yoga in the management of stress.*
2	*Promotion of positive health and overall wellbeing (Physical, mental, emotional, social and spiritual).*
3	*Prevention of stress related health problems by yoga practice.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*To understand yoga and its benefits.*
CO-2	*Enhance Physical strength and flexibility.*
CO-3	*Learn to relax and focus.*
CO-4	*Relieve physical and mental tension through Asanas*
CO-5	*Improve work performance and efficiency.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1						
CO-2						
CO-3						
CO-4						
CO-5						

UNIT – I
Meaning and definition of Yoga - Historical perspective of Yoga - Principles of Astanga Yoga by Patanjali.

UNIT – II
Meaning and definition of Stress - Types of stress - Eustress and Distress. Anticipatory Anxiety and Intense Anxiety and depression. Meaning of Management- Stress Management.

UNIT – III
Concept of Stress according to Yoga - Stress assessment methods - Role of Asana, Pranayama and Meditation in the management of stress.

UNIT – IV

Asanas- (5 Asanas in each posture) - Warm up - Standing Asanas - Sitting Asanas - Prone Asanas - Supine asanas - Surya Namaskar.

UNIT – V
Pranayama- Anulom and Vilom Pranayama - Nadishudhi Pranayama – Kapalabhati-Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama.
Meditation techniques: Om Meditation - Cyclic meditation : Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT).

Suggested Reading:

1	"Yogic Asanas for Group Training - Part-I": Janardhan Swami Yogabhyasi Mandal, Nagpur
2	"Rajayoga or Conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata
3	Nagendra H.R nad Nagaratna R, "Yoga Perspective in Stress Management", Bangalore, Swami Vivekananda Yoga Prakashan

Web resource:

1	https://onlinecourses.nptel.ac.in/noc16_ge04/preview
2	https://freevideolectures.com/course/3539/indian-philosophy/11

AC 036	**PERSONALITY DEVELOPMENT THROUGH LIFE ENHANCEMENT SKILLS**					
(AUDIT COURSE - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To learn to achieve the highest goal happily*
2	*To become a person with stable mind, pleasing personality and determination*
3	*To awaken wisdom in students*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Develop their personality and achieve their highest goal of life.*
CO-2	*Lead the nation and mankind to peace and prosperity.*
CO-3	*To practice emotional self regulation.*
CO-4	*Develop a positive approach to work and duties.*
CO-5	*Develop a versatile personality.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1						
CO-2						
CO-3						
CO-4						
CO-5						

UNIT – I
Neetisatakam – Holistic development of personality - Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)

UNIT – II
Neetisatakam – Holistic development of personality (cont'd) - Verses 52, 53, 59 (dont's) - Verses 71,73,75 & 78 (do's) - Approach to day to day works and duties.

UNIT – III
Introduction to Bhagavad Geetha for Personality Development - Shrimad Bhagawad Geeta: UNIT 2 – Verses 41, 47, 48 - UNIT 3 – Verses 13,21,27,35 - UNIT 6 – Verses 5,13,17,23,35 - UNIT 18 – Verses 45, 46, 48 UNIT – 6: Verses 5, 13, 17, 23, 35; UNIT – 18: Verses 45, 46, 48.

UNIT – IV

Statements of basic knowledge - Shrimad Bhagawad Geeta: UNIT 2- Verses 56, 62,68 - UNIT 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad Bhagawat Geeta.

UNIT – V
Role of Bahgavadgeeta in the present scenario - UNIT 2 – Verses 17 – UNIT 3 – Verses 36, 37, 42 - UNIT 4 – Verses 18, 38, 39 - UNIT 18 – Verses 37, 38, 63.

Suggested Reading:

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

Web resource:

1	NTPEL:http://nptel.ac.in/downloads/109104115

AC 037	**CONSTITUTION OF INDIA**
	(AUDIT COURSE - II)

Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*The history of Indian Constitution and its role in the Indian democracy.*
2	*Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.*
3	*Have knowledge of the various Organs of Governance and Local Administration.*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Understand the making of the Indian Constitution and its features.*
CO-2	*Understand the Rights of equality, the Right of freedom and the Right to constitutional remedies.*
CO-3	*Have an insight into various Organs of Governance - composition and functions*
CO-4	*Understand powers and functions of Municipalities, Panchayats and Co-operative Societies.*
CO-5	*Understand Electoral Process, special provisions.*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1						
CO-2						
CO-3						
CO-4						
CO-5						

UNIT – I
History of making of the Indian constitutions: History, Drafting Committee (Composition & Working). **Philosophy of the Indian Constitution**: Preamble, Salient Features.

UNIT – II
Contours of Constitutional Rights and 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": Parliament: Composition, Qualifications, Powers and Functions, Union executives : President, Governor, Council of Ministers, Judiciary, appointment and transfer of

judges, qualifications, powers and functions.

UNIT – IV
Local Administration - District's Administration head: Role and importance. Municipalities: Introduction, ayor and role of Elected Representative, CEO of Municipal Corporation. Panchayati Raj: Introduction, PRI: Zilla Panchayat, Elected Officials and their roles, CEO Zilla Panchayat: positions 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: 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**.**

Suggested Reading:

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.

Web resource:

1	http://www.nptel.ac.in/courses/103107084/Script.pdf

AC038	**PEDAGOGY STUDIES**

Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2	Identify critical evidence gaps to guide the development.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	What pedagogical practices are being used by teachers in formal and informal classrooms in Developing countries?
CO-2	What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
CO-3	How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	
CO-1					1	
CO-2					1	
CO-3					1	

Correlation rating : Low / Medium / High : 1 / 2 / 3 respectively.

UNIT - I
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
• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. • Curriculum, Teacher education

UNIT - III
• Evidence on the effectiveness of pedagogical practices Methodology for the in depth stage: quality assessment of included studies. • How can teacher education (curriculum and practicum) and the school • Curriculum and guidance materials best support effective pedagogy? • Theory of change. • Strength and nature of the body of evidence for effective pedagogical practices. • Pedagogic theory and pedagogical approaches. • Teachers' attitudes and beliefs and Pedagogic strategies

UNIT - IV
• Professional development: alignment with classroom practices and followup 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
• Research gaps and future directions • Research design • Contexts • Pedagogy • Teacher education • Curriculum and assessment • Dissemination and research impact

Suggested Reading :

1	Ackers J, Hardman F (2001) *Classroom interaction in Kenyan primary schools*, Compare, 31 (2): 245-261.
2	Agrawal M (2004) *Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies,* 36 (3): 361-379.
3	Akyeampong K (2003) *Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1*. London: DFID.
4	Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) *Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count?* International Journal Educational Development, 33 (3): 272–282.
5	Alexander RJ (2001) Culture and pedagogy: *International comparisons in primary education*. Oxford and Boston: Blackwell.
6	Chavan M (2003) *Read India: A mass scale, rapid, 'learning to read' campaign*.
7	www.pratham.org/images/resource%20working%20paper%202.pdf.

CE 382	**MAJOR PROJECT PHASE-II**					
Pre-requisites			**L**	**T**	**P**	**C**
			6	-	-	16
Evaluation	**SEE**	--Marks	**CIE**		200 Marks	

Course Objectives :	
1	*Expand on the defined research problem in dissertation*.
2	*Conduct laboratory/analytical studies.*
3	*Analyse data, develop models, offer solutions and give conclusions*

Course Outcomes :	
CO-1	Develop on the defined research problem in dissertation.
CO-2	Carry out laboratory/analytical studies.
CO-3	Evaluate data, develop models, offer solutions and give conclusions.

Each student will be attached to a faculty member who will monitor the progress of the student. The student is required to submit a technical write-up, presentation of their study (about 20 minutes) followed by a discussion.

The dissertation shall be internally scrutinized by a Viva-Voce committee consisting of the Head of the Department, Chairman Board of Studies, Supervisor and Examiner.

The Dissertation will be scrutinized by an external examiner as per the institute guide lines applicable