



About Department

The department of Applied Mechanics is one of the oldest departments of Faculty of Technology and Engineering of the M. S. University of Baroda. The department teaches the subjects of Applied Mechanics and Materials and Structures to undergraduate students of all the disciplines of engineering.

The department is also engaged in teaching work of all the subjects related to Structural Engineering, Geotechnical Engineering and Computer Applications to undergraduate students of Civil Engineering, Irrigation & Water Management and Architecture.

The growth of the department is largely due to its post-graduate degree programmes in Structural Engineering, Geotechnical Engineering and Fracture Mechanics. On the path of its growth, 23 Doctoral and about 650 Post-graduate candidates are produced by the department in addition to publication of more than 700 Research Papers and about 16 Books.

In the department there are 7 Professors, 11 Associate Professors and 13 Assistant professors sanctioned posts out of which 5 Associate professors and 20 Assistant Professors who are actively engaged in teaching, development and research programmes. Many awards such as Hari Om Ashram Award, Bhaikaka Inter University Award, Prof. Jani Research Promotion Prize, Sir Arthur Cotton Gold Medal Award etc. have also been received by individual members of the department for writing/presenting the best research paper in the fields of Structural and Geotechnical Engineering.

The department is equipped with laboratories in the areas of Applied Mechanics, Materials Testing, Theory of Structure, Soil Mechanics, Concrete Technology, Prestressed Concrete, Experimental Stress Analysis, Computer Aided Designs, AI Applications, Fracture Mechanics, Ground Improvement, Remote Sensing, Rock Mechanics, Soil-Structure Interaction studies etc. These laboratories have been mainly developed by getting grants from different agencies such as AICTE, CSIR, HRD, MOWR and CBIP in addition to equipment grant received under different plans of UGC.

The department has received several industry sponsored research projects and has also been catering the needs of Private Sectors, Government Organizations and Industries situated in and around Baroda by providing them material testing facilities.



Teaching Scheme

A. M.E.-I - CIVIL (STRUCTURAL ENGINEERING)

APM No.	Title of subject	Contact Hrs (per week)				Assessment Marks			Min Marks required for passing		Total Maximum Marks	Equivalent Credit	
		Lect.	Tut.	lab	Total	Theory		P/T/V	Theory	P/T/V		Theory	P/T/V
						Internal	External						
SEMESTER - I													
APM 2146	Elementary Theory of Elasticity and Plasticity	4	-		6	30	70		40		150	4	
APM 2146L	Elementary Theory of Elasticity and Plasticity LAB			2				50		20			1
APM 2140	Design of Metal Structures	4	-		6	30	70		40		150	4	
APM 2140L	Design of Metal Structures LAB			2				50		20			1
APM 2142	Advanced Theory of Structures	4	-		6	30	70		40		150	4	
APM 2142L	Advanced Theory of Structures LAB			2				50		20			1
APM 2149	Computer Aided Design	4	-		6	30	70		40		150	4	
APM 2149L	Computer Aided Design LAB			2				50		20			1
Elective I (Any one of the following)													
APM 21XX	Analysis and Design of Foundations	4	-		6	30	70		40		150	4	
APM 21XXL	Analysis and Design of Foundations LAB			2				50		20			1



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APM No.	Title of subject	Contact Hrs (per week)				Assessment Marks			Min Marks required for passing		Total Maximum Marks	Equivalent Credit	
APM 2143	Dynamics of Structures with Applications to Earthquake Engineering	4	-		6	30	70		40		150	4	
APM 2143L	Dynamics of Structures with Applications to Earthquake Engineering LAB			2				50		20			1
APM 21XX	Mechanics of Fracture	4	-		6	30	70		40		150	4	
APM 21XXL	Mechanics of Fracture LAB			2				50		20			1
APM 21XX	Failure, Repairs, Maintenance and Testing of Structure	4	-		6	30	70		40		150	4	
APM 21XXL	Failure, Repairs, Maintenance and Testing of Structure LAB			2				50		20			1
APM 21XX	Elements of Fracture Mechanics and Structural Dynamics	4	-		6	30	70		40		150	4	
APM 21XXL	Elements of Fracture Mechanics and Structural Dynamics LAB			2				50		20			1
Total of SEMESTER I						150	350	250			750	20	5

SEMESTER - II													
APM 2244	Elementary Theory of Plates & Shells	4	-		6	30	70		40		150	4	
APM 2244L	Elementary Theory of Plates & Shells LAB			2				50		20			1



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APM 2246	Experimental Stress Analysis	4	-		6	30	70		40		150	4	
APM 2246L	Experimental Stress Analysis LAB			2				50		20			1
APM 2242	Design of Concrete Structures Including Earthquake Resistant Design	4	-		6	30	70		40		150	4	
APM 2242L	Design of Concrete Structures Including Earthquake Resistant Design LAB			2				50		20			1
APM 2243	Finite Element Method	4	-		6	30	70		40		150	4	
APM 2243L	Finite Element Method LAB			2				50		20			1
Elective II (Any one of the following)													
APM 22XX	Optimization of Structures	4	-		6	30	70		40		150	4	
APM 22XXL	Optimization of Structures LAB			2				50		20			1
APM 2245	Advanced Concrete Technology and Prestressed Concrete	4	-		6	30	70		40		150	4	
APM 2245L	Advanced Concrete Technology and Prestressed Concrete LAB			2				50		20			1
APM 22XX	Stability of Structure	4	-		6	30	70		40		150	4	
APM 22XXL	Stability of Structure LAB			2				50		20			1
	Seminar	-	-	2	2	-	-	-	-	-	-	-	1
	Total of SEMESTER II					150	350	250			750	20	5
SEMESTER - III & IV													
APM 2402	Dissertation	-	24	-	24	-	-	200 + 100			300		24
	Total of F.S & S.S M.E-II							300			300		24
									Grand Total		1800	40	34



B. M.E.-I (SEMESTER-I)- CIVIL (FRACTURE MECHANICS)

APM No.	Full title of subject	Contact Hrs (per week)				Assessment Marks (max.)			Min Marks required for passing		Total Max. Marks	Equivalent Credit	
		L	T	P	Total	Theory		P/T/V	Theory	P/T/V		Theory	P/T/V
						Internal	External						
SEMESTER - I													
APM 2158	Theory of Elasticity and Plasticity	4	-		6	30	70		40		150	4	
APM 2158L	Theory of Elasticity and Plasticity LAB			2				50		20			1
APM 2154	Fracture of Composite Materials	4	-		6	30	70		40		150	4	
APM 2154L	Fracture of Composite Materials LAB			2				50		20			1
APM 2155	Dynamic Behaviour of Structures	4	-		6	30	70		40		150	4	
APM 2155L	Dynamic Behaviour of Structures LAB			2				50		20			1
APM 2156	Elementary Fracture Mechanics	4	-		6	30	70		40		150	4	
APM 2156L	Elementary Fracture Mechanics LAB			2				50		20			1
APM 2151	Computer Aided Design	4	-		6	30	70		40		150	4	
APM 2151L	Computer Aided Design LAB			2				50		20			1
	Total of Semester I					150	350	250			750	20	5

SEMESTER- II												
APM 2256	Advanced Fracture Mechanics	4	-		6	30	70		40		150	4
APM 2256L	Advanced Fracture Mechanics LAB			2				50		20		1
APM 2257	Numerical Methods in Fracture Mechanics	4	-		6	30	70		40		150	4
APM 2257L	Numerical Methods in Fracture Mechanics LAB			2				50		20		1
APM 2251	Fracture & Fatigue Control in Structures	4	-		6	30	70		40		150	4
APM 2251L	Fracture & Fatigue Control in Structures LAB			2				50		20		1



Elective I & II (Any Two of the following)													
APM 22XX	Selected Topics in Fracture Mechanics	4	-		6	30	70		40		150	4	
APM 22XXL	Selected Topics in Fracture Mechanics LAB			2				50		20			1
APM 2252	Experimental Stress Techniques	4	-		6	30	70		40		150	4	
APM 2252L	Experimental Stress Techniques LAB			2				50		20			1
APM 2258	Deformation & Fracture of Rocks and Concrete	4	-		6	30	70		40		150	4	
APM 2258L	Deformation & Fracture of Rocks and Concrete LAB			2				50		20			1
APM 22XX	Flaw & Fracture of Structural Metals	4	-		6	30	70		40		150	4	
APM 22XXL	Flaw & Fracture of Structural Metals LAB			2				50		20			1
APM 22XX	Fracture and Failure Analysis	4	-		6	30	70		40		150	4	
APM 22XXL	Fracture and Failure Analysis LAB			2				50		20			1
APM 22XX	Microfracture Mechanism of Metals	4	-		6	30	70		40		150	4	
APM 22XXL	Microfracture Mechanism of Metals LAB			2				50		20			1
APM 22XX	Nondestructive Testing Techniques	4	-		6	30	70		40		150	4	
APM 22XXL	Nondestructive Testing Techniques LAB			2				50		20			1
	Seminar	-	2	-	2	-	-	-	-	-	-	-	-
	Total of Semester II					150	350	250			750	20	5
SEMESTER - III & IV													
APM 2403	Dissertation	-	2 4	-	24	-	-	200 + 100			300		24
	Total of F.S & S.S M.E-II							300			300		24
									Grand Total		1800	40	44



C. M.E.-I (PART-I)- CIVIL (GEOTECHNICAL ENGINEERING)

APM No.	Full title of subject	Contact Hrs (per week)				Assessment Marks (maxi.)			Min Marks required for passing		Total Maxi Marks	Equivalent Credit	
		Lect.	Tu.	lab	Total	Theory		P/T/V	Theory	P/T/V		Theory	P/T/V
						Internal	External						
SEMESTER - I													
APM 2160	Computer Aided Design	4	-		6	30	70		40		150	4	
APM 2160L	Computer Aided Design LAB			2				50		20			1
APM 2167	Advances in Soil Mechanics	4	-		6	30	70		40		150	4	
APM 2167L	Advances in Soil Mechanics LAB			2				50		20			1
APM2168	Rock Mechanics	4	-		6	30	70		40		150	4	
APM2168L	Rock Mechanics LAB			2				50		20			1
Elective I & II (Any Two of the following)													
APM 21XX	Modern Testing Techniques in Geotechnical Engineering	4	-		6	30	70		40		150	4	
APM 21XXL	Modern Testing Techniques in Geotechnical Engineering LAB			2				50		20			1
APM 21XX	Theory of Elasticity & Plasticity	4	-		6	30	70		40		150	4	
APM 21XXL	Theory of Elasticity & Plasticity LAB			2				50		20			1
APM 21XX	Constitutive Modelling	4	-		6	30	70		40		150	4	
APM 21XXL	Constitutive Modelling LAB			2				50		20			1
APM 2164	Earthquake & Vibration resistant structures	4	-		6	30	70		40		150	4	



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APM 2164L	Earthquake & Vibration resistant structures LAB			2				50		20			1
APM 21XX	Geotechnical Instrumentations	4	-		6	30	70		40		150	4	
APM 21XXL	Geotechnical Instrumentations LAB			2				50		20			1
APM 2162	Numerical Methods in Geotechnical Engineering	4	-		6	30	70		40		150	4	
APM 2162L	Numerical Methods in Geotechnical Engineering LAB			2				50		20			1
Total of Semester I						150	350	250			750	20	5

SEMESTER - II													
APM 2261	Soil Foundation –Structure Interaction	4	-		6	30	70		40		150	4	
APM 2261L	Soil Foundation –Structure Interaction			2				50		20			1
APM 2262	Analysis & Design of Foundation Systems & Retaining Structures	4	-		6	30	70		40		150	4	
APM 2262L	Analysis & Design of Foundation Systems & Retaining Structures			2				50		20			1
APM 2269	Earth & Rock fill Dams	4	-		6	30	70		40		150	4	
APM 2269L	Earth & Rock fill Dams			2				50		20			1
Elective III & IV (Any Two of the following)													
APM 22XX	Grouting Technology	4	-		6	30	70		40		150	4	
APM 22XXL	Grouting Technology LAB			2				50		20			1
APM 2270	Rock Openings & Tunnels	4	-		6	30	70		40		150	4	
APM 2270L	Rock Openings & Tunnels LAB			2				50		20			1
APM 2267	Geosynthetics and Reinforced Earth	4	-		6	30	70		40		150	4	
APM 2267L	Geosynthetics and Reinforced Earth LAB			2				50		20			1



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APM 22XX	Reinforced Earth & Geotextile	4	-		6	30	70		40		150	4	
APM 22XXL	Reinforced Earth & Geotextile LAB			2				50		20			1
APM 22XX	Finite Element Method in Geotechnical Engineering	4	-		6	30	70		40		150	4	
APM 22XXL	Finite Element Method in Geotechnical Engineering LAB			2				50		20			1
APM 22XX	Pile Diaphragms and Anchorages	4	-		6	30	70		40		150	4	
APM 22XXL	Pile Diaphragms and Anchorages LAB			2				50		20			1
	Seminar	-	2	-	2	-	-	-	-	-	-		
	Total of Semester II					150	350	250			750	20	5
SEMESTER - III & IV													
APM 2401	Dissertation	-	24	-	24			200+			300		24
	Total of F.S & S.S M.E-II							300			300		24
									Grand Total		1800	40	44



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SUBJECTS OFFERED AT M.E.-I (PART-I)- CIVIL (STRUCTURAL ENGINEERING)

APM 2149: Computer Aided Design

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

- CO1** Create structural analysis and design programs in the spreadsheet package, using built-in functions and Visual Basic for Applications (VBA).
CO2 Create structural analysis and design programs in SCILAB using script file, functions and other programming features.
CO3 Apply Artificial Intelligence (AI) tools such as Artificial Neural Network (ANN) and Genetic Algorithm (GA) in structural Engineering.
CO4 Create structural drawings using CAD Commands.
CO5 Apply LISP functions in automation of drafting structural drawings.
CO6 Analyse and design the structures using available softwares.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Design of structural components by Visual Basics for Application (VBA): Introduction to Spreadsheet package, Built-in and User defined functions, Overview of programming, Structured programming, Control Structures, Procedures with array arguments, Advanced features of procedures and modules, Graphics commands and graph plotting. Implementation of VBA in analysis and design of structural components.	20	30	1,2, 3,4,5,6	CO1	PSO1 PSO2 PSO3
2	Software for Technical Computing and its Applications: Basics and commands for matrix operations, graph plotting, Eigen value calculation, script file, functions, Introduction to AI tools.	05	15	1,2,3,4, 5,6	CO2	PSO1 PSO2\ PSO5
3	Artificial Intelligence (AI) and its Applications in Analysis and Design A Brief Introduction to AI, Basics of Genetic Algorithm (GA), Overview of Artificial Neural Network (ANN), Applications of GA and ANN.	05	10	1,2,3, 4,5,6	CO3	PSO1 PSO5
4	CAD and LISP: Computer aided drafting – Principles and concepts. Features of CAD package, Basic drawing tools. Planning and laying out of a drawing using text, dimensions, attributes, Getting and exchanging information. Creating 2D and 3D drawings, Script files and LISP programs.	20	30	1, 2, 3,4,5,6	CO4 CO5	PSO1



5	Introduction to Analysis and Design Software:						PSO1
	Modeling of Structures, Static and Dynamic Analysis, Linear and Non-linear Analysis, Interpretation of Results	10	15	1,2,3,4,5,6	CO6		PSO2 PSO3 PSO4

APM 2149L: Computer Aided Design

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Developing EXCEL programs for design of structural components	5	16	1,2	CO1	PSO1,2,3
2	Developing VBA programs for numerical methods used in Structural analysis	5	17	1,2,3,4,5,6	CO1	PSO1,2
3	Developing VBA programs for structural analysis and design	5	16	1,2,3,4,5,6	CO1	PSO1,2,3
4	Developing SCILAB programs and learning application of ANN AI tools in analysis and design	5	16	1,2,3,4,5,6	CO2 CO3	PSO1,2,5
5	Developing AutoLISP programs for automated drafting	5	16	1,2,3,4,5,6	CO4 CO5	PSO1
6	Developing, analyzing and designing RCC and steel models in the software	5	17	1,2,3,4,5,6	CO6	PSO1,2,3,4

Reference Books:

1. Mastering AutoCAD - George Omura, BPB Publications.
2. The ABC's of Autolisp by George Omura, Sybex Inc.
3. Microsoft EXCEL VBA Programming for Dummies, John Walkenbach, John Wiley & Sons, Inc.
4. Computer Aided Design: Software and Analytical Tools - C. S. Krishnamoorthy and S. Rajeev, Narosa Publishing House, New Delhi, 1991
5. Optimization for Engineering Design by Kalyanmoy Deb, PHI Publisher
6. Genetic Algorithm in Search, Optimization and Machine Learning, David E. Goldberg, Addison-Wesley Longman Publishing Co., Inc., USA
7. A Brief Introduction to Neural Network by David Kriesel

APM 2140: Design of Metal Structures

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

- CO1** Calculate loadings and understand load transfer mechanisms of metal structures such as building frames, industrial structures, bridges etc.
- CO2** Analyse and design aluminium structures and apply it for creating real life structures.
- CO3** Analyse and design light gauge steel structures and apply it for creating real life structures.
- CO4** Design various real life steel structures manually and using software and apply it in the infrastructure development.
- CO5** Execute erection of metal structures for successful completion of the project and thus helping in creating safe structures.
- CO6** Design the steel structural members using plastic analysis.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction and Types of Metal Structures and Connections: Structural behaviour and materials, types of metal structures loads and forces, fundamental of member performance, connections of flexible, semi-rigid and rigid types, tubular connections.	10	10	1,2,3, 4,5	CO1 CO2	PSO1 PSO2 PSO3
2	Analysis and design of Aluminium and Light gauge structures: Analysis of frames, design of aluminium & composite structures	15	40	2,3,4, 5,6	CO2 CO3	PSO1 PSO2 PSO3 PSO4
3	Design of Steel Structure: Design of building frames, design of industrial truss, design of plate girder and latticed girder type bridges, design of water tanks, towers, hoppers, design of chimney, bunkers and silos.	25	40	2,3,4, 5,6	CO1 CO4 CO5	PSO1 PSO2 PSO3 PSO4
4	Construction and Erection of Structures and Software: Construction and erection of structural steel work, use of available software & latest IS Code to be followed.	10	10	2,3,4, 5,6	CO3 CO5	PSO1 PSO2 PSO3 PSO4



APM2140L: Design of Metal Structures

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Design of industrial building with and without gantry crane.	10	50	1,2,3,4,5,6	CO1 CO5 CO6	PSO1 PSO2
2	Design of aluminum and light gauge structures.	10	25	2,3,4,5,6	CO2 CO3	PSO3 PSO4
3	Design of steel truss girder bridge.	10	25	1,2,3,4,5,6	CO1 CO4	

Reference Books:

1. Design of steel structures _ A. S. Arya and J. L. Ajmani, Nemchand & Bros, 1988.
2. Steel Structures - W. M. Guire, Prentice Hall, 1968.
3. Steel Structures – Practical Design Studies – T. J. Mac Ginley E. & F. N. SPON, 1981.
4. Design of Steel Structures – 7th Edition Ramchandra, Standard Book House, Vol.1-2, Delhi, 1991.
5. Design of Steel Structures – Raghupathi M., Tata McGraw Hill Publication, Delhi, 1995.
6. The Theory & Practical Design of Bunkers – Lambert F.W., The British Constructional Steel Work Association Ltd., London, 1968.
7. Steel Designer's Manual – Charles Gray, ELBS Publication.
8. Design of Steel Structures – 2nd Edition - Dr. B. C. Punmia, Laxmi Publications (P) Ltd., New Delhi, 1998.
9. Design Steel Structures – 2nd Edition – S. K. Duggal, Tata McGraw Hill Publishing Ltd., New Delhi, 2000.

APM 2142: Advanced Theory of Structures

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

- CO1** Analyse framed structures with rigid and semi-rigid supports and connections, curved members under primary loading by stiffness member approach.
- CO2** Analyse framed structures including nonprismatic members under secondary effects by SMA using concept of symmetry and cyclosymmetry.
- CO3** Carry out plastic analysis and calculate secondary stresses in trusses using stiffness member approach.
- CO4** Analyse beams on elastic foundation, beams curved in plan.
- CO5** Analyse closed frames, rings and gable frames by classical methods such as column analogy and elastic centre methods.
- CO6** Analyse fixed and interconnected arches by classical methods such as column analogy and elastic centre methods.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Matrix Method of Analysis: Introduction to matrix methods, analysis of framed structures using stiffness member approach under loading, pre-strain, temperature, and support settlement, use of the concept of symmetry and anti-symmetry., Rotation and transformation of axes in two and three dimensions, stiffness characteristics of non-uniform sections and curved members, Semi-rigid (elastic) connections, discontinuities in members, sub-structuring, and effect of shear deformation by the stiffness method.	20	50	1,2,3, 4,5	CO1 CO2	PSO1
2	Plastic Analysis of Structure using Matrix Method: Plastic analysis and secondary stresses in trusses using stiffness method.	06	15	1,2,3, 4,6	CO3	PSO1
3	Analysis of Special Beams: Beams on elastic foundation, beams curved in plan, complementary strain energy method.	08	20	2,3,4	CO4	PSO1 PSO2 PSO3 PSO4
4	Analysis of Different Structure with Classical Methods: Analysis of closed frames and rings by column analogy and elastic center method, analysis of fixed and interconnected arches, analysis of gable framed structures with non-prismatic members.	06	15	1,2,3	CO5 CO6	PSO1 PSO3



APM 2142L: Advanced Theory of Structures

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Basics of Matrix Methods	8	27	1,2	CO1	PSO2 PSO4
2	Column Analogy Method	8	27	1,2,3	CO4	PSO4
3	Beams Curved in Plan	6	19	1,2,3,4	CO4	PSO2 PSO4
4	Matrix Methods	8	27	3,4,5	CO1 CO2	PSO1 PSO2 PSO4

Reference Books:

1. Indeterminate Structural Analysis - J. S. Kinney, Oxford & IBH Publishing Co. Calcutta, 1966.
2. Intermediate Structural Analysis - C. K. Wang, McGraw Hill Book Co., 1983.
3. Strength of Materials Vol. II - S. Timoshenko, East West Student Edition, 1965.
4. Structural Analysis – J. P. Laible, CBS College Publishing, 1985.
5. Matrix Analysis of Framed Structures – W. Weaver and J. M. Gere, CBS Publications and Distributors, 1986.
6. Matrix Methods of Structural Analysis – A. S. Meghre and S. K. Deshmukh, Charotar Books Distributors, 2003.

APM 2143: Dynamics of Structures with Application to Earthquake Engineering

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand fundamentals of dynamics of structure.

CO2 Apply the fundamental concepts, principles and application of earthquake engineering in seismic analysis and design of structures.

CO3 Analyze the application of scientific and technological principles of modelling, analysis, design of buildings according to earthquake resistant design philosophy.

CO4 Analyze the behavior of structures by Equivalent Static and Response-spectrum using IS 1893 code.

CO5 Analyze and design masonry structures for gravity and seismic loads.

CO6 Apply basic aspects of vibration analysis, types and its conceptualization with building structures.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	General Concepts: Introduction to general concept. Systems with one degree of freedom. Free, forced and transient vibrations for structures without and with viscous damping.	09	15	1,2	CO1 CO6	PSO1
2	Single and Multi-Degree of freedom Systems: System with two or more degrees of freedom. Formulation by Lagrange's equations and influence coefficients. Vibration of continuous media, continuous and discrete approaches. Computer methods of analysis in vibrations. System with two or more degrees of freedom. Formulation by Lagrange's equations and influence coefficients. Vibration of continuous media, continuous and discrete approaches. Computer methods of analysis in vibrations.	21	35	1,2,4,5	CO1 CO2	PSO1 PSO2
3	Dynamic Theory and its Application: Fundamentals of earthquake engineering. Introduction to methods of earthquake analysis. Idealization of Structures. Equivalent force concepts. Masonry Structures	12	20	1,2	CO2 CO3 CO5	PSO1 PSO2 PSO4
4	Response Spectrum Analysis: Response spectrum analysis of multistorey buildings. IS code provisions. Concept of push over analysis.	18	30	1,2,4	CO4	PSO1 PSO3 PSO4



APM 2143L: Dynamics of Structures with Application to Earthquake Engineering

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Periodic time for Simple pendulum.	2	10	1,2	CO1 CO6	PSO1
2	Radius of gyration of compound pendulum.	2	10	2	CO1	PSO2
3	Frequency and Periodic time for Helical Springs	4	10	2,3	CO1	PSO1 PSO2
4	Stiffness and Flexibility of Spring systems.	4	10	3,4	CO1	PSO4
5	Verification of Dunkerley's rule.	2	10	2,3	CO2 CO6	PSO1 PSO4
6	Radius of gyration using Bi-Filar suspension.	4	10	2,3	CO1	PSO1
7	Undamped free vibration of equivalent spring mass systems.	2	10	3,4	CO1	PSO2
8	Forced vibration of equivalent spring mass systems.	2	10	2	CO2	PSO4
9	Torsional vibration of rotor shaft systems.	4	10	2	CO1	PSO4
10	Analysis of building frame on shake table	4	10	2,3	CO3	PSO2 PSO4

Reference Books:

1. Dynamics of Framed Structures - G.L.Rogers, John Wiley, 1959.
2. Structural Dynamics - J. M. Biggs, McGraw Hill Book Co. 1964.
3. Dynamics of Structures - Theory and Applications to Earthquake Engineering by A. K. Chopra, Prentice-Hall of India Pvt. Ltd., New Delhi, 2001.
4. Structural Dynamics – Theory and Computation by Mario Paz (2nd Edition), CBS Publishers and Distributors, New Delhi, 2001.
5. Elements of Earthquake Engineering by Jai Krishna, A. R. Chandrasekaran and B. Chandra, South Asian Publishers, New Delhi, 1994.
6. IS:1893 “Criteria for Earthquake Resistant Design of Structures”, Bureau of Indian Standards, New Delhi, 2016.

APM 2122: Analysis and Design of Foundations

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Students will be able to study soil property and basics of foundation design.

CO2 Students will be able to analyze pile foundation resting on different types of soil.

CO3 Students will be able to analyze and design special foundation for various structures.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction: Site investigation, subsoil exploration, plate load tests and penetration tests, pile load test, pressure meter test.	15	25	1,2,4,5	CO1	PSO1 PSO3
2	Basics of Foundation design: Selection and basis for design of foundations, ultimate bearing capacity of axially, eccentrically and inclined loaded footings, structural design of individual and combine footing and rafts. Settlement computation methods, I.S. code-permissible total and differential settlements, forms of deformation and pattern of settlement cracks.	15	25	1,2,5	CO1	PSO1 PSO3
3	Design of Pile foundation: Design considerations for bearing & friction piles, group action of piles, structural settlement of pile groups, lateral earth pressure and earth retaining structures, structural stability of mass gravity retaining structures, strutted walls.	15	25	2,3,4	CO2	PSO1 PSO2 PSO4
4	Special type of foundation: Forces in the struts and base stability of cuts sheet piled walls, foundations in soft and expansive soils, tank foundations and <u>vibration-controlled</u> <u>ions.</u>	15	25	2,3,4	CO3	PSO1 PSO4



APM 2122L: Analysis and Design of Foundations

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Tutorial 1	8	25	1,2	CO1	PSO1
2	Tutorial 2	7	25	2	CO1	PSO2
3	Tutorial 3	8	25	2,3	CO2	PSO1 PSO2
4	Tutorial 4	7	25	3,4	CO2	PSO2

Reference Books:

1. Foundation Engineering – Leonard G.A., Jhon Wiley
2. Foundation Engineering Handbook-Winterkorn & Fang, Van Nostrand.
3. R.C.C. Design – Dr. H.J. Shah
4. R.C.C. Design – P.C. Vergese

APM 2123: Mechanics of Fracture

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Student will understand the failure modes and mechanics behind different failures.

CO2 Student will understand cracks and its initiation and propagation inside the material.

CO3 Student will have a better outlook about fatigue loading and its analysis

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction: Linear Elastic Fracture Mechanics, Elastic stress field approach, Mode-I, Elastic stress field analysis, stress intensity factor, stress concentration, stress field equations for Mode-II and III, Elastic stress field displacements, finite method, Elementary solution, crack as continuous dislocations distribution.	15	25	1,2,4,5	CO1	PSO1 PSO3
2	Energy approach: Theoretical strength, cohesive atomic zone models, energy changes with crack size, Energy balance approach, Griffith theory, Fixed grip and constant load conditions, stress intensity factors from compliance, Energy release rate analysis.	15	25	1,2,5	CO1	PSO1
3	Crack Analysis: Crack tip plasticity, plastic zone shape and size, Irwin and dugdale approach, Plastic zone and thickness of specimen on fracture toughness, Mode-II and Mode-III fracture, Mixed mode fracture, J-Integral, Correlation between Charpy impact value and fracture toughness.	15	25	2,3,4,6	CO2	PSO1 PSO2 PSO4
4	Fatigue Analysis: Fatigue loading, fatigue crack growth, constant amplitude load, sustained load fracture, environment effect, stress corrosion cracking, computer programming in fracture mechanics problems, Theory of Vibrations crack resistance and toughness indices of fiber reinforced concrete. Closed – loop electro-hydraulic Material Test System, Various experimental testing methods and <u>ities.</u>	15	25	2,3,4,6	CO3	PSO1 PSO4



APM 2123L: Mechanics of Fracture

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	LEFM examples	8	25	1,2	CO1	PSO1
2	Energy Approach problems	7	25	2	CO1	PSO2
3	Problems on Crack Analysis	8	25	2,3	CO2	PSO1
4	Fatigue Analysis examples	7	25	3,4	CO3	PSO2

Reference Books:

1. Dynamics of Framed Structure – G.L.Rogers, John Wiley, 1959.
2. A.P.Parker : The mechanics of fracture and fatigue, “ E & F. N. Spon Ltd.
3. Knott J.F : “Fundamental of Fracture mechanics”, Butterworth Group.
4. Borek D, Leyden : “Elementary Engineering Fracture Mechanics”, Noordhoff International, 1974.
5. Rolfe and Barson : “Fracture & Fatigue Control in Structure”, Prentice Hall Inc., 1977.
6. Ewelds H.J. and R.J.H. Wanhill: “Fracture Mechanics”, Edward Arnod Publishers Ltd., London, 1985.
7. Kare HEllan : “ Introduction to Fracture Mechanics,” McGraw – Hill Book Company, New York, 1985.
8. Prashant Kumar : “Elements of Fracture Mechanics”, A.H..Wheeler Publishing, 1991.
9. Jai Krishna And Chandrasekaran : “Elements of earthquake engineering”, Sarita Publications.

APM 2124: Failure repairs Maintenance and Testing of Structures

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Student will be able to understand the different types of failure normally happens in steel and concrete structures.

CO2 Student will be able to do understand and apply different types of repairs and retrofitting schemes.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction: Philosophy & definition of failure, cause of failure, failure in ancient time & recent times, deficiency in design, drag, martial, production, maintenance etc., failure related problems: manmade and natural failure or damage, diagnosis of failure: change in appearance, on exposure, chemical deterioration, mechanical deterioration, cracking in building, failure of flat roofs, balconies, trenches, dams, piles, abutments, piers, silos, chimney, cooling towers, R.C.C. frames, failure information & analysis, format of investigation.	15	25	1,2,4,5	CO1	PSO1 PSO3
2	Concrete & steel structure: Design and detail in shear & torsion compression failure, erection difficulty, frost, temperature change, deformation & cracking, tanks, silos, space frame, pre-cast assemblies, prestressed concrete structure: formwork and failure.	15	25	1,2,5	CO1	PSO1
3	Remedial Measures, repairs & maintenance: Detailed description of various methods of repairs of concrete structures, technical point's application to such methods, maintenance system, standard, planning & cost control, repair to foundation, columns, piles, floor, roofs, walls, sulphate attack on concrete, chloride attack on steel reinforcement, use of concrete admixture in repairs, plasticizer, bonding agents, integral & surface water proofer, membranes, protection against corrosion of steel, dealing with cracks, a few special cases.	15	25	2,3,4,6	CO2	PSO1 PSO2 PSO4

4 Structural Assessment:

Art of structural assessment methods of testing & concrete structure: I.S. code for testing, safety assessment of reinforced concrete structure with cracks, benefits of large-scale structure testing, tests to destruction of three storey reinforced concrete were house slab structure, structural requirement of concrete repairing material, investigation of three storey steel

15

25

2,3,4,
6

CO2

PSO1
PSO4



APM 2124L: Failure Repairs Maintenance and Testing of Structures

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Tutorial 1 Design of concrete structures	8	25	1,2	CO1	PSO1
2	Tutorial 2 Design of steel structures	7	25	2	CO1	PSO2
3	Tutorial 3 Repair and maintenance of structures	8	25	2,3	CO2	PSO1 PSO2
4	Tutorial 4 Structural assessment	7	25	3,4	CO2	PSO2

Reference Books:

1. Building defects & Maintenance, BRE digest.
2. Failure & Repairs of concrete structures by S.Champion.
3. Structural Failure in Residential building Vol.1 by Eirich Schild & Renner Oswal.
4. Construction failure by Feld Jacob.
5. Structural Assessment by F.K. Garas, J.L. Clarke, GST Armer.

APM2146: Elementary Theory of Elasticity and Plasticity

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Analyze the structure using classical theory of elasticity for 3D problems in Cartesian coordinate.

CO2 Evaluate state of stress and strain by basic equations of elasticity 2D problem of elasticity.

CO3 Analyze the 2D problem of structure using polar coordinates.

CO4 Analyze the torsion problems for non-circular cross section using Cartesian coordinates.

CO5 Analyze the structure using classical theory of plasticity for 2D problems in Cartesian coordinate.

CO6 Apply theory of failures for plasticity problems.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction to theory of Elasticity and Cartesian Co-ordinate System: Generalized Hook's law. Differential Equations of equilibrium, boundary conditions, compatibility equations.	10	16.6	1,2	CO1	PSO1 , PSO2
2	State of stress and strain at a point: State of stress and strain at a point in two dimensions, Hook's law. For 2D problem, Plane stress and plane strain problems in Cartesian coordinates, solution by Airy's stress function, Saint Venant's principle, solution of beam problems.	12	20	1,2,3	CO2	PSO1 , PSO2
3	Polar Co-ordinate System: Two dimensional problems in polar coordinates, General equations. Stress distribution is symmetrical about an axis. Pure bending of curved bars, stress concentration	10	16.6	1,2,3	CO3	PSO2
4	Torsion: Problem of torsion, Saint Venant's method. Prandtl's solution using a stress function for various types of engineering sections, a membrane analogy method.	08	13.3	1,2,3	CO4 CO3	PSO2
5	Theory of Plasticity: Plastic stress strain relations, theories of strength. Plastic flow in solid, theory of ideally plastic materials and its applications to thick-walled shells.	12	20	1,2	CO5	PSO4 ,



6	Theory of plastic flow:	08	13.3	1,2,3	CO6	PSO1
	Two-dimensional plastic flow problems and its applications to structural problems.					,
	Application of failure theory					PSO2



APM2146L: Elementary Theory of Elasticity and Plasticity

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	TUTORIAL 1- Elasticity (Cartesian Co-ordinates)	03	3	2,3	CO1	PSO1, PSO2
2	TUTORIAL 2- Elasticity (Numericals of Cartesian Co-ordinates)	03	4	2,3	CO2	PSO1
3	TUTORIAL 3- Elasticity (Polar Co-ordinates)	03	4	2,3	CO3	PSO2
4	TUTORIAL 4- Elasticity (Polar Co-ordinates)	03	4	2,3	CO3	PSO4
5	TUTORIAL 5- Elasticity (Torsion)	03	4	2,3	CO4	PSO4
6	TUTORIAL 6- Plasticity (Stress at a Point)	03	4	2,3	CO5	PSO4
7	TUTORIAL 7- Plasticity (Theory of Failures)	03	4	2,3	CO5	PSO2
8	TUTORIAL 8- Plasticity (Theories of Plastic Flow)	03	3	2,3	CO6	PSO4

Reference Books:

1. Theory of Elasticity - S. Timoshenko and J. N. Goodier, McGraw Hill Book Co. 1970.
2. Structural Mechanics with Introduction to Elasticity & Plasticity - B. Venkataraman and S. A. Patel, Mc Graw Hill Book Co. 1970.
3. Introduction to the Theory of Plasticity for Engineers - Oscar Hoffman & Sachs - Mc Graw Hill Book Co. 1958.
4. Advanced Strength of Materials – Volterra Enrico and I. Gaines, 1971.

APM 2125: Elements of Fracture Mechanics and Structural Dynamics

Credits/Hours per Week: 04

Maximum Marks/Grade: 100

Type: Elective

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Student will understand the application of parameters in fracture mechanics.

CO2 Student will understand the analysis of framed structures under loading and secondary effects by stiffness member approach.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction: Concept of fracture mechanics, different modes of fracture, linear elastic analysis, crack-tip stress and deformation fields in linear elastic solids, energy changes with crack size, compliance methods for determining K, weight function analysis.	15	25	1,2,4,5	CO1	PSO1 PSO3
2	Problems involved in Fracture Mechanics: J-integral fracture criteria for elastic-plastic fracture, plane strain and plane stress fracture toughness, analysis, and testing, notch toughness, fatigue loading, crack growth, importance of S-N curve, singular elasticity solutions in two dimensions, various testing methods and capabilities.	15	25	1,2,5	CO1	PSO1
3	Introduction to Dynamics: A system with one degree of freedom, free, forced, and transient vibrations for structures without and with viscous damping system with two or more degrees of freedom	15	25	2,3,4,6	CO2	PSO1 PSO2 PSO4
4	Engineering Application: Formulation by Lagrange's equations and influence coefficients, engineering application and problems.	15	25	2,3,4,6	CO2	PSO1 PSO4



APM 2125L: Elements of fracture Mechanics and Structural Dynamics

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Elective

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Concept of fracture mechanics	8	25	1,2	CO1	PSO1
2	Problems of fracture mechanics	7	25	2	CO1	PSO2
3	Structural dynamics examples	8	25	2,3	CO2	PSO1 PSO2
4	Engineering applications	7	25	3,4	CO2	PSO2

Reference Books:

1. Roger G.L: dynamics of framed structure, John Willey, 1959.
2. Biggs J.M.: Structural Dynamics, McGraw Hill Book Co. 1964.
3. M. Mukhopadhyay: Vibration, Dynamics and Structural Systems, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 1989.
4. Jai Krishna and Chandrasekaran: Elements of earthquake engineering, Sarita Publications.
5. Prashant Kumar: Elements of Fracture Mechanics, A.H. Wheeler Publishing, 1999.
6. Rolfe and Barsom: Fracture & Fatigue Control in Structures, prentice Hall Inc., 1977.



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SUBJECTS OFFERED AT M.E.-I (PART-II)- CIVIL (STRUCTURAL ENGINEERING)

APM 2246: Experimental Stress Analysis

Credits/Hours per Week: 03

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand Analytical, numerical, and experimental approach of Experimental Stress Analysis.

CO2 Analyze various techniques involved in stress measurement using strain gauges.

CO3 Analyze the application and working of various types of strain gauges.

CO4 Understand the principle of Photoelasticity and various brittle coating techniques.

CO5 Analyze various structural health monitoring techniques.

CO6 Understand the strain evaluation using strain gauges.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction: Overview of Experimental Stress Analysis - Analytical, numerical, and experimental approach - Specific domain of this approach - Advantages and disadvantages - Mechanical, Electrical, Optical, Piezoelectric and Acoustical strain gauges – Strain rosettes and its examples.	15	34	2,3,4	CO1 CO2 CO3	PSO1 PSO2
2	Photo Elasticity: Two- and three-dimensional photoelasticity - photo elastic coatings - Plane and circular Polariscope.	10	22	1,2,3	CO4 CO6	PSO1 PSO2
3	Strain measurements: Brittle coating – Advantages and Disadvantages - Types of brittle coating – Calibration of coating – Crack detection techniques – Moiré fringes and grid techniques.	10	22	1,2,4	CO3	PSO3 PSO4
4	Structural Health Monitoring: Introduction to Structural Health Monitoring – Advantages and Disadvantages – Necessity – Static and dynamic SHM – Sensor technology – Damage detection and assessment.	10	22	3,4,5	CO5 CO2	PSO3 PSO4



APM 2246L: Experimental Stress Analysis

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Experiments

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Measurement of resistance of strain gauge	2	10	1,2,3	CO1 CO2	PSO1 PSO2
2	Evaluation of Young's Modulus of Elasticity for cantilever steel beam using strain gauge	2	10	3	CO1 CO2	PSO2 PSO3 PSO4
3	Evaluation of Young's Modulus of Elasticity for mild steel specimen using strain gauge	2	10	1,4,5	CO1 CO2	PSO2 PSO3 PSO4
4	Evaluation of Young's Modulus of Elasticity for simply supported steel beam using strain gauge	2	10	1,4,5	CO1 CO2	PSO2 PSO3 PSO4
5	Evaluation of Poisson's ratio for mild steel specimen using strain gauge	2	10	1,4,5	CO1 CO2	PSO2 PSO3 PSO4
6	Evaluation of Young's Modulus of Elasticity for Aluminum specimen using strain gauge	2	10	1,4,5	CO1 CO2	PSO2 PSO3 PSO4
7	Evaluation of Young's Modulus of Elasticity for Fiber reinforced specimen using strain gauge	2	10	1,4,5	CO1 CO2	PSO2 PSO3 PSO4
8	Analysis of Howe type truss using strain gauges	2	10	1,4,5	CO1 CO2	PSO2 PSO4
9	Analysis of warren type truss using strain gauges	2	10	1,4,5	CO1 CO2	PSO2 PSO4
10	Study of fringe patterns on photo-elastic bench	2	10	1,2	CO3 CO4	PSO2 PSO4

Reference Books:

1. J.W.Dally and W.F.Riely: "Experimental Stress Analysis", Mc Graw Hill.
2. R.C.Dove and P.H. Adams : "Experimental Stress Analysis", Prentice Hall of India.
3. K. Ramesh: "Digital Photoelasticity-Advanced Techniques and Applications", Springer
4. L. S. Shrinath, M. R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant and K. Ramachandra: "Experimental Stress Analysis", Tata Mc Graw Hill.
5. E-book on Experimental Stress Analysis, K. Ramesh, Published by IIT Madras, India, 2009.
6. Health Monitoring of Structural Materials and Components: Methods with Applications, Douglas E. Adams.
7. Smart Materials and Structures, M.V. Gandhi, and B.S. Thompson.

APM 2242: DESIGN OF CONCRETE STRUCTURES INCLUDING EARTHQUAKE RESISTANT DESIGN

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Design and detailing of a multi storied building for gravity loads.

CO2 Design and detailing of a multi storied building for lateral loads.

CO3 Analyze and Design ductile detailing of reinforcement in RC buildings based on IS:13920- 2016 and Raft foundation for tall buildings.

CO4 Analyze and Design special structures like folded plates, domes, shells etc.

CO5 Analyze and Design the underground structures like water tank, retaining walls, etc.

CO6 Analyze and Design the chimney and special stair cases and Virendral girder etc.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Multi storied buildings Structural analysis and design of high rise buildings for gravity i.e Dead load and Live loads using IS 456-2001 and IS 1893-2015	6	10	1,2,3, 4,5,6	CO1	PSO1 PSO5 PSO3
2	Multi storied buildings Structural analysis and design of high rise buildings for wind and earthquake loads, shear walled buildings under horizontal load, wall frame interaction,	12	20	1,2,3, 4,5,6	CO2	PSO3 PSO5
3	Multi storied buildings Ductile detailing of reinforcement in RC buildings based on IS:13920- 2016. Introduction to design of Tall structures using IS-16700-2017, Raft foundation design for tall building.	12	20	1,2,3, 4,5,6	CO3	PSO1 PSO5 PSO3
4	Water tanks Grid floors, Raft, and Shell type foundations. Circular shaft supported overhead water tank, Large underground tank, Swimming pools.	6	10	1,2,3, 4,5,6	CO5	PSO3 PSO5



5	Domes and shell and Virendral girder	12	20	1,2,3, 4,5,6	CO4	PSO2 PSO3 PSO4
	Cooling tower, Nuclear reactor, Structures for nuclear power plant, Off shore concrete structures, folded plates, cylindrical and hyperbolic and paraboloid shell roof, dome, pyramidal roof. Free standing stairs and Helicoidal stairs, Virendral girders.					
6	Design of bridges and chimney	12	20	1,2,3, 4,5,6	CO6	PSO1 PSO5
	Bridges, Introduction, Loading standards, solid slab bridges, Tee beam and deck slab bridges, Balanced cantilever bridges. Silos, Bunkers and Chimneys.					



APM 2242L: DESIGN OF CONCRETE STRUCTURES INCLUDING EARTHQUAKE RESISTANT DESIGN

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Experiments

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Gravity load Analysis of Building	5	16	1,2,3,4,5	CO1	PSO3
2	Wind Load and Earthquake Analysis of Building	5	17	1,2,3,4,5	CO2	PSO3
3	Complete Design of Building component like foundation, column , beam and slab,shear wall	5	17	1,2,3,4,5	CO3	PSO3
4	Design of Circular Water Tank	5	16	1,2,3,4,5	CO4	PSO3
5	Design of domes and pyramid roof	5	17	1,2,3,4,5	CO5	PSO3
6	Design of chimney and staircases	5	17	1,2,3,4,5	CO6	PSO3

Reference Books:

1. Reinforced Concrete Vol-I & II – Dr. H. J. Shah, Charotar Publishing House, Anand, 2000.
2. Plain & Reinforced Concrete-Jaikrishna& O. P. Jain, Nemchand& Bros, Roorkee.
3. Essentials of Bridge Engineering - D. J. Victor, Oxford & I.B.H. Publishing Co. Ltd., Calcutta.
4. Design and Construction of Concrete Shell Roofs – G. S. Ramswamy, McGraw Hill, New York.
5. Thin Shells – J. E. Gibson, Pergamon Press, Oxford.
6. Thin Shell Structures – D. P. Billington, McGraw Hill, New York.
7. Theory and Design of Concrete Shells – B. K. Chatterjee, Oxford and I.B.H. Pub. Co.
8. Design and Selection of Hyperbolic Cooling Towers – R. F. Rish& T.F. Steel.

APM 2243: Finite Element methods

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Demonstrate the procedures for 1D and 2D Finite difference method (FDM) and Finite element method (FEM).

CO2 Apply the FDM and FEM for solving various 1D and 2D structural mechanics problems.

CO3 Apply various available specialised methods to solve large size FE problems.

CO4 Apply various co-ordinate systems to develop interpolation functions used in the FE analysis of 1D, 2D and 3D problems.

CO5 Develop computer programs based on FEM and create structural models in standard FE software for their analysis.

CO6 Demonstrate the procedure for non linear FE analysis of structures.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction: Introduction to Numerical Methods, Finite difference method of analysis. Concept and solution procedure for finite element displacement approach, One and two dimensional finite element analysis.	12	30	1,2	CO1 CO2	PSO1
2	Linear and non-linear analysis: Calculation of element properties using generalized coordinates for one dimensional bar and beam elements and two-dimensional elements for plane stress, plain strain, plate bending and axisymmetric problems. Introduction to nonlinear analysis. Methods of static condensations and Degrading technique. Substructure Technique and coarse-to-fine sub division method.	13	32	2,3,4	CO2 CO3 CO6	PSO1 PSO2
3	Coordinate systems and interpolation functions: One, two and three dimensional iso-parametric, sub parametric and super parametric elements. Derivation of element properties using natural coordinates. Area and volume coordinates systems. Lagrangian and Hermitian interpolation functions.	07	18	2,3,4	CO4	PSO1 PSO2
4	Dynamic and stability analysis: Introduction to Dynamic and Stability Analysis by Finite Element Method. Data preparation and overall finite element programming logic. Concept of pre- and post-processing. Use of standard software	08	20	2,3,4, 5,6	CO5	PSO1 PSO4 PSO5



APM 2243L: Finite Element Methods

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Preparing report on FDM, FEM and their comparison. Analysis of 1D and 2D problems by FDM	6	20	1,2,3,4,5	CO1 CO2	PSO1 PSO2
2	Analysis of 1D and 2D problems and development of element properties of 3D problems in FEM	8	26	2,3,4,5	CO4 CO6	PSO1 PSO2
3	Developing element properties by natural, area and volume coordinate systems. Calculation of element properties by Hermitian and Lagrangian interpolation functions. Development of element properties for 1D, 2D and 3D iso-parametric elements. Analysis of large size problems. Nonlinear problems.	8	27	2,3,4,5	CO3 CO4	PSO1 PSO2
4	Developing flow chart of FEM for computer programming and creating and analyzing structural models in standard FE software.	8	27	2,3,4,6	CO5	PSO1 PSO2 PSO4 PSO5

Reference Books:

1. Numerical Methods in Finite Element Analysis – K. J. Bathe and E. L. Wilson, Prentice-Hall of India, 1990.
2. Introduction to Finite Element Method - C. S. Desai and J. F. Abel, Affiliated East-West Press Pvt. Ltd, New Delhi, 1977.
3. Finite Element Analysis (Theory and Programming) - C. S. Krishnamoorthy, Tata McGraw Hill Pub. Co. Ltd., New Delhi, 1987.
4. The Finite Element Method - O. C. Zienkiewicz, Tata McGraw Hill Pub. Co. Ltd., New Delhi, 1979.

APM 2244: Elementary Theory of Plates and Shells

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

- CO1** Understand the complete behaviour of plate theory with their structural behavioural difference with respect to beam. Students will understand the basic behaviour of pure bending of plates.
- CO2** Analyze the complete behaviour of plate elements for various types of loading and with different boundary conditions and will understand classification of plates with respect to geometry and deflections.
- CO3** Student will study thin plate with small deflection theory with respect to loading, The complete derivational procedure for thin plate with small deflection theory.
- CO4** Analyze the plate by using Navier's & Levy's method with various loadings.
- CO5** Understand the shell structures and its structural superiority over plate elements using arch theory. Students will understand complete classification of shells based on Gaussian Curvature and surface theory. Study of membrane theory of thin shells with all internal stresses.
- CO6** Understand complete practical behaviour of cylindrical and conical shells with their applications in structural engineering. Evaluation of inplane stress components in orthogonal directions for various loadings..

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction of Plates: Introduction of Plates and difference between plate and beams, Kirchhoff's shear corrections and various boundary conditions of plates, small deflection theory of plates. Pure Bending theory of plates	30	50	1,2,4,5	CO1 CO2	PSO1 PSO3
2	Plates: Fourier series and its application for finding out various parameters i.e, shear force, slope and deflections in beams, Derivation of fourth order partial differential equation for small deflection theory, Navier's method for plate analysis, Levy's method for plate analysis, Solution of various types of plate subjected to different types of transverse loading. Derivation of fourth order differential equation for circular plate.	18	30	1,2,5	CO2 CO3 CO4	PSO1
3	Introduction to shells Shell structures and its importance in structural engineering content, Shell's classification and its mathematical properties, Derivation of in plane stress in shells subjected to transverse loading	06	10	2,3,4,6	CO5	PSO1 PSO2 PSO4



4 **Cylindrical and Conical Shells**

Cylindrical shells analysis with various problems, Conical shells analysis with various problems.

06

10

2,3,4,
6

CO5

PSO1
PSO4



APM 2244L: Elementary Theory of Plates and Shells

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Basics of Plate Theory	8		1,2,4	CO1 CO2	PSO1 PSO3
2	Navier's & Levy's Method for Plate theory.	7		2,4,5	CO2 CO3 CO4	PSO3
3	Shells classification & Problems based on shells of spherical shells.	8		2,4,5	CO5	PSO3
4	Problems based on cylindrical and conical shells	7		3,4,5	CO6	PSO3

Reference Books:

1. Theory of Plates and Shells - S.P.Timoshenko & S.Woinowsky, McGraw Hill Book Co., 1959.
2. Theories and Applications of Plate Analysis Classical, Numerical and Engineering- Rudolf Szilard., John Wiley & Sons Inc, New Delhi, 1963
3. A textbook of Plate Analysis – N K Bairagi, Khanna Publishers, 1959
4. Stresses in Shells – Wilhelm Flugge, Springer Publications, Berlin, 1973
5. Thin Shells – J E Gibson & B G Niel, Elsevier publications, 1980

APM 2245: Advanced Concrete Technology and Prestressed Concrete

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand the basic principles of pre-stressing, materials used, IS codes, system of prestressing, cable profile, cable zone, pressure line etc. including load balancing concept, losses and deflections.

CO2 Analyse prestressing components for flexure, shear, axial, compression, tension, and bond stresses.

CO3 Design the prestressed structures like slab, beam, water tank, pipe and statically indeterminate structure.

CO4 Understand fundamentals of advanced materials for use in concrete, properties of fresh and hardened high performance concrete.

CO5 Design the concrete mixes and apply it in the real-world problems

CO6 Understand durability aspects and apply it to conduct non-destructive testing of concrete for repair/retrofitting the structures and service life prediction of structures.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Concrete Technology: Mix proportioning of ordinary and standard grade of concrete, high strength grade of concrete, self-compacting concrete and mass concrete by latest IS code of practice.	15	25	1,2,3	CO4 CO5	PSO1 PSO3
2	Durability of Concrete and Service Life Prediction of Structures: Durability aspects of concrete under various exposure conditions. Performance and maintenance of concrete structures: conduct of Non-Destructive Tests, repair materials, repair and rehabilitation techniques and service life prediction. Future trends in concrete technology.	15	25	2,3,4,5	CO6	PSO3 PSO4
3	Introduction to Prestressed Concrete: Basics of materials, equipment's and system of prestressing, losses in prestress, transmission zone in pretensioned member, anchorage zone stresses in post tensioned members, redistribution of moments in continuous beams and frames.	15	25	1,2,4,5	CO1 CO2	PSO1 PSO3 PSO4
4	Design of Prestressed Members: Design of prestressed structures like slab, beam, water tank, pipe and statically indeterminate structure by limit state method. Limit state of collapse: flexure, compression, tension, shear, torsion. Limit state of serviceability: deflection, cracking, maximum compression. Reinforcement detailing in prestressed concrete.	15	25	2,3,4,5	CO2 CO3	PSO2 PSO3 PSO4



APM 2245L: Advanced Concrete Technology and Prestressed Concrete

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Practicals

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Site visit – Special types of Concrete	05	30	1,2	CO4	PSO3
2	Site Visit – Technology in prestressed Concrete	10	30	1,2	CO1	PSO3
3	Practical of Mix Proportioning	10	30	4,5	CO5	PSO3
4	Tutorial II	05	10	4,5	CO6	PSO3

Reference Books:

1. Prestressed Concrete by N. Krishna Raju, Tata McGraw-Hill Publishing Co., New Delhi.
2. Prestressed Concrete Structures - Lin T. Y. Asia Publishing House.

APM 2229: Optimization of Structures

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Understanding the basics of optimization and various methods for optimization.

CO2 Learning the application of optimization methods in structural engineering.

CO3 Students will be able to develop computer programs for optimization.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction: Introduction to optimization, optimization Techniques, the concepts of design space, constrain surface and contours of objective functions	15	25	1,2,4,5	CO1	PSO1 PSO3
2	Optimization Techniques: Classical optimization techniques, Linear programming problems, theory and computational aspects of simplex method, Duality theory and its ramifications.	15	25	1,2,5	CO1	PSO1
3	Applications to Real Problems: Applications of linear programming, Nonlinear programming problems, numerical methods of finding the optimum of function of single variable unconstrained optimization. Introduction to geometric, dynamic and integer programming.	15	25	2,3,4,6	CO2 CO3	PSO1 PSO2 PSO4
4	Optimization of the Structure: Optimization of structure, structural design processes, formulation of problems in the optimization of structures, optimization of structural elements, optimum and minimum weight design of structural problems.	15	25	2,3,4,6	CO2 CO3	PSO1 PSO4



APM 2229: Optimization of Structures

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Elective

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Linear programming problems	8	25	1,2	CO1	PSO1
2	Non- linear programming problems	7	25	2	CO1	PSO2
3	Numerical methods for optimization	8	25	2,3	CO2	PSO1 PSO2
4	Structural optimization problems	7	25	3,4	CO3	PSO2

Reference Books:

1. Optimization Theory and Application – S.S.Rao, Wiley Eastern Ltd, New Delhi, 1979.
2. Optimum Design of structures–K.T. Majid, Newnes– Butterworths,1974.
3. Linear Programming – N. Paul, Loomba, Tata Mc Graw Hill Pub, Co. Ltd., New Delhi, 1971.

APM 2230: Stability of Structures

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Able to understand behavior of beams subjected to lateral loads and columns subjected to buckling.

CO2 Able to understand lateral stability of plates and beams.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction: Bending of beams with axial and lateral loads, Axially and eccentrically loaded columns – bifurcation of equilibrium position, southwell plot – inelastic buckling of columns – von karman's reduces modulus theory, Engineer's tangent modulus theory, Experimental & Empirical formula for column design Energy & successive approximation methods as applied to buckling load.	15	25	1,2,4, 5	CO1	PSO1 PSO3
2	Bukling Analysis: Buckling of solid & open web columns with varying section. Buckling of frames. Use of stability function as developed by Merchant. Buckling of columns in torsion and flexure Timoshenko's Bleich and winter approach.	15	25	1,2,5	CO1	PSO1
3	Stability Analysis: Lateral stability of beams with various conditions and loading in elastic lateral buckling.	15	25	2,3,4, 6	CO2	PSO1 PSO2 PSO4
4	Inelastic Analysis: Ultimate strength and stabilities of plates with various edge conditions and effect of stiffness. Introduction to inelastic buckling of plates stowells Lyushin approach.	15	25	2,3,4, 6	CO2	PSO1 PSO4



APM 2230L: Stability of Structures

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Elective

Mode of Transaction: Experiments

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Tutorial 1	8	25	1,2	CO1	PSO1
2	Tutorial 2	7	25	2	CO1	PSO2
3	Tutorial 3	8	25	2,3	CO2	PSO1 PSO2
4	Tutorial 4	7	25	3,4	CO2	PSO2

Reference Books:

1. Theory of Elastic Stability – S.P.Timoshenko & J.M.Gere, McGraw Hill Book Co., New York, 1961.
2. Bulking Strength of Metal Structures – H.Bleich, McGraw Hill Book Co., New York, 1952.



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SUBJECTS OFFERED AT M.E.-I (PART-I)- CIVIL (FRACTURE MECHANICS)

APM 2151: Computer Aided Design

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

- CO1** Create structural analysis and design programs in the spreadsheet package, using built-in functions and Visual Basic for Applications (VBA).
CO2 Create structural analysis and design programs in SCILAB using script file, functions and other programming features.
CO3 Apply Artificial Intelligence (AI) tools such as Artificial Neural Network (ANN) and Genetic Algorithm (GA) in structural Engineering. And Fracture Mechanics.
CO4 Create structural drawings using CAD Commands.
CO5 Apply LISP functions in automation of drafting structural drawings.
CO6 Analyze and design the structures using available software.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Design of structural components by Visual Basics for Application (VBA): Introduction to Spreadsheet package, Built-in and User defined functions, Overview of programming, Structured programming, Control Structures, Procedures with array arguments, Advanced features of procedures and modules, Graphics commands and graph plotting. Implementation of VBA in analysis and design of structural components.	20	30	1,2,3,4,5,6	CO1	PSO1 PSO2 PSO3
2	Software for Technical Computing and its Applications: Basics and commands for matrix operations, graph plotting, Eigen value calculation, script file, functions, Introduction to AI tools.	05	15	1,2,3,4,5,6	CO2	PSO1 PSO2 PSO5
3	Artificial Intelligence (AI) and its Applications in Analysis and Design A Brief Introduction to AI, Basics of Genetic Algorithm (GA), Overview of Artificial Neural Network (ANN), Applications of GA and ANN.	05	10	1,2,3,4,5,6	CO3	PSO1 PSO5
4	CAD and LISP: Computer aided drafting – Principles and concepts. Features of CAD package, Basic drawing tools. Planning and laying out of a drawing using text, dimensions, attributes, Getting and exchanging information. Creating 2D and 3D drawings, Script files and LISP programs.	20	30	1, 2, 3,4,5,6	CO4 CO5	PSO1



5	Introduction to Analysis and Design Software:					PSO1
	Modeling of Structures, Static and Dynamic Analysis, Linear and Non-linear Analysis, Interpretation of Results	10	15	1,2,3,4,5,6	CO6	PSO2 PSO3 PSO4

APM 2151L: Computer Aided Design

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Developing EXCEL programs for design of structural components	5	16	1,2	CO1	PSO1,2,3
2	Developing VBA programs for numerical methods used in Structural analysis	5	17	1,2,3,4,5,6	CO1	PSO1,2
3	Developing VBA programs for structural analysis and design	5	16	1,2,3,4,5,6	CO1	PSO1,2,3
4	Developing SCILAB programs and learning application of ANN AI tools in analysis and design	5	16	1,2,3,4,5,6	CO2 CO3	PSO1,2,5
5	Developing AutoLISP programs for automated drafting	5	16	1,2,3,4,5,6	CO4 CO5	PSO1
6	Developing, analyzing and designing RCC and steel models in the software	5	17	1,2,3,4,5,6	CO6	PSO1,2,3,4

Reference Books:

1. Mastering AutoCAD - George Omura, BPB Publications.
2. The ABC's of Autolisp by George Omura, Sybex Inc.
3. Microsoft EXCEL VBA Programming for Dummies, John Walkenbach, John Wiley & Sons, Inc.
4. Computer Aided Design: Software and Analytical Tools - C. S. Krishnamoorthy and S. Rajeev, Narosa Publishing House, New Delhi, 1991
5. Optimization for Engineering Design by Kalyanmoy Deb, PHI Publisher
6. Genetic Algorithm in Search, Optimization and Machine Learning, David E. Goldberg, Addison-Wesley Longman Publishing Co., Inc., USA
7. A Brief Introduction to Neural Network by David Kriesel

APM 2154: Fracture of Composite Materials

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand the applicability and selection of a composite material for a specific application.

CO2 Analyze the influence of fiber type, volume fraction, interface properties, and stacking sequence on composite fracture performance.

CO3 Analyze mechanics of composite materials.

CO4 Apply constitutive equations of composite materials and understand mechanical behavior at micro and macro level of lamina.

CO5 Understand the analysis of a macro level laminate and application of fracture mechanics to composites.

CO6 Evaluate experimental fatigue and creep test data of composite materials to predict service life and long-term structural performance.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction to Composite Materials: Introduction, different types of fibers used in composites, classification based on matrix - polymer matrix composites, metal matrix composites, ceramic matrix composites mechanics terminology.	10	25	1,2	CO1	PSO1
2	Micromechanical And Macro Mechanical Analysis of a Lamina: Introduction of lamina, volume and mass fractions, density and void content, evaluation of four elastic moduli – strength of materials approach, semi – empirical models, elastic approach and elastic moduli of lamina with transversely isotropic, ultimate strengths of unidirectional lamina, introduction of macro mechanical analysis, Hook's law for different types of materials, Hook's law for a two-dimensional unidirectional lamina.	15	25	2,4,5	CO2 CO3	PSO1 PSO2 PSO4
3	Macro Mechanical Analysis of Laminates: Introduction, stress- strain relations for a laminate, in plane and flexural modulus of a laminate, hygrothermal effects in a laminate, failure criteria of laminate.	15	25	2,3,4,5	CO4 CO5	PSO1 PSO4
4	Fatigue And Creep on Composites: Introduction to fatigue, S-N curves, fatigue crack propagation, damage mechanics of fatigue, creep.	20	25	2,4,5	CO6	PSO3 PSO5



APM 2154L: Fracture of Composite Materials

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Presentation on Introduction of different types of fibers and matrix and it's applications.	2	10	1,2,3	CO1	PSO1
2	Presentation on different types of manufacturing process of composites.	2	10	1,2,3	CO1	PSO1
3	Practice problems based on property determinations for a fiber reinforced composite.	4	15	4,5	CO2	PSO2 PSO4
4	Practice problems based on Elastic modulus calculation of composite materials.	6	20	4,5	CO3	PSO2 PSO4
5	Practice problems based Flexural Modulus of a Laminate	6	15	4,5	CO4	PSO4
6	Practice problems based on fracture toughness of composite.	4	20	4,5	CO4	PSO4
7	Practice problems based on Core Shear Properties of Sandwich Constructions by Beam Flexure based on ASTM C393.	2	5	4,5	CO5	PSO3
8	Case study on fracture on composite structures.	2	5	4,5,6	CO6	PSO4 PSO5

Reference Books:

1. S. P. Shah : "Application of Fracture Mechanisms to Cementitious Composites", Proc. Nato Advanced Research Workshop, Illinois, USA.
2. C. S. Desai and H.J.Siriwardane : "Constitutive laws for Engineering Material with emphasis on Geological Materials", Prentice Hall.
3. K. K. Chawla: "Composite Materials", MRE Springer-Verlag.
4. Leslie Holliday: "Composite Materials", Elsevier Pub. Co.
5. Bryan Harris: "Engineering composites"

APM 2155: Dynamic Behaviour of Structures

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand the fundamentals of dynamics of structure.

CO2 Analyze Computer methods of analysis in vibrations of different medium.

CO3 Apply fundamental concepts, principles and application of earthquake engineering in seismic analysis and design of structures.

CO4 Apply the knowledge of the application of scientific and technological principles of modelling, analysis, design of buildings according to earthquake design philosophy.

CO5 Understand behavior of structures by Equivalent Static and Response-spectrum Analysis using IS 1893 code.

CO6 Analyze and design masonry structures for gravity and seismic loads.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	General Concepts: Introduction to general concept. Systems with one degree of freedom. Free, forced and transient vibrations for structures without and with viscous damping.	09	15	1	CO1	PSO1
2	Single and Multi-Degree of freedom Systems: System with two or more degrees of freedom. Formulation by Lagrange's equations and influence coefficients. Vibration of continuous media, continuous and discrete approaches. Computer methods of analysis in vibrations. System with two or more degrees of freedom. Formulation by Lagrange's equations and influence coefficients. Vibration of continuous media, continuous and discrete approaches. Computer methods of analysis in vibrations.	21	35	1,2,4,5	CO1 CO2	PSO1 PSO2
3	Development of Dynamic Theory: Fundamentals of earthquake engineering. Introduction to methods of earthquake analysis. Idealization of Structures. Equivalent force concepts. Masonry Structures	12	20	1,2	CO3 CO4 CO5	PSO1 PSO2 PSO4
4	Response Spectrum Analysis: Response spectrum analysis of multistory buildings. IS code provisions. Concept of push over analysis.	18	30	1,2,4	CO6	PSO1 PSO3 PSO5



APM 2155L: Dynamic behaviour of Structures

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Periodic time for Simple pendulum.	2	10	1,2	CO1	PSO1
2	Radius of gyration of compound pendulum.	2	10	2	CO1	PSO2
3	Frequency and Periodic time for Helical Springs	4	10	2,3	CO1	PSO1 PSO2
4	Stiffness and Flexibility of Spring systems.	4	10	3,4	CO1	PSO4
5	Verification of Dunkerley's rule.	2	10	2,3	CO2	PSO1 PSO4
6	Radius of gyration using Bi-Filar suspension.	4	10	2,3	CO1	PSO1
7	Undamped free vibration of equivalent spring mass systems.	2	10	3,4	CO1	PSO2
8	Forced vibration of equivalent spring mass systems.	2	10	2	CO3	PSO4
9	Torsional vibration of rotor shaft systems.	4	10	2	CO1	PSO4
10	Analysis of building frame on shake table	4	10	2,3	CO4	PSO2 PSO4

Reference Books:

1. Dynamics of Framed Structures - G.L.Rogers, John Wiley, 1959.
2. Structural Dynamics - J. M. Biggs, McGraw Hill Book Co. 1964.
3. Dynamics of Structures - Theory and Applications to Earthquake Engineering by A. K. Chopra, Prentice-Hall of India Pvt. Ltd., New Delhi, 2001.
4. Structural Dynamics – Theory and Computation by Mario Paz (2nd Edition), CBS Publishers and Distributors, New Delhi, 2001.
5. Elements of Earthquake Engineering by Jai Krishna, A. R. Chandrasekaran and B. Chandra, South Asian Publishers, New Delhi, 1994.
6. IS:1893 “Criteria for Earthquake Resistant Design of Structures”, Bureau of Indian Standards, New Delhi, 2016.

APM 2156: Elementary Fracture Mechanics

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand the basic principles of Fracture Mechanics

CO2 Understand the fundamental concepts of linear elastic fracture and crack interaction.

CO3 Apply the principles of linear elastic and elastic plastic fracture mechanics to characterize the crack

CO4 Evaluate the stress intensity factor of materials.

CO5 Understand the General formalism of J-Integral and the basics of crack tip opening displacement.

CO6 Evaluate the standard experimental fracture mechanics tests and critically interpret test data to determine fracture parameters of engineering materials

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction to Fracture Mechanics: Kinds of failure, historical aspects, brittle and ductile, fracture modes of fracture failure, how potent is a crack, point of view, damage tolerance.	10	10	1	CO1	PSO1
2	Energy Release Rate: Introduction, Griffith's dilemma, surface energy, Griffith's realization, Griffith's analysis energy release rate, energy release rate of DCB specimen, anelastic plastic deformation at crack-tip, crack resistance stable and unstable crack growth R-curve for brittle cracks, thin plate vs thick plate, critical energy release rate.	15	20	2,3,4	CO2	PSO1 PSO2
3	Stress Intensity Factor: Introduction, linear elastic fracture mechanics (LEFM), stress and displacement fields in isotropic elastic materials, stress intensity factor, background for mathematical analysis, Westergaard determination of stress intensity factors, critical stress intensity factor, fracture toughness, SIF of more complex cases.	10	25	2,3,4	CO3 CO4	PSO1 PSO2
4	Elastic Plastic Analysis through J-Integral and CTOD: Relevance and scope, definition of the J-Integral, path independence, stress-strain relation, relationship between CTOD, K and G for small scale yielding, equivalence between CTOD and J.	15	30	2,3,4	CO5	PSO1 PSO2

5 Test Methods:

LEFM testing and plane strain fracture toughness testing, K_{IC}-determination, test methods to determine J_{IC}, test methods to determine G_{IC} and G_{II}, determination of critical CTOD, various experimental testing and capabilities.

10

15

5,6

CO6

PSO2

PSO4

APM 2156L: Elementary Fracture Mechanics

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Case study on five mechanical and structural Failures	2	10	6	CO1	PSO1 PSO2
2	Practice problems based on double cantilever beam	2	10	5	CO2	PSO1 PSO4
3	Practice problems based on crack growth resistance behaviour	4	10	5	CO3	PSO4
4	Practice problems based on fracture toughness	6	20	5	CO4	PSO4
5	Practice problems based on fracture toughness for three-point bend specimen	6	20	5	CO4	PSO2
6	Develop a spreadsheet to calculate stress intensity factor	4	10	6	CO4	PSO1 PSO4
7	Practice problems based on J- integral	2	10	5	CO5	PSO4
8	Practice problems based on CTOD	4	10	5	CO6	PSO1

Reference Books:

1. Elements of Fracture Mechanics, Prashant Kumar, A. H. Wheeler Publishing, 1999.
2. Fracture Mechanics: Fundamentals and Applications, T.L. Anderson, 3rd Edition
3. Elementary Engineering Fracture Mechanics – Broek D., Leyden, Noord Hoff International, 1974.
4. Fundamentals of Fracture of Mechanics – Knott J. F., Halsted Press, 1974.
5. Fracture Mechanics – H. L. Ewalds and R. J. H. Wanhill, Edward Arnold (Publishers) Ltd., London,
6. Introduction to Fracture Mechanics – Kare Hellan, McGraw-Hill Book Co., New York, (Singapore, 1985).

APM 2158: Theory of Elasticity and Plasticity

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Analyze the structure using classical theory of elasticity for 3D problems in Cartesian coordinate.

CO2 Evaluate state of stress and strain by basic equations of elasticity 2D problem of elasticity.

CO3 Analyze the 2D problem of structure using polar coordinates.

CO4 Analyze the torsion problems for non-circular cross section using Cartesian coordinates.

CO5 Analyze the structure using classical theory of plasticity for 2D problems in Cartesian coordinate.

CO6 Apply theory of failures for plasticity problems.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction to theory of Elasticity and Cartesian Co-ordinate System: Generalized Hook's law. Differential Equations of equilibrium, boundary conditions, compatibility equations.	10	16.6	1,2	CO1	PSO1 , PSO2
2	State of stress and strain at a point: State of stress and strain at a point in two dimensions, Hook's law. For 2D problem, Plane stress and plane strain problems in Cartesian coordinates, solution by Airy's stress function, Saint Venant's principle, solution of beam problems.	12	20	1,2,3	CO2	PSO1 , PSO2
3	Polar Co-ordinate System: Two dimensional problems in polar coordinates, General equations. Stress distribution is symmetrical about an axis. pure bending of curved bars, stress concentration	10	16.6	1,2,3	CO3	PSO2
4	Torsion: Problem of torsion, Saint Venant's method. Prandtl's solution using a stress function for various types of engineering sections, a membrane analogy method.	08	13.3	1,2,3	CO4 CO3	PSO2



5	Theory of Plasticity: Plastic stress strain relations, theories of strength. Plastic flow in solid, theory of ideally plastic materials and its applications to thick walled shells.	12	20	1,2	CO5	PSO4
6	Theory of plastic flow: Two-dimensional plastic flow problems and its applications to structural problems. Application of failure theory	08	13.3	1,2,3	CO6	PSO1 , PSO2



APM 2158L: Theory of Elasticity and Plasticity

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	TUTORIAL 1- Elasticity (Cartesian Co-ordinates)	03	3	2,3	CO1	PSO1, PSO2
2	TUTORIAL 2- Elasticity (Numericals of Cartesian Co-ordinates)	03	4	2,3	CO2	PSO1
3	TUTORIAL 3- Elasticity (Polar Co-ordinates)	03	4	2,3	CO3	PSO2
4	TUTORIAL 4- Elasticity (Polar Co-ordinates)	03	4	2,3	CO3	PSO4
5	TUTORIAL 5- Elasticity (Torsion)	03	4	2,3	CO4	PSO4
6	TUTORIAL 6- Plasticity (Stress at a Point)	03	4	2,3	CO5	PSO4
7	TUTORIAL 7- Plasticity (Theory of Failures)	03	4	2,3	CO5	PSO2
8	TUTORIAL 8- Plasticity (Theories of Plastic Flow)	03	3	2,3	CO6	PSO4

Reference Books:

1. Theory of Elasticity - S. Timoshenko and J. N. Goodier, McGraw Hill Book Co. 1970.
2. Structural Mechanics with Introduction to Elasticity & Plasticity - B. Venkataraman and S. A. Patel, Mc Graw Hill Book Co. 1970.
3. Introduction to the Theory of Plasticity for Engineers - Oscar Hoffman & Sachs - Mc Graw Hill Book Co. 1958.
4. Advanced Strength of Materials – Volterra Enrico and I. Gaines, 1971.



Applied Mechanics and Structural Engineering Department,
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SUBJECTS OFFERED AT M.E.-I (PART-II)- CIVIL (FRACTURE MECHANICS)

APM 2256: Advanced Fracture Mechanics

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand the basic principles and applications of Fracture Mechanics

CO2 Understand the fundamental concepts of linear elastic fracture and mixed mode fracture.

CO3 Evaluate the fracture toughness of materials under mixed mode conditions

CO4 Understand the formalism of fracture toughness under stress corrosion cracking

CO5 Understand dynamic and time dependent fracture mechanics

CO6 Understand the micro mechanism of fracture in metals and non-metals

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction to Fracture Mechanics Design Approach : Why structures fail, ductile vs. brittle behavior, notch toughness, fracture mechanics design, fracture criteria, fitness for services, stress analysis for members with crack, the root-mean-square (rms) model.	10	20	1	CO1 CO2 CO3	PSO2
2	Stress Intensity factor in Mixed Mode and Stress Corrosion Cracking: Mixed-mode fracture, the effective-stress intensity factor in mixed mode, crack direction in mixed mode, fracture surface mixed mode crack propagation criteria an example of mixed mode crack growth, crack arresting mechanisms, fracture mechanics approach to scc, experimental procedures, K_{ISCC} -a material property, test duration, crack-growth-rate tests, hydrogen embrittlement, causes and effects, liquid metal embrittlement, causes and effects.	20	30	2,3,4	CO2 CO4 CO5	PSO2 PSO4
3	Dynamic Effects on Crack Propagation: Introduction to dynamic fracture mechanics, drop tests, pressure bar tests, flyer plate tests.	20	30	2,3,4	CO5	PSO2 PSO5
4	Fracture Mechanisms in Metals and Non-Metallic Material: Ductile fracture, cleavage fracture, the ductile-brittle transition, intergranular and transgranular fracture, a mathematical model of cleavage fracture toughness, engineering plastics, ceramics and ceramic composites, concrete and rock.	10	20	1,2,3	CO6	PSO4 PSO5



APM 2256L: Advanced Fracture Mechanics

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Practice Problems Based on GIC	2	10	5	CO1	PSO2 PSO5
2	Practice Problems Based on Double Cantilever Beam	2	5	5	CO1	PSO2 PSO5
3	Practice Problems Based on Crack Growth Resistance Behaviour	2	5	5	CO1	PSO1 PSO5
4	Practice Problems Based on Fracture Toughness	2	10	5	CO2	PSO1 PSO4
5	Practice Problems Based on Fracture Toughness for Three-Point Bend Specimen	4	15	5	CO2	PSO1 PSO4 PSO5
6	Develop A Program to Calculate Stress Intensity Factor for metals and non-metals	6	20	5,6	CO6	PSO5
7	Practice Problems Based on J- Integral	2	10	5	CO5	PSO5
8	Practice Problems Based on CTOD	2	10	5	CO5	PSO2
9	Practice Problems Based on Stress Corrosion Cracking	4	15	5	CO4	PSO2
10	Practice Problems Based on Mixed Mode Fracture	4	10	5	CO2	PSO2

Reference Books:

1. Fracture Mechanics: Fundamentals and Applications, T.L. Anderson, 3rd Edition
2. Elementary Engineering Fracture Mechanics – Broek D., Leyden, Noordhoff International, 1974.
3. Fundamentals of Fracture of Mechanics – Knott J. F., Halsted Press, 1974.
4. The Mechanics of Fracture of Fatigue – A. P. Parkar F & P.N., Spon Ltd., London, 1981.
5. Fracture & Fatigue Control in Structures – Rolfe and Barsom, Prentice Hall Inc., 1977.
6. Fracture Mechanics – H. L. Ewalds and R. J. H. Wanhill, Edward Arnold (Publishers) Ltd., London,
7. Introduction to Fracture Mechanics – Kare Hellan, McGraw-Hill Book Co., N.York, (Singapore, 1985).
8. Elements of Fracture Mechanics, Prashant Kumar, A. H. Wheeler Publishing, 1999.

APM 2257: Numerical Methods in Fracture Mechanics

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

- CO1** Analyze the procedures for 1D and 2D Finite difference method (FDM) and Finite element method (FEM).
- CO2** Apply the FDM and FEM for solving various 1D and 2D structural mechanics problems.
- CO3** Apply various available specialised methods to solve large size FE problems.
- CO4** Apply various co-ordinate systems to develop interpolation functions used in the FE analysis of 1D, 2D and 3D problems.
- CO5** Create computer programs based on FEM and create structural models in standard FE software for their analysis.
- CO6** Analyze the procedure for nonlinear FE analysis of structures and use of FEM for solving Fracture Mechanics problems.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction: Introduction to Numerical Methods, Finite difference method of analysis. Concept and solution procedure for finite element displacement approach, One and two dimensional finite element analysis.	12	30	1,2	CO1 CO2	PSO1
2	Linear Analysis: Calculation of element properties using generalized coordinates for one dimensional bar and beam elements and two-dimensional elements for plane stress, plain strain, plate bending and axisymmetric problems. Introduction to nonlinear analysis. Methods of static condensations and Degradation technique. Substructure Technique and coarse-to-fine sub division method.	13	32	2,3,4	CO2 CO3 CO6	PSO1 PSO2
3	Coordinate systems and interpolation functions: One, two and three dimensional iso-parametric, sub parametric and super parametric elements. Derivation of element properties using natural coordinates. Area and volume coordinates systems. Lagrangian and Hermitian interpolation functions.	07	18	2,3,4	CO4	PSO1 PSO2

4 Dynamic and stability analysis:

Introduction to Dynamic and Stability Analysis by Finite Element Method. Data preparation and overall finite element programming logic. Concept of pre- and post-processing. Use of standard software packages.

08

20

2,3,4,
5,6

CO5

PSO1
PSO4
PSO5

APM 2257L: Numerical Methods in Fracture Mechanics

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Preparing report on FDM, FEM and their comparison. Analysis of 1D and 2D problems by FDM	6	20	1,2,3,4, 5	CO1 CO2	PSO1 PSO2
2	Analysis of 1D and 2D problems and development of element properties of 3D problems in FEM	8	26	2,3,4,5	CO4 CO6	PSO1 PSO2
3	Developing element properties by natural, area and volume coordinate systems. Calculation of element properties by Hermitian and Lagrangian interpolation functions. Development of element properties for 1D, 2D and 3D iso-parametric elements. Analysis of large size problems. Nonlinear problems.	8	27	2,3,4,5	CO3 CO4	PSO1 PSO2
4	Developing flow chart of FEM for computer programming and creating and analyzing structural models in standard FE software.	8	27	2,3,4,6	CO5	PSO1 PSO2 PSO4 PSO5

Reference Books:

1. Numerical Methods in Finite Element Analysis – K. J. Bathe and E. L. Wilson, Prentic-Hall of India, 1990.
2. Introduction to Finite Element Method - C. S. Desai and J. F. Abel, Affiliated East-West Press Pvt. Ltd, New Delhi, 1977.
3. Finite Element Analysis (Theory and Programming) - C. S. Krishnamoorthy, Tata McGraw Hill Pub. Co. Ltd., New Delhi, 1987.
4. The Finite Element Method - O. C. Zienkiewicz, tata McGraw Hill Pub. Co. Ltd., New Delhi. 1979.

APM 2252: Experimental Stress Techniques

Credits/Hours per Week: 03

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand Analytical, numerical, and experimental approach of Experimental Stress Analysis.

CO2 Analyze various techniques involved in stress measurement using strain gauges.

CO3 Analyze the application and working of various types of strain gauges.

CO4 Understand the principle of Photoelasticity and various brittle coating techniques.

CO5 Analyze various structural health monitoring techniques.

CO6 Understand the strain evaluation using strain gauges.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction: Overview of Experimental Stress Analysis: Analytical, numerical and experimental approach - specific domain of this approach, advantages and disadvantages, mechanical, electrical, optical, piezoelectric and acoustical strain gauges, strain rosettes and its examples	20	33	2,3,4	CO1 CO2	PSO2
2	Photo Elasticity: Two and three-dimensional photoelasticity, photo elastic coatings, plane and circular polariscope.	10	18	1,2,3	CO4 CO6	PSO2
3	Strain Measurements: Brittle coating, advantages and disadvantages, types of brittle coating, calibration of coating, crack detection techniques, Moiré fringes and grid techniques.	10	16	1,2,4	CO3	PSO2 PSO4
4	Structural Health Monitoring: Introduction to structural health monitoring, advantages and disadvantages, necessity, static and dynamic SHM, sensor technology, damage detection and assessment.	20	33	3,4,5	CO5	PSO1 PSO2



APM 2252L: Experimental Stress Techniques

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Experiment

No.	Experiment	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Measurement of Resistance of Strain Gauge.	3	10	1,2,3	CO1 CO2	PSO1, PSO2
2	Evaluation of Young's Modulus of Elasticity for Cantilever Steel Beam using Strain Gauge.	3	10	3	CO1 CO2	PSO2, PSO3, PSO4
3	Evaluation of Young's Modulus of Elasticity for Mild Steel Specimen using Strain Gauge.	3	10	1,4,5	CO1 CO2	PSO2, PSO3, PSO4
4	Evaluation of Young's Modulus of Elasticity for Simply Supported Steel Beam using Strain Gauge.	3	10	1,4,5	CO1 CO2	PSO2, PSO3, PSO4
5	Evaluation of Poisson's Ratio for Mild Steel Specimen using Strain Gauge.	3	10	1,4,5	CO1 CO2	PSO2, PSO3, PSO4
6	Evaluation of Young's Modulus of Elasticity for Aluminum Specimen using Strain Gauge.	3	10	1,4,5	CO1 CO2	PSO2, PSO3, PSO4
7	Evaluation of Young's Modulus of Elasticity for Fiber Reinforced Specimen using Strain Gauge.	3	10	1,4,5	CO1 CO2	PSO2, PSO3, PSO4
8	Analysis of Howe Type Truss using Strain Gauges.	3	10	1,4,5	CO1 CO2	PSO2, PSO4
9	Analysis of Warren Type Truss using Strain Gauges.	3	10	1,4,5	CO1 CO2	PSO2, PSO4
10	Study of Fringe Patterns on Photo-Elastic Bench.	3	10	1,2	CO3 CO4	PSO2, PSO4

Reference Books:

1. J.W.Dally and W.F.Riely: "Experimental Stress Analysis", Mc Graw Hill.
2. R.C.Dove and P.H. Adams : "Experimental Stress Analysis", Prentice Hall of India.
3. K. Ramesh: "Digital Photoelasticity-Advanced Techniques and Applications", Springer
4. L. S. Shrinath, M. R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant and K. Ramachandra: "Experimental Stress Analysis", Tata Mc Graw Hill.
5. E-book on Experimental Stress Analysis, K. Ramesh, Published by IIT Madras, India, 2009.
6. Health Monitoring of Structural Materials and Components: Methods with Applications, Douglas E. Adams.

APM 2251: Fracture and Fatigue Control in Structures

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand the basic fracture and fatigue mechanisms.

CO2 Understand the basic yielding and fracture criteria used to predict and control yield and fracture.

CO3 Analyze the interaction between fracture and fatigue under variable amplitude and mixed-mode loading conditions.

CO4 Understand of methodologies for fatigue life assessment of components and welded structures.

CO5 Understand basic techniques used to predict and control fracture.

CO6 Evaluate the fracture- and fatigue-control strategies for the safe design, inspection, and life extension of engineering structures.

Unit No.	Topic/Unit	Cont ct Hour s	Weightage (%)	BT Level	CO	PSO
1	Overview of the Problems in Fracture and Fatigue in Structures: Historical background, fatigue crack initiation, S-N curve, factors affecting fatigue performance, fatigue loading, fatigue testing and NDT techniques, some characteristics of fatigue cracks.	10	15	1,2	CO1	PSO4
2	Fatigue-Crack Propagation under Constant and Variable-Amplitude Load Fluctuation: Fatigue-crack-propagation threshold, crack closer, constant amplitude load fluctuation, variable-amplitude load fluctuation, effect of mean stress on fatigue-crack propagation behavior, effects of stress concentration on fatigue-crack growth, fatigue design examples, single and multiple high-load fluctuations, fracture and fatigue control plan.	25	35	2,4	CO2 CO3	PSO1
3	Applications of Fracture Mechanics - Case Studies: Introduction to importance of fracture toughness and proper fabrication procedures-The Bryte Bend Bridge, AASHTO fracture control plan for steel bridges, Bryte Bend Bridge, brittle fracture, design aspects of the Bryte Bend Bridge as related to the AASHTO fracture control plan (FCP), adequacy of the current AASHTO fracture control plan, Failure in aircraft structures.	10	20	2,3,4, 6	CO4 CO5	PSO5



4 Introduction to Continuum Damage Mechanics:

Damage measurement, definition of damage variable, direct and non-direct measurements, damage growth, crack initiation and crack growth, life prediction.

15

30

1,2,3,
4,6

CO6

PSO1
PSO5

APM 2251L: Fracture and Fatigue Control in Structures

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Recommendation of Specific Design Considerations on Fracture and Fatigue Control Plan.	2	10	1,2	CO1	PSO1
2	Practice Problems Based on Crack Growth and Cyclic Fatigue Failure.	4	10	4,5	CO2	PSO4
3	Practice Problems Based on Crack Propagation Under Cyclic Loading.	4	10	4,5	CO3	PSO1 PSO5
4	Practice Problems Based on Stress-Based Fatigue Design.	4	10	4,5	CO3	PSO2 PSO5
5	Practice Problems Based on Strain-Based Fatigue Design.	4	15	4,5	CO4	PSO1 PSO5
6	A Case Study on Importance of Fracture Toughness and Proper Fabrication Procedures- The Bryte Bend Bridge.	2	10	2,5	CO6	PSO1 PSO5
7	A Case Study Related to Importance of Loading and Inspection – Trans Alaska Pipeline Service Oil Tankers.	4	10	2,5	CO6	PSO1 PSO2
8	A Case Study on Failure Analysis of Lock and Dam Sheet Pilling.	4	15	2,5	CO5	PSO5
9	A Case Study on Importance of Loading Rate on Structural Performance – Burst Tests on Steel Casing.	2	10	2,5	CO5	PSO5

Reference Books:

1. Rolfe and Barsom: "Fracture and Fatigue control in structures-applications of fracture mechanics", Prentice Hall, New Jersey.
2. Seaman, Gran & Curran: "A micro-statical approach to fracture concrete", Proc., Nato Advanced Research Workshop on Application to Fracture Mechanics, P. 349, 1984.
3. R.L. Sierakowski: "Dynamic effects in concrete materials", Proc. Nato Advanced Research Workshop on Application to Fracture Mechanics, P. 391, 1984.
4. Donald J. Wulpi: "Understanding How Components Fails", American society for Metals.
5. International Conference on Fatigue, Corrosion cracking, Fracture Mechanics and Failure Analysis, American Society for Metals, 1985.
6. Donald J. Wulpi: "How Components Fail", American Society of Metals.

APM 2258: Deformation and Fracture of Rock and Concrete

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand the fundamentals of rock mechanics.

CO2 Understand the basic theory of stress-strain.

CO3 Understand the failure criteria of rocks.

CO4 Apply LEFM theory and nonlinear fracture theory to concrete.

CO5 Understand Approximate Nonlinear Fracture Models.

CO6 Understand basics of numerical modelling

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Rock and its Classification: Introduction, the mechanical nature of rock, rock discontinuities and friction stick slip phenomenon and its relation with earthquake, geological and engineering classification of rocks, physical-mechanical properties of rocks, Experimental studies on rock fracture.	10	10	1,2	CO1	PSO4 PSO2
2	Deformation and Failure Theories of Rock: The stress- strain curve, effect of confining stress and temperature, crack propagation and fracture phenomena in rock materials, types of fractures, classical concept of failures, neo-classical theories of failures, modern concepts of failures.	15	35	2,3,4	CO2 CO3	PSO1 PSO4
3	Fracture Mechanics of Concrete: Concepts, five reasons for fracture mechanics' approach, the Two- parameter model, CTOD and Dugdale model, ASTM standards, fracture process zone of concrete, deterioration of concrete.	25	40	2,3,4	CO3 CO4 CO5	PSO4 PSO5
4	Fracture Process in Fiber reinforced Concrete and Fiber Reinforced Cementitious Composites: Introduction, types of fibers, fracture propagation in fiber reinforced concrete, fracture behavior on fiber reinforced cementitious composites	10	15	1,2,3	CO6	PSO1 PSO4 PSO5



APM 2258L: Deformation and Fracture of Rock and Concrete

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Study on Types of Rocks and their Concept of Failures.	2	10	1,2	CO1	PSO4
2	Examples of Stress- Strain in Rocks.	2	10	5	CO2	PSO1
3	Examples Based on Physical-Mechanical Properties of Rock.	2	10	5	CO3	PSO1 PSO5
4	Introduction to Fracture-Based Software.	4	10	2	CO4	PSO1 PSO5
5	Study on Fracture Analysis of Concrete Using Software-I.	4	10	6	CO5	PSO2 PSO5
6	Study on Fracture Analysis of Concrete Using Software-II.	4	10	6	CO5	PSO5
7	Program on Numerical Modelling-I.	6	20	6	CO6	PSO5
8	Program on Numerical Modelling -II.	6	20	6	CO6	PSO5

Reference Books:

1. J. C. Jaeger and N.G.W.Cook : "Fundamentals of Rock Mechanics", Chapman and Hall, London.
2. C.S.Desai and Siriwardone : " Constitutive laws for Engineering Materials with emphasis on Geologic Materials", Prentice Hall INC., Englewood Cliffs NJ 07632.
3. S.P. Shah: "Application of Fracture Mechanics to Cementitious Composites", Proc. Nato Advanced Research Workshop, Illinois, USA.

APM 2224: Selected Topics in Fracture Mechanics

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Student will understand the fundamentals of fracture mechanics.

CO2 Student will acquire a knowledge of crack driving energies.

CO3 Student will understand the fracture properties of different materials.

CO4 Student will learn to implement theories of Stress corrosion cracking.

CO5 Student will understand the process of fatigue crack propagation.

CO6 Student will understand modern application of fracture mechanics.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Effect of Loading Rate, Temperature and Plate Thickness on Fracture Toughness: Plane strain transition temperature behaviour, influence of notch acuity on fracture toughness, loading rate shift for structural steel, crack driving force as related to energy rates, crack intensity factors and j integral, dynamic energy balance, crack instability in thermal residual-stress fields.	10	10	1	CO1 CO2	PSO4 PSO2
2	Fracture Properties of Different Material: Thermal shock problem, nuclear plant piping, case studies, fielding, fracture properties of carbon and alloy steels, wrought stainless steel, titanium alloys, super alloys, design material selections.	10	30	2,3,4	CO2 CO3	PSO1 PSO4
3	Stress Corrosion Cracking Fracture Mechanics Approach: Experimental procedure, crack growth rate tests, corrosion fatigue, general yielding, fracture mechanics, crack opening displacement, practical measurements and results, cleavage fracture, various theories, Thomson's model.	09	25	2,3,4	CO3 CO4	PSO4 PSO5
4	Fatigue Crack Propagation under Constant Amplitude Load Fluctuation: Effect of mean stress, cyclic frequency, wave-form stress, concentration and in homogeneities on fatigue crack growth, fatigue crack propagation under single and multiple variable amplitude load fluctuations, fatigue crack growth under various uni-model distribution curves.	11	15	1,2,3	CO5	PSO1 PSO4 PSO5
5	Applications of Fracture Mechanics: Crack growth by fatigue or stress corrosion mechanism, Laboratory testing based on above techniques. Sustained load fracture, creep rupture, Fracture of non-ferrous metals and non-metallic materials.	10	20	1,2,3	CO6	PSO4 PSO5



APM 2224L: Selected Topics in Fracture Mechanics

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Experimental Test on Carbon and Alloy Steels.	6	20	1,2	CO1	PSO4
2	Test to Calculate SIF of Wrought Stainless Steel.	2	10	5	CO2	PSO1
3	Fatigue Test on Aluminium Alloys.	4	20	5	CO2	PSO1 PSO5
4	Crack Growth Rate Test on Non-Metallic Materials.	2	10	2	CO4	PSO1 PSO5
5	Study on Fracture Analysis of Metals Using Software-I.	4	10	6	CO5	PSO2 PSO5
6	Study on Fracture Analysis of Non-Metals Using Software-II.	4	10	6	CO5	PSO5
7	Program on Numerical Modelling-I.	3	10	6	CO6	PSO5
8	Program on Numerical Modelling -II.	3	10	6	CO6	PSO5

Reference Books:

1. Tetdman A.S. & Mc Evily A.J.: "Fracture of Structural Materials". Wiley, New York, 1967
2. Campbell James E., Gerberich William W. and Underwood John H.: "Application of Fracture Mechanics for Selection of Metallic Materials, American Society for Metal, Park, Ohio, 1982.
3. Popelar and Kanninen: "Advance Fracture Mechanics", Oxford Publ..
4. Parker A. P.: "Mechanics of Fracture", F & P.N. Spon Ltd., London, 1981
5. Ewalds H. L. and R. J.H. Wanhill: "Fracture Mechanics", Edward Arnold Pub. Ltd., London, 1985.



APM 2225: Flaw and Fracture of Structural Metals

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Student will understand the fundamentals of material structures.

CO2 Student will gain an understanding of stress-strain theory.

CO3 Student will learn the true functional behaviour of material variables.

CO4 Student will learn to apply stress corrosion mechanism

CO5 Student will understand the failure concepts.

CO6 Student will have the comprehension of fracture parameters.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Fundamental Concepts of Material Structure: Fundamentals concepts of strength of crystalline engineering materials at atomic, single crystal and polycrystalline levels of association in relation to engineering mechanisms of failure.	10	10	1,2	CO1	PSO4 PSO2
2	Functional Relationship of Stress and Strain: Functional relationship between material variable, state of stress, strain, time, temperature.	20	35	2,3,4,5	CO2 CO3	PSO1 PSO4
3	Failure of Engineering Components: Failure of engineering components by creep, stress rupture, fatigue and brittle fracture, Stress corrosion mechanisms.	20	40	2,3,4	CO3 CO4 CO5	PSO4 PSO5
4	Fracture Parameters: Monotonic modes of fracture during fatigue crack propagation, thermal problems in fracture mechanics.	10	15	1,2,3	CO6	PSO1 PSO4 PSO5



APM 2225L: Flaw and Fracture of Structural Metals

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Experiments

No.	Experiment	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction to Various Structural Materials.	4	10	1,2	CO1	PSO4
2	Fatigue Test on Cast Iron and Mild Steel.	6	30	5	CO2	PSO1
3	Monotonic Mode Test on Aluminium Alloy.	4	10	5	CO2	PSO1 PSO5
4	Stress Corrosion Cracking Test.	6	20	2	CO4	PSO1 PSO5
5	Shear Test on Mild Steel and Cast Iron.	6	20	6	CO5	PSO2 PSO5
6	Compression Test on Cast Iron.	4	10	6	CO5	PSO5

Reference Books:

1. V. Z. Parton and E. M. Morozov: "Elastic Plastic Fracture Mechanics", Mir Publishers, Moscow.
2. H. L. Logan: "The stress corrosion of metals", Wiley, New York, 1966.
3. H. H. Johnson and P. C. Paris: "Subcritical Flow Growth", Engineering Fracture Mechanics.

APM 2226: Fracture and Failure Analysis

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Student will understanding the fundamentals of fracture mechanics.

CO2 Student will acquire a knowledge on the codal provisions.

CO3 Student will understand the engineering approach to failure.

CO4 Student will learn the application of failure theories.

CO5 Student will understand and analyze the failure control plan.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Overview to Fracture Mechanics Applications: Fracture mechanics applications to design, inspection, standards, codes, government safety regulation for structures and buildings and welded structures.	10	10	1	CO1	PSO4 PSO2
2	Failure Parameters and Testing: The engineering approach to component failure, design stresses, critical flow size, fatigue crack growth fracture toughness testing, product testing.	20	35	2,3,4	CO2 CO3	PSO1 PSO4
3	Failure Analysis in Components: Failure analysis of pressure vessels, rotor forgings and aircraft components including failure prediction and product testing, toughness requirements for ferritic materials in nuclear power plant and for steel bridges.	20	40	2,3,4	CO3 CO4	PSO4 PSO5
4	Guidelines to Failure Control: Failure control and structural integrity in military aircraft structures, proposed fracture control guidelines for welded ship hulls, control plan for floating nuclear plant platforms.	10	15	1,2,3	CO5	PSO1 PSO4 PSO5



APM 2226L: Fracture and Failure Analysis

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction to Design and Codal Provisions of Fracture Mechanics.	4	10	1,2	CO1	PSO4
2	Presentation on Failure Analysis on Aircraft Components.	4	10	5	CO2	PSO1
3	Study of AASHTO Fracture Control Plan.	4	10	5	CO2	PSO1 PSO5
4	Fracture Toughness Testing on Mild Steel.	6	20	2	CO4	PSO1 PSO5
5	Fatigue Test on Cast Iron.	6	20	6	CO5	PSO2 PSO5
6	Three Point and Four Bend Tests on Mild Steel.	6	30	6	CO5	PSO5

Reference Books:

1. R. B. Madison: "Application of Fracture Mechanics to Bridges", Britz Engg. Laboratory report no. 335.2, Lehigh University, Inst. of Research, 1969.
2. S. T. Rolfe, Rhea: "Fracture Control guidelines for welded steel ship hulls", SSC-224, Washington D. C. 1974.
3. J. Hodgson: "Brittle Fracture in Welded Ships", Quarterly Transaction, Royal Institute of Naval Architecture (London) R. N. 100, No.3, July, 1958.
4. Rolfe and Barsom: "Fracture and fatigue control in structure", Prentice Hall, INC, 1977.

APM 2227: Microfracture Mechanisms of Metals

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Student will understanding the fundamentals of deformation.

CO2 Student will learn the basic theory of ductile and brittle fracture.

CO3 Student will understand the cleavage crack propagation.

CO4 Student will understand microscopic and macroscopic aspects of deformation.

CO5 Student will learn about environmental fractures.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction to Deformation in Metals: Review of microscopic aspects of plastic deformation, microscopic aspects of cleavage crack propagation, microscopic aspects of normal rupture.	10	10	1	CO1	PSO4 PSO2
2	Ductile Fracture: Cleavage crack nucleation, the ductile-brittle transition in flow free low strength materials.	15	35	2,3,4	CO2 CO3	PSO1 PSO4
3	Microscopic and Macroscopic Aspects: Relation between the microscopic and macroscopic aspects of plane strain fracture, microscopic aspects of fatigue crack nucleation and growth.	25	40	2,3,4	CO3 CO4	PSO4 PSO5
4	Environmental fractures: Fractures at high temperature, other environmental aspects for fractures.	10	15	1,2,3	CO5	PSO1 PSO4 PSO5



APM 2227L: Microfracture Mechanisms of Metals

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Study on Types of Failures.	4	10	1,2	CO1	PSO4
2	Tension and Compression Test on Mild Steel.	4	10	5	CO2	PSO1
3	Flexure Test on Aluminium Alloys.	6	30	5	CO2	PSO1 PSO5
4	Introduction to Ansys Software.	8	30	2	CO4	PSO1 PSO5
5	Study on Fracture Analysis of Aluminum Using Software.	4	10	6	CO5	PSO2 PSO5
6	Study on Fracture Analysis of Mild Steel Using Software.	4	10	6	CO5	PSO5

Reference Books:

1. R. W. Hertzberg: "Deformation and Fracture Mechanics of Engineering Materials", John Wiley, 1974.CO3
2. A. S. Tetelman and A. J. McEvily: "Fracture of Structural Materials", John Wiley, 1967.
3. H. Liebowitz: "Fracture: An Advanced Treatise", Vol.- I Microscopic and Macroscopic Fundamentals.
4. Election Fractography, ASTM, Special Technical Publication, No. 436, 1967.
5. Proceedings of Recent Internal Conferences on Fracture.

APM 2228: Nondestructive Testing Techniques

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Student will understand the fundamentals of fracture mechanics.

CO2 Student will learn the fundamentals of testing.

CO3 Student will understand the principles of test.

CO4 Student will learn the application of NDT techniques.

CO5 Student will understand and analyze the material behaviour under NDT.

CO6 Student will acquire a knowledge about the techniques for different activities.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Fundamental Principles of Testing: Fundamental principles of nondestructive testing of materials.	10	10	1	CO1 CO2	PSO4 PSO2
2	Principles and Description of Test Methods: Visual examinations, leakage testing, penetration methods, magnetic methods, acoustic methods, electrical methods, photoelasticity methods.	20	35	2,3,4	CO2 CO3 CO4	PSO1 PSO4
3	Principles and Description of Test Methods: Thermal tests, mechanical methods, radiographic methods, ultrasonic methods, holography, special technique of thickness measurements, microwave inspection methods.	20	40	2,3,4	CO2 CO3 CO4	PSO4 PSO5
4	Applications of NDT Techniques: Typical applications of the above methods to manufactured components, castings, forgings, weldments, structural elements, concrete, <u>rocks</u>	10	15	1,2,3	CO5 CO6	PSO1 PSO4 PSO5



APM 2228L: Nondestructive Testing Techniques

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Study of Various NDTs.	2	10	1,2	CO1	PSO4
2	Compressive Test on Concrete.	2	10	5	CO2	PSO1
3	Tensile Test on Concrete.	2	10	5	CO2	PSO1 PSO5
4	Crack Growth Rate Test on Concrete.	2	10	2	CO4	PSO1 PSO5
5	Study on Fracture Analysis of Concrete Using Software.	6	20	6	CO5	PSO2 PSO5
6	Rebound Hammer Test Demonstration.	4	10	5	CO5	PSO5
7	Develop a Program for Numerical Modelling for Concrete.	6	10	6	CO6	PSO5
8	Develop a Program for Numerical Modelling for FRC.	6	20	6	CO6	PSO5

Reference Books:

1. W. J. McGonole: "Non-destructive testing", Gordon and Branch, New York, 1961.
2. J. H. Lemble: "Principles and Practice of Non-destructive Testing", Metals Handbook-Vol.II (eight edition), ASM Metals Park, OHIO 44073
3. H. E. Davis, G. E. Troxell and G. F.W. Hauck: "The Testing of Engineering Materials", McGraw – Hill International Book Co., New York, 1982.
4. Rohert M. C. Master: "Non-destructive testing Hand book", Published by American Society for Non-destructive Testing and American Society for Metals



**SUBJECTS OFFERED
AT M.E.-I (PART-I)-
CIVIL
(GEOTECHNICAL
ENGINEERING)**



**Applied Mechanics and Structural Engineering Department,
Faculty of Technology and Engineering,
The Maharaja Sayajirao University of Baroda.**

APM 2160: Computer Aided Design

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

- CO1** Create structural analysis and design programs in the spreadsheet package, using built-in functions and Visual Basic for Applications (VBA).
CO2 Create structural analysis and design programs in SCILAB using script file, functions and other programming features.
CO3 Apply Artificial Intelligence (AI) tools such as Artificial Neural Network (ANN) and Genetic Algorithm (GA) in structural Engineering and geotechnical Engineering.
CO4 Create structural drawings using CAD Commands.
CO5 Apply LISP functions in automation of drafting structural and geotechnical drawings.
CO6 Analyse and design the structures using available softwares.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Design of structural components by Visual Basics for Application (VBA): Introduction to Spreadsheet package, Built-in and User defined functions, Overview of programming, Structured programming, Control Structures, Procedures with array arguments, Advanced features of procedures and modules, Graphics commands and graph plotting. Implementation of VBA in analysis and design of structural components.	20	30	1,2,3,4,5,6	CO1	PSO1 PSO2 PSO3
2	Software for Technical Computing and its Applications: Basics and commands for matrix operations, graph plotting, Eigen value calculation, script file, functions, Introduction to AI tools.	05	15	1,2,3,4,5,6	CO2	PSO1 PSO2 PSO5
3	Artificial Intelligence (AI) and its Applications in Analysis and Design A Brief Introduction to AI, Basics of Genetic Algorithm (GA), Overview of Artificial Neural Network (ANN), Applications of GA and ANN.	05	10	1,2,3,4,5,6	CO3	PSO1 PSO5
4	CAD and LISP: Computer aided drafting – Principles and concepts. Features of CAD package, Basic drawing tools. Planning and laying out of a drawing using text, dimensions, attributes, Getting and exchanging information. Creating 2D and 3D drawings, Script files and LISP programs.	20	30	1, 2, 3,4,5,6	CO4 CO5	PSO1



5	Introduction to Analysis and Design Software:						PSO1
	Modeling of Structures, Static and Dynamic Analysis, Linear and Non-linear Analysis, Interpretation of Results	10	15	1,2,3,4,5,6	CO6		PSO2 PSO3 PSO4

APM 2160L: Computer Aided Design

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Developing EXCEL programs for design of structural components	5	16	1,2	CO1	PSO1,2,3
2	Developing VBA programs for numerical methods used in Structural analysis	5	17	1,2,3,4,5,6	CO1	PSO1,2
3	Developing VBA programs for structural analysis and design	5	16	1,2,3,4,5,6	CO1	PSO1,2,3
4	Developing SCILAB programs and learning application of ANN AI tools in analysis and design	5	16	1,2,3,4,5,6	CO2 CO3	PSO1,2,5
5	Developing AutoLISP programs for automated drafting	5	16	1,2,3,4,5,6	CO4 CO5	PSO1
6	Developing, analyzing and designing RCC and steel models in the software	5	17	1,2,3,4,5,6	CO6	PSO1,2,3,4

Reference Books:

1. Mastering AutoCAD - George Omura, BPB Publications.
2. The ABC's of Autolisp by George Omura, Sybex Inc.
3. Microsoft EXCEL VBA Programming for Dummies, John Walkenbach, John Wiley & Sons, Inc.
4. Computer Aided Design: Software and Analytical Tools - C. S. Krishnamoorthy and S. Rajeev, Narosa Publishing House, New Delhi, 1991
5. Optimization for Engineering Design by Kalyanmoy Deb, PHI Publisher
6. Genetic Algorithm in Search, Optimization and Machine Learning, David E. Goldberg, Addison-Wesley Longman Publishing Co., Inc., USA
7. A Brief Introduction to Neural Network by David Kriesel

APM 2167: Advances in Soil Mechanics

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Identify problematic soil

CO2 Analyze and estimate settlements of structures by various methods

CO3 Evaluate the advanced aspects of shear strength of soil and basic aspects of mechanics of unsaturated soil.

CO4 Analyze flexible retaining walls.

CO5 Apply knowledge of various methods for soil improvement techniques and their suitability for problematic soil.

CO6 Analyze and Design Prefabricated Vertical Drain and Stone column

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Types of Clay/Granular Soil Structures and Settlement Analysis: Recent studies in clay water system - clay structures and packing models in granular materials, geotechnical properties of problematic soils, seepage through saturated and partly saturated soils, recent methods of settlement computation.	15	25	1,2,4	CO1 CO2	PSO1
2	Advanced Techniques of Evaluation of Strength Parameters & Effective Stress: Advanced techniques of evaluation of consolidation and strength parameters, pore pressure parameters; stress path method, rheological models, effective stress concepts of saturated and unsaturated soils.	15	25	3,4	CO3	PSO2
3	Earth Pressure Theories & Sheet Pile Walls: Classical and new earth pressure theories, anchored bulk head - Rowe's moment reduction; diaphragm walls, sheet piles.	10	17	2,3,4	CO4	PSO2
4	Ground Improvement Techniques and Topics of Unsaturated Soil Mechanics: Geodrains, stone column, different methods of soil densification, behavior of unsaturated soils-basic physics, phases and stress state variables, measurement and control of suction: methods and applications, measurement of shear strength and shear behavior.	20	33	2,3,4, 5,6	CO5 CO6	PSO1 PSO2 PSO3



APM 2167L: Advances in Soil Mechanics

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Laboratory Experiments

No.	Laboratory Experiments	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Unconsolidated Undrained, Consolidated Undrained, Consolidated Drained, Constant Water Content Triaxial Test with Measurement of Pore Pressure	4	13	1,2,3,4,5	CO2	PSO1
2	Stress Path Testing in the Triaxial Apparatus	3	10	1,2,3,4,5	CO2	PSO1
3	Triaxial Test using the Osmotic Technique	3	10	1,2,3,4,5	CO2	PSO1
4	Study of Psychrometers	3	10	1,2,3,4,5	CO2	PSO1
5	The Filter Paper Method for Suction Measurement	3	10	1,2,3,4,5	CO2	PSO1
6	Rowe Oedometer for Study of Radial Drainage	4	13	1,2,3,4,5	CO2	PSO1
7	Swelling Potential of Expansive Soil	3	10	1,2,3,4,5	CO1	PSO1
8	Determination of Skempton Pore Pressure Parameters from Triaxial Test	2	7	1,2,3,4,5	CO2	PSO1
9	Study of Pressure Meter Test	2	7	1,2,3,4,5	CO1	PSO1
10	Static Cone Penetration Test	3	10	1,2,3,4,5	CO1	PSO1

Reference Books:

1. T. William Lambe & Robert V. Whitmann, Soil Mechanics, 2012, Wiley India Pvt. Ltd.
2. R.N.Yong and Benno P. Warkentin, Soil Properties and Behaviour, 2012, Elsevier Publisher
3. A.S.Rao and Gopal Ranjan, Basics and applied soil mechanics, 3rd edition, 2016, New Age International Pvt. Ltd.
4. Alam Singh and Parag Rastogi, Modern Geotechnical Engineering, 3rd edition, 2006, CBS Publishers and Distributors.
5. Fang and Winterkorn, Foundation Engineering Hand book, 2010, Galgotia Book source.
6. Bowles, J. E., Foundation analysis and design, 5th edition 2001, McGraw Hill Education.
7. Charles W.W. Ng and Bruce Menzies, Advanced Unsaturated Soil Mechanics and Engineering, 2007, CRC press.
8. K.H. Head, Manual of Soil Laboratory testing, 3rd edition 2014, Whittles Publisher

APM 2164: Earthquake & Vibration Resistant Structures

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand the concepts of various vibration systems.

CO2 Analyze earthquake ground motion data.

CO3 Evaluate the dynamic properties of soil/rock.

CO4 Evaluate soil liquefaction.

CO5 Analyze the slope stability, foundations and retaining structures for earthquake conditions.

CO6 Analyse and Design various types of machine foundations.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Theory of Vibration & Wave Propagation: Theory of vibrations: free vibrations, forced vibrations, damping, isolation techniques.	15	25	1,2,3, 4	CO1	PSO6
2	Seismology & Earthquakes: Earthquake - seismic zoning, causes of earthquakes, geological hazards, magnitude and intensity of earthquake and soil behavior due to earthquake waves, ground motion measurements.	15	25	1,2,3, 5	CO2	PSO6
3	Dynamic Properties & Liquefaction of Soil: Design parameters for foundation and retaining structures, vibrations soil resistance, liquefaction of soils and related problems.	15	25	1,2,3, 4,5	CO3 CO4	PSO6
4	Design of Structures Subjected to Dynamic Force: Design methods of machine foundations, hydrodynamic pressures on earth, rockfill, concrete and masonry dams.	15	25	1,2,3, 4,6	CO5 CO6	PSO6 PSO2



APM 2164L: Earthquake & Vibration Resistant Structures

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Laboratory Experiments

No.	Laboratory Experiments	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Cyclic Triaxial Test	3	10	1,2,3,4	CO3	PSO1 PSO6
2	Cyclic Plate Load Test	3	10	1,2,3,4	CO3	PSO1 PSO6
3	Block Vibration Test	3	10	1,2,3,4	CO3	PSO1 PSO6
4	Ultra-Sonic Pulse Velocity Test	3	10	1,2,3,4	CO3	PSO1 PSO6
5	Piezoelectric Bender Element Test	3	10	1,2,3,4	CO3	PSO1 PSO6
6	Resonant Column Test	3	10	1,2,3,4	CO3	PSO1 PSO6
7	Seismic Refraction Survey	3	10	1,2,3,4	CO3	PSO1 PSO6
8	Seismic Cross Hole Survey	3	10	1,2,3,4	CO3	PSO1 PSO6
9	Seismic Up Hole Survey	3	10	1,2,3,4	CO3	PSO1 PSO6
10	Seismic Down Hole Survey	3	10	1,2,3,4	CO3	PSO1 PSO6

Reference Books:

1. T. H. Hanna, Foundation Instrumentation, 1973, Trans Tech Publication
2. Dunnicliff, John, Geotechnical instrumentation for monitoring field performance, 1988.
3. Singh Alam, "Geotechnical Testing and Instrumentation" Asia Publications. 1982.
4. I.S.- 2974 (Part 1,2,3), 1893, 13372, 5249.
5. Shamsheer Prakash, Soil Dynamics, 1981, McGraw Hill Higher Education
6. Bharat Bhushan Prasad, Fundamentals of Soil Dynamics and Earthquake Engineering, 2009, Prentice Hall India Learning Pvt. Ltd.
7. Bharat Bhushan Prasad, Advanced Fundamentals of Soil Dynamics and Earthquake Engineering, 2010, Prentice Hall India Learning Pvt. Ltd.
8. N.S.V. Kameswara Rao, Vibration Analysis and Foundation Dynamics, 1998, Wheeler Publishing

APM 2168: Rock Mechanics

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand application and classification of intact rock and rock mass.

CO2 Analyze different types of stresses acting on rock to measurement of in-situ stresses on rock.

CO3 Evaluate Bearing capacity and slope stability of rock slopes.

CO4 Evaluate Engineering Properties of intact rocks.

CO5 Apply the concept of different stress strain theories to evaluate different rock engg problems.

CO6 Evaluate Deformation behaviour of rock through different rock classification system.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction and Rock Mass Classification: Introduction, definitions, application of rock mechanics, classification of intact rocks, geological classification, geotechnical classification, RMR(rock mass rating), Q-SYSTEM(rock mass quality), GSI SYSTEM (geotechnical strength index).	15	25	1,2,3	CO1	PSO2
2	Failure Theories, Bearing Capacity and Rock Slope Stability: Strength criteria for intact rock, rock strength criteria by Coulomb-Navier, Griffith's (1924), McClintock and Walsh(1962), empirical failure criteria by Bieniawski (1974), Hoek and Brown (1980), bearing capacity of shallow foundation using codal provision, stability of rock slope: circular failure, wedge failure, plane failure, toppling failure.	15	25	1,2,4	CO2 CO3	PSO2
3	Mechanical/Geotechnical Properties of Rock: Properties of intact rocks, types of specimens for testing uniaxial compressive strength tests, tolerance limits and requirements, preparation of specimen, factors affecting UCS, modes of failure, stress strain curves, post failure behaviour, shear tests, triaxial strength test, Coulomb's theory, Mohr envelope and p-q plots.	15	25	2,3,4	CO4 CO5	PSO1
4	Estimation of Stresses in Rock Mass and Deformational Behaviour of Rock: Absolute stress measurement in rocks, deformational behaviour of jointed rocks, definitions, computation of modulus of deformation through RMR, Q system, GSI, constitutive modelling.	15	25	1,2,3, 4,5	CO6	PSO1 PSO2



APM 2168L: Rock Mechanics

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Laboratory Experiments

No.	Laboratory Experiments	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Physical Properties of Rock	4	13	1,2,3,5	CO4	PSO1
2	Direct Tensile Strength of Rock	4	13	1,2,3,5	CO4	PSO1
3	Brazilian Test	4	14	1,2,3,5	CO4	PSO1
4	Point Load Test	4	13	1,2,3,5	CO4	PSO1
5	Ring Test	4	13	1,2,3,5	CO4	PSO1
6	Uniaxial Compressive Strength Test	4	14	1,2,3,5	CO4	PSO1
7	Triaxial Compression Test	3	10	1,2,3,5	CO4	PSO1
8	Flexure Strength Test	3	10	1,2,3,5	CO4	PSO1

Reference Books:

1. Jaeger, JG, Cook, NGW and Zimmerman, RW, Fundamentals of Rock Mechanics. 4th Ed., Singapore, 2007, Blackwell Publishing.
2. L Obert, W.I. Duvall, Rock Mechanics & Design of structural in rock, 1967, John Wiley & Sons Inc.
3. O.C. Zienkiewicz and K.G. Stagg, Rock Mechanics in Engineering Practice, 1968, Horizon Pubs and Distributors Inc.
4. Hudson. J.A and John P. Harrison, Engineering rock mechanics, 2000, Elsevier Science.
5. Singh B. and Goel R.K., Rock Mass Classification- A Practical Approach in Civil Engineering, 1999, Elsevier Science.
6. Goodman, RE. Introduction to Rock Mechanics, 1989, John Wiley & Sons.
7. Hoek, E and Bray, JW, Rock Slope Engineering. The Institution of Mining and Metallurgy, London, 1977.
8. Hoek, E and Brown, ET Underground Excavations, 1988, Spon Press.

APM 2118: Modern Testing Techniques in Geotechnical Engineering

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Knowledge of Advanced instruments for microstructure analysis, liquefaction analysis and geophysical investigation of soil or rock.

CO2 To Study modern instrument with computer interface for advanced analysis of soil properties.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Microstructure Analysis of Soil and Rock: Microscopic and EDAX analysis of soil and rock structures. Use of data acquisition system with printer interfaced with computer for evaluation of soil parameters.	15	25	2,3,4, 5,6	CO1 CO2	PSO1 PSO4
2	Stress Path Analysis of Soil and Rock using Sophisticated MTS: Use of sophisticated MTS closed loop electro-hydraulic test system for stress-path analysis of soils and rocks.	15	25	2,3,4, 5	CO1 CO2	PSO1 PSO4
3	Liquefaction Analysis of Soil: Liquefaction study of fine sands using dynamic load actuators and load cells.	15	25	2,3,4, 5,6	CO1 CO2	PSO1 PSO4
4	Dynamic Analysis and Centrifuge Modelling of Geotechnical Structures and Geophysical Testing of Soil and Rock: Use of electro-dynamic system for dynamic stability of model. Centrifuge modelling of earth dams and offshore structures, advanced techniques of geophysical investigations of marine and submarine soil deposits.	15	25	2,3,4, 5,6	CO1 CO2	PSO1 PSO4 PSO6



APM 2118L: Modern Testing Techniques in Geotechnical Engineering
Credits/Hours per Week: 02 **Maximum Marks/Grade: 50**
Type: Elective **Mode of Transaction: Laboratory Experiments**

No.	Laboratory Experiments	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Study of Microscopic Structure of Different Clay and Rock Minerals	6	20	1,2,3,4	CO1 CO2	PSO1 PSO4
2	UU, CU and CD Triaxial Test with Data Acquisition System	6	20	1,2,3,4	CO1 CO2	PSO1 PSO4
3	Evaluation of Shear Strength Parameters using Stress Path Method on MTS	6	20	1,2,3,4	CO1 CO2	PSO1 PSO4
4	Study of Liquefaction Potential of Soil Using Cyclic Triaxial Test on MTS	6	20	1,2,3,4	CO1 CO2	PSO1 PSO4
5	Rowe Oedometer Test with Measurement of Pore Pressure and Settlement	6	20	1,2,3,4	CO1 CO2	PSO1 PSO4

Reference Books:

1. Dunnicliff, John - Geotechnical instrumentation for monitoring field performance, 1993, Wiley Interscience.
2. Koerner, R. M., Advances in Geotechnical Engineering, 1992, National Academy Press.
3. Alam Singh, Soil Engineering Theory and Practice – Vol.II (Geotech Testing and Inst.), 1990, CBS Publication.
4. Hanna T. H., Foundation Instrumentation, 1973, Trans Tech Publication.
5. Head, Manuals of Laboratory Testing, 1984, Pentech Press.

APM 2119: Theory of Elasticity and Plasticity

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Students will get knowledge of analysis of stress and strain in two and three dimensions for the analysis of footing, retaining wall, tunnels and excavations in soil/ rock.

CO2 Students will learn about the constitutive relationship for elastic, elasto-plastic and ideally plastic materials which is required for analysis of structures and applications of numerical methods.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Analysis of Stress and Strain in Two Dimensions: General equations of stress and strains in two dimensions, conditions of compatibility, plane stress and plain strain problems of footing and retaining walls.	15	25	2,3,4, 5,6	CO1 CO2	PSO1 PSO2
2	Analysis of Stress and Strain in Three Dimensions and Failure Theories: Stress functions in cartesian and polar co-ordinates, principles of virtual work and minimum energies, general theory and basic law of stress and strain and theory of strength.	18	29	2,3,4, 5	CO1 CO2	PSO1 PSO2
3	Use of Plasticity Theory: Plastic stress-strain relation for tunnels in rocks, plastic flow in solids, theory of ideally plastic materials and its applications to thick-walled shells.	17	29	2,3,4, 5,6	CO1 CO2	PSO1 PSO2
4	Expansion of Cylindrical and Spherical Cavities in Soil Mass: Expansion of cylindrical and spherical cavities in soil mass.	10	17	2,3,4, 5,6	CO1 CO2	PSO1 PSO2



APM 2119L: Theory of Elasticity and Plasticity

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Tutorial

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Problems Based on Plane Stress and Plain Strain State of Footing and Retaining Walls	8	27	3,4,5,6	CO1 CO2	PSO1 PSO2
2	Problems Based on Principles of Virtual Work and Minimum Energies	7	23	3,4,5,6	CO1 CO2	PSO1 PSO2
3	Problems Based on Plastic Stress-Strain Relation for Tunnels in Rocks	8	27	3,4,5,6	CO1 CO2	PSO1 PSO2
4	Problems Based on Expansion of Cylindrical and Spherical Cavities in Soil Mass	7	23	3,4,5,6	CO1 CO2	PSO1 PSO2

Reference Books:

1. Timoshenko S.P. and Goodier J.N, Theory of Elasticity, 3rd edition, 1970, McGraw-Hill Publishers.
3. Harold Malcolm Westergaard, Theory of Elasticity and Plasticity, 1952, Harvard University Press.
4. Sadhu Singh, Theory of Elasticity and Plasticity, 1978, Khanna Publishers.
5. Hoffman and Sacks, Introduction to Theory of Plasticity for Engineers, 2012, Literary Licensing LLC
6. W.T. Wang, Applied Elasticity, 1963, McGraw-Hill Publishers.
7. E.P. Unksov, An Engineering Theory of Plasticity, 1961, Butterworths.



APM 2120: Constitutive Modelling

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Understand the concepts of constitutive modelling.

CO2 Students will be able to determine settlement of soil using constitutive equations.

CO3 Learning analysis of stresses in rock using elasto-plastic constitutive relationship.

CO4 Students will be able to develop numerical modeling for getting soil response under cyclic loading condition.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Concept of Constitutive Modelling: Concepts of constitutive modelling, strain components of stress and strain, strain and stress tensor.	15	25	2,3,4, 5,6	CO1	PSO1 PSO2
2	Settlement Analysis using Constitutive Equations: Constitutive equations for settlement behaviour of soils.	15	25	2,3,4 5	CO2	PSO1 PSO2
3	Different Types of Constitutive Relationships and Models: Elasto-plastic, visco plastic constitutive relationships for rock material, quasilinear and plasticity models, recent developments.	15	25	2,3,4, 5,6	CO3	PSO1 PSO2
4	Numerical Modelling of Soils Response to Cyclic Loading: Numerical modelling of soils response to cyclic loading using stress reversal surfaces.	15	25	2,3,4, 5,6	CO4	PSO1 PSO2



APM 2120L: Constitutive Modelling

Credits/Hours per Week: 02

Type: Elective

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Problems Based on Strain and Stress Analysis	8	27	3,4,5,6	CO1	PSO1
2	Problems of Settlement Calculation Based on Constitutive Equations	8	27	3,4,5,6	CO2	PSO2
3	Problems Based on Elasto-Plastic - Viscoplastic Constitutive Relationships for Rock Material	7	23	3,4,5,6	CO3	PSO2
4	Development of Numerical Model for Soils Response to Cyclic Loading Using Stress Reversal Surfaces	7	23	3,4,5,6	CO4	PSO5

Reference Books:

1. Dungar and Studer, Geotechnical modeling, 1986, Balkema Publishers.
2. C.S. Desai and Siriwardane, Constitutive Laws for Engineering Materials, 1984, Prentice-Hall.
3. C.S. Desai and Gall, Int. Conf. on Constitutive laws for Engineering materials, 1983.
4. Scolt C. R., Development in Soil Mech.-I, 1978, Applied Sc. Pub. Ltd., London.
5. Ziekiewilz O. C., The Finite Element Method, 3rd Edition, 1977, McGraw-Hill, New York.

APM 2121: Geotechnical Instrumentations

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Understand load, stress, strain, pore pressure, settlement, and inclination measuring various types of instruments and its working in the different geotechnical structures.

CO2 Understand executing and monitoring of health of the structure.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Load Measurement: Mechanical load cells, photo elastic load indicators, strain gauged load cells, vibrating wire load cells, load cells in piles.	15	25	2,3,4, 5	CO1	PSO1 PSO4
2	Pore Pressure Measurement: Piezometers - requirement, time lag, sources of errors; piezometer types: open stand pipe, porous and tube, electrical piezometers, air-pneumatic piezometer; installation, observations, recordings techniques.	15	25	2,3,4, 5	CO1	PSO1 PSO4
3	Earth Pressure/Ground Movement Measurement: Cell design, types of pressure cells, measurement of ground movements: bench mark settlement probe, heave gauge, triangulation, laser beam, hydraulic settlement gauge, bore hole extensometer tube settlement gauges, cross-arm, displacement measurement of ground motion by seismograph, measurements inclinometers.	15	25	2,3,4, 5	CO1	PSO1 PSO4
4	Installation Methods of Instruments in Various Structures and Monitoring: Installation methods of instrumentation in diaphragm walls, earth and rock fill dams and masonry and concrete dams, field performance and monitoring; general guide lines on the execution of monitoring programs.	15	25	2,3,4, 5,6	CO2	PSO1 PSO4



APM 2121L: Geotechnical Instrumentations

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Elective

Mode of Transaction: Laboratory Experiments

No.	Laboratory Experiments	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Model Plate Load Test Using Load Cell for Measuring Load and Earth Pressure Cell for Measuring Earth Pressure at a Particular Depth below Plate	8	27	1,2,3,4	CO1 CO2	PSO1 PSO4
2	UU, CU and CD Triaxial Test with Data Acquisition System	8	27	1,2,3,4	CO1 CO2	PSO1 PSO4
3	Measurement of Ground Movement	6	20	1,2,3,4, 5,6	CO1 CO2	PSO1 PSO4
4	Rowe Odometer Test with Measurement of Pore Pressure and Settlement	8	26	1,2,3,4, 5,6	CO1 CO2	PSO1 PSO4

Reference Books:

1. Hanna T. H., Foundation Instrumentation, 1973, Trans Tech Publication.
2. Dunnicliff, John - Geotechnical instrumentation for monitoring field performance, 1993, Wiley Interscience.
3. Singh Alam, Geotechnical Testing and Instrumentation, 1982, Asia Publications.
4. I.S. 6524, 6532, 7356, 8282 (Part- I, II), 12949, 14248, 14750 relevant to Geotechnical Instrumentation.

APM 2162: Numerical Methods in Geotechnical Engineering

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Analyze engineering stress strain behavior including failure of the material under different types of forces.

CO2 Understand Constitutive relationship for soil and rock.

CO3 Understand and apply the basic concept of the Variational Calculus.

CO4 Understand the concept of the finite element method, finite difference method and boundary element method.

CO5 Evaluate the problems using the concept of the finite element method.

CO6 Evaluate engineering problems through different Numerical analysis.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Theory of Elasticity, Plasticity & Constitutive Modeling: Concept of constitutive modeling, elements of theory of elasticity and plasticity, elasto-plastic, visco-plastic constitutive relationships for soil and rock materials, quasilinear and plasticity models.	17	28	3,4,5	CO1 CO2	PSO1
2	Introduction to Variational Calculus and Various Numerical Methods: Variational calculus: Euler-Lagrange, Rayleigh-Ritz and Galerkin methods, numerical methods, matrix methods, finite difference method, boundary element method – concepts.	15	25	3,4	CO3 CO4	PSO1 PSO5
3	Finite Element Method: Finite element discretization, displacement models, natural and general co-ordinate systems, derivation of properties of one- and two-dimensional elements, iso-parametric elements, stiffness matrix and load vectors, numerical integration, assembly and solution techniques.	17	28	3,4,5	CO5	PSO5
4	Application of Various Numerical Methods: Application of numerical methods.	11	19	3,4,5	CO6	PSO5



APM 2162L: Numerical Methods in Geotechnical Engineering

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Problems Related to Theory of Elasticity and Plasticity	6	20	3,4,5	CO1	PSO5
2	Examples Related to Variational Calculus	6	20	3,4	CO3	PSO5
3	Problems Related to Finite Difference Method	6	20	3,4	CO4	PSO5
4	Problems on Solution of Linear Simultaneous Equation	6	20	3,4	CO2	PSO5
5	Examples Related to Finite Element Method	6	20	3,4,5	CO5 CO6	PSO5

Reference Books:

1. Desai C. S. and Abel, J. F., Introduction to Finite Element Method, 1977, Affiliated East-West Press Pvt. Ltd., N. Delhi.
2. Bowles, Analytical and Computer Methods in Found. Engg., 1974, McGraw-Hill, New York.
3. J. N. Reddy, Int. to Finite Element Method, 2nd Edition, 1993, McGraw Hill.
4. S.S. Bhavikatti, Finite Element Analysis, 2005, New Age International Publishers.
5. W. S. Hall, G. Oliveto, Boundary Element Methods for Soil Structure Interactions, 2003, Springer.



**SUBJECTS OFFERED
AT M.E.-I (PART-II)-
CIVIL
(GEOTECHNICAL
ENGINEERING)**

APM 2262: Analysis & Design of Foundations and Retaining Structures

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Analyse bearing capacity of shallow foundations.

CO2 Analyse settlement of shallow foundations.

CO3 Analyse and structural design of different types of shallow foundations.

CO4 Analyse bearing capacity and settlement of pile foundation.

CO5 Evaluate structural design for pile foundation.

CO6 Analyse and design of different types of retaining walls.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Bearing Capacity & Settlement of Foundation: Bearing capacity of foundations, footings with eccentric or inclined loading, foundations settlements; plate load and SPT. tests, design methods of mat foundations.	15	25	1,2,3,4	CO1 CO2	PSO2
2	Structural Design of Shallow Foundation: Structural design of reinforced concrete spread footings, footings subjected to moments, design methods of combined rectangular, trapezoidal and strap footing, combined footings, raft foundations, foundation systems in problematic soils.	15	25	1,2,3,4	CO3	PSO2
3	Design of Pile Foundation: Single pile capacity, group behavior, design considerations of piles and pile caps; battered piles, pile load test.	15	25	1,2,3,4	CO4 CO5	PSO2
4	Structural Design of Retaining Wall: Structural and foundation stability of retaining walls, design of gravity, cantilever and counter fort earth retaining walls	15	25	1,2,3,4	CO6	PSO2



APM 2262L: Analysis & Design of Foundations and Retaining Structures

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Bearing Capacity and Settlement of Shallow Foundations	3	10	1,2,3,4	CO1 CO2	PSO2
2	Structural Design of Isolated Footing Subjected Load and Moment	3	10	1,2,3,4	CO3	PSO2
3	Structural Design of Isolated Footing Subjected Load and Biaxial Moment	3	10	1,2,3,4	CO3	PSO2
4	Structural Design of Rectangular Combined Footing	3	10	1,2,3,4	CO3	PSO2
5	Structural Design of Trapezoidal Combined Footing	3	10	1,2,3,4	CO3	PSO2
6	Structural Design of Strap Footing	3	10	1,2,3,4	CO3	PSO2
7	Structural Design of Raft Foundation	3	10	1,2,3,4	CO3	PSO2
8	Soil Design of Single Pile and Group of Pile	3	10	1,2,3,4	CO4	PSO2
9	Settlement of Group Pile	2	7	1,2,3,4	CO4	PSO2
10	Structural Design for Single Pile and Group Pile	2	7	1,2,3,4	CO5	PSO2
11	Cantilever Retaining Wall and Counterfort Retaining Wall	2	6	1,2,3,4	CO6	PSO2

Reference Books:

1. Joseph E. Bowles, Foundation Analysis and Design, 5th edition, 2001, McGraw Hill.
2. Shamsheer Prakash et al, Analysis Design of foundation and Retaining Structures, 1979, Sarita Prakashan.
3. Fang and Winterkorn, Foundation Engineering, Handbook, 2010, Galgotia Book Source.
4. S. P. Brahama, Foundation Engineering, 1985, Tata McGraw Hill.
5. B. Das, Principles of Foundation Engineering, 9th Edition, 2018, Cengage India Private Ltd.

APM 2269: Earth and Rockfill Dams

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Analyze and Design of slope in the Earth Dams.

CO2 Apply the concept of Quality control and instrumentation in Earth dams.

CO3 Apply knowledge of modern construction techniques in Rockfill dam

CO4 Analyze and Design Drainage system and freeboard for earth dam

CO5 Understand slope protection methods and relief wells in earth dam

CO6 Apply soil and rock treatment by grouting

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Design and construction of Earth Dams: Design of earth dam, stability analysis for various conditions, failure of dams, special problems pertains to foundation treatment construction	13	22	3,4,5	CO1	PSO2
2	Quality Control & Instrumentation in Earth Dams: laboratory parameters evaluations, quality control, earth pressure problems at interface of earth fills and abutments, maintenance and safety of dams, monitoring of dam, Instrumentation in dam section	12	20	3,4	CO2	PSO2 PSO4
3	Rockfill & Earth Dams: Introduction to Rockfill dams; Design details and modern construction techniques of rockfill dam special problems, settlement	12	20	3,4,5	CO3	PSO2
4	Design of drainage systems and slope protection: Relief well and upstream blanket, foundation treatment methods, design of filters slope protections, design of freeboard	10	15	3,4,5	CO4 CO5	PSO2 PSO4
5	Alluvial and rock Grouting: Grout materials, grout mix design tests, design of grout curtains, alluvial grouting methods, rock grouting methods, efficacy and monitoring of grouting	13	23	3,4,5	CO6	PSO1 PSO2 PSO4



APM 2269L: Earth and Rockfill Dams

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Design of Riprap	2	6	2,3,4,5	CO5	PSO1 PSO2
2	Problems Related to Stability of Slopes	3	6	2,3,4,5	CO1	PSO1 PSO2
3	Design of Free board	2	6	2,3,4,5	CO4	PSO1 PSO2
4	Design of Filters	3	6	2,3,4,5	CO4	PSO1 PSO2
5	Design of Relief Wells	3	6	2,3,4,5	CO5	PSO1
6	Gellification Time Test	1	5	1,2,3,5	CO6	PSO1
7	Bleeding Potential	1	5	1,2,3,5	CO6	PSO1
8	Fluidity Test by marsh cone	1	5	1,2,3,5	CO6	PSO1
9	Specific Gravity Test	1	5	1,2,3,5	CO6	PSO1
10	pH Test	1	5	1,2,3,5	CO6	PSO1
11	Needle Penetration Resistance Test	1	5	1,2,3,5	CO6	PSO1
12	Vane Shear Test	1	5	1,2,3,5	CO6	PSO1
13	Syneresis Test	2	5	1,2,3,5	CO6	PSO1
14	Unconfined Compressive Strength Test	1	5	1,2,3,5	CO6	PSO1
15	Triaxial Compression Test	2	5	1,2,3,5	CO6	PSO1
16	Viscosity Test	2	5	1,2,3,5	CO6	PSO1
17	Penetrability Test	1	5	1,2,3,5	CO6	PSO1
18	Washout Strength Test	1	5	1,2,3,5	CO6	PSO1
19	Water Retentivity Test	1	5	1,2,3,5	CO6	PSO1

Reference Books:

1. Sherand, Earth and Rockfill Dam, 1967, Wiley.
2. Singh, B. Earth and Rockfill dam, 1976, Sarita Prakashan.
3. Design of Small Dams, USDI, Oxford and IBH, 1976.
4. Sharma H. D., Embankment Dams, 1991, Oxford and IBH Pub.
5. IS 5050 (1992), 9429 (1999), 10635 (1993), 7894 (1975), 7356 (Part 1, 2002),

APM 2204: Grouting Technology

Credits/Hours per Week: 04

Type: Elective

Course Outcome (CO)

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

CO1 Students will study the characteristics of different grout materials and to learn grout mix design for appropriate application.

CO2 Students will study grouting plants, different techniques of grouting and instrumentation for alluvial and rock grouting.

CO3 Students will understand quality as well as efficiency of grouting and alternate grouting technology.

CO4 Students will be able to study case studies.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Introduction to Grouting and Grout Materials: Definition of grouting; grout materials, physical and chemical properties, strength, rheological, penetrability and permanence aspects of coarse and fine grouts, various applications of grouting.	14	24	1,2,3	CO1	PSO1
2	Grouting Plant, Equipment & Techniques: Grouting plants-geological investigation-drilling methods, water tests, grout hole pattern, rock grouting – injection technology, thickening steps, refusal criteria, types of grouting.	17	28	1,2,3	CO1 CO2	PSO1 PSO3
3	Grout Mix Design: Alluvial grouting-grout mix design, selection of optimum w:c ratio and starting mix, field techniques of grouting-upstage, down stage, tube-a-manchette.	13	22	2,3,5,6	CO2	PSO1 PSO3
4	Monitoring and Efficacy of Grouting Operation and Alternate Grouting Technology: Grouting pressure electronic monitoring system, upheaval, observation, efficacy of grouting, quality control of grouting, case studies.	16	26	1,2,3,5,6	CO3 CO4	PSO1 PSO3



APM 2204L: Grouting Technology

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Elective

Mode of Transaction: Laboratory Experiments

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Gellification Time Test	2	7	1,2,3,5	CO1	PSO3
2	Bleeding Potential	2	7	1,2,3,5	CO1	PSO3
3	Fluidity Test by Marsh Cone	2	7	1,2,3,5	CO1	PSO3
4	Specific Gravity Test	2	7	1,2,3,5	CO1	PSO3
5	pH Test	2	7	1,2,3,5	CO1	PSO3
6	Needle Penetration Resistance Test	2	7	1,2,3,5	CO1	PSO3
7	Vane Shear Test	2	7	1,2,3,5	CO1	PSO3
8	Syneresis Test	2	7	1,2,3,5	CO1	PSO3
9	Unconfined Compressive Strength Test	2	6	1,2,3,5	CO1	PSO3
10	Triaxial Compression Test	2	6	1,2,3,5	CO1	PSO3
11	Viscosity Test	2	6	1,2,3,5	CO1	PSO3
12	Penetrability Test	3	10	1,2,3,5	CO1	PSO3
13	Adherent Washout Strength Test	3	10	1,2,3,5	CO1	PSO3
14	Water Retentivity Test	2	6	1,2,3,5	CO1	PSO3

Reference Books:

1. A. Shroff and D. L. Shah, Grouting Technology for Dam Const. And Tunnelling, 2nd Edition, 1999, Oxford and IBH Pub.
2. R. F. Bowen, Grouting in Engineering Practice, 1978, Applied Science Pub.
3. A. C. Houlsby, Grouting Manual, 1977, Water resources Commission, Australia.
4. R. H. Karol, Chemical Grouting, 1986, Applied Science Pub.

APM 2270: Rock Openings and Tunnels

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand criteria for stability of rock in underground excavation.

CO2 Classify tunnels based on geotechnical factors.

CO3 Evaluate elastic and plastic analysis in the design of underground openings

CO4 Analyze and Design of underground opening for Different ground conditions

CO5 Understand modern Construction methods of Tunnels

CO6 Analyze and design of underground support system.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Site investigation for underground projects Introduction, planning of and exploration for various underground construction projects, stereographic projection method, principle and its application in underground excavation design	12	20	1,2,3,	CO1 CO2	PSO1
2	Elastic-Plastic analysis and design methods of underground openings : Elastic stress distribution around tunnels, stress distribution for different shapes and under different in-situ stress conditions, Greenspan method, design principles, multiple openings, openings in laminated rocks, elasto-plastic analysis of tunnels, Daemen's theory.	12	20	1,2,3,4	CO3	PSO1 PSO2
3	Analysis of underground openings in problematic ground conditions, Field tests and construction methods: Application of rock mass classification systems, ground conditions in tunneling, analysis of underground openings in squeezing and swelling ground, empirical methods, estimation of elastic modulus and modulus of deformation of rocks; uniaxial jacking / plate jacking tests, radial jacking and Goodman jacking tests, long term behaviour of tunnels and caverns, New Austrian Tunneling Method (NATM), Norwegian Tunneling Method (NTM), construction dewatering.	12	20	2,3,4	CO4 CO5	PSO1 PSO2
4	Analysis and Design of Support Systems for Underground Openings : Rock mass-tunnel support interaction analysis, ground response and support reaction curves, Ladanyi's elasto-plastic analysis of tunnels, design of various	12	40	2,3,4	CO6	PSO1 PSO3



support systems including concrete and shotcrete linings, steel sets, rock bolting and rock anchoring, combined support systems, estimation of load carrying capacity of rock bolts, Grouting and freezing.

APM 2270L: Rock Openings and Tunnels

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Elective

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Examples Based on Stereographic projection	5	16	1,2,3,5	CO1	PSO1 PSO2
2	Examples based on Elasto-Plastic Analysis	8	27	1,2,3,5	CO2 CO3	PSO1 PSO2
3	Examples for Ground Condition Prediction	10	34	1,2,3,5	CO4 CO5	PSO1 PSO2
4	Examples Based on Support System	7	23	1,2,3,5	CO6	PSO1 PSO2

Reference Books:

- 1 K. Szechy, The art of Tunneling, 2nd edition, 1973, John Deere Publisher.
- 2 M. L. Jeremic, Ground Mechanics in Hard Rock mining, 1987, C.R.C Press.
- 3 Obert et al, Rock Mechanics and design of structures in Rock, 1967, John Wiley and Sons Inc.
- 4 Jaeger & Cook, Fundamentals of Rock Mechanics, 4th edition, 2012, Wiley India Pvt. Ltd.
- 5 T.M. Megaw, Tunnels- Planning, Design , Construction , Vol-II, 1982, John Wiley and Sons.

APM 2221: Reinforced Earth & Geotextiles

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Students will learn analysis, design, construction techniques and application of reinforced earth wall.

CO2 Students shall learn testing and evaluation of geosynthetics for various application.

CO3 Students shall learn application of geosynthetics.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Concept of reinforced earth: Concept of reinforced earth - mechanism and working - factors influencing components, analysis, design and stability of reinforced mass.	15	25	1,2,4,5	CO1	PSO1 PSO2
2	Application and construction Techniques: Application and techniques of construction, performance comparison of different types of facial elements and reinforcing elements, performance and case studies of reinforced earth walls, embankments, road subgrades, foundation beds etc.	15	25	1,2,4,5	CO1 CO3	PSO1 PSO2
3	Types of Geosynthetics: Geosynthetics-geogrids, geotextiles, and geomembranes. their physical and manufacturing properties, functions: reinforcement, separation, filtration, and drainage.	15	25	1,2,3,5	CO2 CO3	PSO1 PSO2 PSO3
4	Functions of Geosynthetics and Ground Improvement: Geosynthetics-geogrids, geotextiles, and geomembranes. their use in formations of roads and railways tracks, in reinforced embankments, in erosion protection of bunds, as filter-cum-drain in earth dams and drains, for lining of canals and in prevention of pollution, ground improvement of soft soil by drains.	15	25	1,2,4,5	CO2 CO3	PSO1 PSO2 PSO3



APM 2221L: Reinforced Earth & Geotextiles

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Elective

Mode of Transaction: Laboratory Experiments

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Determination of Physical Properties of Geotextiles	7	23	1,2,3,4	CO2 CO3	PSO1 PSO2 PSO3
2	Determination of Mechanical Properties of Geotextile	8	27	1,2,3,4	CO2 CO3	PSO1 PSO2 PSO3
3	Survivability Tests for Geotextiles	7	23	1,2,3,4	CO2 CO3	PSO1 PSO2 PSO3
4	Hydraulic Properties of Geotextile	8	27	1,2,3,4	CO2 CO3	PSO1 PSO2 PSO3

Reference Books:

1. P. R. Rankilior, Membranes in Ground Engineering, 1981, Wiley & Blackwell.
2. Van Zanten, Geotextiles and Geomembranes in Civil Engineering, 1986, A. A. Balkema Publication.
3. T. S. Ingold and K. S. Miller, Geotextile Handbook, 1990, Thomas Telford.
4. Robert M. Koerner, Designing with geosynthetics, 4th edition, 1997, Pearson.
5. BS- 8006:2010, 15284:2003.



APM 2222: Finite Element Method in Geotechnical Engineering

Credits/Hours per Week: 04

Maximum Marks/Grade: 100

Type: Elective

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Learning of numerical methods particularly finite difference method and finite element method.

CO2 Students will learn about Application of numerical methods for the analysis of foundation, embankment dams, consolidation excavation cuts, seepage and stress distributions around openings.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Matrix Calculation: Matrix Algebra, inversion of matrix, solution of large number of simultaneous equations.	15	25	1,2,4	CO1	PSO2
2	Finite differences method: Finite differences method and its applications to Geotechnical problems. Equations of equilibrium and compatibility, stress-strain relations, plane stress and plane strain and axis-symmetric problems.	15	25	3,4	CO2	PSO5
3	Finite element Method: Discretization of continuum, types of elements, displacement models, convergence requirements, natural co-ordinates system, analysis of linear and quadratic models of triangular and rectangular elements, energy concepts and variational principles, stiffness matrix and its derivation, numerical integration, assembly and solution techniques computerization.	15	25	2,3,4	CO1 CO2	PSO5
4	Techniques of nonlinear analysis and computer programming: Techniques of nonlinear analysis, constitutive modeling for soils, determination of soil parameters for such analysis. Applications to study of embankment dams, problem of strip footing, excavations, stress distribution around opening etc. Computer programming.	15	25	2,3,4, 5,6	CO1 CO2	PSO5



APM 2222L: Finite Element Method in Geotechnical Engineering

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Core

Mode of Transaction: Tutorials

No.	Tutorials	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Problems On Gauss Elimination and Gauss Doolittle Decomposition Techniques.	3	10	3,4,5,6	CO1	PSO5
2	Examples Related to Variational Methods	3	10	3,4,5,6	CO1	PSO5
3	Problems on Numerical Integration	6	20	3,4,5,6	CO1	PSO5
4	Geotechnical Problems Based on Finite Difference Methods (Rate of Consolidation, Seepage Analysis, Laterally Loaded Pile, Combined Footing)	3	10	3,4,5,6	CO1	PSO5
5	FEM Software Application Study on Embankment Dams, Strip Footing, Excavation Around Openings.	3	10	3,4,5,6	CO1	PSO5
6	Geotechnical Problems Related to FEM.	6	20	3,4,5,6	CO1	PSO5
7	Piles Diaphragms and Anchorages.	6	20	3,4,5,6	CO1	PSO5

Reference Books:

1. Krishnamoorthy, C. K., "Finite element analysis theory and programming, 1987, Tata McGraw Hill Publishing Cop.
2. Desai C. S. and Abel, J. F., Introduction to Finite Element Method, 1977, Affiliated East-West Press Pvt. Ltd., N. Delhi.
3. Gauri Dhatt and Gilbert Tauzot, The Finite Element Method Displayed, John Wiley & Sons.
4. Cook R. D. et. Al., Concept and Application of finite element analysis, 4th edition, 2003, John Wiley & Sons Inc.
5. Logan D.L., A first course in finite element method, 3rd editin, 2004, Thomson Asia Pvt. Ltdm, Bangalore.
6. J. N. Reddy, Int. to Finite Element Method, 3rd Edition, 2005, McGraw Hill.



APM 2223: Piles, Diaphragms and Anchorages

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

CO1 Learn design and construction of various types of pile foundation for different loading and soil conditions.

CO2 Learning construction techniques and application of different types of diaphragm walls.

CO3 Students will learn different types, design and protection of soil and rock anchors.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Bearing Capacity and settlement of Pile: Selection of pile design parameters, bearing capacity of individual and group piles, settlement of individual and groups piles, design of under reamed pile.	15	25	2,3,4,5	CO1	PSO2
2	Piles subjected to various loads: Piles subjected to lateral force, negative skin friction and dynamic forces, various types of load tests. Structural design of pile cap.	15	25	2,3,4,5	CO1	PSO2
3	Diaphragm wall : Diaphragm wall construction, technique, construction material and specification, design methods, precast diaphragm wall, instrumentation in diaphragm wall, case studies.	15	25	2,3,4,5	CO2	PSO2
4	Anchors: Anchor applications, investigation, grouting method.	15	25	2,3,4,6	CO3	PSO2



APM 2223L: Piles, Diaphragms and Anchorages

Credits/Hours per Week: 02

Maximum Marks/Grade: 50

Type: Elective

Mode of Transaction: Laboratory Experiments

No.	Laboratory Experiments	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Anchor Pull-Out Test	4	14	3,4,5,6	CO1	PSO1 PSO4
2	Model Pile Load Test- Compression, Tension and Lateral Load	6	20	3,4,5,6	CO2	PSO1 PSO4
3	Bentonite Slurry Density by Mud Balance	1	3	3,4,5,6	CO3	PSO1
4	Ph Indicator	1	3	3,4,5,6	CO4	PSO1
5	Marsh Cone for Fluidity of Bentonite Slurry	1	3	1,2,3,4	CO1 CO2	PSO1 PSO1
6	Model Cyclic Pile Load Test to Separate Skin Friction and End Bearing Resistance	5	17	1,2,3,4	CO1	PSO1 PSO4
7	Sand Content of Bentonite	1	3	1,2,3,4	CO1 CO2	PSO1
8	Liquid Limit of Bentonite	2	7	1,2,3,4	CO1 CO2	PSO1
9	Free Swell Index of Bentonite	1	3	1,2,3,4	CO1 CO2	PSO1
10	Cement Grout Tests	8	27	1,2,3,4	CO3	PSO1

Reference Books:

1. J. E. Bowles, "Foundation analysis and design", 5th edition, 2001, McGraw Hill International edition.
2. Poulos and Davis, "Pile foundation", 1980, John Wiley.
3. Boyes, "Structural and cutoff diaphragm walls", 1975, Applied Science Publication.
4. Diaphragm walls and anchorages, conference organized by institution of engineers, London.
5. Hanna T. H, "Foundations in Tension Ground Anchors", 1982, Trans. Tech. Publication, McGraw Hill Book Company.
6. Little John, "Soil Anchors", Proc. Ground engineering conference, 1970, Institution of Civil Engineering, London.
7. Majnal, I. "Construction of diaphragm walls", 1984, Wiley Blackwell.

APM 2261: Soil-Foundation-Structure Interaction

Credits/Hours per Week: 04

Type: Core

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will be able to

CO1 Understand conventional and advanced methods of analysis of foundations.

CO2 Analyze soil-structure interaction aspects of shallow and deep foundation..

CO3 Analyze beams on elastic foundation and flexible retaining structures.

CO4 Analyze and design of foundations considering machine soil foundation interactions.

CO5 Evaluate piles subjected to lateral loads.

CO6 Evaluate lateral stability of well foundation by I.R.C codes.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Basics of Soil Design & Evaluation of Parameters: Critical study of conventional methods of foundation design, nature and complexity of soil structure interaction, advanced techniques of analysis, evaluations of soil - foundation parameters, codal provisions.	12	20	1,2,3, 4,5	CO1	PSO2
2	Soil Structure Interaction Aspect of Shallow and Deep Foundations: Soil structure interaction problems of shallow foundations contact pressures under rigid footings, differential foundation settlement of high rise buildings - pressure settlement prediction from constitutive laws, lateral stability of well foundation using IRC. elastic and ultimate soil resistance method.	16	27	3,4,5	CO2 CO6	PSO2
3	Beams & Plates on Elastic Foundations and Earth Pressure Distribution in Flexible & Rigid Structure: Combined footings and rafts on elastic foundations, well foundations, large oil tanks, tunnels - bulkheads and retaining walls.	16	27	2,3,4, 5	CO3 CO6	PSO2
4	Machine-Soil-Foundation Interaction & Laterally and Inclined Loaded Piles: Machine-soil-foundation interaction, other problems of soil foundations structure analysis - laterally loaded pile supported on elastic medium: Brom's method, Matlock and Reese method, codal provisions, P-Y curve method.	16	26	2,3,4, 5,6	CO4 CO5	PSO2 PSO4



APM 2261L: Soil-Foundation-Structure Interaction

Credits/Hours per Week: 02

Type: Core

Maximum Marks/Grade: 50

Mode of Transaction: Tutorials

No.	Tutorial	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Problems Based on Conventional Method of Foundation Analysis	5	17	2,3,4,5	CO1	PSO2 PSO6
2	Problems on Lateral Stability of Well Foundations	5	17	2,3,4,5	CO6	PSO2 PSO6
3	Problems Related to Calculation of Differential Settlement of High Rise Building	4	13	2,3,4,5	CO2	PSO2 PSO6
4	Problems Related to Pressure Settlement Prediction from Constitutive Laws	4	13	2,3,4,5	CO2	PSO2 PSO6
5	Problems on Analysis of Flexible Footing and Rigid Footing Using Beams & Plates on Elastic Foundations	4	14	2,3,4,5	CO3	PSO2 PSO6
6	Problems on Machine-Soil-Foundation Interaction	4	13	2,3,4,5	CO4	PSO2 PSO6
7	Problems on Laterally Loaded Pile	4	13	2,3,4,5	CO5	PSO2 PSO6

Reference Books:

1. Shamsheer Prakash et al, Analysis, Design of foundations and Retaining Structures, 1979, Sarita Prakashan.
2. Bowles J. E., Computer Programming in Geotechnical Engineering, 5th edition, 2001, McGraw Hill Pub.
3. I. S. Code No. 2950 (Pt.I) - 1981 - Code of Practice for Design and Construction of Raft Foundations.
4. Kaniraj, Design Aids in Soil Mech. and Found. Engg., 1995, Tata McGraw.
5. B. Das, Principles of Found. Engg., 9th Edition, 2018, Cengage.

APM 2267: Geosynthetics and Reinforced Earth

Credits/Hours per Week: 04

Type: Elective

Maximum Marks/Grade: 100

Mode of Transaction: Lectures

Course Outcome (CO)

Students will able to

CO1 Evaluate and analyze physical, mechanical, hydraulic, endurance, environmental properties of various geosynthetics material

CO2 Analyze and design geotextile for roads, filtration and drainage applications.

CO3 Apply knowledge of geomembrane and geosynthetics clay liners in design of various hydraulic structures and landfills.

CO4 Apply knowledge of geofoam, geopipe and other geocomposite in design of various structure

CO5 Analysis and design of reinforced earth wall by various methods.

CO6 Analysis and design of reinforced earth slopes.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO
1	Types of Geosynthetics, their Functions, Properties and Applications: Geosynthetics- geogrids, geotextiles, geomembranes, geonets, Geosynthetics clay liners, geocells, geopipes, geofoam, Geo composites; their materials, physical, mechanical, hydraulic, endurance, manufacturing properties and functions, design for: reinforcement, separation, filtration and drainage, containment concept of reinforced earth - mechanism and working - factors influencing components.	15	25	1,2,4, 5	CO1,2, 4	PSO1 PSO2
2	Design Principles of Reinforced Earth Walls, Slopes and Basal Reinforcements: Comparison of different types of facial elements and reinforcing elements, analysis, design, stability of reinforced earth walls, embankments, basal reinforcement, road sub grades, foundation beds etc. application and techniques of construction, performance case studies.	20	33	1,2,4, 5	CO5 &6	PSO1 PSO2
3	Design Principles of Geomembranes for Different Liners: Geomembranes, liquid containment liners, water conveyance liners, landfill liners and covers and its design, geosynthetic clay liners- design applications.	15	25	1,2,3, 5	CO3	PSO1 PSO2 PSO3



Design applications of geo pipes and geofoms, geo composites, construction methods using different geosynthetics.

PSO3

Mode of Transaction: Laboratory Experiments

1. P. R. Rankilior, Membranes in Ground Engineering, 1981, Wiley & Blackwell.
2. Van Zanten, Geotextiles and Geomembranes in Civil Engineering, 1986, A. A. Balkema Publication.
3. T. S. Ingold and K. S. Miller, Geotextile Handbook, 1990, Thomas Telford.
4. Robert M. Koerner, Designing with geosynthetics, 4th edition, 1997, Pearson.
5. BS- 8006:2010, 15284:2003.
6. FHWA-NHI-00-043.