M.Tech-STRUCTURAL ENGINEERING

(AY 2023-24 onwards)

Course Structure

DEPARTMENT OF CIVIL ENGINEERING

GIRIJANANDA CHOWDHURY UNIVERSITY

Hathkhowapara, Azara , Guwahati 781017, Assam

Course Structure

(AY 2023-24 onwards)

Semester I

Theory/ Practical	Sl. No	Course Type	Course Code	Course Name	Hours per week			Credit	% Mark	
					L	T	P	C	CA	ESA
T	1.	PCC	MSE23501T	Continuum Mechanics	3	1	0	4	40	60
T	2.	PCC	MSE23502T	Structural Dynamics	3	1	0	4	40	60
T	3.	PCC	MSE23503T	Advanced Structural Analysis	3	1	0	4	40	60
T	4.	OEC	--	Open Elective	3	0	0	3	40	60
T	5.	MC	MSE23504T	Research Methodology	2	0	0	2	40	60
T	6.	AC	--	Audit Course – I	2	0	0	0	-	100
				Total	**16**	**3**	**0**	**17**		

Semester II

Theory/ Practical	Sl. No	Course Type	Course Code	Course Name	Hours per week			Credit	% Mark	
					L	T	P	C	CA	ESA
T	1.	PCC	MSE23505T	Advanced Concrete Technology	3	1	0	4	40	60
T	2.	PCC	MSE23506T	Advanced Structural Design	3	1	0	4	40	60
T	3.	PCC	MSE23507T	Earthquake Engineering	3	1	0	4	40	60
P	4.	PCC	MSE23508P	Structural Engineering Lab -I	0	0	4	2	40	60
T	5.	PEC	--	Professional Elective – I	3	0	0	3	40	60
T	6.	AC	--	Audit Course - II	2	0	0	0	-	100
				Total	**14**	**3**	**4**	**17**		

Semester III

Theory/ Practical	Sl. No	Course Type	Course Code	Course Name	Hours per week			Credit	% Mark	
					L	T	P	C	CA	ESA
T	1.	PEC	--	Professional Elective - II	3	1	0	4	40	60
T	2.	PEC	--	Professional Elective - III	3	1	0	4	40	60
P	3.	PCC	MSE23509P	Structural Engineering Lab -II	0	0	4	2	40	60
R	4.	PROJ	MSE23510R	Dissertation Phase – I	0	0	16	8	40	60
				Total	**6**	**2**	**20**	**18**		

Semester IV

Theory/ Practical	Sl. No	Course Type	Course Code	Course Name	Hours per week			Credit	Mark	
					L	T	P	C	IA	EA
R	1.	PROJ	MSE23511R	Dissertation Phase – II	0	0	32	16	40	60
				Total	**0**	**0**	**32**	**16**		

Professional Elective – I

Sl.No.	Course Type	Code	Course
1.	PEC	MSE23521T	Numerical Methods in Structural Engineering
2.	PEC	MSE23522T	Statistical Method
3.	PEC	MSE23523T	Theory of Stability of Structures

Professional Elective – II

Sl.No.	Course Type	Code	Course
1.	PEC	MSE23524T	Plates, Shells and Elastic Stability
2.	PEC	MSE23525T	Design of Pre-stressed Concrete Structures
3.	PEC	MSE23526T	Design of Bridges and Flyover

Professional Elective – III

Sl.No.	Course Type	Code	Course
1.	PEC	MSE23527T	Advanced Design of Foundation
2.	PEC	MSE23528T	Finite Element Analysis
3.	PEC	MSE23529T	Seismic Hazard and Risk Analysis

Open Elective

Sl.No.	Course Type	Code	Course
1.	OEC	TFE23531T	Operation Research Technique
2.	OEC	MSE23531T	Industrial safety
3.	OEC	MSE23532T	Cost Management of Engineering Projects

Audit Course – I

Sl.No.	Course Type	Code	Course
1.	AC	MEN23581T	English for Research paper writing
2.	AC	MSE23581T	Disaster Management
3.	AC	MCS23581T	Business Analytics

Audit Course – II

Sl.No.	Course Type	Code	Course
1.	AC	MEN23582T	Digital Humanities
2.	AC	MPO23582T	Constitution of India
3.	AC	TFE23582T	Pedagogy Studies

MSE23501T	Continuum Mechanics	L	T	P	C
		3	1	0	4

Pre-requisite: Mechanics of Solids during under graduation

Course Objectives:

1. To understand the basic concepts of the theory of continuous medium.
2. To obtain knowledge on various concepts of theory of elasticity and plasticity.
3. To study the energy principles and various methods of analysis.
4. To understand the basic concepts of stability and torsion.

Expected Course Outcome:

Upon completion of this course, the student will be able to
1. analyze the stresses and strains for two dimensional and three dimensional elements,
2. understand the equilibrium and compatibility condition in Cartesian and Polar coordinates,
3. understand the concept of plasticity and energy principles,
4. solve the problems on torsion of bars with different cross-sections.

Module:1 *Basic concepts of the theory of continuous media*	**10 hours**
Introduction to tensor algebra; theory of stresses; infinitesimal and finite strains; strain-displacement relationships; compatibility; stress-strain relationships.	
Module:2 *Boundary value problem in elasticity*	**8 hours**
Plane stress and plane strain case; stress function approaches; plane problems in Cartesian and polar coordinates; bending of a beam; thick cylinder under pressure.	
Module:3 *Concept of Plasticity*	**8 hours**
Elements of plasticity; yield criteria; flow rule and hardening. Plastic stress-strain relationships.	
Module:4 *Energy Principles and Methods of Analysis*	**6 hours**
Energy principles, variational methods and numerical methods; Introduction to Hamilton's principles; Rayleigh-Ritz and Weighted residual methods.	
Module:5 *Introduction of Stability and Torsion*	**6 hours**
Introduction to stability, stability of thin plates; elasto-plastic analysis of torsion and bending problems; torsion of non-circular sections.	
Total Lecture hours	**40 hours**

Text Book(s)

1.	D. S. Chandrasekharaiah and L. Debnath, Continuum Mechanics, Prism Books Pvt. Ltd., Bangalore, 1994.

Reference Books

1.	S. Timoshenko and J.N. Goodier, Theory of Elasticity, McGraw Hill Book Company, International Ed, 1970.
2.	J. Chakrabarty, "Theory of Plasticity", 3rd Edition, Elsevier Butterworth, Heinmann, UK, 2006.
3.	Sadhu Singh, "Theory of Elasticity", Khanna Publishers, New Delhi 1988.
4.	Ansel. C. Ugural and Saul. K. Fenster, " Advanced Strength and Applied Elasticity," 4th Edition, Prentice Hall Professional Technical Reference, New Jersy, 2003

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23502T	**STRUCTURAL DYNAMICS**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**

Pre-requisite: Structural Analysis

Course Objectives:

1. To know various dynamic forces acting on a building and their response.
2. To obtain knowledge on modes of failure and remedial solutions.
3. To study the analysis procedure for calculating the response of structures.
4. To understand the linear and no-linear behaviour of structures.

Expected Course Outcome:

Upon completion of this course, the student will be able to
1. Understand the effect of vibration on structures.
2. Identify and Evaluate the response of single storied building subjected to dynamic load.
3. Identify and Evaluate the response of multi-storied building subjected to dynamic load.
4. Understand the effect of nonlinearity in structural response.
5. Conceptualize the importance of structural dynamics in design code provisions.

Module:1 *Introduction*	**6 hours**

Sources of Structural vibrations - Dynamic analysis and their importance to structural engineering problems - Degrees of freedom - D'Alembert's principle - Lagrange's equation - Simple harmonic motion.

Module:2 *Single Degree of Freedom System*	**12 hours**

Equations of Motion - Free vibration - Undamped - Damped - Critical damping - Measurement of damping - Forced vibrations under harmonic, impulse and general loadings - Response spectrum Generalized SDOF systems: Rigid body distributed mass and stiffness systems - Response of SDOF system to Harmonic Loading, Periodic loading and Impulse Loading - Transmissibility - Fourier series - Duhamel's integral - Numerical integration.

Module:3 *Multi Degree of Freedom System*	**8 hours**

Equation of motion - Free vibration - Undamped - Damped - Evaluation of structural property matrices - Mode shape - Orthogonality relationship - Dynamic properties - modal damping - classical damping - modal superposition methods - Numerical methods in dynamics: Eigen value analysis, direct integration scheme - methods of solving eigenvalue problems - Characteristic equation method and other methods.

Module:4 *Continuous Systems*	**6 hours**

Differential equation of motion - Transverse vibration - Axial vibration - Natural frequency and mode shape of simple beams with different end conditions - Numerical schemes for obtaining frequencies and mode shapes.

Module:5 *Non-linear Numerical Techniques*	**6 hours**

Nonlinear Systems: material and geometric nonlinearity; - Seismic Response of Nonlinear Systems: Earthquake analysis of multi-storey building frames – time step analysis - Dynamic origin of Earthquake code provisions. Wilson Theta method - Newmark Beta method –Runge-Kutta method.

Total Lecture hours	**38 hours**

Text Book(s)

1.	Mario Paz and William Leigh (2010), Structural Dynamics - Theory and Computation, Springer.

Reference Books

1.	Clough and Penzien (2015), Dynamics of Structures, CBS Publishers and Distributors, New Delhi.
2.	Chopra. A. K. (2011), Dynamics of Structures - Theory and Applications to Earthquake Engineering, 4th edition, Prentice Hall, London.
3.	Roy R.Craig, Jr. Andrew J. Kurdila (2011), Fundamentals of Structural Dynamics, John Wiley and Sons, London.

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23503T	**ADVANCED STRUCTURAL ANALYSIS**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**

Pre-requisite: Structural Analysis

Course Objectives:

1. To know matrix method of analysis of structure by stiffness and flexibility method.
2. To obtain knowledge on finite element method.
3. To study the analysis procedure for beam on elastic foundation and non-linear structures.
4. To apply computer applications in structural analysis.

Expected Course Outcome:

Upon completion of this course, the student will be able to
1. Analyze structural problems with the matrix method.
2. Understand the fundamental principles of Finite Element Method.
3. Evaluate the response of special structure and non-linear structure.
4. Apply computer software in structural analysis.

Module:1 *Introduction of Matrix Method of Structural Analysis*	**8 hours**
Static and kinematics indeterminacy of structures; Fundamentals of Flexibility and Stiffness method; Basic examples of application of Flexibility and Stiffness Method.	
Module:2 *Direct Stiffness Matrix Method*	**12 hours**
Derivation of local stiffness matrices for prismatic and non-prismatic members, transformation matrices and global stiffness matrices, assembling, compatibility equation. Application of Matrix Displacement Method to plane truss, space truss, beams, grids, plane frames and space frames subjected to various loadings including effects of temperature change and support displacements, Applications of software in structural analysis.	
Module:3 *Introduction to Finite Element Method*	**12 hours**
Introduction to principles of Finite Element Method and its application using two/three nodded bar element, beam element, three/four nodded plane elements.	
Module:4 *Special Structure*	**6 hours**
Beam on elastic foundation. Introduction to nonlinear structural analysis: Material and geometric nonlinear problems; incremental and iterative procedures, Convergence criteria, P-Δ effect, buckling of frames.	
Total Lecture hours	**38 hours**

Text Book(s)

1.	Weaver Jr, W., Gere, J. M., & Saunders, H. (1982). Matrix Analysis of Framed Structure.
2.	Reddy, J. N. (2019). Introduction to the finite element method. McGraw-Hill Education.

Reference Books

1.	Jain, M. K., & Kanchi, M. B. (1993). Matrix methods of structural analysis. New Age International.
2.	Bathe, K. J. (2006). Finite element procedures. Klaus-Jurgen Bathe.

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23505T	ADVANCE CONCRETE TECHNOLOGY	L	T	P	C
		3	1	0	4

Pre-requisite: Concrete Technology during under graduation

Course Objectives:

1. Understanding of advanced concrete terminology
2. Understanding of the mixed design of concrete, high strength of concrete requirements for advanced concrete and
3. Understanding to use plasticizers, effect of water cement ratio and super plasticizers used in the construction works.

Expected Course Outcome:

Upon completion of this course, the student will be able to

1. Understand the advanced concrete terminology.
2. Understand the mixed design of concrete, high strength of concrete requirements for advanced concrete.
3. Understand the use of plasticizers, effect of water cement ratio and super plasticizers used in the construction works.

Module:1	**6 hours**

Standards – specifications – Ingredients –Cement production - reaction mechanism - Types of Portland Cement. Coarse Aggregate and Fine Aggregate. Chemical admixtures and mineral admixtures, their types and mechanism. Rheological behaviour of fresh concrete -Transition zone in concrete.
Mix Design by IS: 10262-2019 - Mix Design by ACI :312 - Other methods of mix design.

Module:2	**8 hours**

Normal Vibrated Concrete - High volume fly ash concrete -Reactive powder concrete & Oil well concrete - Ready mix concrete, pervious concrete.

Fiber reinforced concrete – mechanism of Fiber reinforcement, types of Fibers, properties of Fiber reinforced concrete. High strength concrete- constituents, mix proportioning, properties at fresh and hardened state. Self compacting concrete – Bacterial Concrete–Light weight concrete - Self curing concrete - Geopolymer Concrete - their constituents, properties and significance.

Module:3	**10 hours**

Permeability of concrete. Deterioration of concrete - Factors effecting the durability - Sulphate attack - Acid attack - Alkali Aggregate reaction – Carbonation - Abrasion Freezing and Thawing - Corrosion of Rebar - Rapid Chloride penetration test.

Module:4	**6 hours**

Use of waste materials in concrete- Waste from industry - Recycled aggregates – Sustainability. Green concrete - Eco-Friendly Concrete.

Module:5	**6 hours**

Non-destructive evaluation of reinforced concrete by surface hardness techniques, wave propagation techniques - Rebound hammer – Windsor probe – Ultrasonic pulse velocity.

Total Lecture hours	**36 hours**

Text Book(s)

1.	P. K. Mehta and P. J. M. Monteiro, Concrete: Microstructure, Properties and Materials, McGraw-Hill, 3rd Ed., 2006.
2.	J. Newman and B. S. Choo, Advanced Concrete Technology: Processes, Elsevier, Butterworth Heinemann, 2003.

Reference Books

1.	A. M., Neville and J. J. Brooks, Concrete Technology, Pearson Education, 4th Indian reprint, 2004.
2.	M. S. Mamlouk and J. P. Zaniewski, Materials for Civil and Construction Engineers, Pearson, Prentice Hall, 2nd Ed., 2006.
3.	P. C. Aitcin, High Performance Concrete, E &Fn Spon, 1998.
4.	E. G. Nawy, Fundamentals of High-Performance Concrete, John Wiley & Sons Inc., 2nd Ed., 2001

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23506T	ADVANCED STRUCTURAL DESIGN	L	T	P	C
		3	1	0	4

Pre-requisite: Design of RCC & Steel

Course Objectives:

1. To know design philosophies, P-M and M-phi relationships.
2. To obtain knowledge on strut-and-tie method.
3. To study the analysis procedure for shear walls subjected to lateral loading.
4. To understand the design procedure for water tanks.
5. To learn about stability design, design of beam-columns and fatigue resistant design.

Expected Course Outcome:

Upon completion of this course, the student will be able to
1. Understand the basic concept of design philosophies, P-M & M-phi relationships.
2. Analyze deep beams and corbels with strut-and-tie method; and also design shear walls for lateral load.
3. Evaluate and design different types of water tank with IS standard.
4. Apply basic of steel design to design beam-columns and also fatigue resistant design.

Module:1 *Brief Introduction*	**6 hours**
Design philosophy, modeling of loads, material characteristics. P-M & M-phi relationships; compression field theory for shear design.	
Module:2 *Strut-and-tie method*	**6 hours**
Basic Introduction - Method of formulating strut-and-tie method - Limitations of truss analogy - Design of deep beam - Design of corbel - Numerical Examples.	
Module:3 *Design of shear walls*	**6 hours**
Seismic behavior of shear wall - Lateral Forces on shear wall - Design of shear wall - IS provisions for ductile detailing - Numerical Examples.	
Module:4 *Water tank design*	**6 hours**
Design principles of underground and elevated water tanks - Detailed design of Rectangular and Circular elevated water tanks as per IS 3370 - Design of Ring Beam and staging for elevated water tanks - Numerical Examples.	
Module:5 *Steel structures*	**10 hours**
Stability design - Torsional buckling (pure, flexural and lateral) - Design of beam-columns - fatigue resistant design - Indian and AISC Standards; Eurocode - Numerical Examples.	
Total Lecture hours	**34 hours**

Text Book(s)

1.	Pillai, S. U., & Menon, D. (2005). Reinforced concrete design 3rd edition.
2.	Subramanian, N. (2008). Design of steel structures. Oxford university press.

Reference Books

1.	Varghese, P. C. (2009). Advanced reinforced concrete design. PHI Learning Pvt. Ltd..
2.	Park, R., & Paulay, T. (1991). Reinforced concrete structures. John Wiley & Sons.

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23508P	STRUCTURAL ENGINEERINGLABORATORY – I	L	T	P	C
		3	1	0	4

Pre-requisite: Concrete Technology.

Course Objectives:

1. To get knowledge about the standard mix and design mix.
2. To familiar about casting, curing and testing of specimens.
3. To evaluate the strength of cube, cylinder and beam specimens.
4. To know about NDT test on concrete specimens.

Expected Course Outcome:

Upon completion of this course, the student will be able to

1. Cube compressive strength, split tensile strength and flexural strength of the standard mix.
2. Cube compressive strength, split tensile strength and flexural strength of the design mix.
3. Cube compressive strength, split tensile strength and flexural strength of the high strength concrete.
4. Cube compressive strength, split tensile strength and flexural strength of the high performance concrete.
5. Strength of concrete specimens using Non Destructive Tests.

List of experiments

1. Conducting Cube compressive strength test, split tensile test and flexure test for the standard mix M20.
2. Conducting Cube compressive strength test, split tensile test and flexure test for the standard mix M25.
3. Design M30 grade mix and conducting compressive strength test, split tensile test and flexure test.
4. Design M35 grade mix and conducting compressive strength test, split tensile test and flexure test.
5. Design High strength concrete mix and conducting compressive strength test, split tensile test and flexure test.
6. Design High performance concrete mix and conducting compressive strength test, split tensile test and flexure test.
7. Evaluating the strength of concrete specimen using rebound hammer.
8. Conducting UPV test on given concrete specimen.

Total Lecture hours

Text Book(s)

1.	1. IS 10262-2019 Guidelines to Concrete mix design.
2.	IS-13311 (Part 2):1992 (Reaffirmed- 2013) Non Destructive Testing of Concrete-Methods of Test (Rebound hammer).
3.	IS-13311 (Part 1):1992 (Reaffirmed- 2004) Non Destructive Testing of Concrete-Methods of Test (UPV).

Reference Books

1.	Advanced Concrete Technology, 2nd Edition, Zongjin Li, Xiangming Zhou, Hongyan Ma, Dongshuai Hou
2.	Concrete Technology, 2nd Edition, A.M.Neville , J.J Brooks.
3.	IS 456:2000 Plain and reinforced concrete code of practice.

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

		L	T	P	C
MSE23509P	**STRUCTURAL ENGINEERING LABORATORY – II**	**0**	**0**	**4**	**2**

Pre-requisite: Design of RCC Structures, Design of Steel Structures.

Course Objectives:

1. 1. To get knowledge about the analysis and design software StaadPro.
2. To familiar about the analysis and design software ETab.
3. To know about SAP 2000 software.

Expected Course Outcome:

At the end of the course, the students are able to know about,
1. CO1: Modules about the analysis and design softwares.
2. CO2: Code of practice used in analysis and design softwares.
3. CO3: Analysis and Design of RCC & Steel structures using STAADPro.
4. CO4: Analysis and Design of RCC & Steel structures using ETABS.
5. CO5: Analysis and Design of RCC & Steel structures using SAP2000.

List of experiments

1. Analysis and design of RCC multi storied building using STAADPro.
2. Analysis and design of RCC multi storied building using ETABS.
3. Analysis and design of RCC multi storied building using SAP2000.
4. Analysis and design of Steel multi storied building using STAADPro.
5. Analysis and design of Steel multi storied building using ETABS.
6. Analysis and design of Steel multi storied building using SAP2000.

Total Lecture hours

Text Book(s)

1.	IS 456 (2000): Plain and Reinforced Concrete - Code of Practice
2.	IS 800 (2007): General Construction in Steel - Code of Practice
3.	Design of Steel Structures 1 and 2 (NPTEL web material) by Sathish Kumar and Shantha Kumar (IITM)

Reference Books

1.	1. RCC Design by B.C Punamia and Ashok Kumar Jain, Lakshmi Publications.
2.	Reinforced Concrete Design by Devdas Menon. McGraw Hill Educations.
3.	Design of Steel Structures by A.S. Arya and J.L. Ajmani. Nem Chand Piblishers.
4.	Design of Steel Structures by L.S. Negi. Tata McGraw-Hill.

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23507T	EARTHQUAKE ENGINEERING	L	T	P	C
		3	1	0	4

Pre-requisite: SE01PC02: Structural Dynamics

Course Objectives:

1. To study the basic concepts of engineering seismology and ground motion characteristics.
2. To understand the strength and capacity design principles of earthquake resistant design.
3. To study linear and nonlinear earthquake analysis.
4. To study the behavior of various types of buildings under static and dynamic forces.
5. To study the geotechnical aspect of earthquake engineering
6. To study the retrofitting and strengthening techniques.

Expected Course Outcome:

Upon completion of this course, the student will be able to
1. Identify the characteristics of seismic waves and its measures.
2. Understand the principles of earthquake resistant design and response spectrum.
3. Analyze and design the various types of structures under static and dynamic loading conditions.

Module:1 *Seismology and Earthquake*	**6 hours**
Internal structure of the earth, continental drift and plate tectonics, Faults, Elastic rebound theory, seismic waves and characteristics, earthquake size, Magnitude and Intensity, Ground Motions, Site effects, Sensors, strong ground motion, seismic zoning map of India, Seismic hazard assessment.	
Module:2 *Response spectrum and Earthquake analysis*	**8 hours**
Construction, Characteristics, Design Response spectrum, Idealization of structures, Response spectrum analysis, Torsionally coupled systems, Frequency domain analysis, Time domain analysis, Determination of design lateral forces as per IS: 1893-2016 – equivalent static force and dynamic analysis procedure. Effect of infill stiffness on analysis of frames – Equivalent diagonal strut.	
Module:3 *Nonlinear Earthquake analysis*	**8 hours**
Force-deformation relationships, Equation of motion, Controlling parameters, Ductility demand, Allowable ductility;	
Module:4 *Earthquake resistant design of R.C. buildings*	**6 hours**
Earthquake and vibration effects on structure, identification of seismic damages in buildings, effect of structural irregularities on the performance of buildings during earthquakes and seismic resistant building architecture, ductility based design, Detailing provisions, Codal Provisions, Concepts of passive controls	
Module:5 *Modelling, Analysis and Design of Structures*	**6 hours**
Seismic analysis and design of RC structures using software - static and dynamic methods – equivalent static, response spectrum and time history methods, Retrofitting and strengthening of Buildings and Bridges	
Module:6 *Geotechnical aspects*	**6 hours**
Dynamic properties of soil, dynamic earth pressures, Liquefaction and ground improvement techniques	
Total Lecture hours	**40 hours**

Text Book(s)

1.	Pankaj Agarwal and Manish Shrikhande., (2010), Earthquake resistant design of structures, Prentice-Hall India Pvt. Ltd., New Delhi.

Reference Books

1.	Clough and Penzien (2015), Dynamics of Structures, CBS Publishers and Distributors, New Delhi.
2.	Chopra. A. K. (2011), Dynamics of Structures - Theory and Applications to Earthquake Engineering, 4th edition, Prentice Hall, London.
3.	Roy R.Craig, Jr. Andrew J. Kurdila (2011), Fundamentals of Structural Dynamics, John Wiley and Sons, London.
4.	T. Paulay and M.S.N. Priestley, Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley and Sons, 1992.
5.	M. N. S. Priestley, F. Seible and G.M. Calvi, Seismic Design and Retrofit of Bridges, John Wiley and Sons, 1996.

6.	Mario Paz and William Leigh (2010), Structural Dynamics - Theory and Computation, Springer.		
7.	D. J. Dowrick, Earthquake Resistant Design for Engineers and Architects, John Wiley and Sons, 1987.		
8.	IS: 1893:2016 (Part 1), Criteria for earthquake resistant design of structures.		
9.	IS:13920: 2016, Ductile detailing of reinforced concrete structures subjected to seismic forces.		
Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies			
Approved by Academic Council		Date	

<table>
<tr><td rowspan="2">MSE23521T</td><td rowspan="2">NUMERICAL METHODS IN STRUCTURAL ENGINEERING</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td colspan="6">Pre-requisite: Mathematics</td></tr>
<tr><td colspan="6">Course Objectives:</td></tr>
<tr><td colspan="6">1. To obtain knowledge on various numerical methods for direct solution of linear systems.
2. To obtain knowledge on iterative solution techniques for direct solution of linear systems.
3. To understand the concept of eigen values and their applications.
4. To obtain knowledge on the concept and application of partial differential equations and methods of finite differences.</td></tr>
<tr><td colspan="6">Expected Course Outcome:</td></tr>
<tr><td colspan="6">Upon completion of this course, the student will be able to
1. formulate structural problems using numerical methods,
2. carry out numerical simulations of many structural engineering problems,
3. relate different aspects of the structural engineering aspects in order to have a global picture of the behavior of a given problem,
4. develop program for solve particular problems in structural systems.</td></tr>
<tr><td colspan="5">Module:1 Introduction</td><td>10 hours</td></tr>
<tr><td colspan="6">Introduction to Numerical Methods, error in numerical solutions, Order of accuracy; Direct Solution of Linear systems- Gauss elimination, Gauss Jordan elimination, Pivoting, inaccuracies due to pivoting, Factorization, Cholesky decomposition, Diagonal dominance, condition number, ill conditioned matrices, singularity and singular value decomposition.</td></tr>
<tr><td colspan="5">Module:2 Iterative Solution Techniques</td><td>10 hours</td></tr>
<tr><td colspan="6">Iterative solution of Linear systems- Jacobi iteration, Gauss Seidel iteration, Convergence criteria, Direct Solution of Non Linear systems- Newton Raphson iterations to find roots of a 1D nonlinear equation, Newton Iterations, Quasi Newton iterations. Introduction to programming for solving system of equations (linear and nonlinear).</td></tr>
<tr><td colspan="5">Module:3 Concept of Eigen Values</td><td>6 hours</td></tr>
<tr><td colspan="6">Properties of Eigenvalues and Eigenvectors, Diagonalization and Numerical techniques to compute eigenvalues, Vector Iteration, QR algorithm, Jacobi Method.</td></tr>
<tr><td colspan="5">Module:4 Numerical Integration</td><td>6 hours</td></tr>
<tr><td colspan="6">Introduction, Newton – Cotes formulas, Adaptive Integration, Gaussian Quadrature; Numerical differentiation- Equally Spaced Data, Taylor Series Approach, Difference Formula, Error Estimation.</td></tr>
<tr><td colspan="5">Module:5 Partial differential equations and Finite Differences</td><td>6 hours</td></tr>
<tr><td colspan="6">Elliptic, parabolic and hyperbolic PDEs; Numerical Solution of Boundary Value Problems, Finite Difference Method, Explicit and Implicit Approaches; Method of Weighted Residuals, Galerkin’s Method.</td></tr>
<tr><td colspan="5">Total Lecture hours</td><td>38 hours</td></tr>
<tr><td colspan="6">Text Book(s)</td></tr>
<tr><td>1.</td><td colspan="5">J. B. Scarborough, Numerical Mathematical Analysis, Oxford & IBH Publishing Co. Pvt. Ltd., 2000.</td></tr>
<tr><td colspan="6">Reference Books</td></tr>
<tr><td>1.</td><td colspan="5">K. K. Jain, S. R. K Iyengar and R. K. Jain, Numerical Methods - Problem and Solutions, Wiley India Pvt. Ltd, 2001.</td></tr>
<tr><td>2.</td><td colspan="5">R.W. Hamming, Numerical Methods for Scientist and Engineers, McGraw Hill, 1998.</td></tr>
<tr><td>3.</td><td colspan="5">J. H. Mathews and K.D. Fink, Numerical Methods using MATLAB, Pearson Education, 2004.</td></tr>
<tr><td colspan="6">Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test</td></tr>
<tr><td colspan="2">Recommended by Board of Studies</td><td colspan="4"></td></tr>
<tr><td colspan="2">Approved by Academic Council</td><td></td><td>Date</td><td colspan="2"></td></tr>
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MSE23522T	STATISTICAL METHOD	L	T	P	C
		3	1	0	4

Pre-requisite: Mathamatics

Course Objectives:

1. To provide students with a framework that will help them choose the appropriate descriptive methods in various data analysis situations related to Engineering field.
2. To apply estimation and testing methods to make inference and modelling techniques for decision making.

Expected Course Outcome:

Upon completion of this course, the student will be able to

1. Compute and interpret descriptive statistics using numerical and graphical techniques.
2. Apply statistical methods like correlation, regression analysis in analysing, interpreting experimental data and make appropriate decisions using statistical inference.
3. Use statistical methodology and tools in reliability of engineering problems.

Module:1 — **6 hours**

Introduction to statistics and data analysis, Measures of Central Tendency & Measures of Dispersions and their applications in Civil Engineering; Percentile Ranks and Percentiles.

Module:2 — **8 hours**

Concept of Standardization; Applications of Scatter Plots; Covariance; Correlation Coefficients and their properties in field data. Correlation and Regression – Rank Correlation– Partial and Multiple correlation– Multiple regression. Curve Fitting & Least Square Techniques and their use in the experimental methods in Civil Engineering.

Module:3 — **10 hours**

Introduction to probability and set theory–random variables–Probability mass Function, Conditional probability and Bayes' theorem; Discrete and continuous random variables; Probability Density Functions; Probability Distributions of Single and Multiple Random Variables; Discrete & continuous distributions.

Module:4 — **6 hours**

Testing of hypothesis – Introduction–Types of errors, critical region, procedure of testing hypothesis, Large sample tests– Z test for Single Proportion, Difference of Proportion, mean and difference of means. Small sample tests- Student's t-test, F-test, chi-square test, goodness of fit, independence of attributes, Design of Experiments - Analysis of variance – one- and two-way classifications - CRD-RBD-LSD.

Module:5 — **6 hours**

Expectations and Moments and their applications in Random Vibrations and other fields of Civil Engineering; Random Processes and their properties; Some important Random Processes and their applications in Civil Engineering.

Total Lecture hours — **36 hours**

Text Book(s)

1. Probability and Statistics for engineers and scientists, R. E. Walpole, R. H. Myers, S. L. Mayers and K. Ye, 9th Edition, Pearson Education (2012).
2. Applied Statistics and Probability for Engineers, Douglas C. Montgomery, George C. Runger, 6th Edition, John Wiley & Sons (2016).

Reference Books

1. Reliability Engineering, E. Balagurusamy, Tata McGraw Hill, Tenth reprint 2017
2. Probability and Statistics, J. L. Devore, 8th Edition, Brooks / Cole, Cengage Learning (2012).
3. Probability and Statistics for Engineers, R. A. Johnson, Miller Freund's, 8th edition, Prentice Hall India (2011).
4. Probability, Statistics and Reliability for Engineers and Scientists, Bilal M. Ayyub and Richard H. McCuen, 3rd edition, CRC press (2011).

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23523T	THEORY OF STABILITY OF STRUCTURES	L	T	P	C
		3	1	0	4

Pre-requisite: Mathematics

Course Objectives:

1. To know basic concept of structural stability and approaches to stability analysis.
2. To obtain knowledge on stability analysis of beam-column-frames.
3. To study the approximate methods for solving stability problems.
4. To understand the concept of stability of plates, shells and columns.

Expected Course Outcome:

Upon completion of this course, the student will be able to
1. understand the concept of structural stability and nonlinear structural behavior,
2. determine and interpret the buckling loads for simple columns and frames,
3. analyze basic structural components and systems that are susceptible to instability,
4. design and evaluate advanced numerical techniques to bucking analysis of structures.

Module:1 *Basic Concepts*	**6 hours**
Concept of stability, Structural instability and bifurcation, Basic approaches to stability analysis. Discrete Systems: Law of minimum potential energy, Concept of dynamics and energy criteria; Stability of single and multi-degrees of freedom systems, large deflection analysis.	
Module:2 *Analysis of Columns*	**8 hours**
Governing differential equation and boundary conditions; End-restrained columns; Effect of imperfection; Eccentrically loaded columns; Large deflection solution of elastic columns.	
Module:3 *Analysis of Beam-Columns and Frames*	**10 hours**
Behavior of beam-columns; continuous columns and beam columns, single-storey frames, frames with sway and no-sway, buckling analysis using stiffness and flexibility method.	
Module:4 *Approximate Methods*	**6 hours**
Solution of boundary value problems; Rayleigh-Ritz Method; Method of weighted residuals; Eigenvalue problems; Numerical solution of elastically supported columns.	
Module:5 *Stability of Plates and Buckling of Columns*	**8 hours**
Governing differential equation for rectangular plates, plates with different boundary conditions and loading conditions; buckling under in-plane shear, post buckling analysis. Buckling snap through and post-buckling; Inelastic buckling; Torsional buckling, torsional-flexural buckling, lateral-torsional buckling of symmetric cross-sections.	
Total Lecture hours	**38 hours**

Text Book(s)

1.	W. F. Chen and E. M. Lui (1987), Structural Stability: Theory and implementation, Prentice-Hall.

Reference Books

1.	S. P. Timoshenko and J. M. Gere (1961), Theory of Elastic Stability, McGraw-Hill.
2.	T. V. Galambos and A. E. Surovek (2008), Structural Stability of Steel: Concepts and applications for structural engineers, Wiley.
3.	Z.P. Bazant and L. Cedolin (1991), Stability of structures, Dover.

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23524T	PLATES SHELLS AND ELASTIC STABILITY	L	T	P	C
		3	1	0	4

Pre-requisite: Design of RCC

Course Objectives:

1. To understand the theory of rectangular and circular plates and cylindrical shell bending problems by different approaches.
2. Students will be able to analyse doubly curved shell structures including domes, hyperbolic, paraboloid, elliptic and conoidal shells.

Expected Course Outcome:

Upon completion of this course,

1. Students can understand the action of plates and shells in structures
2. Students will be able to articulate plate/shell problems and determine the component responses
3. Students can analyze plate and shell structures using analytical and numerical methods
4. Students can evaluate the elastic plate/shell theories and design structural engineering systems

Module:1	**6 hours**
Review of Concepts of Elasticity, Classical Plate Theory: Basic Assumptions, Formulations, Boundary Conditions, Governing Equations.	
Module:2	**8 hours**
Pure Bending of rectangular plates with Various Loadings and Boundary Conditions, Navier's Solution for Rectangular Plates, Levy's Solution, distributed and concentrated load. Circular plates: governing differential equations in polar coordinate system, annular plate, rotationally symmetric loading, eccentric concentrated load; simultaneous bending and stretching of thin plates.	
Module:3	**10 hours**
Potential Energy Minimization, Energy Principles and Rayleigh-Ritz Methods, Numerical Integration Method, Finite Element Analysis of Plates. Introduction to large deflection theory of plates, Plates with Shear Deformation, Higher Order Plate Bending Theory, Thermal Stresses in Plates	
Module:4	**6 hours**
Shells - geometry and classifications; stress resultants; membrane theory and its applications to shells of surface of revolutions; membrane theory for cylindrical shell; general theory in bending of cylindrical shell; simplified method for cylindrical shell.	
Module:5	**6 hours**
Elastic stability of columns - eigenvalue problem; buckling modes and critical load; beam- columns; beam-columns with elastic restraints; effect of initial curvature; buckling of bar on elastic foundation, Buckling of frames; inelastic stability; lateral buckling of beams in pure bending. Buckling of thin plates; rectangular plates under uniaxial and biaxial compression; combined bending and compression; shear bucking; application of energy methods for calculation of buckling loads and modes.	
Total Lecture hours	**36 hours**

Text Book(s)

1.

Reference Books

1. Timoshenko, S. P. and Krieger, S. W., "Theory of Plates and Shells", McGrawHill.
2. Szilard, R.,"Theory and Analysis of Plates: Classical and Numerical Methods", Prentice Hall, New York
3. Gould, P. L., "Analysis of Shells and Plates", Springer-Verlag.
4. Bairagi, N. K., "Shell Analysis", Khanna Publishers, New Delhi
5. Timishenko, S.P. and Goodier, J. N., "Theory of Elasticity", McGraw-Hil

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23525T	DESIGN OF PRE-STRESSED CONCRETE STRUCTURES	L	T	P	C
		3	1	0	4

Pre-requisite: Design of RCC

Course Objectives:

1. To understand the basic aspects of pre-stressed concrete.
2. To identify and interpret the appropriate relevant industry design codes.
3. To get familiar with professional and contemporary issues in the analysis and design of pre-stressed concrete members.
4. To get familiar with professional and ethical issues and the importance of lifelong learning in structural engineering.

Expected Course Outcome:

Upon completion of this course, the student will be able to
1. Understand the basic characteristics of pre-stressed concrete.
2. Evaluate and design members under various loading conditions.
3. Analyze and design beams, its deflection and cable profiles.
4. Apply the concept of prestress to design special structures.

Module:1 *Introduction*	**8 hours**

Basic Concept: Definitions; Advantages & Limitations of Prestressing; Types of Prestressing; Properties of Prestressed members.
Losses in Prestress: Elastic shortening; Pre-tensioned axial members; Pre-tensioned bending members; Post-tensioned axial members; Post-tensioned bending members.

Module:2 *Analysis & Design of Members*	**8 hours**

Analysis of Members: Under axial load - Analysis at transfer, at services loads, at ultimate strength and analysis of behavior; Under flexure - based on stress concept, force concept and load balancing concept; stress calculation.
Design of Members: For axial tension and flexure; Choice of sections; Determination of limiting zone; Detailing requirements; IS Specifications

Module:3 *Analysis and Design for Shear and Torsion*	**6 hours**

Analysis for Shear: Stress in an uncracked beam; types of cracks; Modes of failure; Limit state of collapse for shear; Design steps; Design of transverse reinforcement; Detailing requirement for shear.
Analysis for Torsion: Stresses in an uncracked beam; Components of resistance for pure torsion; Modes of failure; Effect of prestressing force; Limit state of collapse for torsion; Design of longitudinal reinforcement and transverse reinforcement; Detailing requirements.

Module:4 *Design of Beams & Deflection Calculation*	**10 hours**

Cantilever Beams: Introduction; Analysis; Determination of limiting zone; cable profile
Continuous Beams: Introduction; Analysis; Incorporation of moment due to reactions; Pressure line due to prestressing force; Cable profiles
Calculation of Deflection: Deflection due to various loads; Total deflection; Calculation of crack width.

Module:5 *Special Topics*	**6 hours**

Composite Sections: Introduction; Analysis of composite sections; Design of composite sections
Slabs: One-way & Two-way slab modelling and analysis; Check for shear capacity
Compression members: Introduction; Analysis; Development of interaction diagram; Effect of prestressing force.

Total Lecture hours	**38 hours**

Text Book(s)

1.	Lin, T. Y., & Burns, N. H. (1981). Design of prestressed concrete structures.
2.	Krishna Raju (1981). Pre-stressed Concrete, Tata McGraw-Hill.

Reference Books

1.	Rajagopalan, N. (2002). Prestressed concrete. CRC Press.
2.	Nawy, E. G. (1996). Prestressed concrete. A fundamental approach.
3.	IS: 1343- Code of Practice for Pre-stressed Concrete.

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies	

Approved by Academic Council		Date	

MSE23526T	DESIGN OF BRIDGES AND FLYOVER	L	T	P	C
		3	1	0	4

Pre-requisite: Design of RCC

Course Objectives:

1. To understand the basic concept of design of bridges
2. To analyse box culvert, T beams and deck slab bridge
3. To analyse and design prestressed bridges
4. To design piers and abutments
5. To design pile foundation and bearings.

Expected Course Outcome:

Upon completion of this course, the student will be able to

1. To enlist, classify and recommend the structural forms used for bridges.
2. To select different standard loads for road/railway bridges conforming to IRC, MOST, Railway Ministry codes as per current practice.
3. To design road bridges using different forms and materials, and prepare detailed drawings of the same.
4. To design various types of bearings.

Module:1 *General*	**6 hours**
Introduction, historical review, Engineering and aesthetic requirements in bridge design, Introduction to bridge codes, economic evaluation of a bridge project, site investigation and planning, types of bridges, selection of suitable types of bridges.	
Module:2 *Bridge analysis*	**8 hours**
IRC loadings and introduction to bridge loading worldwide, Analysis of box culverts, solid slab bridges by IRC/Effective width method, Pigeaud's method, Analysis of girder bridges by Courbon's method and Grillage method, Introduction to other methods of analysis like Finite element, Finite strip method.	
Module:3 *Design of bridges and culverts*	**10 hours**
Reinforced concrete bridges: design of deck slab; T-beam bridge; balanced cantilever type; design and details of articulation. Prestressed concrete bridges: Pretensioned and post tensioned concrete bridges; analysis of section for flexure, shear and bond; losses in prestress, deflection of girder;	
Module:4 *Long span & Special type bridges*	**6 hours**
Analysis & design principles of continuous bridges, arch bridges, integral bridges, cable stayed bridges and suspension bridges.	
Module:5 *Design of Sub-Structure*	**6 hours**
Design of piers & abutments: Introduction to wing walls & returns and Reinforced Earth in flyover approaches. Design of foundation: Pile, Pile cap and well foundation	
Module:6 *Design of bearings*	**4 hours**
Types of bearings, design of different type of bearings	
Total Lecture hours	**40 hours**

Text Book(s)

1.	Johnson Victor. D., (2012), Essentials of Bridge Engineering, Oxford Publishing Company, New Delhi

Reference Books

1.	Jain and Jai Krishna.,(2007), Plain and reinforced concrete, Vol.2.,Nem Chand Brothers, New Delhi.
2.	Krishna Raju. N., (2014), Design of Bridges, Oxford and IBH Publishing Co., New Delhi
3.	Rakshit. K. S., (2010), Design and Construction of Highway Bridges, New central Book Agency, New Delhi.
4.	Standard specifications and code of practice for road bridges, (2005) – IRC section I, II, III and IV.
5.	Ponnuswamy (2008), Bridge Engineering, McGraw-Hill Education (India) Pvt Limited
6.	Principles and Practices of Bridge Engineering- S P Bindra, Dhanpat Rai Publications

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies			
Approved by Academic Council		Date	

MSC23527T	ADVANCE DESIGN OF FOUNDATION	L	T	P	C
		3	1	0	4

Pre-requisite: Design of RCC

Course Objectives:

1. To impart knowledge about the foundation and the effect of foundation on the behavior of structures.
2. To introduce the fundamental concepts relevant to foundation design, which enables to understand the factors that cause the design of foundation for static and dynamic design of foundation.

Expected Course Outcome:

Upon completion of this course, the student will be able to

1. Analyse given soil condition to decide suitability of a particular foundation.
2. Design shallow foundations for structures.
3. Design deep foundations for structures and retaining wall.

Module:1 *Shallow foundations*	**6 hours**

Design considerations- factors of safety (including limit state), allowable settlements, location and depth of foundations. Bearing capacity theories, layered soils, choice of shear strength parameters, bearing capacity from N-values, static cone tests, plate load tests. Total and differential settlement, stress distribution, consolidation settlement in clays (with correction factors), immediate settlement. Settlement in sands from N-values, elastic solutions static cone tests, plate load tests. Design of shallow foundations, combined footings, strap foundation, mat foundations including floating raft.

Module:2 *Pile foundations*	**8 hours**

Types of piles, construction methods, axial capacity and design of single pile & group of piles, dynamic formulae, static formula, soil mechanics approach. Skin friction and end bearing in sands and clays. Single and multiple under reamed pile. Negative skin friction, piles subjected to uplift load (including under reamed piles), pile load tests, pile integrity tests settlement of single piles and group. Influence of pile cap, influence of pile driving in sand, pull out capacity, laterally loaded piles.

Module:3 *Well foundations*	**10 hours**

Different types, components, construction methods, design methods (Terzaghi, IS and IRC approaches), check for stability, base pressure, side pressure and deflection.

Module:4 *Retaining walls*	**6 hours**

Types (types of flexible and rigid earth retention systems: counter fort, gravity, diaphragm walls, sheet pile walls, soldier piles and lagging). Support systems for flexible retaining walls (struts, anchoring), construction methods, stability calculations, design of flexible and rigid retaining walls.

Module:5 *Sheet pile walls*	**6 hours**

Cantilever and anchored sheet pile walls.

Total Lecture hours	**36 hours**

Text Book(s)

1.	

Reference Books

1.	Basic and Applied Soil Mechanics by Gopal Ranjan & A. S. R. Rao
2.	Foundation Analysis and Designby J. E. Bowles
3.	Pile Foundations in Engineering Practice by Prakash and Sharma
4.	Design of Foundation Systems- Principles and Practices by N. P. Kurian
5.	Principles of Foundation Engineering by Braja M. Das
6.	Foundation Design and Construction by M. J. Tomlinson
7.	Advanced Foundation Engineering by V. N. S. Murthy.

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23528T	FINITE ELEMENT METHOD	L	T	P	C
		3	1	0	4

Pre-requisite: Advanced Structural Analysis

Course Objectives:

1. To know various frameworks of finite element analysis.
2. To obtain knowledge on the procedure to analyze various structures in FEM.
3. To study the basic idea of formulation of FEM in dynamic problems of structures.
4. To learn and apply concept of FEM in structural problems using computer applications.

Expected Course Outcome:

Upon completion of this course, the student will be able to

1. Understand various frameworks for finite element formulation (based on: variational methods, Galerkin and other weighted residual methods, principle of virtual work) and realize the finite element discretization.
2. Apply FEM (formulations as well as methodology) for analysis of various types of structure/solid.
3. Evaluate the formulation of FEM for structural dynamics.
4. Analyze & Conceptualize the computer implementations of FEM-algorithms.

Module:1 *Introduction*	**6 hours**
Finite element formulations based on: Variational methods, Galerkin method, Virtual displacement; Fundamentals of discretization and shape functions; Isoparametric formulation; Analysis of truss using FEM; Analysis of frame using FEM;	
Module:2 *Plane stress and plane strain problems*	**8 hours**
Basic concepts, derivation of linear strain triangular element, examples, rectangular plane stress element, isoparametric formulations, numerical integration, stiffness matrix and stress matrix by Gaussian quadrature, higher order shape functions.	
Module:3 *Axisymmetric problems*	**6 hours**
Derivation of stiffness matrix, axisymmetric pressure vessels, applications.	
Module:4 *Three dimensional stress analysis*	**6 hours**
Three dimensional stress and strain, tetrahedral element, isoparametric formulation, examples.	
Module:5 *Plate bending elements*	**6 hours**
Basic concepts, derivation of plate bending element stiffness matrix, examples.	
Module:6 *Structural dynamics*	**6 hours**
Dynamics of spring-mass system, eigenvalue and eigenvector problems, computer implementations of algorithms.	
Total Lecture hours	**38 hours**

Text Book(s)

1.	Cook, R. D. (2007). Concepts and applications of finite element analysis. John wiley & sons.
2.	Reddy, J. N. (2019). Introduction to the finite element method. McGraw-Hill Education.

Reference Books

1.	Rao, S. S. (2017). The finite element method in engineering. Butterworth-heinemann.
2.	Zienkiewicz, O. C., Taylor, R. L., & Zhu, J. Z. (2005). The finite element method: its basis and fundamentals. Elsevier.
3.	Hughes, T. J. (2012). The finite element method: linear static and dynamic finite element analysis. Courier Corporation.

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23529T	Seismic Hazard and Risk Analysis	L	T	P	C
		3	1	0	4

Pre-requisite: Mathematics

Course Objectives:

1. To acquire knowledge and ability to exposure to development, declustering, homogenization of earthquake catalogues.
2. To acquire knowledge and ability to performance of deterministic and probabilistic seismic hazard analysis.
3. To acquire knowledge and ability to introduction to various methods and approaches of vulnerability assessment.
4. To acquire knowledge and ability to introduction to various methods and approaches of risk assessment.

Expected Course Outcome:

Upon completion of this course, the student will be able to

1. understand the concept of different components of seismic risk and hazard,
2. carry out deterministic and probabilistic seismic hazard analysis,
3. understand the concept of various methods and approaches of vulnerability assessment,
4. understand the concept of various methods and approaches of risk assessment and carry out risk analysis .

Module:1 *Introduction*	**6 hours**
Components of seismic risk, Hazard, Exposure, Vulnerability; difference between risk and hazard; probabilistic and deterministic seismic hazard approaches; earthquake sources; estimation of maximum magnitude; maximum credible earthquake; design basis earthquake.	
Module:2 *Seismicity Data and Treatment*	**6 hours**
Seismicity catalogues; spatial coverage; temporal coverage; completeness in size and time; cut off magnitude; foreshocks and aftershocks; declustering of data; homogenization of catalogue; estimation of maximum probable magnitude; Gutenberg Richter frequency magnitude distribution; return period; Poissonian model, time dependent Poisson process.	
Module:3 *Deterministic and Probabilistic Seismic Hazard Analysis*	**10 hours**
Strong motion attenuation relationships; PGA and spectral accelerations, response spectra, displacement spectra. Deterministic and probabilistic seismic hazard methods; Types of earthquake sources-point, line and areal sources; geological slip rate method; deaggregation; logic tree; hazard estimation at the bedrock level; probability of exceedance and return periods in earthquake engineering.	
Module:4 *Seismic Vulnerability of Buildings and Lifelines*	**8 hours**
Empirical, analytical, experimental and hybrid approaches; building typology; intensity scales, use of intensity scales for estimating seismic vulnerability; HAZUS methodology.	
Module:5 *Risk Estimation and Post Earthquake Damage Studies*	**8 hours**
Convolution of hazard, vulnerability and exposure to quantify risk; loss ratios, indoor and outdoor casualty rates; Earthquake damage surveys, questionnaires and data to be collected, handling and processing of data, classification of damage, estimation of fragility from damage data.	
Total Lecture hours	**38 hours**

Text Book(s)

1.	Geotechnical Earthquake Engineering. Kramer, S. L., Pearson Education.

Reference Books

1.	Earthquake Hazard Analysis, Issues and Insights. Reiter, L. Columbia University Press.
2.	Seismic Hazard and Risk Analysis. McGuire, Robin K Earthquake Engineering Research Institute.

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

TFE23531T	Operation Research Techniques	L	T	P	C
		3	1	0	4

Pre-requisite: Nil

Course Objectives:

1. To introduce the basic concepts of Operational Research and linear programming to the students.

Expected Course Outcome:

Upon completion of this course, the student will be able to
1. Identify and develop operational research models from the verbal description of the real system
2. Understand the mathematical tools that are needed to solve optimisation problems.
3. Develop a report that describes the model and the solving technique, analyse the results and propose recommendations in language understandable to the decision-making processes

Module:1	**6 hours**
Definition of operations research, models of operations research, scientific methodology of operations research, scope of operations research, importance of operations research in decision making, role of operations management, limitations of OR.	
Module:2	**6 hours**
Linear Programming: Introduction – Mathematical formulation of a problem – Graphical solutions, standard forms the simplex method for maximization and minimization problems. Method application to management decisions. Transportation problem – Introduction – Initial basic feasible solution - NWC method – Least cost method – Vogel's method – MODI – moving towards optimality - solution procedure without degeneracy	
Module:3	**10 hours**
Assignment problem – Algorithm – Hungarian method – simple problems.	
Module:4	**8 hours**
Sequencing and replacement model: Sequencing problem – processing through 2 machines, 3 machine – s jobs and k machines and traveling salesman problem. Replacement of items that deteriorate gradually – with time, without time, that fails completely – individual replacement – group replacement.	
Module:5	**8 hours**
Network models and simulation. Network models for project analysis CPM; Network construction and time analysis; cost time trade off, PERT – problems	
Total Lecture hours	**38 hours**

Text Book(s)

1. P. Sankara Iyer, "Operations Research", Tata McGraw-Hill, 2008.
2. A.M. Natarajan, P. Balasubramani, A. Tamilarasi, "Operations Research", Pearson Education, 2005..

Reference Books

1. J K Sharma., "Operations Research Theory & Applications , 3e", Macmillan India Ltd, 2007.
2. P. K. Gupta and D. S. Hira, "Operations Research", S. Chand & co., 2007.
3. J K Sharma., "Operations Research, Problems and Solutions, 3e", Macmillan India Ltd.
4. N.V.S. Raju, "Operations Research", HI-TECH, 2002

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council		Date	

MSE23531T	Industrial Safety	L	T	P	C
		3	0	0	3

Pre-requisite: Nil

Course Objectives:

1. To give knowledge of various safety management principles, various safety systems, various machine guarding devices, hazard identification techniques, energy sources, systems & applications and the need in the present context.
2. Learners will be able to compare different hazard identification tools and choose the most appropriate based on the nature of industry. It aims to equip students in working with projects and to take up research work in connected areas

Expected Course Outcome:

Upon completion of this course, the student will be able to

1. Describe the theories of accident causation and preventive measures of industrial accidents.
2. Explain about personal protective equipment, its selection, safety performance & indicators and importance of housekeeping.
3. Explain different issues in construction industries.
4. Describe various hazards associated with different machines and mechanical material handling.
5. Utilise different hazard identification tools in different industries with the knowledge of different types of chemical hazards.

Module:1 *Safety Introduction* — **5 hours**

Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization-objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.

Module:2 *Personal Protection In Work Environment* — **7 hours**

Personal protection in the work environment, Types of PPEs, Personal protective equipment respiratory and non-respiratory equipment. Standards related to PPEs.

Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5s of housekeeping.

Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.

Module:3 *Safety Issues In Construction* — **7 hours**

Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space –Temporary Structures. Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders..

Module:4 *Safety Hazards In Machines* — **8 hours**

Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices. Safety in turning, and grinding. Welding and Cutting-Safety Precautions of Gas welding and Arc Welding. Material Handling-Classification-safety consideration- manual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking. Material Handling equipment-operation & maintenance. Maintenance of common elements-wire rope, chains slings, hooks, clamps. Hearing Conservation Program in Production industries.

Module:5 *Hazard Identification and Analysis* — **8 hours**

Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants - The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operability study (HAZOP)) – methodology, criticality analysis, corrective action and follow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS).

Total Lecture hours		**35 hours**
Text Book(s)		
1.	R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.	
Reference Books		
1.	Paul S V (2000), Safety management System and Documentation training Programme handbook, CBS Publication.	
2.	Krishnan, N.V. (1997). Safety management in Industry. Jaico Publishing House, New Delhi..	
3.	John V. Grimaldi and Rollin H.Simonds. (1989) Safety management. All IndiaTraveller Book Seller, Delhi.	
4.	Ronald P. Blake. (1973). Industrial safety. Prentice Hall, NewDelhi.	
5.	Alan Waring. (1996). Safety management system. Chapman & Hall, England.	
6.	Vaid, K.N., (1988). Construction safety management. National Institute of Construction Management and Research, Mumbai.	
7.	AIChE/CCPS. (1992). Guidelines for Hazard Evaluation Procedures. (second edition). Centre for Chemical Process Safety, American Institute of Chemical Engineers, New York.	
Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test		
Recommended by Board of Studies		
Approved by Academic Council		Date

MSE23532T	Cost Management of Engineering Projects	L	T	P	C
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Pre-requisite: Nil

Course Objectives:

1. To summarize the costing concepts and their role in decision making
2. To infer the project management concepts and their various aspects in selection
3. To interpret costing concepts with project execution
4. To develop knowledge of costing techniques in service sector and various budgetary control techniques
5. To illustrate with quantitative techniques in cost management

Expected Course Outcome:

Upon completion of this course, the student will be able to

1. Understand the costing concepts and project management concepts
2. Interpret costing concepts with project execution.
3. Gain knowledge of costing techniques in service sector and various budgetary control techniques.
4. Become familiar with quantitative techniques in cost management.

Module	Hours
Module:1 *Introduction to Costing Concepts*	**6 hours**
Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.’	
Module:2 *Introduction to Project Management*	**6 hours**
Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member, Importance Project site: Data required with significance, Project contracts	
Module:3 *Project Execution and Costing Concepts*	**10 hours**
Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing	
Module:4 *Costing of Service Sector and Budgetary Control*	**8 hours**
Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.	
Module:5 *Quantitative Techniques for Cost Management*	**8 hours**
Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.	
Total Lecture hours	**38 hours**

Text Book(s)

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991.

Reference Books

1. John M. Nicholas, Herman Steyn Project Management for Engineering, Business and Technology, Taylor & Francis, 2 August 2020, ISBN: 9781000092561.
2. Albert Lester ,Project Management, Planning and Control, Elsevier/Butterworth- Heinemann, 2007, ISBN: 9780750669566, 075066956X.
3. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988.
4. Charles T. Horngren et al Cost Accounting a Managerial Emphasis, Prentice Hall of India, New Delhi, 2011.
5. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003.
6. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007.

Mode of Assessment: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

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