Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2021-22

Course Information	
Programme	M. Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. I
Course Code	5ST560
Course Name	Research Methodology (PC)
Desired Requisites:	NA

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	2 Hrs/Week	**Credits: 2**			

Course Objectives	
1	To prepare students for undergoing research, identify and formulate the research problems, state the hypothesis, design a research layout, set a research process and methodology.
2	To enable students to investigate the problem, interpret the results, propose theories, suggest possible/alternative solutions, solve and prove the solution adapted–logically and analytically, conclude the research findings.
3	To impart knowledge to analyze critically the literature and publish research in conferences, journals and to expose students to research ethics, IPR

Course Outcomes (CO)	
CO1	**Analyze** research and its significance in economic, social and legal aspects.
CO2	**Discuss** research problems and its design for solution logically and critically.
CO3	**Produce** research solution, publication, Dissertation, IPR and patent doc.

Module	**Module Contents**	**Hours**
I	**Engineering Research process** Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Definition, scope and objectives of research problem. Approaches of investigation of solutions for research problems, data collection, analysis, interpretation, Necessary instrumentations.	7
II	**Research methodology** Problem statement formulation, resources identification for solution, Experimental and Analytical modelling, Numerical and Statistical methods in engineering research, Software tools like spreadsheets, Effective literature studies approaches, critical analysis	7
III	**Effective Technical Writing** Plagiarism, Research ethics, Effective technical writing, how to write reports, Paper. Presentation of paper/report/seminar.	7
IV	**Patents and IPR** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT. Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies	7

Text Books	
1	Melville Stuart and Goddard Wayne, “Research Methodology: An Introduction for Science & Engineering Students” Juta and Company Ltd, 2000.
2	Goddard Wayne and Melville Stuart, “Research Methodology: An Introduction”, Juta and Company Ltd., 2nd Ed.-2004
3	Merges Robert, Menell Peter, Lemley Mark, “Intellectual Property in New Technological Age”, ASPEN Publishers, 2016.
4	Kumar Ranjit, “Research Methodology: A Step by Step Guide for beginners”, SAGE Publications, 4th Ed.-2014.

References	
1	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007
2	Mayall, “Industrial Design”, McGraw Hill, 1992.
3	Niebel, “Product Design”, McGraw Hill, 1974
4	Asimov, “Introduction to Design”, Prentice Hall, 1962
5	Ramappa T., “Intellectual Property Rights Under WTO”, S. Chand, 2008

Useful Links	
1	NPTEL :: General - NOC:Introduction to Research
2	Introduction to Research - Course (nptel.ac.in)
3	Qualitative Research Methods And Research Writing - Course (nptel.ac.in)

CO-PO Mapping

	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3					
CO2		2		3	2	
CO3		3		2		

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High.
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom’s Taxonomy Level

Bloom’s Taxonomy Level	T1	T2	ESE	Total
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information

Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. I
Course Code	5ST501
Course Name	Mechanics of Structures (PC1)
Desired Requisites:	Solid Mechanics, Structural analysis, Structural Mechanics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives

1	To impart the knowledge of advanced methods of structural analysis.
2	To provide knowledge for analyzing special types of structures.
3	To prepare students to develop computer programs by using matrix methods of structural analysis.

Course Outcomes (CO)

CO1	**Apply** advanced methods for analysis of structures.
CO2	**Calculate** forces and displacements for special structures.
CO3	**Formulate** program by using matrix methods of structural analysis for field applications.

Module	Module Contents	Hours
I	**a) Basics in structural analysis** Types of structures, various loads and methods of structural analysis, energy theorems and application of virtual work principle. Introduction to basic software for structural analysis. **b) Influence line Diagrams for Indeterminate Structures** Concept of ILD, Muller-Breslau's principle and its application for continuous beams. ILD for two hinged arches.	7
II	**Beams Curved in Plan** Structural behaviour of curved beam. Analysis of determinate and indeterminate beams curved in plan, bent beams.	7
III	**Beams on Elastic Foundations** Basic concept of beams on elastic foundation, analysis of infinite, semi-infinite and finite beams.	6
IV	**Beam Columns** Concept of geometric and material nonlinearity, governing differential equations. Analysis of beam-columns subjected to different loadings and support conditions. Buckling of frames–symmetrical and unsymmetrical, stiffness and carry-over factors for beam-columns, fixed end actions due to various loads.	6
V	**Matrix method of analysis: Flexibility Method** Element approach, flexibility matrix, equivalent loads, applications to beams, frames and trusses, lack of fit, temperature stresses.	7
VI	**Matrix method of analysis: Stiffness Methods** Element approach, stiffness matrix, equivalent loads, applications to beams, frames and trusses, direct stiffness method.	7

Textbooks

1	Vazirani. V.N. & Ratwani M.M., “Advanced Theory of Structures”, Khanna Publishers, 2008
2	Timoshenko. S. P. & Gere. J. M., “Theory of Elastic Stability", Tata McGraw-Hill Publishing company Ltd., 2nd Edition,1985
3	Gere. J. M. & Weaver. W.,“Matrix Analysis of Framed Structures”, CBS Publishers and Distributor, 2nd Edition,2004.
4	Krishna Raju N., “Advanced Mechanics of Solids and Structures”, McGraw-Hill Education, 08-Nov-2018 - Technology & Engineering
References	
1	Mcquire and Gallghar. R. H. "Matrix Structural Analysis", John Wiley, 2nd Edition, 2000
2	Beaufit F.W et al. "Computer Methods of Structural Analysis", Prentice Hall, illustrated,1970
3	John L. and Meek, "Matrix Structural Analysis", McGraw Hill Book Company, illustrated,1971
4	Pandit G. and Gupta S., "Structural Analysis - A Matrix Approach2008",McGraw Hill Education; 1st edition
Useful Links	
1	https://nptel.ac.in/courses/105/105/105105108/
2	https://nptel.ac.in/courses/105/101/105101086/
3	http://engineeringvideolectures.com/course/281?pn=0#videolist
4	https://nptel.ac.in/courses/105/105/105105109/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1			2	2		3
CO2			2	2		3
CO3	1		2			2
The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High. Each CO of the course must map to at least one PO.						
Assessment						
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.						

Assessment Plan based on Bloom’s Taxonomy Level				
Bloom’s Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. I
Course Code	5ST502
Course Name	Theory of Elasticity and Plasticity (PC 2)
Desired Requisites:	Solid Mechanics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives	
1	To impart knowledge of various theories of elasticity and apply them to solve 2D Cartesian and polar problems.
2	To impart knowledge of various theories of torsion and apply them to solve 2D torsional problems.
3	To provide knowledge of various theories of plastic behavior and apply them to solve 2D problems.

Course Outcomes (CO)	
CO1	**Apply** the knowledge of fundamental methods of elasticity for 2-D Cartesian and Polar problems.
CO2	**Analyze** torsional problems and apprise various theories to solve 2-D torsional problems.
CO3	**Discuss** concept of material yielding and plastic behavior of structures.

Module	**Module Contents**	**Hours**
I	**Introduction to Elasticity** Introduction to Elasticity: Body force, Surface force, Stress at a point, Stress & Strain, Transformation of stress, Equilibrium equations in two and three dimensions in Cartesian coordinates, Boundary conditions, Strain displacement relations, Compatibility equations, Generalized Hooke's Law, Stress invariants.	8

II	**Plane Stress and Strain** 2D problems in Cartesian coordinates, Equations of equilibrium and compatibility, Plane stress and Plane strain problems, Airy stress function approach, 2D problems in polar coordinates, Thick walled cylinder under radial pressure, Plate with stress concentration.	8
III	**Torsion** Introduction to Torsion: St. Venant's theory, Warping function, Prandtl's membrane analogy, Torsion of circular, thin rectangular and open sections. Strain energy in axial, bending and torsion. Principle of virtual work and minimum potential energy.	7
IV	**Plasticity** Introduction to plasticity: Plastic behavior of solids, Idealized plastic solids, Similarities& differences when compared with elasticity, Idealized material behavior, Coulomb friction model for elasticity and plasticity.	8
V	**Hydrostatic Stresses** Hydrostatic stresses, Deviatoric stresses, Invariants of deviatoric stresses, Yield criteria, Graphical representation of yield criteria, Flow rules, Stress-strain relation for perfectly plastic flow, Elastic-plastic analysis of beam in bending, Thick walled cylinder and circular shaft under torsion.	7
VI	**Plastic analysis of structures** Plastic analysis of structures – plastic hinge, Moment – curvature relation, Shape factor, Upper bound, lower bound and uniqueness theorems, Methods of analysis to find collapse loads for beams and frames.	7

Textbooks	
1	Ameen M., "Computational Elasticity", Alpha Science International, 1st Revised Edition, 2008.
2	Singh Sadhu, "Theory of Elasticity", Khanna Publishers, 4th Edition, 2012.
3	Singh Sadhu, "Theory of Plasticity", Khanna Publishers, 3rd Edition, 2013

References	
1	Timoshenko. S & Goodier. J. N., "Theory of Elasticity", McGraw-Hill book Company, 3rd Edition, 2010.
2	Chakrabarthy. J, "Theory of Plasticity", Tata McGraw-Hill P. Co. Ltd., 2nd Edition, 2007.
3	Johnson W. and Mellor P. B., "Engineering Plasticity", Van Nostrand Reinhold, London, 1973

Useful Links	
1	https://nptel.ac.in/courses/105/105/105105177/

2	https://nptel.ac.in/courses/105/105/105105108/
3.	https://nptel.ac.in/courses/105/102/105102090/
4.	https://onlinecourses.nptel.ac.in/noc21_ce45/preview

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		3	2		2
CO2	1			3		2
CO3	1			3		2
The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High. Each CO of the course must map to at least one PO.						

Assessment
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. I
Course Code	5ST511
Course Name	Structural Dynamics and Earthquake Engineering (PE1)
Desired Requisites:	Engineering Mechanics, Engineering Geology

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives	
1	To impart knowledge of ground motion characteristics and its effect on Civil Engineering structures
2	To prepare students to solve problems on dynamics of structures in SDOF and MDOF Systems
3	To illustrate national and global codal provisions for design of earthquake resistant structures and implementation of same for seismic retrofit.

Course Outcomes (CO)	
CO1	**Use** engineering seismology and its characteristics for development of response spectra.
CO2	**Estimate** response of structures subjected to earthquake loads for various building configurations.
CO3	**Evaluate** forces for design of earthquake resistant structure.

Module	**Module Contents**	**Hours**
I	**Seismological Aspect in Earthquake Engineering** Characteristics of Earthquakes, Elastic rebound theory, Measurement of earthquakes, Magnitude, Intensity, magnitude relationship, Seismograph, Liquefaction. Attenuation relationship, MCE and DBE, Performance of various structures in past earthquakes**.**	6

II	**SDOF Systems and Estimation of Forces** Earthquake response of linear SDOF systems and its application in dynamic analysis. Concept of earthquake response spectrum, Tripartite plot of response spectrum, Construction of design response spectrum. Use of Code Spectra to find response of structures. Equivalent static method to find story shear and its distribution along height of building.	6
III	**MDOF Systems and Dynamic Analysis** Earthquake response of linear MDOF systems, Modal analysis, Participation factors, Modal contributions, Dynamic analysis of Multistoried buildings.	7
IV	**ERD of Structure and Role of Ductility** Concept of earthquake resistant design, Objectives, Ductility and different types of ductility. Over strength, Response reduction factor, Ductile Detailing of structural components as per code. lateral stiffness, Conceptual design, Building configuration.	7
V	**Distribution of Lateral Forces and Codal Provisions** Floor diaphragm, Rigid floor diaphragm, Center of mass and center of stiffness, Torsionally uncoupled and coupled systems, Lateral load distribution, Minimum eccentricity, Provisions of IS: 1893 for buildings, Base shear, Application to Multistory buildings, Load combinations, Ductile detailing, Provisions of IS: 13920.	6
VI	**Structural Control and Retrofit Issues** Different lateral load resisting systems, Configuration of tall structures with modeling. Nonlinear analysis of structures. Concepts of structural Control, Energy dissipating devices. Retrofit issues and their solutions with advanced techniques.	7
Text Books		
1	Clough R. W. andPenziene Joseph, "*Dynamics of Structures' '*, McGraw Hill Education (ISE Editions); International 2 Revised edition August 1993.	
2	Chopra A.K., "*Dynamics of Structure: Theory & Application to Earthquake Engineering*", Pearson Education Lim., 4th Edition, 2014	
3	Agarwal P. and Shrikhande M., "*Earthquake Resistant Design of Structures*", PHI Learning Pvt. Ltd., 2006.	
References		
1	Key David, "*Earthquake Design Practice for Buildings*", Thomas Telford Publication London, 2nd Edition, 2006.	
2	Dowrick D. J., "*Earthquake Resistant Design for Engineers & Architects*", John Wiley & Sons., 2nd Edition, 1987.	
3	Manual of "Earthquake Resistant Non-Engineering Construction", University of Roorkee,	

	2000.
Useful Links	
1	https://nptel.ac.in/courses/105/101/105101209/
2	https://nptel.ac.in/courses/105/104/105104200/
3	https://nptel.ac.in/courses/105/108/105108204/
4	https://nptel.ac.in/courses/105/107/105107204/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		3	2		2
CO2		2				2
CO3			2	2	2	3

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High.

Each CO of the course must map to at least one PO.

Assessment

The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. I
Course Code	5ST512
Course Name	Advanced Design of Steel Structures (PE1)
Desired Requisites:	Design of Steel Structures

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives	
1	To provide the knowledge of design of steel structures such as bridges, multistory buildings and portal frames.
2	To impart the knowledge of cold formed sections and composite beams.
3	To illustrate plastic analysis and design of steel frames.

Course Outcomes (CO)	
CO1	To provide the knowledge of design of steel structures such as bridges, multistory buildings and portal frames.
CO2	To impart the knowledge of cold formed sections and composite beams.
CO3	To illustrate plastic analysis and design of steel frames.

Module	**Module Contents**	**Hours**
I	**Foot Bridges** Analysis and design of footbridges, Deck of through type bridges, Flooring system, Bracing system.	7
II	**Cold Formed Sections** Cold formed light gauge steel sections, Various profiles, Stiffened and unstiffened sections, Roof sheeting, Purlins, Flexure and column behavior, IS code provisions.	6
III	**Composite Sections** Composite section consisting of structural steel and concrete, Composite beams, Shear connectors, Composite decks using light gauge steel and concrete, Composite columns, IS code provisions.	7
IV	**Introduction to Plastic Analysis** Introduction to Plastic Analysis, Plastic bending of beam, Plastic hinge, Shape factor of cross section, Static and kinematic methods of analysis, Plastic analysis and design of propped cantilever, fixed beam and continuous beams.	6
V	**Multistorey Buildings** Multistory buildings, Lateral load resisting systems, Types of bracing systems, Shear wall, Inelastic analysis of multistory, multi-bay frames.	8
VI	**Low Rise Portal Frames** Analysis of low rise rectangular and gable portal frames, Various basic mechanisms, Combination of mechanisms, Limit state design of frames, Haunches and column bases.	7

Text Books	
1	Vazirani V. N., and Ratwani M. M., "Steel Structures and Timber Structures", Khanna Publishers, Delhi.
2	Ramchandran, "Design of Steel Structures – Vol. II", Standard Book House, Delhi.
3	Punmia B. C., Jain A. K. and Jain A. K. "Design of Steel Structures", Firewell Media.
References	
1	Taranath B. S., "Structural Analysis and Design of Tall Buildings",McGrawhill.
2	Bekar J. F., Horne M. R., Heyman J., "Steel Skeleton Vol. II Plastic Behavior& Design", ELBS
3	Neal B. G., "Plastic Methods of Structural Analysis", Chapter & Hall.
Useful Links	
1	https://nptel.ac.in/courses/105/105/105105162/
2	https://nptel.ac.in/courses/105/106/105106112/
3	https://nptel.ac.in/courses/105/106/105106113/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		2	3		
CO2	1		2	3		
CO3				3	2	2
The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High. Each CO of the course must map to at least one PO.						

Assessment
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level					
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**		**Total**
Remember					
Understand	5		5		**10**
Apply	10	15	5		**40**
Analyze		15	10		**35**
Evaluate					**10**
Create					**5**
Total	**10**	**30**	**10**		**100**

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Course Information	
Programme	M.Tech. (Civil - Structural Engineering)
Class, Semester	First Year M. Tech., Sem. I
Course Code	5ST513
Course Name	Advanced Design of Reinforced Concrete Structures (PE2)
Desired Requisites:	Design of Concrete Structures I, Design of Concrete Structures II

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives	
1	To provide advanced knowledge for analyzing different kinds of RC structures.
2	To impart advanced knowledge for design of different kinds of RC structures using IS codes.
3	To provide advanced knowledge for detailing of the structural members designed as per IS codes.

Course Outcomes (CO)	
CO1	**Analyze** various reinforced concrete structures.
CO2	**Size up** structural details of components of structures.
CO3	**Design** the appropriate section for structural members using codal provisions.

Module	**Module Contents**	**Hours**
I	**Flat Slabs and Circular Slabs** Introduction to flat slabs, Codal provisions, Analysis and design of flat slab,Circular slabs.	7
II	**Design of Concrete Deep Beams** Introduction, Minimum thickness, IS code requirements, Design of deep beams, Checking for local failures, Detailing, Design of Corbel.	6
III	**Redistribution of moments** Introduction, redistribution of moments in fixed beams, IS code conditions for redistribution of moments, Advantages and Disadvantages of moment redistribution, Various methods to determine redistribution of moments in beams, Estimation of crack width in reinforced concrete members.	6
IV	**Water Tank** Analysis and Design of overhead water tank- Rectangular and Circular with flat bottom, Design of staging for wind and seismic loads.	7
V	**Retaining Wall** Retaining Walls – Function, Theories of earth pressure, Stability of retaining wall, Reinforced concrete retaining walls, Cantilever retaining wall, Counterfort retaining wall.	7
VI	**Bunkers and Silos** Bunkers and Silos – Classification, Square bunkers, Circular bunkers, Silos, Lateral Pressure in silos, Airy's theory, Shallow bins, Deep bins, Design examples.	6

Textbooks	
1	Ramamruthm, S., "Design of Reinforced Concrete Structures", Dhanpat Rai Publishing, 17th Edition, 2010.
2	Shah V. and Karve S., "Limit State Theory and Design of Reinforced Concrete", Structures

	Publications, 4th Edition, 2003.
3	Punmia, B. C., Jain, A. K. and Jain, A. K. "Limit State Design of Reinforced Concrete", Laxmi Publication, 1st Edition, 2013.
4	
References	
1	Purushothaman, P. "Reinforced Concrete Structural Elements", Tata McGraw Hill, 3rd Edition, 2004.
2	Pillai. S. V. and Menon. D, "Reinforced Concrete Design", Tata McGraw Hill Book Co., 5th Edition, 2005.
3	Park. R and Paulay. T, "Reinforced Concrete Structures", John Wiley and Sons, 1975.
4	IS 456: 2000 Indian Standard Plain and Reinforced Concrete - Code of Practice
Useful Links	
1	Advanced Concrete Design by Prof Devdas Menon Lecture 1 - YouTube
2	NPTEL :: Civil Engineering - Design of Reinforced Concrete Structures
3	Design Of Reinforced Concrete Structures - Course (nptel.ac.in)

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		3	2		2
CO2		2				2
CO3			2	2	2	3
The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High. Each CO of the course must map to at least one PO.						

Assessment
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply				
Analyze	5	5	15	**35**
Evaluate	10	10	5	**40**
Create	5	5	10	**25**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. I
Course Code	5ST514
Course Name	Computer Aided Analysis and Design (PE2)
Desired Requisites:	Dynamics of Concrete Structures, Design of Steel Structures

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

Course Objectives	
1	To provide knowledge of numerical approach and significance of analysis by computers.
2	To impart necessary knowledge of numerical tools required for analyzing and solving problems in the field of engineering.
3	To provide pre-requisite knowledge to the students for analyzing and designing structures by professional software.

Course Outcomes (CO)	
CO1	**Apply** various softwares for modeling of structures.
CO2	**Analyze Various** RC and Steel structures.
CO3	**Create** various programs for the design of structures.

Module	**Module Contents**	**Hours**
I	**Algorithm Development and Programming Languages** Basics of computer hardware and os, WWW and Apps, Algorithm essentials: problem analysis and flowcharting, fundamentals of sequential programming: Variables, data types & functions + input-output + data handling + various development units, Introduction to programming in MS EXCEL®, MATLAB®, PYTHON.	5
II	**Matrix Methods and Programming** Matrix operations: product-inverse etc., Simultaneous linear equations, Eigen analysis method, Algorithm /Programming techniques of above methods.	5
III	**Numerical Methods and Programming** Numerical Integration methods, Numerical differentiation methods, Regression Analysis tools and curve fitting, Numerical Methods in structural dynamics. Algorithm/Programming techniques of above methods.	5
IV	**Computer Aided Structural Analysis** Analysis of Trusses by Stiffness method. Analysis of CB by Stiffness method, Analysis of PF by Stiffness method. 3D Analysis issues. Algorithm development for each structural analysis type.	5
V	**Computer Aided Structural Design** Design of Steel Truss members by IS-800, Design of Beam sections in RCC, Design of One way and Two-way slabs by IS-456. Algorithm development for each structural design type.	5
VI	**Commercial Software Applications** Application in commercial software SAP®/ABACUS®/ANSYS®: Analysis of TRUSS, Analysis of 2D frame, Analysis of 3D structure for various LOAD	5

	COMBINAIONS. Design of building members- Beam, Slab, Column, Footing by STAAD®, Introduction to other commercial soft-wares.	

Textbooks	
1	Pratap Rudra,"Getting started with MATLABTM", Oxford University press, 2010.
2	Jain M. K., Iyengar S. R. K. & Jain R. K. " Numerical Methods for Scientific and Engineering Computation ", 4th ed. 2004.
3	Pundit & Gupta "Structural Analysis", Tata MC Graw Hill Book company.
References	
1	Steve Otto and James P. Denier "An Introduction to Programming and Numerical Methods" in, Springer International books, 1st Edition, 2007
2	Cotes, R.C., Couties, M.G., and Kong, F.K., Structural Analysis, ELBS.
3	Chopra A. K., "Structural Dynamics for Earthquake Engineering", Pearson Publications.
Useful Links	
1	https://nptel.ac.in/courses/105/105/105105180/
2	http://www.nptelvideos.in/2012/11/numerical-methods-in-civil-engineering.html
3	https://in.mathworks.com/matlab/trial
4	http://www.gnumeric.org/freewarespreadsheetshttps://d.wps.com/?from=premiumpage#/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		3	2		2
CO2				2		2
CO3	1		2	2	2	3
The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High. Each CO of the course must map to at least one PO.						

Assessment
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M. Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. I
Course Code	5ST553
Course Name	Presentation and Technical Report Writing

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	-				
Interaction	1 Hr/Week	**Credits: 1**			

Course Objectives	
1	Produce effective dialogue for business related situations
2	Use listening, speaking, reading and writing skills for communication purposes and attempt tasks by using functional grammar and vocabulary effectively

Course Outcomes (CO)	
CO1	Analyze critically different concepts / principles of communication skills
CO2	Demonstrate productive skills and have a knack for structured conversations
CO3	Appreciate, analyze, evaluate business reports and research papers

Module	**Module Contents**	**Hours**
I	**Defining the Features of Technical Writing** Principles and Strategies of Technical Report, Knowing Your Audience, Purpose and Length of Report	1
II	**Formatting Technical Reports Headings** Chapters and sections, Running headers and footers, Types of reports and templates to use,	2
III	**Get to the Point** Discovering the Main Idea and arranging details in logical sequence, Writing styles & techniques, rules of Writing	2
IV	**The Importance of Audience Awareness** Focus on audience's needs, Deter word choice, tone, and amount of details to include	3
V	**Style of Writing** Writing Clear Sentences and paragraphs, Remove Jargon, Redundancy and Wordiness	3
VI	**Presentation skill** Punching Up the Presentation Kinds of graphics and their messages, Suitability for placement in a graphic representation, Group Practice and Interactive Session, Spotting common language problems (lengthy and confusing sentence structures, weak vocabulary, etc), Editing Content, Logic and Language, Guided writing practice with examples	3

Textbooks	
1	Shirley Taylor, "Model Business Letters, Emails and Other Business Documents" (seventh edition), Prentice Hall.

2	Thomas Huckin, Leslie Olsen "Technical writing and Professional Communications for Non-native speakers of English", McGraw Hill
References	
1	Raman Sharma, "Technical Communication", Oxford University Press
2	Raymond Murphy "Essential English Grammar" (Elementary & Intermediate) Cambridge University Press
3	Mark Hancock "English Pronunciation in Use" Cambridge University Press
Useful Links	
1	NPTEL :: Humanities and Social Sciences - NOC:Interpersonal Skills
2	Mod-10 Lec-01 Oral Presentation Lecture-01 - YouTube

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3				2	
CO2				2	2	
CO3		3		2		
The strength of mapping is to be written as 1,2,3; Where, 1: Low, 2: Medium, 3: High. Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing. LA1, LA2 together is treated as In-Semester Evaluation.				
Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities,	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10			**10**
Apply	20	20	20	**60**
Analyze		10	10	**20**
Evaluate			10	**10**
Create				
Total	**30**	**30**	**40**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem I
Course Code	5ST551
Course Name	Activity Based Lab - Mechanics of Structures (PC1)
Desired Requisites:	Solid Mechanics and mechanics of structures

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture		**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/week				
Interaction	-	**Credits: 1**			

Course Objectives	
1	To impart the knowledge of advanced methods of structural analysis.
2	To provide knowledge for analyzing special types of structures.
3	To prepare students to develop computer programs by using matrix methods of structural analysis.

Course Outcomes (CO)	
CO1	**Apply** advanced methods for analysis of structures.
CO2	**Calculate** forces and displacements for special structures.
CO3	**Formulate** program by using matrix methods of structural analysis for field applications.

Module Contents

Students will be asked to work upon **minimum two** of the following topics during the semester. They will submit the report of each topic containing the information (as per need of topic) like: introduction, general information, usage/application (if any) detailed description of work/process, relevant diagrams, drawings & tabulation (if any), observation and results (as applicable) or any other relevant information as per topic.

i) Construct ILD for existing bridge structure for various structural parameters and hence analyze the variation in these structural parameters under the service load.

ii) Analysis and design of curved beams of any existing structure. Validate the analytical results in relevant software

iii) Develop a FEM program for the analysis of beams on elastic foundation

iv) Analysis of multi-story 2D frames using matrix method and validation of analysis results in relevant software.

Text Books	
1	Vazirani. V.N. & Ratwani M.M., "Advanced Theory of Structures",Khanna Publishers, 2008
2	Timoshenko. S. P. & Gere. J. M., "Theory of Elastic Stability", Tata McGraw-Hill Publishing ompany Ltd., 2nd Edition,1985
3	Gere. J. M. & Weaver. W.,"Matrix Analysis of Framed Structures", CBS Publishers and Distributor, 2nd Edition,2004.
4	Krishna Raju N., "Advanced Mechanics of Solids and Structures", McGraw-Hill Education, 08-Nov-2018 - Technology & Engineering

References	
1	Mcquire and Gallghar. R. H. "Matrix Structural Analysis", John Wiley, 2nd Edition, 2000

2	Beaufit F.W et al. "Computer Methods of Structural Analysis", Prentice Hall, illustrated,1970
3	John L. and Meek, "Matrix Structural Analysis", McGraw Hill Book Company, illustrated,1971
4	Pandit G. and Gupta S., "Structural Analysis - A Matrix Approach2008",McGraw Hill Education; 1st edition
Useful Links	
1	https://nptel.ac.in/courses/105/105/105105108/
2	https://nptel.ac.in/courses/105/101/105101086/
3	http://engineeringvideolectures.com/course/281?pn=0#videolist
4	https://nptel.ac.in/courses/105/105/105105109/
5	**VisualFEA**(Free Student version) **, Intuition Software, Inc.**
6	**RFEM**(Free Student version)a 3D finite element analysis software

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		3	2		2
CO2		2				2
CO3			2	2	2	3
The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High. Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing. LA1, LA2 together is treated as In-Semester Evaluation.				
Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities,	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10			**10**
Apply	20	20	20	**60**
Analyze		10	10	**20**
Evaluate			10	**10**
Create				
Total	**30**	**30**	**40**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem I
Course Code	5ST552
Course Name	Activity Based Lab- Theory of Elasticity and Plasticity (PC2)
Desired Requisites:	Solid Mechanics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture		**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/week				
Interaction	-	**Credits: 1**			

Course Objectives	
1	To impart knowledge of various theories of elasticity and apply them to solve 2D Cartesian and polar problems.
2	To impart knowledge of various theories of torsion and apply them to solve 2D torsional problems.
3	To provide knowledge of various theories of plastic behavior and apply them to solve 2D problems.

Course Outcomes (CO)	
CO1	**Apply** the knowledge of fundamental methods of elasticity for 2-D Cartesian and Polar problems.
CO2	**Analyze** torsional problems and apprise various theories to solve 2-D torsional problems.
CO3	**Discuss the concept** of material yielding and plastic behaviour of structures.

Module Contents

Students will be asked to work upon **minimum two** of the following topics during the semester. They will submit the report of each topic containing the information (as per need of topic) like: introduction, general information, usage/application (if any) detailed description of work/process, relevant diagrams, drawings & tabulation (if any), observation and results (as applicable) or any other relevant information as per topic.

v) Demonstrate 2D element, plane stress and plane strain condition by computer program.
vi) Problems related with torsion of circular sections.
vii) Study of plastic behaviour of structure in relevant software.

Text Books	
1	Ameen M., "Computational Elasticity", Alpha Science International, 1st Revised Edition, 2008.
2	Singh Sadhu, "Theory of Elasticity", Khanna Publishers, 4th Edition, 2012.
3	Singh Sadhu, "Theory of Plasticity", Khanna Publishers, 3rd Edition, 2013

References	
1	Timoshenko. S & Goodier. J. N., "Theory of Elasticity", McGraw-Hill book Company, 3rd Edition, 2010.

2	Chakrabarthy. J, “Theory of Plasticity”, Tata McGraw-Hill P. Co. Ltd., 2nd Edtion, 2007.
3	Johnson W. and Mellor P. B., “Engineering Plasticity”, Van Nostrand Reinhold, London, 1973
Useful Links	
1	https://nptel.ac.in/courses/105/105/105105177/
2	https://nptel.ac.in/courses/105/105/105105108/
3	https://nptel.ac.in/courses/105/102/105102090/
4	https://onlinecourses.nptel.ac.in/noc21_ce45/preview

CO-PO Mapping

	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		3	2		2
CO2	1			3		2
CO3	1			3		2

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High.

Each CO of the course must map to at least one PO.

Assessment

There are three components of lab assessment, LA1, LA2 and Lab ESE.
IMP: Lab ESE is a separate head of passing. LA1, LA2 together is treated as In-Semester Evaluation.

Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities,	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40

Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.

Assessment Plan based on Bloom’s Taxonomy Level

Bloom’s Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10			**10**
Apply	20	20	20	**60**
Analyze		10	10	**20**
Evaluate			10	**10**
Create				
Total	**30**	**30**	**40**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. II
Course Code	5OE102
Course Name	Structural Health Monitoring (Open elective)
Desired Requisites:	Advanced concrete technology

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

Course Objectives	
1	To impart knowledge of smart materials.
2	To illustrate principles of structural health monitoring.
3	To provide quantitative means to assess the structural integrity loss a system undergoes after natural disasters and other hazardous events.

Course Outcomes (CO)	
CO1	**Apply** knowledge of smart materials and techniques to SHM
CO2	**Appraise** structural conditions by various techniques of SHM.
CO3	**Assess** civil engineering structures by SHM techniques and simulation.

Module	**Module Contents**	**Hours**
I	**Introduction to Smart Materials and Their Applications** Emerging SHM technologies, using piezo sensors, SHM using magnetostrictive sensors, SHM using optical fibers and other sensors. Overview of application potential of SHM. Piezoelectric materials (Constitute relation, unimorph, bi-orph, electromechanical, coefficient, resonance/ antiresonance), electrostrictive materials, (consecutive relations, sensor, actuator, figures of merit), Magnetostrictive	5

	materials. (consecutive relations, sensor, actuator, figures of merit), Shape Memory Alloys (Constitutive relation, transition temperatures, shape memory effect, pseudo elasticity, sensor, actuator), Optical Fiber (Fiber Bragg Grating, strain sensing, ultrasonic sensing).	
II	**Introduction to Structural Health Monitoring (SHM)** Definition & motivation for SHM, SHM - a way for smart materials and structures, SHM and bio mimetic - analog between the nervous system of a man and a structure with SHM, SHM as a part of system management, Passive and Active SHM, NDE, SHM and DECS, basic components of SHM, materials for sensor design.	5
III	**Condition Survey and NDE of Civil Structure**	5
	Definition and objective of Condition survey, stages of condition survey (Preliminary, Planning, Inspection and Testing stages), possible defects in concrete structures, quality control of concrete structures - Definition and need, Quality control applications in concrete structures, NDT as an optionfor Non-Destructive Evaluation (NDE) of Concrete structures, case studies of a few NDT procedures on concrete structures, Non Destructive Testing of Concrete Structures	
IV	**SHM of Composite Structures** Introduction to composites and their applications in structural Industry. Learning from failures. Various kinds of damage detection techniques. Repair &rehabilitation & retrofitting of composite structures, damage assessment of composites structures, Case studies.	5
V	**Introduction to FE Simulations of Various SHM Techniques** Introduction to FE analysis of typical smart materials. Applications of FE simulation technique, case studies 1) Metallic structures 2) Composite structures	5
VI	**Advanced Signal Processing** Methods for Data processing and Result interpretation, Wavelet, Neural networks, Vecto rsupport machine.	5

Textbooks	
1	Daniel Balageas, Claus - Peter Fritzenam I Alfredo Guemes, Structural Health Monitoring, Published by ISTE Ltd., UK 2006.
2	Guidebook on Non-destructive Testing of Concrete Structures, Training course series No. 17, International Atomic Energy Agency, Vienna, 2002.
3	Gandhi, M.V., Thompson B. D., Smart Materials and Structures, ISBN 978-0-412-37010-6.

References	
1	Handbook on “Repair and Rehabilitation of RCC Buildings”, Published by Director General, CPWD, Govt. of India, 2002.
2	Handbook on Seismic Retrofitting of Buildings, Published by CPWD & Indian Building Congress in Association with IIT, Madras, Narosa Publishing House, 2008.

Useful Links	
1	https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-mm07/
2	https://onlinecourses.nptel.ac.in/noc20_mm07/preview
3	https://nptel.ac.in/courses/105/108/105108141/

CO-PO Mapping

	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		3	2		2
CO2		2				2
CO3			2	2	2	3

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High.

Each CO of the course must map to at least one PO.

Assessment

The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level

Bloom's Taxonomy Level	T1	T2	ESE	Total
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. II
Course Code	5ST521
Course Name	Structural Health Monitoring and Retrofitting (PC3)
Desired Requisites:	Solid Mechanics, Advanced concrete technology

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives	
1	To impart knowledge of smart materials.
2	To illustrate principles of structural health monitoring.
3	To provide quantitative means to assess the structural integrity loss a system undergoes after natural disasters and other hazardous events.

Course Outcomes (CO)	
CO1	**Apply** knowledge of smart materials and techniques to SHM
CO2	**Appraise** structural conditions by various techniques of SHM.
CO3	**Assess** civil engineering structures by SHM techniques and simulation.

Module	**Module Contents**	**Hours**
I	**Introduction to Smart Materials and Their Applications** Emerging SHM technologies, using piezo sensors, SHM using magnetostrictive sensors, SHM using optical fibers and other sensors. Overview of application potential of SHM. Piezoelectric materials (Constitute relation, unimorph, bi-orph, electromechanical, coefficient, resonance/ antiresonance), electrostrictive materials, (consecutive relations, sensor, actuator, figures of merit), Magnetostrictive materials. (consecutive relations, sensor, actuator, figures of merit), Shape Memory Alloys	7

	(Constitutive relation ,transition temperatures, shape memory effect, pseudo elasticity, sensor, actuator), Optical lFiber (Fiber Bragg Grating, strainsensing, ultrasonic sensing).	
II	**Introduction to Structural Health Monitoring (SHM)** Definition & motivation for SHM, SHM - a way for smart materials and structures, SHM and bio mimetic - analog between the nervous system of a man and a structure with SHM, SHM as a part of system management, Passive and Active SHM, NDE, SHM and DECS, basic components of SHM, materials for sensor design.	6
III	**Condition Survey & NDE of Civil Structure** Definition and objective of Condition survey, stages of condition survey (Preliminary, Planning, Inspection and Testing stages), possible defects in concrete structures, quality control of concrete structures - Definition and need,Quality control applications in concrete structures, NDT as an optionfor Non-Destructive Evaluation (NDE) of Concrete structures, case studies of a few NDT procedures on concrete structures, **Non Destructive Testing of Concrete Structures:** Introduction to NDT - Situations and contexts, where NDT is needed, classification of NDT procedures, visual Inspection, half-Cell electrical potential methods, Schmidt Rebound Hammer Test, resistivity measurement, electromagnetic methods, radiographic Testing, ultrasonic testing, Infra-Red thermography, ground penetrating radar, radioisotope gauges, other methods.	7
IV	**SHM of Composite Structures** Introduction to composites and their applications in structural Industry. Learning from failures. Various kinds of damage detection techniques. Repair & rehabilitation & retrofitting of composite structures, damage assessment of composites structures, Case studies.	7
V	**Introduction to FE Simulations of Various SHM Techniques** Introduction to FE analysis of typical smart materials. Applications of FE simulation technique, case studies 1) Metallic structures 2) Composite structures	6
VI	**Advanced Signal Processing** Methods for Data processing and Result interpretation, Wavelet, Neural Networks,Vector Support Machine.	6

Textbooks	
1	Daniel Balageas, Claus - Peter Fritzenam I Alfredo Guemes, Structural Health Monitoring, Published by ISTE Ltd., UK 2006.
2	Guidebook on Non-destructive Testing of Concrete Structures, Training course series No. 17, International Atomic Energy Agency, Vienna, 2002.
3	Gandhi, M.V., Thompson B. D., Smart Materials and Structures, ISBN 978-0-412-37010-6.

References	
1	Handbook on “Repair and Rehabilitation of RCC Buildings”, Published by Director General, CPWD, Govt. of India, 2002.
2	Handbook on Seismic Retrofitting of Buildings, Published by CPWD & Indian Building Congress in Association

	with IIT, Madras, Narosa Publishing House, 2008.

Useful Links	
1	https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-mm07/
2	https://onlinecourses.nptel.ac.in/noc20_mm07/preview
3	https://nptel.ac.in/courses/105/108/105108141/

CO-PO Mapping

	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		3	2		2
CO2		2				2
CO3			2	2	2	3

The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High.

Each CO of the course must map to at least one PO.

Assessment

The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level

Bloom's Taxonomy Level	T1	T2	ESE	Total
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year. M. Tech., Sem. II
Course Code	5ST522
Course Name	Finite Element Method (PC4)
Desired Requisites:	Mechanics of Structures

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives	
1	To impart knowledge of finite element method for 1-D, 2-D,3-D elements.
2	To discuss finite element method in structural engineering
3	To illustrate applications of FEM for plates, shells and structural dynamics.

Course Outcomes (CO)	
CO1	**Implement** finite element methodology for solving 1-D, 2-D, 3-D problems.
CO2	**Analyze** nodal degrees of freedom and stress resultants.
CO3	**Discuss** finite element model for solution of various field Problems.

Module	**Module Contents**	**Hours**
I	**1-D Elements** 1-D Elements Basic concept of finite element analysis, Discretization, nodes, element incidences, displacement model, shape function, selection of order of polynomials, application to bars with constant and variable cross sections subjected to axial forces. Principle of minimum potential energy, variation principle, development of element stiffness matrix and nodal load vector for truss, beam and plane frame elements, Transformation of matrices, relevant structural engineering applications.	8
II	**2-D Elements** 2-D Elements 2-D elements of triangular and quadrilateral shapes for plane stress and plane strain problems. Pascal's triangle, convergence requirements and compatibility conditions, shape functions, boundary conditions, element aspect ratio, applications to a continuum.	6
III	**3-D Elements** 3-D Elements Development of element stiffness matrix and nodal load vector for Tetrahedron, Hexahedral elements, Ax symmetric Elements - Development of element stiffness matrix and nodal load vector.	6
IV	**Isoperimetric Element** Isoperimetric Elements Shape function, Natural coordinate systems, classification of isoperimetric- subprarmatric, super parametric elements, 1-D & 2-D isoperimetric elements, Gauss-quadrature integration.	6
V	**Plate and Shell Elements** Plate and Shell Elements Formation of stiffness matrix for plate bending elements of triangular and quadrilateral shapes, cylindrical thin shell elements.	7
VI	**Finite Element Applications to Structural Dynamics** Finite Element Applications to Structural Dynamics Formulation, Hamilton's	6

	principle, element mass matrices, evaluation of Eigen values and eigenvectors.	
Textbooks		
1	Seshu P. N., "Finite Element Analysis", 2003.	
2	Reddy J. N., "An Introduction to the Finite Element Method" McGraw Hill, 3rd Edition, New York, 2006.	
3	Cook Robert D., Malkus David S., Plesha Michael E., and Witt Robert J., "Concepts and Applications of Finite Element Analysis", 2003	
References		
1	Bathe Klaus-Jurgen, "Finite Element Procedures in Engineering Analysis",1982.	
2	Chandrupatla T. R. and Belegundu A. D., "Introduction to Finite Element in Engineering", Prentice.	
3	Zienkiewicz. O. C. & Taylor. R. L., "The Finite Element Method- Vol I &Vol II Tata McGraw-Hill Publishing Company Limited, 1989, 4th Edition.	
Useful links		
1	https://nptel.ac.in/courses/105/107/105107209/	
2	https://nptel.ac.in/courses/105/106/105106051/	
3	https://nptel.ac.in/courses/112/104/112104116/	

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1	2		2		
CO2		3		2		2
CO3	1		2			3
The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High. Each CO of the course must map to at least one PO.						

Assessment
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. II
Course Code	5ST523
Course Name	Advanced Earthquake Engineering (PE 3)
Desired Requisites:	Dynamics of Structures

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

Course Objectives	
1	To provide knowledge of various concepts of earthquake resistant design of structures.
2	To impart the knowledge of modelling and analysis of structures for displacement-based design.
3	To illustrate seismic behavior and codal provisions for design of various earthquake resistant structures.

Course Outcomes (CO)	
CO1	**Differentiate** various concepts of earthquake resistant design of structures.
CO2	**Calculate** response of structures for displacement and performance-based design.
CO3	**Design** earthquake resistant structures based on its performance.

Module	**Module Contents**	**Hours**
I	**Concepts of Earthquake Resistant Design** Force based vs. displacement-based design, performance-based design, seismic input characteristics and their effect on seismic design, comparative study of different national codes.	5

II	**Modelling and Analysis of Structures for Displacement Based Design** Back-bone curve, Idealized component models, estimation and modelling of stiffness, strength and ductility of RC, steel and masonry structures, nonlinear static and dynamic analyses.	5
III	**Direct Displacement Based Design** Structure performance objectives, performance levels and limit states; P-Delta effects; Torsion; Capacity design for direct displacement-based design.	5
IV	**Performance Based Design** Structural and non-structural performance, quantification of performance, performance evaluation of structures, services and equipment.	5
V	**Overhead Water Tanks** Modelling and analysis of overhead water tanks, hydrostatic and hydrodynamic effects, earthquake resistant provisions.	5
VI	**Seismic Risk Assessment** Seismic vulnerability assessment, HAZUS, Different types of MBT, Fragility curve, DPM, Simplified Vulnerability assessment as per ASCE 41.Assesment procedures of NDT results	5
Textbooks		
1	Agarwal P. andShrikhande M., "Earthquake Resistant Design of Structures", PHI publications, New Delhi, 3rd Edition, 2006.	
2	Key David, "Earthquake Design Practice for Buildings", Thomas Telford Publication, London,2nd Edition, 2006.	
3	Paulay, T. and Priestley, M.J.N. "Seismic Design of Reinforced Concrete and Masonry Buildings," John Wiley & Sons, 1992.	
References		
1	Kelly James M., "Earthquake Resistant Design with Rubber", Springer-Verlag Publication, London, 2nd Edition, 2012.	
2	George G. Penelis and Andreas J. Kappos, "Earthquake Resistant Concrete Structures," E & FN Spon, 1997.	
3	FEMA-356, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings," Federal Emergency management Agency, 2000.	
Useful Links		
1	https://nptel.ac.in/courses/105/101/105101209/	

2	https://nptel.ac.in/courses/105/104/105104200/
3.	https://nptel.ac.in/courses/105/108/105108204/
4.	https://nptel.ac.in/courses/105/107/105107204/
5.	https://nptel.ac.in/courses/105/101/105101004/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1		2	2			2
CO2	1			3		2
CO3			2	2		2
The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High. Each CO of the course must map to at least one PO.						

Assessment
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. II
Course Code	5ST524
Course Name	Numerical Methods in Structural Engineering (PE3)
Desired Requisites:	Applied Mathematics, Structural Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

Course Objectives	
1	To provide knowledge of Matrix methods and statistical tools for solution of problems.
2	To impart knowledge of numerical differentiation, integration, root finding, curve fitting and other numerical approximations.
3	To provide exposure to field application of numerical methods in structural engineering.

Course Outcomes (CO)	
CO1	**Execute** numerical recipes for problem solving in engineering.
CO2	**Examine** different numerical tools for solution of engineering problems.
CO3	**Discuss** numerical schemes for modelling and solving field applications.

Module	**Module Contents**	**Hours**
I	**Solving Linear Algebraic Equations and Eigen Analysis** System of linear algebraic equations, conditions for existence of solution, Classification of solution approaches as direct and iterative, solution by matrix decomposition, Introduction to methods for solving Block-diagonal, triangular, block-triangular systems. Introduction to sparse linear systems: Thomas algorithm for tridiagonal and block tridiagonal matrices, Iterative methods: Jacobi, Gauss-Siedel and successive over relaxation methods, Convergence of iterative solution schemes. Ill conditioning of equations. Eigen Analysis by Jacobi and other Methods.	8
II	**Solving Nonlinear Algebraic Equations [Root Locating methods]** Method of successive substitutions derivative free iterative solution approaches, Secant method, regulafalsi method, Modified Newton's method and qausi-Newton method with Broyden's update, Optimization based formulations and Leverberg-Marquardt method	7
III	**Solving Ordinary Differential Equations and Approximations** Solutions of Linear ODE-IVPs by implicit and explicit methods, Taylor series based and Runge-Kutta methods, Multi-step approaches, Stability issues. Problem discretization using approximation theory, polynomial approximations, Finite difference method for solving ODE-BVP with examples, Polynomial and function interpolations, Least square approximations, Model Parameter Estimation using linear least squares method, Gauss Newton Method.	6
IV	**Probability, Statistics, Reliability Analysis** Probability basics and applications in engineering, Statistical parameters, distributions, methods and applications. Reliability analysis in structural	8

	engineering.	
V	**Numerical Integration** Newton-Cotes schemes, Romberg, Gauss-quadrature, Multiple Integrals.	7
VI	**Structural Engineering Applications** Digital Signal Processing, Nonlinear structural analysis, Structural dynamics and Earthquake engineering applications. SHM.	6

Textbooks	
1	Chapra Steven and Canale Raymond, "Numerical Methods for Engineers", Mc-Graw Hill, 7th Edition, 2012.
2	Gourdin A. and Boumhrat M., "Applied Numerical Methods", Prentice Hall India, New Delhi, 2000.
3	Joe D Hoffman, "Numerical Methods for Engineers and Scientists", Marcel Dekker, 2nd Edition, 2001.
References	
1	Gilbert Strang, "Computational Science and Engineering", Wellesley-Cambridge Press.
2	Gilbert Strang, "Linear Algebra and Its Applications", Wellesley Cambridge Press, 4th Edition, 2009.
3	Philips, G. M., and Taylor P. J. "Theory and Applications of Numerical Analysis", Academic Press, 2nd Edition, 1996.
Useful links	
1	https://nptel.ac.in/courses/105/105/105105043/
2	https://nptel.ac.in/courses/111/107/111107107/
3	https://nptel.ac.in/courses/111/107/111107105/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		2			
CO2	1		2			
CO3	1			3		3
The strength of mapping is to be written as 1,2,3; Where, 1: Low, 2: Medium, 3: High. Each CO of the course must map to at least one PO.						

Assessment
The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Civil - Structural Engineering)
Class, Semester	First Year M. Tech., Sem. II
Course Code	5ST525
Course Name	Analysis and Design of Bridges (PE4)
Desired Requisites:	Design of Concrete Structures

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

Course Objectives	
1	To provide knowledge of loads and analysis for different types of bridges.
2	To impart knowledge for design of different types of bridges including substructures with relevant codes.
3	To provide knowledge for construction, inspection and maintenance of bridges.
Course Outcomes (CO)	
CO1	**Illustrate** types of bridges, their components and selection of bridge site.
CO2	**Analyze** various types of bridges with appropriate loads and methods.
CO3	**Design** of bridges and bearings along with reinforcement details.

Module	**Module Contents**	**Hours**
I	**Introduction to Bridge** Components of bridge, Importance of bridge, Types of bridges, Selection of bridge type and site, Economic span, Superstructure – Alignment, Drainage, Clearance, Road curb, Design loads for bridges, IRC Loading	5
II	**Analysis of Culverts** Design of RC Culvert, Pipe culvert, Box culvert.	7
III	**RC Deck Slabs** Design of RC deck slab, Beam and slab, T-beam bridge, Pigeaud's theory, Corbon's theory, Balanced cantilever bridge.	8
IV	**Prestressed Concrete Bridges** Prestressed Concrete Bridges – General aspects, Advantages, Design of pre-tensioned and post-tensioned concrete bridge decks.	8
V	**Design of Composite Bridges** Design of composite bridges, Reinforced concrete slab on steel plate girder, Stiffeners, Shear connectors, Connections.	6
VI	**Design of Substructure** Design of substructure – Abutment, Pier, Approach slab, Pile and well foundation. Bearings and expansion joints.	5

Textbooks	
1	Krishna Raju N., "Design of Bridges, Oxford and IBH Publishing Co. Ltd.", New Delhi and Kolkata, 2001.
2	Jagdeesh T. R., Jayaram M. A., "Design of Bridge Structures, Prentice Hall of India Pvt. Ltd.", New Delhi, 2003.
3	Johnson Victor, "Essentials of Bridge Engineering, Oxford and IBH Publishing Co. Ltd.", 5th Edition, 2001.

References	
1	Raina V. K., “Concrete Bridge Practice: Construction and maintenance and rehabilitation”, Tata Mc Graw Hill Publishing Company, New Delhi.
2	Raina V. K., “Concrete Bridge Practice: Analysis, design and economics”, Tata Mc Graw Hill Publishing Company, New Delhi.
3	IRC Codes.

Useful Links	
1	Reinforced Concrete Road Bridges - Course (nptel.ac.in)
2	NPTEL :: Civil Engineering - NOC:Reinforced Concrete Road Bridges

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		2	3		2
CO2			2	2	1	2
CO3			2	2	1	2

The strength of mapping is to be written as 1,2,3; Where, 1: Low, 2: Medium, 3: High.
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom’s Taxonomy Level

Bloom’s Taxonomy Level	T1	T2	ESE	Total
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. II
Course Code	5ST526
Course Name	Theory of Plates and Shells (PE4)
Desired Requisites:	Theory of Elasticity and Plasticity

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs/week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

Course Objectives	
1	To impart knowledge of plate and shell behavior under different loading and boundary conditions.
2	To discuss use of classical, approximate and numerical methods to solve plate and shell problems.
3	To provide knowledge of plate and shell modelling for practical applications.

Course Outcomes (CO)	
CO1	**Illustrate** the behavior of various plates and shells.
CO2	**Analyses** plates and shells using different methods.
CO3	**Evaluate** structural actions for practical applications of plates and shells.

Module	**Module Contents**	**Hours**
I	**Bending of Circular Plates** Thin and Thick Plates, small and large deflection theory of thin plates - assumptions, moment-curvature relations, stress resultants, governing differential Equation for bending of plates, various boundary conditions. Bending of Circular Plates: Symmetrical loading.	6
II	**Bending of Rectangular Plates** **Rectangular Plates** Navier's and Levy's solutions for rectangular plates of various boundary conditions and subjected to various types of loads.	6
III	**Finite Difference Method for Plates** **Finite Difference Method** Solution of plate problems derivation of delta/ pattern/ stencil for biharmonic form for a rectangular mesh, two stage solutions, solution for various loadings and boundary conditions, use of symmetry & anti-symmetry, extrapolation formula, introduction to improved Finite Difference Technique.	8
IV	**Introduction to Shells** **Shells** Classification of shells based on geometry, thickness and loading. Thin shell theory, equation of shell surfaces, stress resultants, stress-displacement relations, compatibility and equilibrium equations.	6
V	**Analysis of Various Shells by Membrane Theory** **Membrane Analysis** Equation of equilibrium for synclastic and anticlastic shells under self-weight and live load, equations of equilibrium in rectangular co-ordinate system. Spherical and cylindrical shells under internal pressure, Cylindrical shells-equation of equilibrium with different directrix and shells with closed ends. Cylindrical and Hyperbolic paraboloid roofs.	8

VI	**Cylindrical Shell Roofs** Symmetrically loaded circular cylindrical Shell-Derivation of Governing Differential Equation, resembling that for beam on elastic foundation, beam theory. Finsterwalder's Theory-Derivation of governing differential equation of 8th order. D. K. J. Theory-Donnell's equation, Characteristic equation. Schorer's theory-Derivation of differential equation.	6

Text Books	
1	Timoshenko. S.P. And Krieger. S.W, "Theory of Plates & Shells", Tata McGraw-Hill Publishing Company Limited, 2nd Edition, 1985.
2	Ramaswamy G. S., "Design and Construction of Concrete Shell Roofs", CBS Publishers and Distributors, 1st revised Edition, 1984.
References	
1	Chandrashekhara K., "Analysis of Thin Concrete shells", Tata McGraw-Hill Publishing Company Limited, 2nd Revised Edition, 2011.
2	Flugge. W., "Stresses in Shells", 2nd Edition, Springer, Berlin, 1990.
Useful Links	
1	https://nptel.ac.in/courses/105/103/105103209/
2	https://nptel.ac.in/courses/105/105/105105177/
3	https://nptel.ac.in/courses/105/105/105105108/

CO-PO Mapping

	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1		1	2			
CO2	2			2		2
CO3	1		3			2

The strength of mapping is to be written as 1,2,3; Where, 1: Low, 2: Medium, 3: High.
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on 2 in-semester examinations in the form of T1 (Test-1) and T2 (Test-2) of 20 marks each. Also, there shall be1 End-Sem examination (ESE) of 60 marks. T1 shall be typically on modules 1 and 2, T2 based typically on modules 3,4 and ESE shall be on all modules with nearly 50% weightage on modules 1 to 4 and 50% weightage on modules 5, 6.

Assessment Plan based on Bloom's Taxonomy Level

Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	5	10	15	**30**
Evaluate	5		15	**20**
Create			20	**20**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. II
Course Code	5ST573
Course Name	Industrial Project
Desired Requisites:	Design of concrete and steel structures, mechanics of structures

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	-				
Interaction	2 Hrs/week	**Credits: 2**			

Course Objectives	
1	To interact with industrial experts
2	To learn advanced analysis software.
3	To learn about making structural documents and reports.

Course Outcomes (CO)	
CO1	**Apply** advanced methods for analysis and design of structures.
CO2	**Calculate** forces and displacements for special structures.
CO3	**Formulate** structural drawings using advanced technique of drafting.

Module Contents

Students will be asked to visit the construction industry and interact with structural consultants. Each student or group of students have to work on a special structure. The type of special structure shall be based on their interest, industrial relevance and shall have an innovative model. In case of the work in a group, the number of students in each group shall be based on the quantum of the work. They will submit the report of topic containing the information (as per need of topic) like: introduction, general information, usage/application (if any) detailed description of work/process, relevant diagrams, drawings & tabulation (if any), observation and results (as applicable) or any other relevant information as per topic.

At the end of the semester, the work completed will be assessed based on the report and presentation.

CO-PO Mapping

	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3					2
CO2			2	2	3	
CO3		2				2

The strength of mapping is to be written as 1,2,3; Where, 1: Low, 2: Medium, 3: High.
Each CO of the course must map to at least one PO.

Assessment

There are three components of lab assessment, LA1, LA2 and Lab ESE.
IMP: Lab ESE is a separate head of passing. LA1, LA2 together is treated as In-Semester Evaluation.

Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance,	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week	30

	journal		6	
LA2	Lab activities,	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10			**10**
Apply	20	20	20	**60**
Analyze		10	10	**20**
Evaluate			10	**10**
Create				
Total	**30**	**30**	**40**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem II
Course Code	5ST571
Course Name	Activity Based Lab- Structural Health Monitoring and Smart Materials (PC3)
Desired Requisites:	Solid Mechanics, Advanced concrete technology

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture		**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/week				
Interaction	-	**Credits: 1**			

Course Objectives	
1	To impart knowledge of smart materials.
2	To illustrate principles of structural health monitoring.
3	To provide quantitative means to assess the structural integrity loss a system undergoes after natural disasters and other hazardous events.

Course Outcomes (CO)	
CO1	**Apply** knowledge of smart materials and techniques to SHM
CO2	**Appraise** structural conditions by various techniques of SHM.
CO3	**Assess** civil engineering structures by SHM techniques and simulation.

Module Contents

Students will be asked to work upon **minimum two** of the following topics during the semester. They will submit the report of each topic containing the information (as per need of topic) like: introduction, general information, usage/application (if any) detailed description of work/process, relevant diagrams, drawings & tabulation (if any), observation and results (as applicable) or any other relevant information as per topic.

viii) Visit the existing old bridge and prepare a detailed condition assessment report.

ix) Visit the existing old RC building and prepare a detailed condition assessment report. Identify structural deficiencies and suggest suitable retrofitting strategies.

x) Laboratory testing of various retrofitted elements like column, beam, slab and joints under the action of flexure, shear and axial loading.

Textbooks	
1	Daniel Balageas, Claus - Peter Fritzenam I Alfredo Guemes, Structural Health Monitoring, Published by ISTE Ltd., UK 2006.
2	Guidebook on Non-destructive Testing of Concrete Structures, Training course series No. 17, International Atomic Energy Agency, Vienna, 2002.
3	Gandhi, M.V., Thompson B. D., Smart Materials and Structures, ISBN 978-0-412-37010-6.

References	
1	Handbook on “Repair and Rehabilitation of RCC Buildings”, Published by Director General,

	CPWD, Govt. of India, 2002.
2	Handbook on Seismic Retrofitting of Buildings, Published by CPWD & Indian Building Congress in Association with IIT, Madras, Narosa Publishing House, 2008.
Useful Links	
1	https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-mm07/
2	https://onlinecourses.nptel.ac.in/noc20_mm07/preview
3	https://nptel.ac.in/courses/105/108/105108141/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		3	2		2
CO2		2				2
CO3			2	2	2	3
The strength of mapping is to be written as 1,2,3; Where, 1: Low, 2: Medium, 3: High. Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing. LA1, LA2 together is treated as In-Semester Evaluation.				
Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities,	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10			**10**
Apply	20	20	20	**60**
Analyze		10	10	**20**
Evaluate			10	**10**
Create				
Total	**30**	**30**	**40**	**100**

Walchand College of Engineering, Sangli

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Course Information

Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. II
Course Code	5ST572
Course Name	Activity Based Lab- Finite Element Method (PC4)
Desired Requisites:	Mechanics of structures

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture		**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/week				
Interaction	-	**Credits: 1**			

Course Objectives

1	To impart knowledge of finite element method application for 1-D, 2-D,3-D elements.
2	To discuss finite element method application in structural engineering
3	To illustrate applications of FEM for plates, shells and structural dynamics.

Course Outcomes (CO)

CO1	**Implement** finite element methodology for solving 1-D, 2-D, 3-D problems.
CO2	**Analyze** nodal degrees of freedom and stress resultants.
CO3	**Discuss** finite element model for solution of various field Problems.

Module Contents

Students will be asked to work upon a minimum **four** of the following topics during the semester. They will submit the report of each topic containing the information (as per need of topic) like: introduction, general information, usage/application (if any) detailed description of work/process, relevant diagrams, drawings & tabulation (if any), observation and results (as applicable) or any other relevant information as per topic.

xi) Perform simple skeleton structural analysis by FE Methodology using EXCEL/Programming.
xii) Analyse 2D/3D problems of structural mechanics using EXCEL/Programming.
xiii) Analyse building structure for min.-3 load cases using relevant FE software.
xiv) Analyse Industrial structure component/s for min.-3 load cases using relevant FE software.
xv) Analyse special structure for DL+LLusing relevant FE software.
xvi) Analyse structural dynamics problem by FE methodology using EXCEL/Programming/ relevant FE software.

Textbooks

1	Seshu P. N., “Finite Element Analysis”, 2003.
2	Reddy J. N., “An Introduction to the Finite Element Method” McGraw Hill, 3rd Edition, New York, 2006.
3	Cook Robert D., Malkus David S., Plesha Michael E., and Witt Robert J., “Concepts and Applications of Finite Element Analysis”, 2003

References

1	Bathe Klaus-Jurgen, “Finite Element Procedures in Engineering Analysis”,1982.
2	Chandrupatla T. R. andBelegundu A. D., “Introduction to Finite Element in Engineering”, Prentice.
3	Zienkiewicz. O. C. & Taylor. R. L., “The Finite Element Method- Vol I &Vol II Tata

	McGraw-HillPublishing Company Limited, 1989, 4th Edition.
Useful Links	
1	https://nptel.ac.in/courses/105/107/105107209/
2	https://nptel.ac.in/courses/105/106/105106051/
3	https://nptel.ac.in/courses/112/104/112104116/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1	2		2		
CO2		3		2		2
CO3	1		2			3
The strength of mapping is to be written as 1,2,3; Where, 1: Low, 2: Medium, 3: High. Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing. LA1, LA2 together is treated as In-Semester Evaluation.				
Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities,	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10			**10**
Apply	20	20	20	**60**
Analyze		10	10	**20**
Evaluate			10	**10**
Create				
Total	**30**	**30**	**40**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem II
Course Code	5ST575
Course Name	Activity based Lab- Seismic Design of Multistoried Building Lab
Desired Requisites:	Structural Dynamics and Earthquake Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture		**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/week				
Interaction	-	**Credits: 1**			

Course Objectives	
1	To provide knowledge of various concepts of earthquake resistant design of structures.
2	To impart the knowledge of modeling and analysis of structures for displacement-based design.
3	To illustrate seismic behavior and codal provisions for design of various earthquake resistant structures.

Course Outcomes (CO)	
CO1	**Differentiate** various concepts of earthquake resistant design of structures.
CO2	**Calculate** response of structures for displacement and performance-based design.
CO3	**Design** earthquake resistant structures based on its performance.

Module Contents

Students will be asked to work upon **minimum two** of the following topics during the semester. They will submit the report of each topic containing the information (as per need of topic) like: introduction, general information, usage/application (if any) detailed description of work/process, relevant diagrams, drawings & tabulation (if any), observation and results (as applicable) or any other relevant information as per topic.

xvii) Analysis and design of multi-storey buildings under seismic loading in relevant software.
xviii) Analysis and design of overhead water tank under seismic loading in relevant software.
xix) Laboratory testing of confined and unconfined concrete stations under axial, flexural loading.
xx) Prepare detail drawing in relevant software of reinforcing detailing in primary structural elements as per IS 13920-2016 code..

Textbooks	
1	Agarwal P. and Shrikhande M., "Earthquake Resistant Design of Structures", PHI publications, New Delhi, 3rd Edition, 2006.
2	Key David, "Earthquake Design Practice for Buildings", Thomas Telford Publication, London,2nd Edition, 2006.
3	Paulay, T. and Priestley, M.J.N. "Seismic Design of Reinforced Concrete and Masonry Buildings," John Wiley & Sons, 1992.

References	
1	Kelly James M., "Earthquake Resistant Design with Rubber", Springer-Verlag Publication, London, 2nd Edition, 2012.
2	George G. Penelis and Andreas J. Kappos, "Earthquake Resistant Concrete Structures," E & FN Spon, 1997.
3	FEMA-356, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings," Federal Emergency management Agency, 2000.
Useful Links	
1	https://nptel.ac.in/courses/105/101/105101209/
2	https://nptel.ac.in/courses/105/104/105104200/
3	https://nptel.ac.in/courses/105/108/105108204/
4	https://nptel.ac.in/courses/105/107/105107204/
5	https://nptel.ac.in/courses/105/101/105101004/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1		2	2			2
CO2	1			3		2
CO3			2	2		2
The strength of mapping is to be written as 1,2,3; Where, 1: Low, 2: Medium, 3: High. Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing. LA1, LA2 together is treated as In-Semester Evaluation.				
Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities,	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10			**10**
Apply	20	20	20	**60**
Analyze		10	10	**20**
Evaluate			10	**10**
Create				
Total	**30**	**30**	**40**	**100**

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Course Information

Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. II
Course Code	5ST576
Course Name	Activity Based Lab- Numerical Methods for Linear and Nonlinear Systems Lab
Desired Requisites:	Applied Mathematics, Structural Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture		**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/week				
Interaction	-	**Credits: 1**			

Course Objectives

1	To provide knowledge of Matrix methods and statistical tools for solution of problems.
2	To impart knowledge of numerical differentiation, integration, root finding, curve fitting and other numerical approximations.
3	To provide exposure to field application of numerical methods in structural engineering.

Course Outcomes (CO)

CO1	**Execute** numerical recipes for problem solving in engineering.
CO2	**Examine** different numerical tools for the solution of engineering problems.
CO3	**Discuss** numerical schemes for modelling and solving field applications.

Module Contents

Students will be asked to work upon a minimum **four** of the following topics during the semester. They will submit the report of each topic containing the information (as per need of topic) like: introduction, general information, usage/application (if any) detailed description of work/process, relevant diagrams, drawings & tabulation (if any), observation and results (as applicable) or any other relevant information as per topic.

xxi) Solve problems by developing Numerical differentiation using EXCEL/Programming
xxii) Solve problems by developing Numerical Integration using EXCEL/Programming
xxiii) Solve Regression problem using EXCEL/Programming
xxiv) Apply numerical method/s to field problems of static nonlinear structural analysis
xxv) Apply numerical method/s to field problems of structural dynamic analysis.
xxvi) Apply special numerical methods such as FDM to structural analysis of plates etc.

Textbooks

1	Chapra Steven and Canale Raymond, "Numerical Methods for Engineers", Mc-Graw Hill, 7th Edition, 2012.
2	Gourdin A. and Boumhrat M., "Applied Numerical Methods", Prentice Hall India, New Delhi, 2000.
3	Joe D Hoffman, "Numerical Methods for Engineers and Scientists", Marcel Dekker, 2nd Edition, 2001.

References

1	Gilbert Strang, "Computational Science and Engineering", Wellesley-Cambridge Press.
2	Gilbert Strang, "Linear Algebra and Its Applications", Wellesley Cambridge Press, 4th

	Edition, 2009.
3	Philips, G. M., and Taylor P. J. "Theory and Applications of Numerical Analysis", Academic Press, 2nd Edition, 1996.
Useful Links	
1	https://nptel.ac.in/courses/105/105/105105043/
2	https://nptel.ac.in/courses/111/107/111107107/
3	https://nptel.ac.in/courses/111/107/111107105/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		2			
CO2	1		2			
CO3	1			3		3
The strength of mapping is to be written as 1,2,3; Where, 1:Low, 2:Medium, 3:High. Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing. LA1, LA2 together is treated as In-Semester Evaluation.				
Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities,	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10			**10**
Apply	20	20	20	**60**
Analyze		10	10	**20**
Evaluate			10	**10**
Create				
Total	**30**	**30**	**40**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem II
Course Code	5ST577
Course Name	Activity Based Lab- Design of Bridge Components Lab
Desired Requisites:	Design of Concrete Structures

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture		**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/week				
Interaction	-	**Credits: 1**			

Course Objectives	
1	To provide knowledge of loads and analysis for different types of bridges.
2	To impart knowledge for design of different types of bridges including substructures with relevant codes.
3	To provide knowledge for construction, inspection and maintenance of bridges.

Course Outcomes (CO)	
CO1	**Illustrate** types of bridges, their components and selection of bridge site.
CO2	**Analyze** various types of bridges with appropriate loads and methods.
CO3	**Design** of bridges and bearings along with reinforcement details.

Module Contents

Students will be asked to work upon **minimum two** of the following topics during the semester. They will submit the report of each topic containing the information (as per need of topic) like: introduction, general information, usage/application (if any) detailed description of work/process, relevant diagrams, drawings & tabulation (if any), observation and results (as applicable) or any other relevant information as per topic.

xxvii) Analysis and design of deck slab and girders
xxviii) Analysis and design of bearings
xxix) Analysis and design of bridge piers
xxx) Analysis and design of bridge foundation system
xxxi) Bridge design in relevant software using relevant code

Textbooks

1	Krishna Raju N., "Design of Bridges, Oxford and IBH Publishing Co. Ltd.", New Delhi and Kolkata, 2001.
2	Jagdeesh T. R., Jayaram M. A., "Design of Bridge Structures, Prentice Hall of India Pvt. Ltd.", New Delhi, 2003.
3	Johnson Victor, "Essentials of Bridge Engineering, Oxford and IBH Publishing Co. Ltd.", 5th Edition, 2001.

References

1	Raina V. K., "Concrete Bridge Practice: Construction and maintenance and rehabilitation", Tata Mc Graw Hill Publishing Company, New Delhi.
2	Raina V. K., "Concrete Bridge Practice: Analysis, design and economics", Tata Mc Graw Hill Publishing Company, New Delhi.

3	IRC Codes.
Useful Links	
1	Reinforced Concrete Road Bridges - Course (nptel.ac.in)
2	NPTEL :: Civil Engineering - NOC:Reinforced Concrete Road Bridges
3	Reinforced Concrete Road Bridges - Course (nptel.ac.in)

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		2	3		2
CO2			2	2	1	2
CO3			2	2	1	2
The strength of mapping is to be written as 1,2,3; Where, 1: Low, 2: Medium, 3: High. Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing. LA1, LA2 together is treated as In-Semester Evaluation.				
Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities,	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10			**10**
Apply	20	20	20	**60**
Analyze		10	10	**20**
Evaluate			10	**10**
Create				
Total	**30**	**30**	**40**	**100**

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Course Information	
Programme	M.Tech. (Structural Engineering)
Class, Semester	First year M. Tech., Sem. II
Course Code	5ST578
Course Name	Activity Based Lab- Design of roof using Plate and Shell
Desired Requisites:	Theory of Elasticity and Plasticity

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture		**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2 Hrs/week				
Interaction	-	**Credits: 1**			

Course Objectives	
1	To impart knowledge of plate and shell behavior under different loading and boundary conditions.
2	To discuss use of classical, approximate and numerical methods to solve plate and shell problems.
3	To provide knowledge of plate and shell modelling for practical applications.

Course Outcomes (CO)	
CO1	**Illustrate** the behavior of various plates and shells.
CO2	**Analyses** plates and shells using different methods.
CO3	**Evaluate** structural actions for practical applications of plates and shells.

Module Contents

Students will be asked to work upon **minimum two** of the following topics during the semester. They will submit the report of each topic containing the information (as per need of topic) like: introduction, general information, usage/application (if any) detailed description of work/process, relevant diagrams, drawings & tabulation (if any), observation and results (as applicable) or any other relevant information as per topic.

xxxii) Assignment on bending of circular and rectangular plates
xxxiii) Assignment on shell by membrane theory.
xxxiv) Assignment on shell by bending theory.
xxxv) Study of structural behaviour of plate and shell in relevant software.

Textbooks	
1	Timoshenko. S.P. And Krieger. S.W, "Theory of Plates & Shells", Tata McGraw-Hill Publishing Company Limited, 2nd Edition, 1985.
2	Ramaswamy G. S., "Design and Construction of Concrete Shell Roofs", CBS Publishers and Distributors, 1st revised Edition, 1984.

References	
1	Chandrashekhara K., "Analysis of Thin Concrete shells", Tata McGraw-Hill Publishing Company Limited, 2nd Revised Edition, 2011.
2	Flugge. W., "Stresses in Shells", 2nd Edition, Springer, Berlin, 1990.

Useful Links	
1	https://nptel.ac.in/courses/105/103/105103209/
2	https://nptel.ac.in/courses/105/105/105105177/
3	https://nptel.ac.in/courses/105/105/105105108/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1		1	2			
CO2	2			2		2
CO3	1		3			2
The strength of mapping is to be written as 1,2,3; Where, 1: Low, 2: Medium, 3: High. Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing. LA1, LA2 together is treated as In-Semester Evaluation.				
Assessment	Based on	Conducted by	Typical Schedule (for 26-week Sem)	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 6 Marks Submission at the end of Week 6	30
LA2	Lab activities,	Lab Course Faculty	During Week 7 to Week 12 Marks Submission at the end of Week 12	30
Lab ESE	attendance, journal	Lab Course Faculty	During Week 15 to Week 18 Marks Submission at the end of Week 18	40
Week 1 indicates starting week of a semester. The typical schedule of lab assessments is shown, considering a 26-week semester. The actual schedule shall be as per academic calendar. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10			**10**
Apply	20	20	20	**60**
Analyze		10	10	**20**
Evaluate			10	**10**
Create				
Total	**30**	**30**	**40**	**100**