INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

CIVIL ENGINEERING

COURSE DESCRIPTOR

Course Title	**THEORY OF THIN PLATES AND SHELLS**				
Course Code	BSTB03				
Programme	M.Tech				
Semester	I	STE			
Course Type	Elective				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. Gude Ramakrishna, Associate Professor				
Course Faculty	Mr. Gude Ramakrishna, Associate Professor				

I. COURSE OVERVIEW:

A plate is a structural element which is thin and flat. By “thin,” it is meant that the plate’s transverse dimension, or thickness, is small compared to the length and width dimensions. A mathematical expression of this idea is,where‘t’ represents the plate’s thickness and L represents a representative length or width dimension. More exactly, L represents the minimum wave length of deformation, which can be much smaller than the plate minimum lateral dimension for problems of localized loading, dynamics and stability. The “classical” theory of plates is applicable to very thin and moderately thin plates, while “higher order theories” for thick plates are useful. For the very thick plates, however, it becomes more difficult and less useful to view the structural element as a plate - a description based on the three-dimensional theory of elasticity is required.

II. COURSEPRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
-	-	-	STRUCTURAL ANALYSIS	-

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Theory of thin plates and shells	70 Marks	30 Marks	100

IV.DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	CHALK & TALK	✘	QUIZ	✔	ASSIGNMENTS	✘	MOOCS
✔	LCD / PPT	✘	SEMINARS	✘	MINI PROJECT	✔	VIDEOS
✘	OPEN ENDED EXPERIMENTS						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper.

Table 1: Assessment pattern for CIA

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Alternative Assessment Tool (AAT)	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 9th and 17th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration, consisting of 5 one mark compulsory questions in part - A and 4 questions in part – B. The student has to answer any 4 questions out of five questions, each carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning centre. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Level	Proficiency assessed by
PO3	Capable to apply the core, multidisciplinary knowledge for understanding the problems instructural engineering and allied fields.	2	Assignments/ Mini Projects
PO4	Apply appropriate techniques, resources, modern engineering and Information Technology (IT)tools including predictions, modeling of complex structural engineering activities.	2	Assignment
PO6	Conceptualize and design civil engineering structures considering various socio-economic factors.	3	Assignment/ Exams
PO7	Ability to demonstrate in-depth knowledge of Structural Engineering and build capability to applythat knowledge to real problem.	3	Assignment/ Exams

3 = High; 2 = Medium; 1 = Low

VII. COURSE OBJECTIVES:

The course should enable the students to:	
I	Use analytical methods for the solution of thin plates and shells.
II	Use analytical methods for the solution of shells.
III	Apply the numerical techniques and tools for the complex problems in thin plates.
IV	Apply the numerical techniques and tools for the complex problems in shells.

VIII. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Understand the concepts of space Curves, surfaces, shell co-ordinates, boundary conditions.	CLO 1	Understand the concepts of space curves, surfaces, shell co-ordinates, boundary conditions.
		CLO 2	Understand the concept of displacement field approximations, stress resultants.
		CLO3	Determination of equation of equilibrium using principle of virtual work .
		CLO 4	Understand the concept of bending of thin plates and assumptions.
CO 2	Describe thegoverning equation for a rectangular plate, Naviersolution for simply- supported rectangular plate under various loadings, Levy solution for rectangular plate with other boundary conditions**.**	CLO 5	Determination ofNaviersolution for simply-supported rectangular plate under various loadings.
		CLO 6	Determination of deflection of uniformly loaded simply supported rectangular plate.
		CLO 7	Solution of Navier and Levy type, large plate loaded at equidistant points byconcentrated forces.
CO 3	Analyzeunderaxi- symmetricloading, governing differential equation in polar co-ordinates. Approximatemethods of analysis- of Rayleigh-Ritz methods	CLO 8	Understand basic relations in polar coordinates of circular plates.
		CLO 9	Analyze the use of superposition for the axisymmetric analysis of circular plates.
		CLO 10	Able to analyze the circular plates on elastic foundation, asymmetric bending of circular plates.
		CLO 11	Analysis of Rayleigh-Ritz approach for simple cases.
CO 4	Understand the membrane theory of cylindrical, conicaland spherical shells.	CLO 12	Analysis of membrane theory for cylindrical shells.
		CLO 13	Understand the general theory in bending of cylindrical shell, simplified method for cylindrical shell.
		CLO 14	Understand the simplified method for cylindrical shell.
		CLO 15	Analyze shells of revolution under axisymmetric loads.Understand the thermal stresses in plates/shells.
CO 5	Understand thecylindrical and conical shells,application to pipes and pressure vessels,thermal stresses in plate/shell.	CLO 16	Understand the thermal stresses in plate/shell..
		CLO 17	Analyze the Axisymmetricloaded conical shells.
		CLO 18	Able to analyze the axisymmetric deformation of toroidalshells.

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
BSTB03.01	CLO 1	Understand the concepts of space curves, surfaces, shell co-ordinates, boundary Conditions.	PO 3	3
BSTB03.02	CLO 2	Understand the concept of displacement field approximations, stress resultants	PO 3	3
BSTB03.03	CLO 3	Determination of equation of equilibrium using principle of virtual work.	PO 3,PO 4	3
BSTB03.04	CLO 4	Understand the concept of bending of thin platesand assumptions.	PO 4	2
BSTB03.05	CLO 5	Determination of Navier solution for simply-supported rectangular plate under various loadings.	PO 4, PO 6	2
BSTB03.06	CLO 6	Determination of deflection of uniformly loaded simply supported rectangular plate.	PO 4, PO 6	2
BSTB03.07	CLO 7	Solution of Navier and Levy type, large plateloaded at equidistant points by concentrated forces.	PO 4, PO 6	2
BSTB03.08	CLO 8	Understand Basic Relations in Polar Coordinatesof Circular Plates.	PO 6	2
BSTB03.09	CLO 9	Analyze the use of superposition for the axisymmetric analysis of circular plates.	PO 6	2
BSTB03.10	CLO 10	Able to analyze the circular plates on elastic foundation, asymmetric bending of circular plates.	PO 6, PO 7	2
BSTB03.11	CLO 11	Analysis of Rayleigh-Ritz approach for simple cases in rectangular plates.	PO 7	3
BSTB03.12	CLO 12	Analysis of membrane theory for cylindrical shells.	PO 7	3
BSTB03.13	CLO 13	Understand the general theory in bending of cylindrical shell, simplified method for cylindrical shell.	PO 7	2
BSTB03.14	CLO 14	Understand the simplified method for cylindrical shell.	PO 6, PO 7	3
BSTB03.15	CLO 15	Understand the thermal stresses in plate/shell.	PO 6, PO 7	2
BSTB03.16	CLO 16	Analyze shells of revolution under axisymmetric loads.	PO 6, PO 7	3
BSTB03.17	CLO 17	Analyze the axisymmetric loaded conical shells.	PO 6, PO 7	2
BSTB03.18	CLO 18	Able to analyze the axisymmetric deformation of toroidal shells.	PO 6, PO 7	2

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XI. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

COURSE OBJECTIVES	PROGRAM OUTCOMES			
	PO3	PO4	PO6	PO7
CO 1	3	1	2	3
CO 2		2	1	
CO 3	1	3		3

CO 4	3	1	3	1
CO 5	3	1		1

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XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Learning Outcomes	Program Outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
BSTB03.01							
BSTB03.02				1			2
BSTB03.03			1			1	3
BSTB03.04							
BSTB03.05				2		2	
BSTB03.06							3
BSTB03.07							1
BSTB03.08				2		2	1
BSTB03.09			3				
BSTB03 .10			2	3			1
BSTB03 .11			2				3
BSTB03 .12				1		1	3
BSTB03 .13				3			
BSTB03 .14			1				3
BSTB03 .15						3	1
BSTB03 .16							
BSTB03 .17				3		3	
BSTB03 .18				2			1

3= High; 2 = Medium; 1 = Low

XIII. ASSESSMENT METHODOLOGIES – DIRECT

√	CIE XAMS	√	SEE EXAMS	√	ASSIGMENTS	√	SEMINARS
✘	LABORATORY PRACTISES	√	STUDENT VIVA	√	MINI PROJECT	√	CERTIFICATION
✘	TERM PAPER						

XIV. ASSESMENT METHODOLOGIES – INDIRECT

√	ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	√	STUDENT FEEDBACK ON FACULTY (TWICE)
√	ASSESSMENT OF MINI PROJECTS BY EXPERTS		

XV. SYLLABUS

UNIT– I	INTRODUCTION
Space curves, surfaces, shell co-ordinates, strain displacement relations, assumptions in shell theory, displacement field approximations, stress resultants, equation of equilibrium using principle of virtual work, boundary conditions.	
UNIT – II	**STATIC ANALYSIS OF PLATES**
Governing equation for a rectangular plate, Naviersolution for simply- supported rectangular plate under various loadings, Levy solution for rectangular plate with other boundary conditions.	
UNIT III	**CIRCULAR PLATES**
Introduction, basic relations in polar coordinates, analysis under axi-symmetric loading, governing differentialequation in polar co-ordinates. Approximate methods of analysis: asymmetrical bending of circular plates, Rayleigh-Ritz approach forsimple cases in rectangular plates.	
UNIT IV	**STATIC ANALYSIS OF SHELLS: MEMBRANE THEORY OFSHELLS**
Introduction, membrane theory, membrane stresses, cylindrical shells under general load and buckling,conical shells and spherical shells.	
UNIT – V	**SHELLS OF REVOLUTION: WITH BENDING RESISTANCE**
Cylindrical and conical shells, application to pipes and pressure vessels, thermal stresses in plate/shell, stress-strain and displacement relations, the governing differential equation.	
Text Books:	
1. Timoshenko S. and Krieger, “Theory of Plates and Shells”, McGraw Hill. 2. Chandra shekhara. K, “Theory of Plates”, Universities Press. 3. Timoshenko ,”Theory of Plates and Shells” , Tata McGraw Hill.	
Reference Books:	
1. UguralAnselC,”Stresses in Plates and Shells”, McGraw Hill. 2. Kraus.H, “Thin Elastic Shells”, John Wiley and Sons.	
Web References:	
1. https://pdfs.semanticscholar.org/presentation/ce6d/b61238325d60d3f6dc0f1fbe7af33e372c1.pdf.	
E-Text Books:	
1. https://ocw.mit.edu/courses/mechanical-engineering/2-081j-plates-and-shells-spring2007/readings/lecturenote.pdf.2.http://community.wvu.edu/~bpbettig/MAE456/Lecture_10_Shell_Elements_b.pdf.	

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-3	Explainthe conceptsof space curves, surfaces, shell co-ordinates, boundaryconditions.	CLO 1	T2:24.6 T2:24.8
4-6	Explain the strain displacement relations, assumptions in shell theory, solved problems.	CLO 1	T1:12.14

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
7	Explain the displacement field approximations, stress resultants.	CLO 3	T2:3.10 T2:24.7
8-9	Explain the concept of equation of equilibrium using principle of virtual work.	CLO 4	T2:3.11 T2:3.12
10-13	Explain about governing equation for a rectangular plate.	CLO 6	T1:16.2
14-16	Explain the concept of Navier solution for simply-supported rectangular plate under various loadings.	CLO 6	T1:16.6.2
17-18	Explain the concept Levy solution for rectangular plate and boundary conditions.	CLO 9	T2:26.9
19-22	Explain the concept of analysis under axi- symmetric loading governing differential equation in polar co-ordinates.	CLO 11	T2:26.11
23-25	Solve the governing differential equation in polar co-ordinates.	CLO 12	**T1:16.7**
26-27	Explain the concept of approximate methods of analysis- Rayleigh-Ritzapproach for simple cases in rectangular plates.	CLO12	T2:26
29-31	Explain the concept of static analysis of shells of membrane theory of cylindrical shells.	CLO 13	T2:20.4
32-34	Explain the concept of static analysis of shells of membrane theory of conical shells	CLO 13	T2:23.4
35-36	Explainthe concept ofstatic analysisof shells, membranetheory of spherical shells.	CLO 14	T2:20.9
37-39	Explain the concept of shells of revolution with bending resistance.	CLO 15	T2:5.13
40-41	Explain theconceptofshells of revolution with bendingresistance for conical shells.	CLO 16	T2:21.1 T2: 21.2
42-45	Explain the concept of shells of revolution with bending resistance, application to pipesand Pressurevessels, thermal stresses in plate/shell.	CLO 18	T1:6.5

XVII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1; PO 3; PO 4	SEE Exams	PO 1; PO 3; PO 4	Assignments	PO 3	Seminars	PO 4
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XVIII. ASSESSMENT METHODOLOGIES-INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XIX. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSIONREQUIREMENTS:

S. No.	Description	Proposed actions	Relevance with POs
1	Bending of plates with a small internal curvature.	Seminars/Guest Lectures/NPTEL	PO 1,PO 2,PO 3
2	Stress analysis of cylindrical roof shells.	Seminars/Guest Lectures/NPTEL	PO 2,PO 3

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