INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**MATERIALS AND MECHANICS OF SOLIDS**				
Course Code	AMEB11				
Programme	B. Tech.				
Semester	IV	ME			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	2	1
Chief Coordinator	Dr. K Vishwanath Allamraju, Professor				
Course Faculty	Dr. K Vishwanath Allamraju, Professor Mr. A. Somaiah, Assistant Professor				

I. COURSE OVERVIEW:

Materials and mechanics of solids is a domain of materials science and engineering that studies the physical and chemical behavior of metallic elements, their inter-metallic compounds, and their mixtures, which are called alloys. The basis of virtually all mechanical design lies in how the material reacts to outside forces. Mechanics is the core of engineering analysis and is one of the oldest of the physical sciences. An in-depth understanding of material properties as well as how certain materials react to outside stimulus is paramount to an engineering education.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHSB04	I	Waves and Optics	4
UG	AMEB03	III	Engineering Mechanics	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
MATERIALS AND MECHANICS OF SOLIDS	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 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question 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 (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentation on real-world problems
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Seminar
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Term Paper

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	1	Seminar
PSO 2	**Software Engineering Practices:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	-	-
PSO 3	**Successful Career and Entrepreneurship:** To build the nation, by imparting technological inputs and managerial skills to become technocrats.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES :

The course should enable the students to:	
I	Understand the nature of stresses developed in simple geometries such as bars, cantilevers, beams, shafts, cylinders and spheres for various types of simple loads.
II	Calculate the elastic deformation occurring in various simple geometries for different types of loading.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe the different types of crystal structures.	CLO 1	Understand the concepts crystallography, crystal structures, unit cells, crystallographic planes, directions and miller indices.
		CLO 2	Discuss the crystal imperfections and Frank Reed source of dislocation.
		CLO 3	Demonstrate the concept of Bauschinger‟s effect, twinning, strain hardening and seasons cracking.
		CLO 4	Knowledge of yield point phenomenon, cold/hot working, recovery, re-crystallization, grain growth and strengthening of metals.
CO 2	Discuss the phase transformations and equilibrium diagram.	CLO 5	Discuss the constitution of alloys and phase diagrams, constitution of alloys, solid solutions, substitutional and interstitial.
		CLO 6	Demonstrate the phase diagrams, isomorphous, eutectic, peritectic, eutectoid and peritectoid reactions.
		CLO 7	Construction of iron –Iron carbide equilibrium diagram.
		CLO 8	Classification of steel and cast-Iron microstructure, properties and application.

COs	Course Outcome	CLOs	Course Learning Outcome
CO 3	Ability to apply the principles of elasticity, plasticity, stresses, strains and their relationships under various types of loads and to analyze the composite bars.	CLO 9	Discuss Hooke's law, stresses and strains
		CLO 10	Derive relationship between elastic constants.
		CLO 11	Describe the concept of poisson's ratio, linear and lateral strains.
		CLO 12	Construct the Mohr's circle to solve principal stresses and strains.
CO 4	Able to draw shear force and bending moment diagrams for various loads.	CLO 13	Understand the beams and types transverse loading on beams, shear force and bend moment diagrams.
		CLO 14	Discuss types of beam supports, simply supported and over-hanging beams, cantilevers.
		CLO 15	Understand theory of bending of beams, bending stress distribution and neutral axis.
		CLO 16	Understand the shear stress distribution, point and distributed loads.
CO 5	Determination of slope and deflection of various types of beams.	CLO 17	Understand moment of inertia about an axis and polar moment of inertia.
		CLO 18	Derive the deflection of a beam using double integration Method.
		CLO 19	Computation of slopes and deflection in beams.
		CLO 20	Discuss Maxwell"s reciprocal theorems.

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
AMEB11.01	CLO 1	Understand the concepts crystallography, crystal structures, unit cells, crystallographic planes, directions and miller indices.	PO 1	3
AMEB11.02	CLO 2	Discuss the crystal imperfections and Frank Reed source of dislocation.	PO 2	2
AMEB11.03	CLO 3	Demonstrate the concept of Bauschinger"s effect, twinning, strain hardening and seasons cracking.	PO 1	3
AMEB11.04	CLO 4	Knowledge of yield point phenomenon, cold/hot working, recovery, re-crystallization, grain growth and strengthening of metals.	PO 1	3
AMEB11.05	CLO 5	Discuss the constitution of alloys and phase diagrams, constitution of alloys, solid solutions, substitutional and interstitial.	PO 2	2
AMEB11.06	CLO 6	Demonstrate the phase diagrams, isomorphous, eutectic, peritectic, eutectoid and peritectoid reactions.	PO 2	2
AMEB11.07	CLO 7	Construction of iron –Iron carbide equilibrium diagram.	PO 1	3
AMEB11.08	CLO 8	Classification of steel and cast-Iron microstructure, properties and application.	PO 2	2
AMEB11.09	CLO 9	Discuss Hooke's law, stresses and strains	PO 4	1
AMEB11.10	CLO 10	Derive relationship between elastic constants.	PO 2	2
AMEB11.11	CLO 11	Describe the concept of poisson's ratio, linear and lateral strains.	PO 2	2
AMEB11.12	CLO 12	Construct the Mohr's circle to solve principal stresses and strains.	PO 1 PO 2	3
AMEB11.13	CLO 13	Understand the beams and types transverse loading on beams, shear force and bend moment diagrams.	PO 1	3
AMEB11.14	CLO 14	Discuss types of beam supports, simply supported and over-hanging beams, cantilevers.	PO 1	3
AMEB11.15	CLO 15	Understand theory of bending of beams, bending stress distribution and neutral axis.	PO 1	3
AMEB11.16	CLO 16	Understand the shear stress distribution, point and distributed loads.	PO 1, PO 2	3

AMEB11.17	CLO 17	Understand moment of inertia about an axis and polar moment of inertia.	PO 1, PO 2	3
AMEB11.18	CLO 18	Derive the deflection of a beam using double integration Method.	PO 1, PO 2	3
AMEB11.19	CLO 19	Computation of slopes and deflection in beams.	PO 1	3
AMEB11.20	CLO 20	Discuss Maxwell‟s reciprocal theorems.	PO 2	2

3= High; 2 = Medium; 1 = Low

XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 4	PSO1
CO 1	3	2		1
CO 2	3	2		
CO 3	3	3	1	
CO 4	3	2		1
CO 5	3	2		1

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

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3												1		
CLO 2		2													
CLO 3	3												1		
CLO 4	3												1		
CLO 5		2													
CLO 6		2													
CLO 7	3														
CLO 8		2													
CLO 9				1											
CLO 10		2													
CLO 11		2											1		
CLO 12	3	2											1		

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 13	3														
CLO 14	3														
CLO 15	3														
CLO 16	3	2											1		
CLO 17	3	2											1		
CLO 18	3	2											1		
CLO 19	3												1		
CLO 20		2											1		

3 = High; 2 = Medium; 1 = Low

XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO4	SEE Exams	PO1, PO2, PO4	Assignments	-	Seminars	PO1, PO2, PO4
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1, PO2, PO4						

XIV. ASSESSMENT METHODOLOGIES - INDIRECT

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

XV. SYLLABUS

Module-I	FUNDAMENTALS OF MATERIAL SCIENCE
Basic Crystallography Crystal structure BCC, FCC and HCP structure, unit cell, crystallographic planes and directions, miller indices. Crystal imperfections, point, line, planar and volume defects, grain size, ASTM grain size number. Frank Reed source of dislocation Elastic & plastic modes of deformation, slip & twinning, strain hardening, seasons cracking, Bauschinger‟s effect, yield point phenomenon, cold/hot working, recovery, re-crystallization, and grain growth, strengthening of metals.	
Module-II	**ALLOYS AND PHASE DIAGRAMS**
Constitution of alloys and phase diagrams; constitution of alloys, solid solutions, substitutional and interstitial. phase diagrams, isomorphous, eutectic, peritectic, eutectoid and peritectoid reactions. iron – iron carbide equilibrium diagram. classification of steel and cast-iron microstructure, properties and application.	
Module-III	**SIMPLE STRESSES AND STRAINS, PRINCIPAL STRESSES**

Hooke‟s law, stress and strain- tension, compression and shear stresses elastic constants and their relations Volumetric, linear and shear strains principal stresses and principal planes, Mohr‟s circle.	
Module-IV	**SHEAR FORCE AND BENDING MOMENT DIAGRAMS, FLEXURAL STRESSES, SHEAR STRESSES**
Beams and types transverse loading on beams shear force and bend moment diagrams types of beam supports, simply supported and over-hanging beams, cantilevers. theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads.	
Module-V	**SLOPE AND DEFLECTION**
Moment of inertia about an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, Maxwell‟s reciprocal theorems.	
Text Books:	
1. Sidney H Avner, “Introduction to Physical Metallurgy”, McGraw-Hill Education, 2nd Edition, 2008. 2. Donald R Askeland, Thomson, “Essentials of Material Science and Engineering”, Thomson Press, 1st 3. Edition, 2005. 4. R. S. Kurmi, Gupta, “Strength of Materials”, S Chand & Co, New Delhi, 1st Edition, 2013. 5. Egor P. Popov, “Solid Mechanics” Pearson, 2nd Edition, 2002.	
Reference Books:	
1. Jindal, “Strength of Materials”, Pearson Education, 1st Edition, 2012. 2. Vazirani, Ratwani, “Analysis of Structures”, Khanna Publishers, 19th Edition, 2014. 3. S. Ramamrutam, “Strength of Materials”, Dhanpat Rai Publishing Company, 18th Edition, 2014. 4. R K. Rajput, “Strength of Materials”, S.Chand & Co New Delhi, 4th Edition, 2007.	

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	Basic Crystallography and Crystal structure.	CLO 1	T2:2.3
2-3	BCC, FCC and HCP structure	CLO 1	R1:2.6
4	Unit cell, crystallographic planes and directions, miller indices.	CLO 2	T1:2.6
5-6	Crystal imperfections, point, line, planar and volume defects, Grain size, ASTM grain size number	CLO 2	T2:2.7 R1:2.18
7	Frank Reed source of dislocation elastic & plastic modes of deformation.	CLO 3	T2:2.22
8	Slip & twinning, strain hardening, seasons cracking.	CLO 3	T2:2.25
9	Bauschinger‟s effect, yield point phenomenon	CLO 3	T2:2.26 R1:2.55
10	Cold/hot working and recovery.	CLO 4	T2:2.16 R1:2.61
11-12	Re-crystallization, and grain growth, strengthening of metals.	CLO 4	T2:2.30 R1:2.58
13	Constitution of alloys and solid solutions.	CLO 5	T2:3.6 R1:4.29
14	Substitutional and interstitial.	CLO 5	T2:3.14 R1:4.31
15	Phase diagrams,	CLO 6	T2:3.14 R1:4.33
16-17	Isomorphous, eutectic, peritectic, eutectoid and peritectoid reactions.	CLO 6	R1:4.36

18-19	Iron – iron carbide equilibrium diagram. Classification of steel and cast-iron microstructure	CLO 7	T2:3.18 R1:4.64
20	Properties and application.	CLO 8	T2:3.22
21	Introduction to mechanics of solids: Hook's law	CLO 9	T2:3.28 R1:4.67
22	Stress, strain and diagrams for different materials.	CLO 9	T2:4.2
23	Tension, compression and shear stresses	CLO 10	T2:4.3 R1:4.71
24-25	Elastic constants and derivations	CLO 10	T1:4.8 R2:4.68
26	Relationship between elastic moduli.	CLO 11	T2:4.15 R1:5.74
27	Volumetric, linear and shear strains	CLO 11	T1:4.12 R2:5.75
28-29	Principal stresses and derivations	CLO 12	T1:4.8 R1:5.72
30-31	Principal planes and problems	CLO 12	T1:5.8 R1:5.73
32-33	Mohr‟s circle construction and problems	CLO 12	T1:5.14 R1:6.78
34	Introduction to beams and types.	CLO 13	T2:5.19 R1:6.81
35	Transverse loading on beams shear force.	CLO 13	T1:6.4 R2:6.8
36	Bending moment diagrams	CLO 14	T2:7.7 R1:7.74
37	types of beam supports,	CLO 14	T1:7.12 R2:8.75
38	simply supported	CLO 15	T1:7.8 R1:8.72
39	Over-hanging beams and cantilevers.	CLO 15	T1:8.8 R1:8.73
40-41	Theory of bending of beams and bending stress distribution.	CLO 16	T1:9.14 R1:10.78
42-43	Neutral axis and shear stress distribution	CLO 16	T2:9.19 R1:10.814
44	Point and distributed loads	CLO 17	T1:10.4 R2:11.68
45	Moment of inertia about an axis and polar moment of inertia.	CLO 17	T2:10.7 R1:12.74
46	Introduction to deflection of a beam using double integration method	CLO 18	T1:11.12 R2:12.75
47	Deflection of a beam using double integration method: Cantilever	CLO 18	T1:12.4 R2:13.68
48	Deflection of a beam using double integration method: Simply supported beam.	CLO 18	T2:13.7 R1:14.74
19	Introduction to slope	CLO 19	T1:14.12 R2:15.75
50-51	Derivations of cantilever and simply supported beams slope	CLO 19	T2:9.19 R1:10.814
52-53	Deflection of beams and derivations.	CLO 20	T1:10.4 R2:11.68
54-55	Maxwell‟s reciprocal theorems.	CLO 20	T2:10.7 R1:12.74

XVII. GAPS IN THE SYLLABUS-TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	To improve standards and analyze the concepts.	Seminars	PO 1	PSO 1
2	To understand the technology of thermo-electric refrigeration, solar powered refrigeration, etc.	Seminars / NPTEL	PO 4	PSO 1
3	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO 2	PSO 1

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