INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

CIVIL ENGINEERING

COURSE DESCRIPTION

Course Title	**STRENGTH OF MATERIALS – I**			
Course Code	**A30107**			
Regulation	**R13 – JNTUH**			
Course Structure	Lectures	Tutorials	Practicals	Credits
	4	-	-	4
Course Coordinator	Dr. Akshay Naidu, Professor, Civil Engineering Department			
Team of Instructors	Dr. Akshay Naidu, Professor, Civil Engineering Department			

I. COURSE OVERVIEW:

Civil Engineers are required to design structures like building, beams, dams, bridges, etc. The loads coming onto these structures, along with the self-weight, have to be safely transmitted to the ground. A structural engineer must be able to design a structure in such a way that none of its members fail during load transfer process. This foundational course in civil engineering is intended to introduce to concepts of stress and strain due to external loading on a structural member, and their calculations. For this, the concept and calculations of (a) shear force diagrams and bending moment diagram for different type of beams, (b) bending and shear stresses in beams, (c) slope and deflection of beams using various methods are covered in depth. The important calculations of principal stresses and principal strains and the consequent theory of failures for prediction of the strength of the materials are also discussed. Through this course content engineers can design the structures for safety and serviceability.

II. PREREQUISITE(S):

Level	Credits	Periods/ Week	Prerequisites
UG	4	4	Engineering Mechanics

III. MARKS DISTRIBUTION:

Sessional Marks	University End Exam marks	Total marks
There shall be 2 midterm examinations. Each midterm examination consists of subjective test. The subjective test is for 20 marks, with duration of 2 hours. Subjective test of each semester shall contain 5 one mark compulsory questions in part-A and part-B contains 5 questions, the student has to answer 3 questions, each carrying 5 marks. First midterm examination shall be conducted for the first two and half units of syllabus and second midterm examination shall be conducted for the remaining portion. Five marks are earmarked for assignments. There shall be two assignments in every theory course. Marks shall be awarded considering the average of two assignments in each course.	75	100

IV. EVALUATION SCHEME:

S. No	Component	Duration	Marks
1.	I Mid Examination	80 minutes	20
2.	I Assignment	-	5
3.	II Mid Examination	80 minutes	20
4.	II Assignment	-	5
5.	External Examination	3 hours	75

V. COURSE OBJECTIVES:

The objective of the teacher is to impart knowledge and abilities to the students to:

I. **Relate** mechanical properties of a material with its behaviour under various load types
II. **Classify** the types of material according to the modes of failure and stress-strain curves.
III. **Apply** the concepts of mechanics to find the stresses at a point in a material of a structural member
IV. **Analyze** a loaded structural member for deflections and failure strength
V. **Evaluate** the stresses & strains in materials and deflections in beam members
VI. **Create** diagrams for shear force, bending moment, stress distribution, mohr's circle, elastic curve
VII. **Design** simple beam members of different cross-sections to withstand the loads imposed on them.

VI. COURSE OUTCOMES:

After completing this course the student must demonstrate the knowledge and ability to:

1. **Calculate** the stress and strain developed in any structural member due to applied external load.
2. **Differentiate** the type of beams, and the various loading and support condition upon them.
3. **Apply** the formulae for beams under different loading condition.
4. **Draw** shear force diagram and bending moment diagram for different type of beams.
5. **Derive** the pure bending equation, and on its basis explain the existence of normal stresses and shear stresses in the different layers of the beam.
6. **Explain** the importance of and evaluate the section modulus for various beam cross-sections.
7. **Calculate** the normal and tangential stresses on an inclined section of a bar under uniaxial, biaxial, pure shear and plain stress conditions.
8. **Evaluate** the principal stress and principal strain at a point of a stressed member and draw the Mohr's circle of stresses.
9. **Predict** failure of a material using various theories of failure, and their relative applications.
10. **Calculate** the slope and deflection in beams by using methods like Double integration, Macaulay method, Moment-area method, Conjugate beam, etc.
11. Participate and succeed in competitive examination like GATE, PSUs, etc.

VII. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Level	Proficiency assessed by
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	H	Assignments, Exams
PO2	**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.	H	Assignments, Exams
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	H	Assignments, Exams
PO4	**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.	S	Discussion
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	S	-
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	H	Exams, Assignment, Discussions
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	S	Discussions
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	S	Discussions
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	S	Assignment, Discussions
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	S	Discussions
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	S	-
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	S	Discussions

N – Not Applicable **S – Supportive** **H - Highly Related**

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Level	Proficiency assessed by
PSO1	**UNDERSTANDING:** Graduates will have an ability to understand, analyze and solve problems using basic mathematics and apply the techniques related to irrigation, structural design, etc.	H	Lectures, Assignments, Exams
PSO2	**ANALYTICAL SKILLS:** Graduates will have an ability to design civil structures, using construction components and to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety manufacturability and reliability and learn to work with multidisciplinary teams.	H	Lectures, Assignments, Exams
PSO3	**BROADNESS:** Graduates will have an exposure to various fields of engineering necessary to understand the impact of other disciplines on civil engineering blueprints in a global, economic, and societal context and to have necessary focus for postgraduate education and research opportunities at global level.	S	Lectures, Guest Lectures, Discussions, Industrial visits

N – None **S – Supportive** **H - Highly Related**

IX. SYLLABUS:

UNIT - I

SIMPLE STRESSES AND STRAINS: Elasticity and plasticity – Types of stresses and strains – Hooke's law – stress – strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson's ratio and volumetric strain – Elastic modulii and the relationship between them – Bars of varying section – composite bars – Temperature stresses. Elastic constants.

STRAIN ENERGY: Resilience – Gradual, sudden, impact and shock loadings – simple applications.

UNIT - II

SHEAR FORCE AND BENDING MOMENT: Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contraflexure – Relation between S.F., B.M and rate of loading at a section of a beam.

UNIT - III

FLEXURAL STRESSES: Theory of simple bending – Assumptions – Derivation of bending equation: M/I = f/y = E/R - Neutral axis – Determination of bending stresses – Section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections – Design of simple beam sections.

SHEAR STRESSES: Derivation of formula – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.

UNIT - IV

PRINCIPAL STRESSES AND STRAINS: Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses – Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear – Mohr's circle of stresses – Principal stresses and strains – Analytical and graphical solutions.

THEORIES OF FAILURE: Introduction – Various theories of failure - Maximum Principal Stress Theory, Maximum Principal Strain Theory, Strain Energy and Shear Strain Energy Theory (Von Mises Theory).

UNIT - V

DEFLECTION OF BEAMS : Bending into a circular arc – slope, deflection and radius of curvature – Differential equation for the elastic line of a beam – Double integration and Macaulay's methods – Determination of slope and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, Uniformly varying load-Mohr's theorems – Moment area method – application to simple cases including overhanging beams.

CONJUGATE BEAM METHOD: Introduction – Concept of conjugate beam method, Difference between a real beam and a conjugate beam, Deflections of determinate beams with constant and different moments of inertia.

Textbooks:

1. Mechanics of Materials by B. C. Punmia, A. K. Jain and A. K. Jain, Laxmi Publications (P) Ltd, New Delhi.
2. Strength of Materials – A Practical Approach Vol.1 by D. S. Prakash Rao, Universities Press, Hyderabad, India.
3. Mechanics of materials by F. Beer, E. R. Johnston and J. Dewolf (Indian Edition – SI units), Tata McGraw Hill Publishing Co. Ltd., New Delhi

Reference Books:

1. Mechanics of Materials (SI edition) by J.M. Gere and S. Timoshenko, CL Engineering, India
2. Engineering Mechanics of Solids by E. G. Popov, Pearson Education, New Delhi, India
3. Strength of Materials by R. K. Bansal, Laxmi Publications (P) ltd., New Delhi, India.
4. Strength of Materials by S.S.Bhavikatti, Vikas Publishing House Pvt. Ltd.
5. Strength of Materials by R.K Rajput, S.Chand & Company Ltd.
6. Strength of Materials by R. S. Khurmi, S. Chand publication New Delhi, India.
7. Fundamentals of Solid Mechanics by M.L.Gambhir, PHI Learning Pvt. Ltd
8. Strength of Materials by R.Subramanian, Oxford University Press.

COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

Lecture No.	Topics to be covered	Course Learning Outcomes	References
1-2	**UNIT - I** Elasticity and plasticity – Types of stresses and strains – Hooke's law	**Understand** the concept of elasticity and plasticity, concept of stress and strain, concept of Hooke's law	T1: 1.1-3, 2.1-5
3-4	Stress – strain diagram for mild steel – Working stress – Factor of safety	**Explain** Relation between stress and strain for mild steel. **Understand** working stress and factor of safety.	T1: 2.4
5-6	Bars of varying section	**Understand** the concept of bars for varying section.	T1: 2.6-14
7-8	Composite bars – Temperature stresses	**Understand** the concept of composite bars and temperature stresses.	T1: 2.15-20
9-10	Lateral strain, Poisson's ratio and volumetric strain – Elastic modulii and the relationship between them	**Explain** lateral strain, Poisson's ratio, volumetric strain, elastic modulii and relation between them	T1: 3.1-.3
11-12	Elastic constants.	**Explain** Bulk modulus, longitudinal strain, lateral strain and relation between them	T1: 3.5-14
13-14	Strain Energy, Resilience – Gradual, sudden, impact and shock loadings – simple applications.	**Explain** resilience, proof resilience, modulus of resilience. **Derive** strain energy for various loadings and simple	T1: 6.1-5

		applications.	
15-16	**UNIT - II** Definition of beam – Types of beams – Concept of shear force and bending moment	**Define** beam, types of beams. Explain the concept of shear force and bending moment	T1: 9.1-5
17-19	S.F and B.M diagrams for cantilever, subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure	**Derive and evaluate** the shear-force and bending moment for cantilever beam for various types of loading and solved problems	T1: 9.6-7
20-22	S.F and B.M diagrams simply supported subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure –	**Derive** and **evaluate** the shear-force and bending moment for simply supported beam for various types of loading and solved problems	T1: 9.6-7
23-25	S.F and B.M diagrams for overhanging beams subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure	**Derive** and **evaluate** the shear-force and bending moment for overhanging beam for various types of loading and solved problems	T1: 9.6-7
26	Relation between S.F., B.M and rate of loading at a section of a beam.	**Explain** the relation between shear force and bending moment and rate of loading at a section for beams	T1:9.6-11
27-28	**UNIT -III** FLEXURAL STRESSES: Theory of simple bending – Assumptions – Derivation of bending equation: M/I = f/y = E/R	**Explain** the concept of simple bending with assumptions and derive the bending equation	T1: 10.1-5
29-30	Neutral axis – Determination of bending stresses	**Define** neutral axis and determine the bending stresses for various conditions	T1: 10.5-7
31-32	Section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections	**Derive** the section modulus for rectangular, circular, I, T sections and solved problems	T1: 10.7
33-34	Design of simple beam sections.	**Solve** problems for design of simple beams	T1: 10.7
35-38	SHEAR STRESSES: Derivation of formula – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.	**Derive** the formula for shear stress and **evaluate** the shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.	T1: 11.1-7
39	**UNIT-IV** PRINCIPAL STRESSES AND STRAINS: Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses	**Define** principal stresses and strains. **Explain** the stresses on a inclined section of a bar under axial loading and **explain** the concept of compound stresses	T1: 4.1

40-42	Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear - Mohr's circle of stresses, Principal stresses	**Evaluate** Normal and tangential stresses on an inclined plane for biaxial stresses and evaluate stresses for two perpendicular normal stresses accompanied by a state of simple shear	T1: 4.2 - 4.11
42-45	Principal Strains – Analytical and graphical solutions.	**Explain** the concept of Mohr's circle of stresses and **derive** the principal stresses and strains using analytical and graphical method.	T1: 5.1-8
46-47	THEORIES OF FAILURE: Introduction – Various theories of failure - Maximum Principal Stress Theory	**Explain** Maximum Principal Stress Theory and **evaluate** failure criteria	T1: 7.1-3
48-49	Maximum Principal Strain Theory, Strain Energy and Shear Strain Energy Theory (Von Mises Theory).	**Explain** Maximum Principal Strain Theory, Strain Energy and Shear Strain Energy Theory (Von Mises Theory) and **evaluate** failure criteria	T1: 7.4-7
50-52	**UNIT-V** DEFLECTION OF BEAMS: Bending into a circular arc – slope, deflection and radius of curvature – Differential equation for the elastic line of a beam	**Derive** relation between slope, deflection and radius of curvature and **derive** the differential equation for the elastic line of a beam	T1: 12.1-3
53-56	Double integration and Macaulay's methods – Determination of slope and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, Uniformly varying load	**Determine** slope and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, Uniformly varying load using Double integration and Macaulay's methods	T1: 12.4-11
57-58	Mohr's theorems – Moment area method – application to simple cases including overhanging beams.	**Explain** mohr's theorem and moment area method and **apply** it to simple beams.	T1: 13.1-9
59-62	Conjugate Beam Method: Introduction – Concept of conjugate beam method. Difference between a real beam and a conjugate beam.	**Explain** conjugate beam method and differentiate between real beam and a conjugate beam.	T1: 14.1-8

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

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
I	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
II	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
III	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
IV	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S

V	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
VI	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
VII	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S

S – Supportive **H - Highly Related**

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

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
2	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
3	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
4	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
5	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
6	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
7	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S

S – Supportive **H - Highly Related**

Prepared by: Dr. Akshay Naidu, Professor, CE
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HOD, CE