UE24CV141A/B : Engineering Mechanics - Statics (4–0–0–4–4)

Course Introduction:

Engineering mechanics is both a foundation and a framework for most of the branches of engineering. Many of the topics in such areas as civil, mechanical, aerospace, and agricultural engineering, and of course engineering mechanics itself, are based upon the subjects of statics and dynamics.

Course Objectives:

- Understand concepts of Engineering mechanics required for analysis of structures under static loads and predict the effect of loads.
- Understand the concept of Free body diagram to analyze the effect of forces on the structures.
- Analyze the distribution of forces acting on the structures by determining sectional properties and study the external effects of forces on structural members.
- To study and understand the effects of friction on bodies in contact for supporting loads.

Course Outcomes:

- Develop skill to determine resultants and apply conditions of static equilibrium to plane force systems.
- Develop skill to identify and quantify all forces associated with a static frame work.
- Develop skill to identify, formulate and solve engineering problems.

Course Content:

UNIT 1: Introduction to statics & Force Systems

Mechanics, Basic Concepts, Scalars and Vectors

Force Systems Introduction, Force, Rectangular Components, Moment, Couple, Resultants, Numerical problems.

13 Hours

UNIT 2: Equilibrium & Structures

Introduction, Equilibrium in Two Dimensions - System Isolation and the Free-Body Diagram, Equilibrium conditions, Numerical problems.

Introduction, Plane Trusses, Method of Joints, Numerical problems.

15 Hours

UNIT 3: Distributed Forces

Introduction, Centroids of Areas, Centroids of Composite Bodies and figures, Numerical problems.
Beams: External effects, Numerical problems.

Area Moments of Inertia Introduction, Definitions, Composite areas, Numerical problems (Composite area method only).

15 Hours

UNIT 4: Friction

Introduction, Frictional Phenomena - Types of Friction, Dry Friction, Fluid Friction, Internal Friction, Mechanism of Dry Friction, Static Friction, Kinetic Friction, Friction Angles, Factors Affecting Friction, Numerical problems involving bodies placed on Horizontal surfaces and inclined Surface, Application of Friction in Machines – Wedges, Numerical problems.

13 Hours

Text Book:

1."Engineering Mechanics Statics" SI Version J.L. Meriam, L.G. Kraige, J.N. Bolton, Wiley India Edition. 8th Edition – Reprint 2018

Reference:

1. "Engineering Mechanics Statics and Dynamics" R C Hibbeler, Prentice Hall, 2010.
2. "Engineering Mechanics Statics and Dynamics" Irving Herman Shames, Prentice Hall, 1997.
3. "Vector Mechanics for Engineers: Statics", Ferdinand Beer, E. Johnston and David Mazurek, McGraw-Hill Education; 11 edition, 2015.

Text Book: "Engineering Mechanics Statics" SI Version J.L. Meriam, L.G. Kraige, J.N.Bolton, Wiley India Edition. 8th Edition – Reprint 2018
(Chapter Sections – 1/1-1/3, 1/5, 2/1 to 2/6 for Unit – I
3/1 to 3/3, 4/1 to 4/3 for Unit – II
5/1 to 5/4, 5/6 A/1 to A/3 for Unit - III
6/1 to 6/4 for Unit- IV

UNIT I CHAPTER 1: 1/1, 1/2, 1/3, 1/5 CHAPTER 2: 2/1, 2/2, 2/3, 2/4, 2/5, 2/6 Numerical	**UNIT III** CHAPTER 5: 5/1, 5/2, 5/3, 5/4, 5/6 Appendix A: A/1, A/2, A/3 Numerical
UNIT II CHAPTER 3: 3/1,3/2, 3/3 CHAPTER 4: 4/1, 4/2, 4/3 Numerical	**UNIT IV** CHAPTER 6: 6/1, 6/2, 6/3, 6/4 Numerical

NUMERICAL PROBLEMS

UNIT I: Introduction to statics & Force Systems

CHAPTER 2: Problem No. 2/1 to 2/100, Excluding 2/29, 2/48, 2/56, 2/58, 2/88, 2/95, 2/99.

Total– 93

Note: 47 Problems to be solved in class – 46 Problems Assignment/Revision/Self study

UNIT II: Equilibrium & Structures

CHAPTER 3: Problem No. 3/1 to 3/57 – Excluding 3/22, 3/28, 3/29, 3/36, 3/38, 3/41, 3/46, 3/50, 3/51, 3/55, 3/56 Total – 46

Note: 23 Problems to be solved in class – 23 Problems Assignment/Revision/Self study

CHAPTER 4: Problem No. 4/1 to 4/29 - Excluding 4/14, 4/18, 4/20, 4/25, 4/27, 4/28

Total – 23

Note: 11 Problems to be solved in class – 12 Problems Assignment/Revision/Self study

UNIT III: Distributed Forces

CHAPTER 5: Problem No. 5/47 to 5/61, 5/101 to 5/111, 5/116, 5/122 – Excluding 5/54, 5/60, 5/108, 5/109 Total – 24

Note: 25 Problems to be solved in class – 25 Problems Assignment/Revision/Self study

ANNEXURE A: Problem No. A/1 to A/19 and A/35 to A/62

Excluding A/2, A/5, A/8, A/10, A/11, A/12, A/13, A/14, A/15, A/17, A/47, A/50, A/52, A/61.

Total – 33

Note: 17 Problems to be solved in class – 16 Problems Assignment/Revision/Self study

UNIT IV: Friction

CHAPTER 6: Problem No. 6/1 to 6/33, 6/53, 6/55, 6/56, 6/63, 6/66, 6/67, 6/69 - Excluding 6/7, 6/10, 6/21, 6/22, 6/25, 6/26, 6/27, 6/29, 6/30, 6/31, 6/32. Total – 29

Note: 15 Problems to be solved in class – 14 Problems Assignment/Revision/Self study

Assessment criteria

ISA - 50 Marks

Sl. No.	Component	Marks
1.	ISA - 1 – Hybrid for 1 & 2 Units 40/2 = 20	20
2.	ISA - 2 – Hybrid for 3 & 4 Units 40/2 = 20	20
3.	Experiential Component	05
4.	Supervised Assignment	05
TOTAL		50

ESA - 50 Marks (100 scaled down to 50)

NEP Attributes	Description
Professional Education	Experiential learning – Computer based solutions. Supervised Assignments
Technology Use and Integration	Live classroom session recordings, AV summaries, Notes, Assessments, Attendance, Concept Videos
Usage of Tools	**Python / MATLAB / C Programming**

Digital Deliverables Status: Available

Course	Unit	AV Summary	Live Videos	Slides	Notes	Question bank	QA	Assignment	MCQ	References
UE24CV131A/ UE24CV131B	I	17	39	14	1	1	1	1	20	1
	II	11	19	11	1	1	1	1	20	1
	III	10	18	12	1	1	1	1	20	1
	IV	13	26	14	1	1	1	1	20	1

LESSON OUTLINE SUMMARY – 86 (84) Slots / 64.5 (63) HOURS								
UNITS	L	EL	A	T	R	ISA	TOTAL	
							Slots	Hours
1	17		1		1		19	14.25
2	20	1	1	1		1	24	18.00
3	20		1		1		22	16.50
4	17	1	1	1		1	21	15.75
Total	74	2	4	2	2	2	86	64.50

L – Lecture; EL –Experiential Learning; **A** – Assignments/Open Book Tests; **T** – Tutorial Sessions; R - Revision; ISA – In Semester Assessment

Course Instructor: Dr. S V Venkatesh **No of Hours: 64.5 (63)**
No. of Slots: 86 (84)

Class (Slots 45 mins each) No.	Chapter Title/ Reference Literature	Topics to be covered	% of portions covered	
			Reference unit	Cumulative
1	**Introduction to statics T1: page 3-7**	**Unit I** Mechanics, Basic Concepts, Definitions – Space, Time, Mass, Force, Particle, Rigid body, Scalar quantity and Vector quantity.	25	25
2-3	**Force Systems T1: page 23-28**	Introduction; Force; External and internal effects; Principle of transmissibility; Force classification; Action and reaction; Components of a force; Rectangular Components; Conventions for Describing Vector Components: Determining the components of a force.		
4-6	**Numerical problems T1: page 32-38**	Numerical on Force system; 2/1 to 2/30 Excluding: 2/29		
7	**Moment T1: page 39-41**	Moment about a point; The cross product; Varignon's Theorem		
8-10	**Numerical problems T1: page 44-49**	Numerical on Moment; 2/31 to 2/57 Excluding: 2/48, 2/56		
11	**Couple T1: page 50 - 51**	Equivalent Couples; Force-Couple Systems		
12-13	**Numerical problems T1: page 53 – 57**	Numerical on Couple; 2/59 to 2/78		
14	**Resultant T1: page 58 - 59**	Resultants; Principle of Moments		
15-17	**Numerical problems T1: page 61 - 65**	Numerical on Resultant; 2/79 to 2/100 Excluding: 2/88, 2/95, 2/99		
18	**Revision**	Unit 1		
19	**Assignment**	Supervised assignment on Unit 1		

20-22	**Equilibrium** **T1: page 109 -126**	**Unit II** Introduction; Equilibrium in Two Dimensions - System Isolation and the Free-Body Diagram: Modeling the Action of forces; Equilibrium Conditions; Categories of Equilibrium; Constrains & Statical Determinacy.	25	**50**
23-30	**Equilibrium** **T1: page 130 -141**	Numerical on Equilibrium; 3/1 to 3/57 Excluding: 3/22, 3/28, 3/29, 3/36, 3/38, 3/41, 3/50, 3/51, 3/56		
31	**Structures** **T1: page 169- 171**	Introduction, Plane Trusses, Simple Trusses,		
32-34	**Structures** **T1: page 172- 175**	Method of joints, Internal and External Redundancy, Special conditions.		
35-39	**Structures** **T1: page 172- 175**	Numerical on Structures; 4/1 to 4/29 - Excluding 4/25, 4/27,4/28		
40	**Experiential Learning**	Computer based solutions for Numerical using MATLAB/Python		
41	**Assignment**	Supervised assignment on Unit 2		
42	**Tutorial Session**	Tutorial Session on Unit 2		
43 - ISA 1 - Unit 1 & 2				
44	**Distributed Forces** **T1: page 229 -237**	**Unit III** Introduction; Area Distribution; Center of mass; Determining the Center of Gravity; Centroid of Areas.	25	75
45	**Distributed Forces** **T1: page 250 -251**	Composite Bodies and figures; Approximations		
46-48	**Distributed Forces** **T1: page 269 -256**	Numerical on Centroid; 5/47 to 5/61 Excluding : 5/54, 5/60		
49	**Distributed Forces** **T1: page 254 -256**	Beams - External Effects: Types of Beams: Distributed loads		
50-53	**Distributed Forces** **T1: page 274 -275**	Numerical on Beams: 5/101 to 5/111, 5/116, 5/122 – Excluding 5/108, 5/109		
54-55	**Distributed Forces**	Area Moments of Inertia		

	T1: page 434-438	Introduction, Definitions; Radius of Gyration; Transfer of axis		
56-59	**Moment of Inertia T1: page 443 -445**	Numerical on Moment of Inertia; A/1 to A/19 Excluding A/2, A/5, A/8, A/10, A/11, A/12, A/13, A/14, A/15, A/17.		
60-63	**Moment of Inertia T1: page 449 -456**	Numerical on Moment of Inertia; A/35 to A/62 Excluding A/47, A/50, A/52, A/61		
64	**Revision**	Unit 3		
65	**Assignment**	Supervised assignment on Unit 3		
66	**Friction T1: page 331 -334**	**UNIT IV** Introduction, Frictional Phenomena - Types of Friction, Dry Friction, Fluid Friction, Internal Friction, Mechanism of Dry Friction	25	100
67	**Friction T1: page 334 -337**	Static Friction, Kinetic Friction, Friction Angles, Factors affecting Friction, types of friction problems.		
68-73	**Friction T1: page 342 -348**	Numerical on dry friction involving bodies placed on Horizontal surfaces and inclined Surface; 6/1 to 6/33 Excluding 6/7, 6/10, 6/21, 6/22, 6/25, 6/26, 6/27, 6/29, 6/30, 6/31, 6/32		
74	**Friction T1: page 353 -354**	Application of Friction in Machines – Wedges.		
75-82	**Friction T1: page 359 -362**	Numerical on Wedges; 6/53, 6/55, 6/56, 6/63, 6/66, 6/67, 6/69		
83	**Experiential Learning**	Computer based solutions for Numerical using MATLAB / Python		
84	**Tutorial Session**	Tutorial Session on Unit 4		
85	**Assignment**	Supervised assignment on Unit 4		
86 - ISA 2 - Unit 3 & 4				

Experiential Learning

1. The details of the problems to be solved in every experiential learning hours provided to the students.
2. Students have to come prepared with the solution for these problems as well as script file. Coming to the class without these will carry a penalty of 5 marks.
3. At the end of the class, the results obtained by executing the script files will be evaluated for 10 Marks.
4. Final Experiential Learning marks will be for 05 Marks.

Supervised Assignments

1. Supervised Assignments will be conducted in the designated classroom.
2. Supervised Assignments will involve writing answers to concept-based questions (similar to CBT based) and numerical problems (with changed data) – pertaining to the topics covered in the previous classes
3. Students will write the answers in A4 size sheets and submit the same to the faculty-in-charge at the end of the class.
4. Each supervised assignment is evaluated for 10 marks.
5. Four supervised assignments will be conducted and the marks obtained will be reduced to 05 marks for the calculation of ISA.

THEORY QUESTION BANK

UNIT I: Introduction to statics & Force Systems

1. Explain the terms
   a. Space b. Time c. Mass d. Force e. Particle f. Rigid body
2. Explain the difference between Scalars and Vectors
3. Explain the terms a. Fixed Vector b. Sliding Vector c. Free Vector
4. Explain the terms (with sketches)
   a. Coplanar Forces b. Concurrent Forces c. Collinear Forces
5. What are (Explain with sketches)
   a. Rectangular Components of a force b. Components of a force
   c. Projections of a force
6. Explain the Transmissibility of a force with a neat sketch
7. Define Force and state its characteristics
8. Explain the term Moment of a force with neat sketch
9. State and prove the Varignon's theorem.
10. What is a Couple?
11. Define the term Couple and state its characteristics
12. Explain the term Force-Couple System with the help of neat sketch
13. State and prove the Principle of Moments

UNIT II: Equilibrium & Structures

14. Define the term Equilibrium
15. State and explain the conditions of equilibrium required for a system of coplanar, concurrent forces
16. State and explain the conditions of equilibrium required for a system of coplanar, non-concurrent forces
17. Explain the difference between statically determinacy and statically indeterminacy of a structure
18. What is meant by Free Body Diagram and why are they important?
19. What do you understand by the terms "Roller Support", "Hinge support" and "Fixed Support".
20. Explain the terms internal redundancy and external redundancy as applied to trusses
21. What do you understand by $m+3 = 2j$ in case of a truss? What are the implications if this equation is not satisfied?

UNIT III Distributed Forces

22. Distinguish between Centroid, Centre of Mass and Centre of Gravity
23. Determine the Centroid for an area of a circular sector
24. Determine the Centroid distance of a triangle of base width, b, and height, h, from its base.
25. What are the different types of beams? Explain with sketches
26. Differentiate between statically determinant and statically in-determinant beam
27. Explain the different types of loadings on a beam
28. Explain with a neat sketch the moment of inertia of a plane lamina about X, Y and polar axis

29. What is radius of gyration?
30. State and prove the parallel axis theorem
31. Determine the moment of inertia of a rectangular area about its centroidal X, Y and polar Z axis
32. Determine the moment of inertia of a triangle about an axis passing through its base, centroid and its vertex
33. Determine the moment of inertia of a circle about its centroidal X, Y and Z axis

UNIT IV FRICTION

34. What do you understand by the terms Roller Support, Hinge support and Fixed Support
35. What are the different types of beams? Explain with sketches
36. Differentiate between statically determinant and statically in-determinant beam
37. Explain the different types of loadings on a beam
38. What are the types of friction, briefly explain them?
39. Explain the theory of Dry (Coulomb) friction, with the help of sketches
40. Derive an expression for Belt Friction
41. Explain the terms
    a. Coefficient of static friction b. Coefficient of kinetic friction
42. Explain the terms a. Angle of friction b. Cone of friction c. Angle of repos