

PES University
Civil Engineering, Department of S & H
UE25CV141A : 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:

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

Course Outcomes:

- Develop skills to determine resultants and apply conditions of static equilibrium to plane force systems.
- Develop skills to identify and quantify all forces associated with a static frame work.
- Develop skills to identify, formulate and solve engineering problems.
- Construct Shear force and Bending moment diagram for statically determinate beams with various loads.

Course Content:

UNIT 1: Introduction to statics & Force Systems

Introduction to statics: Mechanics, Basic Concepts, Scalars and Vectors.

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

13 Hours

UNIT 2: Equilibrium & Structures

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

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

15 Hours

UNIT 3: Distributed Forces

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

Beams: External effects, Internal effects, Numerical problems.

13 Hours**UNIT 4: Area Moment of Inertia & Friction**

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

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.

15 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, 5/7 for Unit - III.
 A/1 to A/3, 6/1 to 6/3 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, 5/7 Numerical
UNIT II CHAPTER 3: 3/1, 3/2, 3/3 CHAPTER 4: 4/1, 4/2, 4/3 Numerical	UNIT IV Appendix A: A/1, A/2, A/3 CHAPTER 6: 6/1, 6/2, 6/3 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: 12 Problems to be solved in class – 11 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, 5/125 to 5/134

Excluding 5/54, 5/60, 5/108, 5/109, 5/131.

Total – 33

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

UNIT IV: Area moment of inertia & Friction

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.

CHAPTER 6: Problem No. 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.

Total – 22

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

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, 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	Couple, 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.		
15-16	Numerical problems T1: page 61 - 65	Numerical on Resultant; 2/79 to 2/100 Excluding: 2/88, 2/95, 2/99.		

17	Experiential Learning - 01	Computer based solutions for Numerical using MATLAB/Python and any Civil engineering software (Civils.ai, Skyciv.com).		
18-20	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
21-28	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, 3/46, 3/50, 3/51, 3/55, 3/56.		
29	Experiential Learning - 02	Computer based solutions for Numerical using MATLAB/Python and any Civil engineering software (Civils.ai, Skyciv.com).		
30	Structures T1: page 169- 171	Introduction, Plane Trusses, Simple Trusses.		
31-32	Structures T1: page 172- 175	Method of joints, Internal and External Redundancy, Special conditions.		
33-36	Structures T1: page 172- 175	Numerical on Structures; 4/1 to 4/29 - Excluding 4/14, 4/18, 4/20, 4/25, 4/27, 4/28.		
37	Revision - 01	Unit 1 & 2.		
38	Experiential Learning - 03	Computer based solutions for Numerical using MATLAB/Python and any Civil engineering software (Civils.ai, Skyciv.com).		
39	Assignment - 01	Supervised assignment on Unit 1 & 2.		
40 - ISA 1 - Unit 1 & 2				

41	Distributed Forces T1: page 229 -237	Unit III Introduction; Area Distribution, Center of mass, Determining the Center of Gravity, Centroid of Areas (Derivation - Right angle triangle, Semi Circle, Quater Circle, Sector of a Circle).	25	75
42	Distributed Forces T1: page 250 -251	Composite Bodies and figures; Approximations.		
43-46	Distributed Forces T1: page 269 -256	Numerical on Centroid; 5/47 to 5/61 Excluding : 5/54, 5/60.		
47	Experiential Learning - 04	Computer based solutions for Numerical using MATLAB/Python and any Civil engineering software (Civils.ai).		
48	Distributed Forces T1: page 269 -270	Beams - External Effects: Types of Beams: Distributed loads.		
49-52	Distributed Forces T1: page 272 -275	Numerical on Beams: 5/101 to 5/111, 5/116, 5/122 – Excluding 5/108, 5/109.		
53-54	Distributed Forces T1: page 276 - 277	Beams - Internal effects, Shear, Bending & Torsion, Shear force and Bending moment diagram.		
55-58	Distributed Forces T1: page 283 - 284	Numerical on Shear force and Bending moment diagram 5/125 - 5/134. Excluding 5/131.		
59	Experiential Learning - 05	Computer based solutions for Numerical using MATLAB/Python and any Civil engineering software (Civils.ai, Skyciv.com).		
60-61	Area Moments of Inertia T1: page 434-438	UNIT IV Area Moments of Inertia Introduction, Definitions; Radius of Gyration; Transfer of axis.		

		(Derivation - Rectangle, Right angle triangle, Circle, Semi Circle, Quarter Circle, Sector of a Circle).	25	100
62-65	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.		
66-70	Moment of Inertia T1: page 449 -456	Composite area, Numerical on Moment of Inertia; A/35 to A/62 Excluding A/47, A/50, A/52, A/61.		
71	Friction T1: page 331 -334	Introduction, Frictional Phenomena - Types of Friction, Dry Friction, Fluid Friction, Internal Friction, Mechanism of Dry Friction.		
72	Friction T1: page 334 -337	Static Friction, Kinetic Friction, Friction Angles, Factors affecting Friction, types of friction problems.		
73-76	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.		
77	Tutorial Session - 01	Tutorial Session.		
78	Experiential Learning - 06	Computer based solutions for Numerical using MATLAB / Python and any Civil engineering software (Civils.ai, Skyciv.com).		
79	Assignment - 02	Supervised assignment on Unit 3 & 4.		
80 - ISA 2 - Unit 3 & 4				

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UE25CV141A/B - Engineering Mechanics Statics

Experiential Learning

1. Students have to submit the manual solution for problems of their choice covering all units, as well as script file using any one of the software i.e. Matlab, Python or C Programme and [by using any of the civil engineering software \(Civils.ai, Skyciv.com\)](#). This will carry 2.5 marks.
2. Students have to explain the solution and the script to the class, the presentation and the results obtained by executing the script files for any data values will be evaluated for 2.5 Marks.
3. Final Experiential Learning marks will be for 05 Marks (Submission 2.5 + Presentation 2.5).

Supervised Assignments

- Two supervised assignments will be conducted after unit 1 & 2 and Unit 3 & 4. Each for 10 marks finally reduced to 05 marks.
- Supervised Assignments will be conducted in the designated classroom.
- Supervised Assignments will involve writing answers to concept-based questions and numerical problems (with changed data) – pertaining to the topics covered in the previous classes.
- Students will write the answers in blue books and submit the same to the faculty-in-charge at the end of the class.

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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. Collinear Forces b. Coplanar parallel Forces c. Coplanar Concurrent Forces
d. Coplanar Non-Concurrent Forces e. Non-Coplanar parallel Forces f. Non-Coplanar
Concurrent Forces g. Non-Coplanar Non-Concurrent 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?
22. With a neat diagram explain symmetry in case of a truss.
23. What are the different methods of finding the forces in the members of a truss.

UNIT III Distributed Forces

24. Distinguish between Centroid, Centre of Mass and Centre of Gravity.
25. Determine the Centroid for an area of a circular sector.
26. Determine the Centroid distance of a triangle of base width, b , and height, h , from its base.
27. Determine the Centroid distance of a semicircle of radius R .
28. Determine the Centroid distance of a quarter circle of radius R .
29. Determine the Centroid distance of a sector of a circle of radius R .
30. What are the different types of beams? Explain with sketches.
31. Differentiate between statically determinate and statically indeterminate beam.
32. Explain the different types of loadings on a beam.
33. Define Shear force, Bending moment and torsional moment.
34. What do you mean by SFD and BMD?

UNIT IV Area Moment of Inertia & Friction

35. Explain with a neat sketch the moment of inertia of a plane lamina about X, Y and polar axis.
36. What is radius of gyration?
37. State and prove the parallel axis theorem.
38. Determine the moment of inertia of a rectangular area about its centroidal X, Y and polar Z axis.
39. Determine the moment of inertia of a triangle about an axis passing through its base, centroid and its vertex.
40. Determine the moment of inertia of a circle about its centroidal X, Y and Z axis.
41. What are the types of friction, briefly explain them?
42. Explain the theory of Dry (Coulomb) friction, with the help of sketches.
43. Explain the terms
 - a. Coefficient of static friction
 - b. Coefficient of kinetic friction
44. Explain the terms
 - a. Angle of friction
 - b. Cone of friction
 - c. Angle of repose.

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NUMERICAL PROBLEMS FOR EXPERIENTIAL LEARNING

Students have to submit a hard copy of the manual solution for problems of their choice as per the list below covering all units as well as script file using any one of the software i.e. Matlab, Python or C Programme and [by using any of the civil engineering software \(Civils.ai, Skyciv.com\)](#). (Level 1, Level 2, Level 3)

UNIT 1: Introduction to statics & Force Systems

Resolution

Level 1 - 2/1, 2/2, 2/3, 2/4, 2/9.

Level 2 - 2/5, 2/6, 2/7, 2/8, 2/11, 2/12, 2/13, 2/14, 2/16, 2/21, 2/22, 2/26.

Level 3 - 2/10, 2/15, 2/17, 2/18, 2/19, 2/23, 2/24, 2/25, 2/27, 2/28, 2/30.

Moment

Level 1 - 2/31, 2/32, 2/33, 2/34, 2/36.

Level 2 - 2/35, 2/37, 2/39, 2/42, 2/43, 2/46, 2/47, 2/49, 2/51, 2/52.

Level 3 - 2/38, 2/40, 2/41, 2/44, 2/45, 2/50, 2/53, 2/54, 2/55, 2/57.

Couple

Level 1 - 2/59, 2/60, 2/61, 2/62, 2/63, 2/64, 2/65, 2/66, 2/72.

Level 2 - 2/67, 2/71, 2/75, 2/76, 2/77.

Level 3 - 2/68, 2/69, 2/70, 2/73, 2/74, 2/78.

Resultant

Level 1 - 2/79, 2/80, 2/82, 2/84, 2/85, 2/86, 2/87, 2/93.

Level 2 - 2/81, 2/89, 2/90, 2/94, 2/96.

Level 3 - 2/91, 2/92, 2/97, 2/98, 2/100.

UNIT II: Equilibrium & Structures

Equilibrium

Level 1 - 3/1, 3/2, 3/3, 3/4, 3/5, 3/12, 3/24, 3/26.

Level 2 - 3/6, 3/7, 3/8, 3/9, 3/16, 3/21, 3/23, 3/27, 3/30, 3/31, 3/32, 3/33, 3/35, 3/37, 3/40, 3/42, 3/52.

Level 3 - 3/10, 3/11, 3/13, 3/14, 3/15, 3/17, 3/18, 3/19, 3/20, 3/25, 3/34, 3/39, 3/43, 3/44, 3/45, 3/47, 3/48, 3/49, 3/53, 3/54, 3/57.

Structures

Level 1 - 4/1, 4/2, 4/3, 4/4.

Level 2 - 4/5, 4/6, 4/7, 4/8, 4/12.

Level 3 - 4/9, 4/10, 4/11, 4/13, 4/15, 4/16, 4/17, 4/19, 4/21, 4/22, 4/23, 4/24, 4/26, 4/29.

UNIT III Distributed Forces

Centroid

Level 1 - 5/47, 5/48, 5/50, 5/53, 5/55.

Level 2 - 5/49, 5/51, 5/52, 5/56, 5/57.

Level 3 - 5/58, 5/59, 5/61.

Beams

Level 1 - 5/101, 5/102, 5/103, 5/104, 5/106, 5/125, 5/126, 5/128.

Level 2 - 5/105, 5/107, 5/110, 5/130, 5/133, 5/127.

Level 3 - 5/111, 5/116, 5/122, 5/129, 5/132, 5/134.

UNIT IV Area Moment of Inertia & Friction

Area Moment of Inertia

Level 1 - A/1, A/4, A/35, A/36, A/38, A/40, A/41, A/42.

Level 2 - A/3, A/6, A/7, A/9, A/37, A/39, A/46, A/49.

Level 3 - A/16, A/43, A/44, A/45, A/48, A/51, A/53, A/54, A/55, A/56, A/57, A/58, A/59, A/60, A/62.

Friction

Level 1 - 6/1, 6/2, 6/3, 6/4.

Level 2 - 6/5, 6/6, 6/8, 6/9, 6/20, 6/24, 6/33.

Level 3 - 6/11, 6/12, 6/13, 6/14, 6/15, 6/16, 6/17, 6/18, 6/19, 6/23, 6/28.

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BANANA (B), ORANGE (O), JACKFRUIT (J) - BOJ PROBLEMS

UNIT 1: Introduction to statics & Force Systems

Resolution

Level 1 - BANANA (B) - 2/1, 2/4, 2/9.

Level 2 - ORANGE(O) - 2/7, 2/11, 2/13, 2/14, 2/16, 2/21, 2/26.

Level 3 - JACKFRUIT(J) - 2/10, 2/19, 2/24, 2/27, 2/28.

Moment

Level 1 - BANANA (B) - 2/32, 2/34, 2/36.

Level 2 - ORANGE(O) - 2/37, 2/43, 2/46, 2/49, 2/51, 2/52.

Level 3 - JACKFRUIT(J) - 2/40, 2/45, 2/54, 2/57.

Couple

Level 1 - BANANA (B) - 2/59, 2/62, 2/63, 2/64, 2/66, 2/72.

Level 2 - ORANGE(O) - 2/71, 2/77.

Level 3 - JACKFRUIT(J) - 2/69, 2/78.

Resultant

Level 1 - BANANA (B) - 2/79, 2/82, 2/84, 2/85, 2/87, 2/93.

Level 2 - ORANGE(O) - 2/89, 2/90, 2/96.

Level 3 - JACKFRUIT(J) - 2/91, 2/92, 2/98.

UNIT II: Equilibrium & Structures

Equilibrium

Level 1 - BANANA (B) - 3/2, 3/12, 3/24, 3/26.

Level 2 - ORANGE(O) - 3/9, 3/21, 3/30, 3/33, 3/37, 3/40, 3/52.

Level 3 - JACKFRUIT(J) - 3/14, 3/15, 3/18, 3/20, 3/44, 3/45, 3/47, 3/48.

Structures

Level 1 - BANANA (B) - 4/1, 4/3.

Level 2 - ORANGE(O) - 4/5, 4/8.

Level 3 - JACKFRUIT(J) - 4/9, 4/15, 4/21, 4/23, 4/24, 4/26.

UNIT III Distributed Forces

Centroid

Level 1 - BANANA (B) - 5/48, 5/53.

Level 2 - ORANGE(O) - 5/56, 5/57.

Level 3 - JACKFRUIT(J) - 5/58.

Beams

Level 1 - BANANA (B) - 5/101, 5/106, 5/125, 5/128.

Level 2 - ORANGE(O) - 5/105, 5/110, 5/130.

Level 3 - JACKFRUIT(J) - 5/122, 5/129.

UNIT IV Area Moment of Inertia & Friction**Area Moment of Inertia**

Level 1 - BANANA (B) - A/4, A/35, A/36, A/38, A/41, A/42.

Level 2 - ORANGE(O) - A/7, A/37, A/46, A/49.

Level 3 - JACKFRUIT(J) - A/44, A/53, A/55, A/57, A/58, A/62.

Friction

Level 1 - BANANA (B) - 6/1, 6/4.

Level 2 - ORANGE(O) - 6/20, 6/24 .

Level 3 - JACKFRUIT(J) - 6/12, 6/15, 6/18, 6/28.