G24 Free Body Mechanics 1 **3:1**

Preamble: Mechanics is the branch of physics concerned with the behavior of physical bodies when subjected to forces or displacements, and the subsequent effect of the bodies on their environment. The discipline has its roots in several ancient civilizations. Scientists such as Galileo, Kepler and especially Newton, during the early modern period, laid the foundation for what is now known as classical mechanics. The major division of the mechanics discipline separates classical mechanics from quantum mechanics. Both are commonly held to constitute the most certain knowledge that exists about physical nature. Quantum mechanics is of a wider scope, as it encompasses classical mechanics as a sub-discipline which applies under certain restricted circumstances. There is no contradiction or conflict between the two subjects, each simply pertains to specific situations. Quantum mechanics has superseded classical mechanics at foundational level and is indispensable for the explanation and prediction of processes at molecular and (sub) atomic level. However, for macroscopical processes classical mechanics is able to solve problems which are unmanageably difficult in quantum mechanics and hence remains useful and well used.

The often-used term 'body' in the field of mechanics stands for a wide assortment of objects, including particles, projectiles, spacecraft, stars, parts of machinery, parts of solid, parts of fluids (gases and liquids) etc. Distinctions between the various sub-disciplines of mechanics, concern the nature of the bodies being described. Sub-disciplines of mechanics include Newtonian mechanics (dynamics, theory of motion and forces), Lagrangian mechanics (a theoretical formalism based on the principle of conservation of energy), Hamiltonian mechanics (another theoretical formalism based on the principle of the least action), Celestial mechanics (the motion of heavenly bodies: planets, comets, stars, galaxies, etc.), Astrodynamics (spacecraft navigation etc.), Solid mechanics (properties of rigid bodies), Elasticity (properties of semi-rigid bodies), Acoustics (density variation propagation in solids, fluids and gases), Statics (semi-rigid bodies in (mechanical equilibrium), Fluid mechanics (the motion of fluids), Soil mechanics (mechanical behavior of soils), Continuum mechanics (mechanics of continua - both solid and fluid), Hydraulics (mechanical properties of liquids), Fluid statics (liquids in equilibrium)

Program outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics, and science

c. An ability to design a system or component, or process to meet stated specifications

d. An ability to identify, formulate and solve engineering problems

Competencies: At the end of the course the student should be able to

1. Identify the nature (static, dynamic or static-dynamic) of operating conditions of a machine element.
2. Identify the forces acting on machine elements.
3. Draw the free body diagram of machine members
4. Determine the equilibrium conditions of machine members subjected to forces and moments normally encountered in operating conditions.
5. Analyze a given machine in terms of its constituent parts and their interrelationships.

Learning Objectives

Remember

1. What is equilibrium of mechanical system?
2. Define centroid of gravity
3. locate the centroid of a semicircle
4. State parallel – axis theorem
5. State perpendicular axis theorem
6. Define couple and its characteristics
7. Name the types of stresses
8. What are the conditions of equilibrium
9. Name the different types of beams
10. How do you identify the given cylinder'

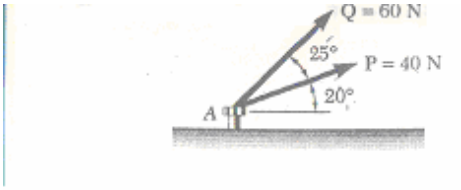
Understand

1. How do you resolve a force system into components?
2. What is meant by resultant force
3. A simply supported beam is acted upon with central point load. What types of forces are action on it?
4. Weight of roof is acting on a truss. How forces are distributed on the members of the truss
5. Define polar moment of inertia
6. Distinguish between truss and frame
7. Differentiate between fixed beam and overhanging beam
8. A cantilever beam is acted upon by a vertical load at it is free end. What is the condition of beam?

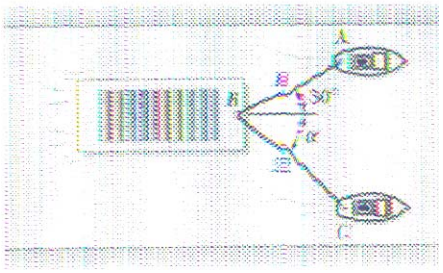
9. What are the various stress acting on thick cylinder ?
10. A shaft is transmitting power. What kind of stress will induce?

Apply

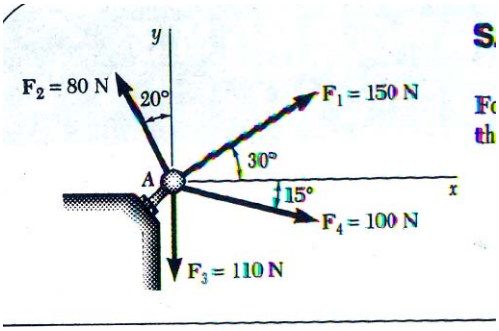
1. Determine the resultant of two force P and Q act on a bolt A



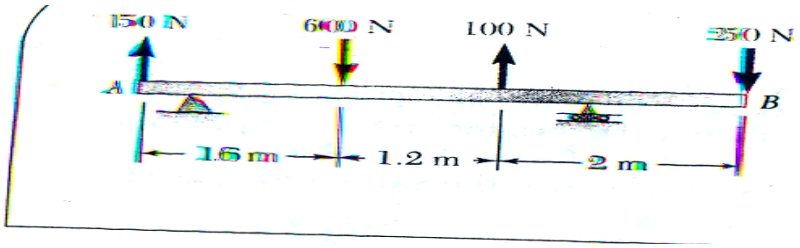
2. A barge is pulled by two tugboats. If the resultant of the forces exerted by the tugboats is a 5000 N force directed along the axis if the barge, determine the a) the tension in each of the ropes knowing that α = 45° b) the value of α for which the tension in rope 2 is minimum.



3. Four forces act on bolt A shown, Determine the resultant of the forces on the bolt,

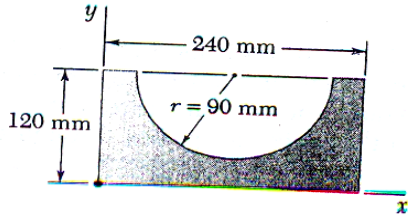


4. A 4.8 m long beam is subjected to the force shown. Reduce the given system of forces to a) an equivalent force couple system at a b) an equivalent force couple system at B, c) a single force of resultant.

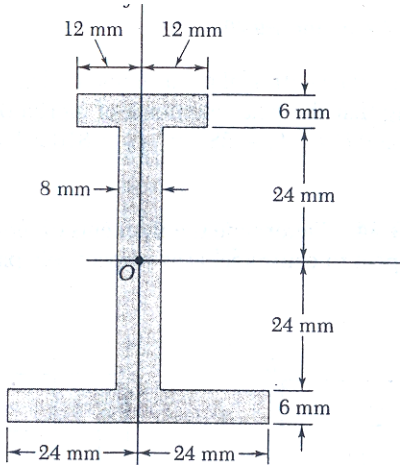


Note: since the reaction at the supports are not included in the given system of forces

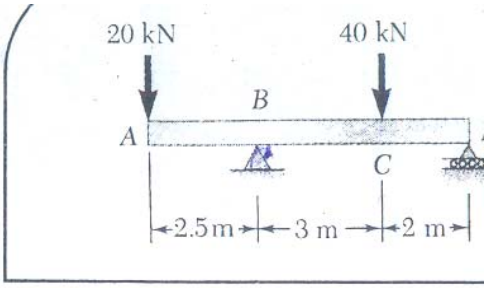
5. Determine the moment of inertia of the shaded are with respect to the x axis



6. Determine the moment of inertia and radius of gyration of the shaded are with respect to the x axis



7. Draw the shear and bending moment diagram for the beam and loading shown.



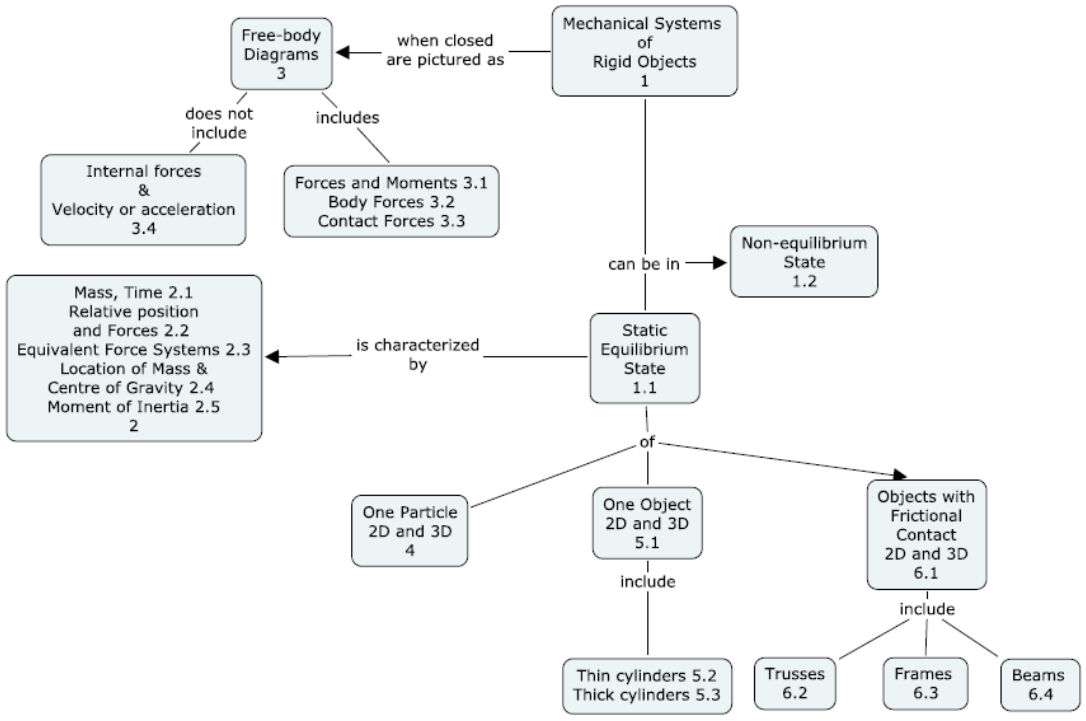
Analyze

1. A 50 mm diameter shaft is simply supported on two bearings 600 mm apart the shaft carry a horizontal belt drive resulting in belt tension the shaft is sufficiently heavy Derive the suitable equation to find the shear stress induced in the shaft . A shaft is also heavy , A shaft is supported by two bearing at its end. Diameter of the shaft is 50 mm

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	10	10
2	Understand	40	30	20
3	Apply	40	40	40
4	Analyze	0	20	30
5	Evaluation	0	0	0
6	Create	0	0	0

Concept Map



Lecture Schedule

Sl. No.	Topic	Hrs
1.	**Mechanical Systems of Rigid Objects**	
1.1	Static Equilibrium State	1
1.2	Non-equilibrium State	1
2.	**Static Equilibrium of Mechanical Systems**	
2.1	Mass and Time	1
2.2	Relative Position and Forces	1
2.3	Equivalent Force Systems	1
2.4	Location of Mass and Centre of Gravity	3
2.5	Moment of Inertia	2
3.	**Free Body Diagrams**	
3.1	Forces and Moments	1
3.2	Body Forces	1
3.3	Contact Forces	1
4.	**One Particle in 2D and 3D**	1
5.	**One Object in 2D and 3D**	
5.1	Introduction	1
5.2	Thin Cylinders	3
5.3	Thick Cylinders	3
6.	**Objects with Frictional Contact in 2D and 3D**	
6.1	Introduction	1
6.2	Trusses	3
6.3	Frames	2
6.4	Beams	
6.4.1	Types of beams	1
6.4.2	Stresses in beams	2

6.4.3	SFD and BMD	3
6.4.4	Slope and deflection	3
6.4.5	Bending stresses in beams	2
6.4.6	Torsional shear stresses in beams	2

Syllabus

Mechanical Systems of Rigid Objects: Static Equilibrium State, Non-equilibrium State **Static Equilibrium of Mechanical Systems ;** Mass and Time, Relative Position and Forces, Equivalent Force Systems, Location of Mass and Centre of Gravity, Moment of Inertia **Free Body Diagrams:** Forces and Moments, Body Forces, Contact Forces, Internal Forces, Velocity and Acceleration **One Particle in 2D and 3D. One Object in 2D and 3D:** Thin Cylinders, Thick Cylinders **Objects with Frictional Contact in 2D and 3D:** Trusses, Frames, Beams

Textbooks

1. Beer F.P. and Johnston Jr. E.R., Vector Mechanics for Engineers: Statics and Dynamics, Seventh Edition, Tata McGraw Hill, 2004
2. Beer F.P., Johnston Jr. E.R. and Dewolf J.T.: Mechanics of Materials, McGraw Hill

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2. Shames, I.H.: Engineering Mechanics – Statics and Dynamics, Prentice Hall of India, New Delhi, 2001
3. Palanichamy and Nagan S.: Engineering Mechanics – Statics, Tata McGraw Hill, 1997
4. Lakshmana Rao: Engineering Mechanics – Statics and Dynamics, Prentice Hall of India, New Delhi, 2003
5. Gere J.M. and Timoshenko S.P.: Mechanics of Materials, Nelson Thoranes, 2002
6. Popov E.P.: Engineering Mechanics of Solids, Second Edition, Pearson Education, New Delhi, 2001
7. Bansal R.K.: A Text Book of Strength of Materials, Lakshmi Publications, 2004

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