PVP 23

Code: 23CE3201, 23ME3201

I B.Tech - II Semester – Regular / Supplementary Examinations JUNE 2026

ENGINEERING MECHANICS

(Common for CE, ME)

Duration: 3 hours Max. Marks: 70

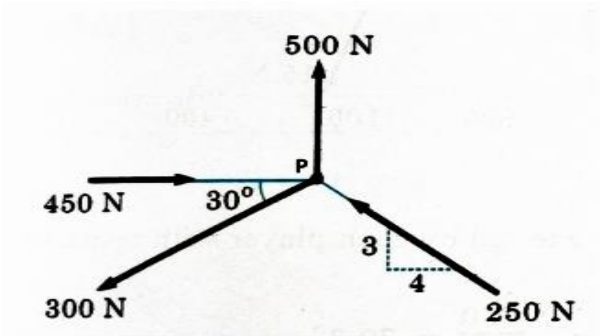
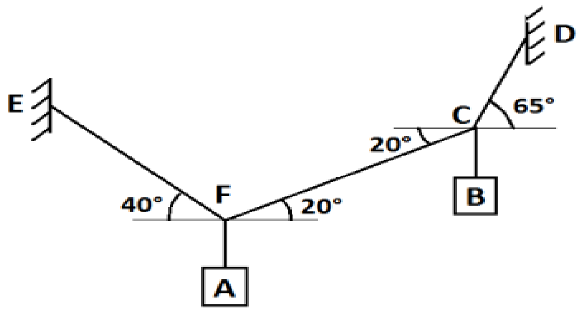
Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

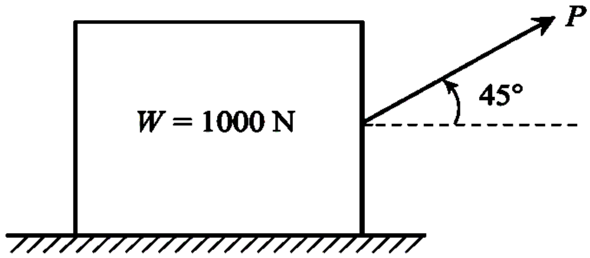
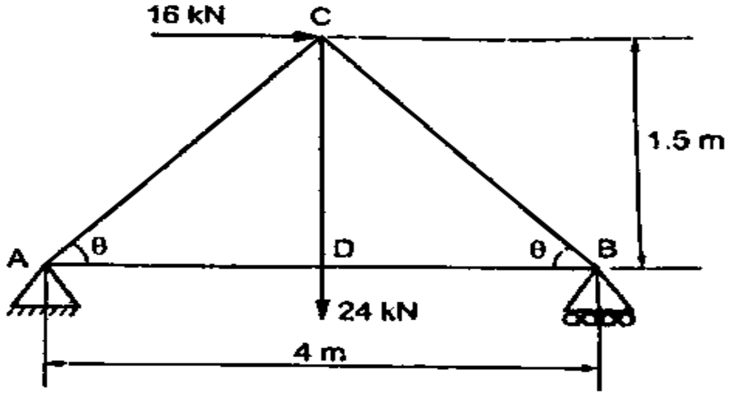
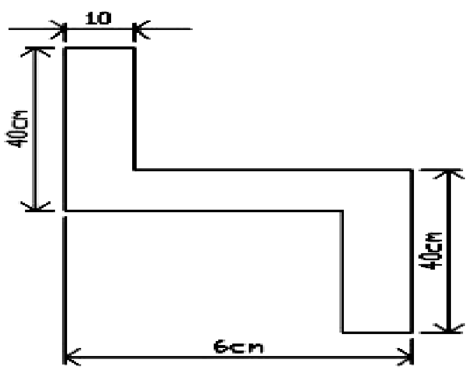
BL – Blooms Level CO – Course Outcome

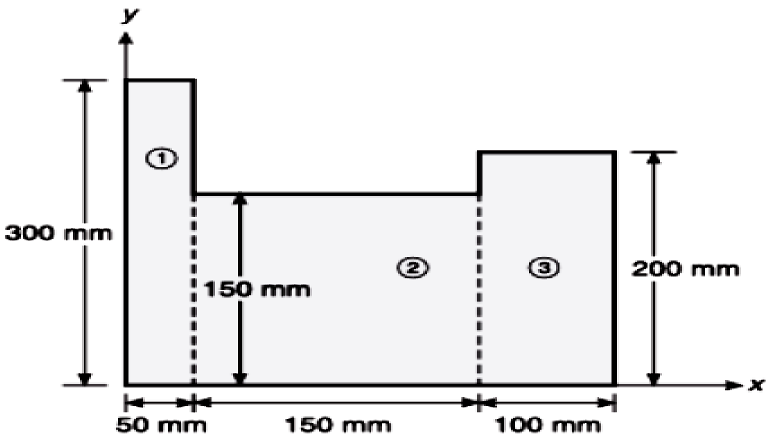
PART – A

		BL	CO
1.a)	Define Engineering Mechanics and mention its scope.	L1	CO1
1.b)	What is the moment of a force? Write its formula.	L1	CO1
1.c)	Define limiting friction and Explain its significance.	L1	CO2
1.d)	List the assumptions made in the analysis of plane trusses.	L1	CO2
1.e)	State the Perpendicular Axis Theorem and Mention where it is used.	L1	CO3
1.f)	Differentiate between area moment of inertia and polar moment of inertia.	L2	CO3
1.g)	What is the Work-Energy Principle? State its basic expression.	L1	CO4
1.h)	Why is acceleration in curvilinear motion resolved into tangential and normal components?	L2	CO4
1.i)	Explain the relationship between torque and angular acceleration in rotational dynamics.	L2	CO5
1.j)	Why is moment of inertia important in determining the rotational behavior of a rigid body?	L2	CO5

PART – B

			BL	CO	Max. Marks
UNIT-I					
2	a)	Explain Parallelogram law of forces with a neat sketch.	L2	CO1	4 M
	b)	Find the resultant of the force acting on a particle P shown in Fig. 	L3	CO1	6 M
OR					
3	a)	State and prove Lamis theorem.	L2	CO1	4 M
	b)	If the cords suspend the two buckets in the equilibrium position shown in Fig. Determine the weight of bucket B. Bucket A has a weight of 60 N. 	L3	CO1	6 M
UNIT-II					
4	a)	Explain Coulomb's Laws of Dry Friction (any four points).	L2	CO2	4 M
	b)	A body weighting 1000N is lying on a horizontal plane. Determine the necessary force to move the body along the plane if the force is applied at angle of 45° to the horizontal with the coefficient of friction 0.24	L3	CO2	6 M

					
OR					
5	a)	Explain the basic steps involved in the Method of Joints.	L2	CO2	4 M
	b)	Determine the forces in the truss shown in Fig. It carries a horizontal load of 16 kN and vertical load of 24 kN 	L3	CO2	6 M
UNIT-III					
6	a)	Derive the expression for centroid of a rectangle with a neat sketch.	L2	CO3	4 M
	b)	Design Moment of Inertia about the co-ordinate axes of plane area shown in fig. Also find Polar Moment of Inertia. 	L3	CO3	6 M
OR					
7	a)	Derive an expression for Centroid of circle with a neat sketch.	L3	CO3	4 M
	b)	Determine Centroid for following figure.	L3	CO3	6 M

					
UNIT-IV					
8	a)	Explain the Work-Energy principle and write its governing equation.	L2	CO4	4 M
	b)	Explain curvilinear motion and write expressions for velocity and acceleration in rectangular components.	L3	CO4	6 M
OR					
9	a)	Illustrate the types of motion of particle with neat sketches.	L2	CO4	4 M
	b)	A motion of a particle along a stright line is given by a equation $a=t^2-2t+2$ where a=acceleration in m/s^2, t=time in sec, After 1 sec the distance travelled by the particle and the velocity of the particle where found to be 14.75m and 6.3m/sec. Find the distance travelled, velocity and acceleration of the particle after 2 seconds.	L3	CO4	6 M
UNIT-V					
10	a)	A rigid body rotates under constant torque about a fixed axis. Derive governing equations and explain the nature of motion with graphs.	L2	CO5	4 M
	b)	The armature of an electric motor has angular speed N=1800rpm at the instant when the power is cut off (i) If it comes to rest in 6sec, calculate the angular deceleration (ii) Assuming it is constant. How many complete revolutions does the armature make during this period?	L3	CO5	6 M

OR					
11	a)	Explain kinetics of rotational motion and compare it with kinetics of rectilinear motion using equations of motion.	L2	CO5	4 M
	b)	A flywheel starts from rest and attains 120 rad/s in 20s under uniform angular acceleration. It then rotates at constant speed for 10s and finally comes to rest in 30s under uniform retardation. Find: (i) angular acceleration in each stage (ii) total angular displacement.	L2	CO5	6 M

I - B.Tech - II Semester - Regular/supplementary - June-202

Code:- 23CE3201
23ME3201

Engineering Mechanic's

Scheme of Valuation

Part A

1) a) 1 Mark - Definition, 1 mark - explaination

b) 1 mark - Definition, 1 mark - Formula

c) 1 mark - Definition, 1 mark - significance

d) 1 mark - Two Assumptions, 1 mark - explanation

e) 1 mark - Statement, 1 mark - Formula

f) 1 mark - Area MoI, 1 mark - Polar MoI

G) 1 mark - Statment, 1 mark - formula

h) 1 mark - Reason, 1 mark - explanation

i) 1 mark - Formula, 1 mark - explanation

j) 1 mark - Definition, 1 mark - significance.

Part - B

2(a) Definition - 1 M
Diagram - 1 M
formula - 1 M
formula - 1 M.
} - 4m

2b) Given Data - [1m]
f.B.D - [1m]
Answers - {4m}
} - 6m

~~2(b)~~
3(a) Definition - 1m
figure - 1m
explanation - 1m
formula - 1m
} - 4m

3(b) Given Data - {1m}
f.B.D - {1m}
Answers - {4m}
} - 6m

4(a) - Definition - {1m}
four laws - {3M} - 4m

4b) Given Data - 1m
f.B.D - 1m
formula & Answers - 4m - 6m

5 a) - Definition - {1m}
figures - {2m}
steps - {1m} - 4m

(5b) Given data - 1m
f.B.D - 1m
formulas & Answers - 4m - 6m

6 a) - Statement - {1.M}
figures - {1m}
Derivation - {1m}
Result - {1m} - 4m

6 b) Attemted & section's mention - {6m}

7(a) - Statment - {1m}
figures - {1m}
Derivation - {1m}
Result - {1m} - 4m

7(b) Given Data - 1m
f.B.D - 1m
Answers - 4m - 6m

8(a) - Definition - {1m}
explanation - {1m}
Derivation - {1m}
final equation - {1M} - 4m

8(b) - 6m
Definition - 1m
Rectengul component - 2m
Derivatn - 1m
equation - 2m

9(a) - Rectilinear motion {1m}
Curvillinear Motion - {1m}
Circular motion {1m}
Oscillary motion - {1m} - 4m

9(b) - 6m
Given data - 1m
equations - 2m
Answers - 3m

10(a) formula -{1M}
Angular velocity -{1M}
Angular Displacment -{1M}
velocity displacment -{1M}
} - 4M

<u>10(b) - 6M</u>
Given data -{1M}
formulas - {2M}
Answers -{3M}

11(a) - Definition -{1M}
formula - {1M}
Comparsion - {2M}
} - 4M

<u>11(b) - 6M</u>
Given data -{1M}
formulas -{2M}
Answers - {3M}

Engineering Mechanics – Part A Solutions (2 Marks Each)

1.a) Define Engineering Mechanics and mention its scope.

Answer: Engineering Mechanics is the branch of science that studies the behavior of physical bodies under the action of forces. Scope includes statics (bodies at rest) and dynamics (bodies in motion, including kinematics and kinetics).

Valuation Scheme: 1 mark: Definition, 1 mark: Scope

1.b) What is the moment of a force? Write its formula.

Answer: Moment of a force is the turning effect produced by a force about a point or axis. Formula: $M = F \times d$, where d is perpendicular distance.

Valuation Scheme: 1 mark: Definition, 1 mark: Formula

1.c) Define limiting friction and explain its significance.

Answer: Limiting friction is the maximum frictional force just before motion starts. Significance: It determines the maximum resistance to motion and helps in design of stable structures.

Valuation Scheme: 1 mark: Definition, 1 mark: Significance

1.d) List assumptions in plane trusses.

Answer: Members are connected by pin joints, loads act only at joints, members are straight and weightless, and forces are axial only.

Valuation Scheme: 1 mark: Any two assumptions, 1 mark: remaining

1.e) State Perpendicular Axis Theorem and its use.

Answer: Perpendicular Axis Theorem: $I_z = I_x + I_y$ for a plane lamina. Used to find moment of inertia about perpendicular axis.

Valuation Scheme: 1 mark: Statement, 1 mark: Use

1.f) Differentiate between area MOI and polar MOI.

Answer: Area MOI is about a single axis (I_x, I_y), while polar MOI is about perpendicular axis ($J = I_x + I_y$).

Valuation Scheme: 1 mark: Area MOI, 1 mark: Polar MOI

1.g) Work-Energy Principle.

Answer: Work done by all forces equals change in kinetic energy. Expression: $W = \Delta KE$

Valuation Scheme: 1 mark: Statement, 1 mark: Expression

1.h) Why resolve acceleration in curvilinear motion?

Answer: Because motion has changing direction and magnitude. Tangential component changes speed, normal component changes direction.

Valuation Scheme: 1 mark: Reason, 1 mark: Components explanation

1.i) Relationship between torque and angular acceleration.

Answer: Torque = I × α, where I is moment of inertia and α is angular acceleration.

Valuation Scheme: 1 mark: Formula, 1 mark: Explanation

1.j) Importance of moment of inertia in rotation.

Answer: It measures resistance to angular motion and affects angular acceleration under torque.

Valuation Scheme: 1 mark: Definition idea, 1 mark: Importance

PART – B

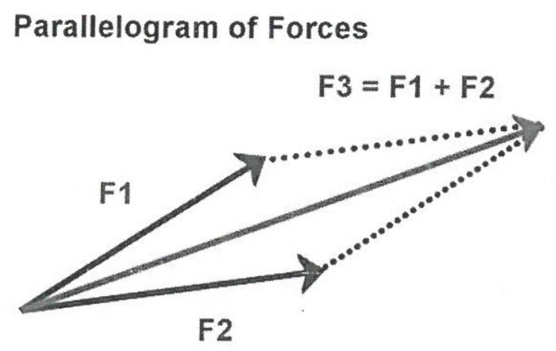
2a)

Parallelogram Law of Forces

Statement:

If two forces acting simultaneously at a point are represented in magnitude and direction by the two adjacent sides of a parallelogram, then their resultant is represented in magnitude and direction by the diagonal of the parallelogram passing through that point. [1]

Neat Sketch (for exam):



[1]

Derivation of Resultant:

Let two forces P and Q act at a point with angle θ between them.

Construct a parallelogram with sides representing P and Q. Let the diagonal represent resultant R.

Magnitude of Resultant (R):

Using cosine rule in triangle:

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$ [1]

Direction of Resultant (α):

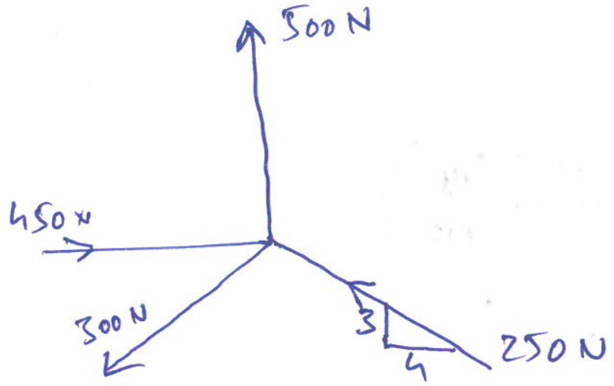
$$\tan\alpha = \frac{Q\sin\theta}{P + Q\cos\theta}$$ [1]

☞ Where:

- R = resultant force
- α = angle between resultant and force P

Part - B

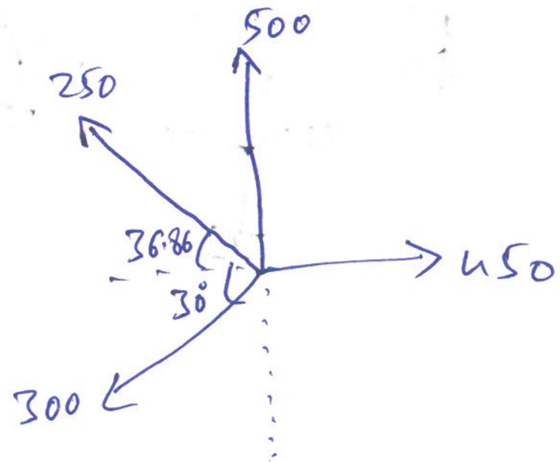
2(b) Find the resultant of the force acting on a Particle. P - as shown in figure.



Ans:

$$\tan\theta = \frac{3}{4}, \theta = 36.86$$ — {1 m}

F.B.D — [1 m]



$$\Sigma F_x = 450 - 250\cos(36.86) - 300\cos 30^\circ$$ — {1 m}

$$= 450 - 200.0 - 259.80$$

$$= -9.8\ N$$

$$\Sigma F_y = 500 + 250\sin 36.86 - 300\sin 30^\circ$$ — {1 m}

$$= 499.8\ N$$

Resultant magnitud & direction — [1M]

$$R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$$

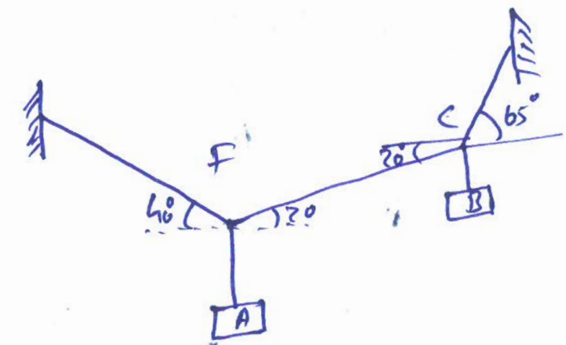
$$= 500.10\ N$$

Direction (θ) — [1M]

$$\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$$

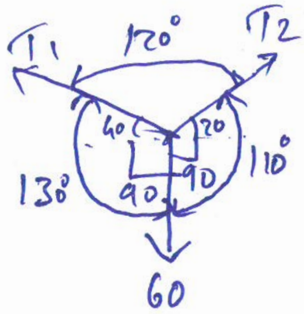
$$= 88.8^\circ$$

3 (b)



Point F

F.B.D



$$\frac{T_1}{\sin 110} = \frac{60}{\sin 120}$$

$$T_1 = 69.28 \times \sin 110$$

$$T_1 = 65\ N$$

[2]

$$\frac{T_2}{\sin 130} = \frac{60}{\sin 120}$$

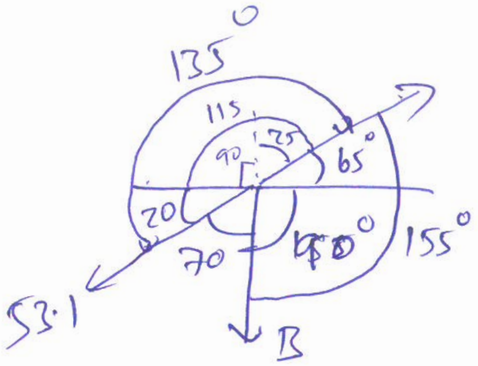
$$T_2 = 69.28 \times \sin 130$$

$$T_2 = 53.1\ N$$

[2]

4

Jointe C



$$\frac{53\cdot 1}{\sin 155} = \frac{B}{\sin 135^\circ}$$

$B = 88{\cdot}8\,kN$

[2]

for - 3(a) - P.T.O

5

3 a)

Lami's Theorem

Statement:

If a body is in equilibrium under the action of **three concurrent and non-collinear forces**, then each force is proportional to the sine of the angle between the other two forces. [1]

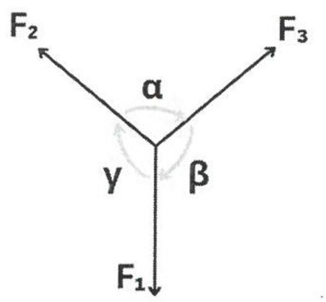
Mathematical Expression:

$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$ [1]

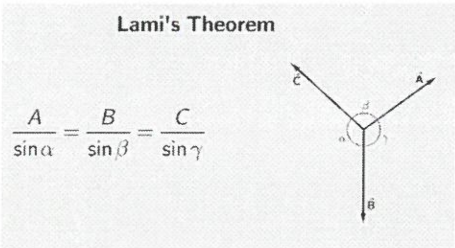
☞ Where:

- F_1, F_2, F_3 are the three forces
- α, β, γ are the angles opposite to the respective forces

Neat Sketch (for exam):



[1]



Proof of Lami's Theorem:

Step 1: Consider a body in equilibrium

Let three forces F_1, F_2, F_3 act at a point and keep the body in equilibrium.

Step 2: Apply triangle law of forces

Since the body is in equilibrium, the three forces can be represented in magnitude and direction by the sides of a triangle taken in order. [1]

Step 3: Form triangle of forces

Construct a triangle where:

- Each side represents one force
- Angles between forces are α, β, γ

Step 4: Apply sine rule in triangle

From trigonometry:

$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$

7

4a)

Coulomb's Laws of Dry Friction

Definition:

Dry friction is the resisting force that acts between two solid surfaces in contact when there is relative motion or a tendency of motion. {1}

Coulomb's Laws of Dry Friction:

1. Friction acts tangentially

The frictional force always acts **along the surface of contact** and **opposes motion** or the tendency of motion.

2. Friction is proportional to normal reaction

The limiting friction is directly proportional to the normal reaction between the surfaces. {1}

$$F \propto N$$
$$F = \mu N$$

☞ Where:

- F= frictional force
- N= normal reaction
- μ= coefficient of friction

3. Limiting friction depends on nature of surfaces

The coefficient of friction (μ)depends on:

- Roughness
- Material of surfaces

4. Friction is independent of area of contact {1}

For a given normal force, friction does **not depend on contact area.**

5. Kinetic friction is less than limiting friction

Once motion starts:

$$F_k < F_{max}$$

☞ Kinetic friction is slightly less than static (limiting) friction.

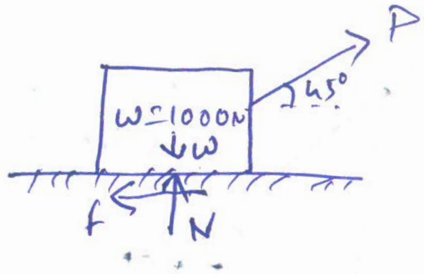
6. Friction is independent of velocity (low speeds) {1}

At ordinary speeds, friction does not change with velocity.

Types of Friction (for clarity):

- Static friction
- Limiting friction
- Kinetic (sliding) friction

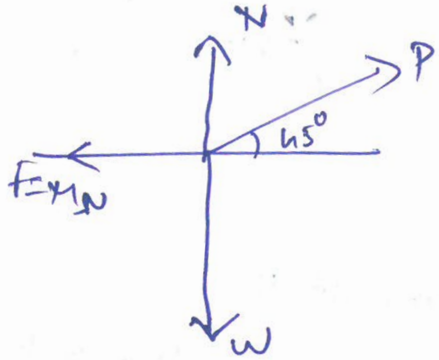
4 (b)



— {1M}

Soln

F.B.D



— {1M}

$\Sigma F_y = 0$

$$N + P\sin 45^\circ - W = 0$$

$$N = W - P\sin 45^\circ \quad \text{— \{1M\}}$$

$$N = 1000 - P\sin 45^\circ \quad \text{— (1)}$$

$\Sigma F_x = 0$

$$P\cos 45^\circ - F = 0 \quad \text{— \{1M\}}$$

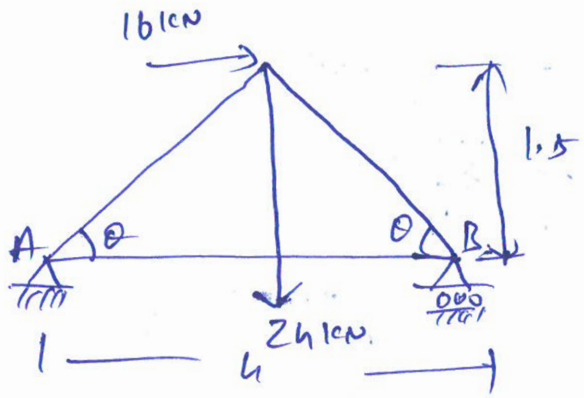
$$P\cdot\cos 45^\circ - \mu_s N = 0 \quad \text{— (2)}$$

Sub eq (1) in (2)

$$P\cos 45^\circ = \mu(1000 - P\sin 45^\circ)$$

$$\boxed{P = 273.2\ N} \quad \text{— \{2M\}}$$

5 b



Given Data

Support Reaction's at A {1}

$$\Sigma M|_A = 0 \Rightarrow R_B \times 4 - 24 \times 2 - 16 \times 1.5$$

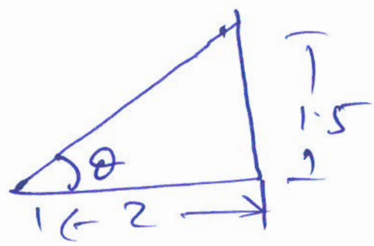
$$4R_B = 48 + 24 = 72$$

$$R_B = 18\,kN$$

$\Sigma V = 0$ $\quad R_A + R_B = 24$ {1}

$$R_A = 24 - 18 = 6\,kN$$

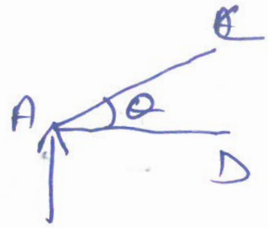
$\Sigma H = 0$ $\quad HA = 16\,kN$



$$\tan\theta = \frac{1.5}{2}$$

$$\theta = 36.87^\circ$$

Joint-A



[1]

$\Sigma V \Rightarrow \cancel{f_{CA}}\ f_{AC} \sin\theta = 6$

$f_{AC} \sin(36.87) = 6$

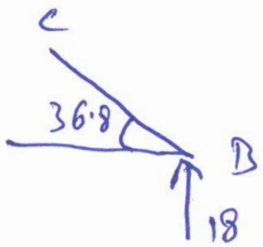
$f_{AC} = 10\ kN$ (Tension)

$\Sigma H \Rightarrow \quad f_{AB} = H_A + f_{AC} \cos\theta$

$f_{AB} = 16 + 10 \cdot \cos(36.87)$

$f_{AB} = 24\ kN$ (compression)

Joint - B



[1]

$\Sigma V = 0$

$f_{BC} \sin\theta = 18$

$f_{BC} = 30\ kN\ (T)$

$\Sigma H = 0$

$f_{AB} = f_{BC} \cos\theta$

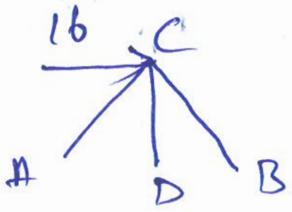
$24 = 30 \times 0.8$

$24 = 24$

Horizontal check

Joint C

{1}



$\Sigma V \Rightarrow$

$$f_{CD} = (f_{AC} + f_{BC}) \sin\theta$$

$$f_{CD} = 24\,kN\ (C)$$

{1}

Member	Force	Nature
AC	10 kN	(T)
BC	30 kN	(T)
AB	24 kN	(C)
CD	24 kN	(C)

(for 5a - PTO)

10

5a) Method of Joints (Trusses) – Basic Steps

Definition:

The **Method of Joints** is used to determine the forces in members of a truss by applying **equilibrium conditions at each joint**. {1}

Basic Steps:

1. Determine Support Reactions

- Apply equilibrium equations to the whole truss:

$$\sum F_x = 0, \sum F_y = 0, \sum M = 0$$

- Find unknown reactions at supports.

2. Select a Joint

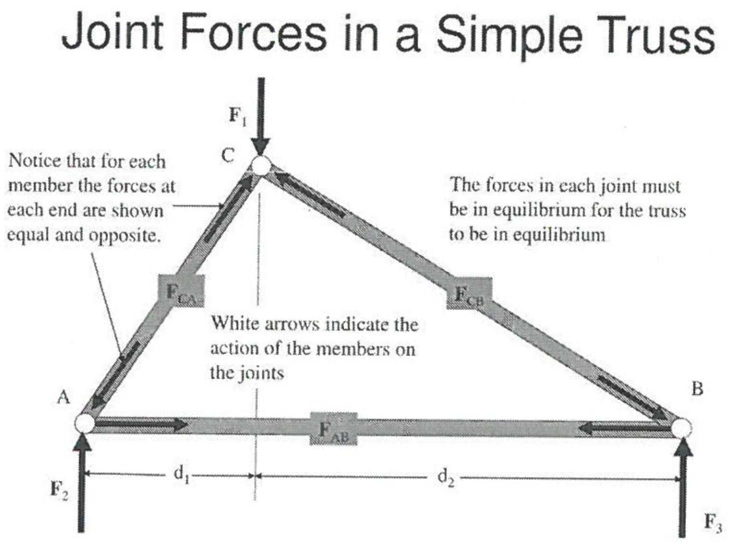
- Choose a joint where **maximum two unknown forces** are present.
- Start from supports or ends (usually easier).

3. Draw Free Body Diagram (FBD)

- Isolate the joint.
- Show all forces acting:
  - Member forces (assume tension → arrows away from joint)
  - External loads/reactions

Typical Joint Diagram:

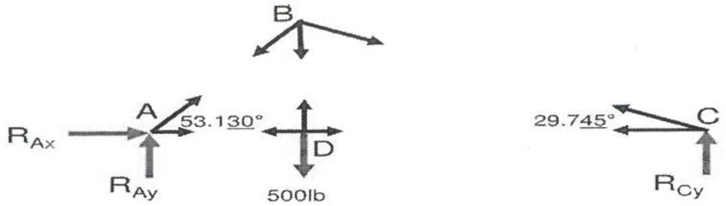
{1}



11

Method of Joints

Draw a free body diagram of each pin.



{1}

Every member is assumed to be in tension. A positive answer indicates the member is in tension, and a negative answer indicates the member is in compression.

4. Apply Equilibrium Equations

At each joint:

$$\sum F_x = 0$$
$$\sum F_y = 0$$

Solve for unknown member forces.

{1}

5. Move to Next Joint

- Proceed to adjacent joints.
- Use already calculated forces to reduce unknowns.

6. Identify Nature of Forces

- **Positive result → Tension**
- **Negative result → Compression**

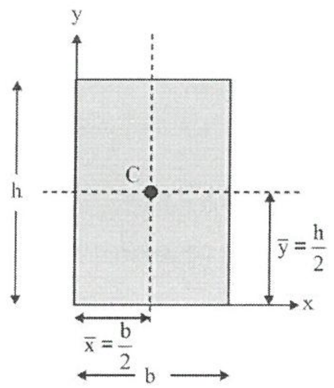
6 a) Centroid of a Rectangle – Derivation

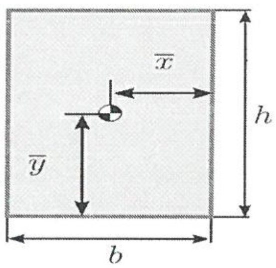
Statement:

To derive an expression for the **centroid of a rectangular lamina** of width b and height h.

[1]

Neat Sketch (for exam):





Assumptions:

- Rectangle of width **b** along X-axis and height **h** along Y-axis
- One corner at origin (0,0)
- Uniform density

[1]

Consider:
Take a **horizontal elemental strip** of thickness **dy** at a distance **y** from X-axis
Area of elemental strip:

$$dA = b\,dy$$

Total area:

$$A = b \times h$$

13

Centroid Coordinates:

1. X-coordinate of centroid ($\bar{x}$)

$$\bar{x} = \frac{\int x\, dA}{\int dA}$$

Since the rectangle is symmetric about the vertical center line:

$$\bar{x} = \frac{b}{2}$$

{1}

2. Y-coordinate of centroid ($\bar{y}$)

$$\bar{y} = \frac{\int y\, dA}{\int dA}$$

Substituting:

$$\bar{y} = \frac{\int_0^h y(b\, dy)}{bh}$$

$$\bar{y} = \frac{b\int_0^h y\, dy}{bh}$$

$$\bar{y} = \frac{b\left[\frac{y^2}{2}\right]_0^h}{bh}$$

$$\bar{y} = \frac{b \cdot \frac{h^2}{2}}{bh}$$

$$\bar{y} = \frac{h}{2}$$

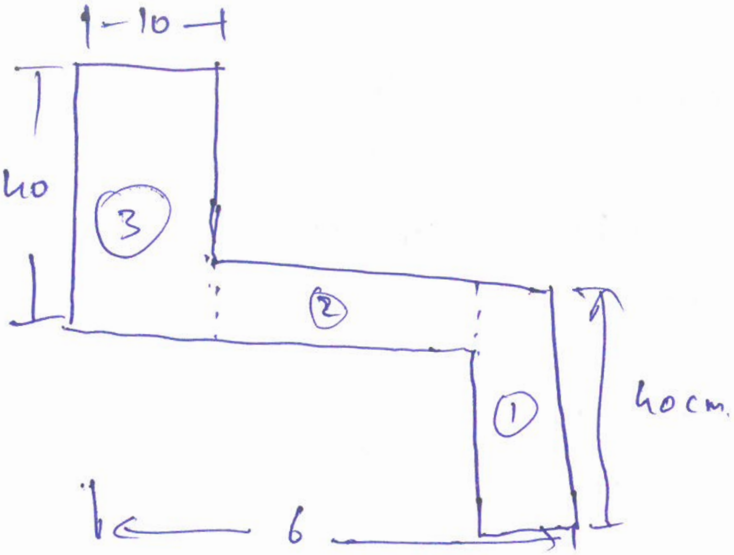
{1}

Final Result:

$$\boxed{\bar{x} = \frac{b}{2}, \bar{y} = \frac{h}{2}}$$

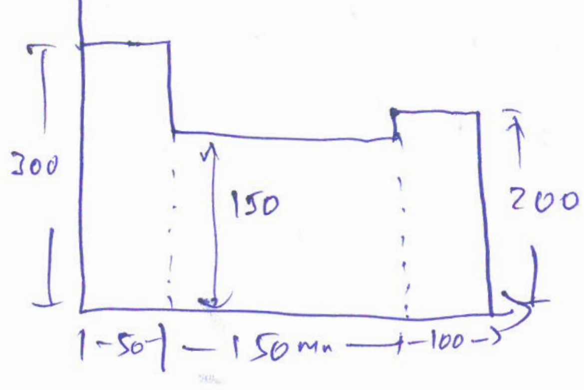
6(b)

{6}



∴ <u>Note</u> :- Since Some data is missing the Problem So ~~Please~~ kindly Grant the Mark's if the Problem is attempted and divided in to Section's, and it Rectangle Area formula's are mentioned

7(b)



{1}

Shape.

Shape	Area	x	y
1	$300 \times 50 = 15{,}000$	$x_1 = 150$	$y_1 = 275$
2	$150 \times 150 = 22{,}500$	$x_2 = 75$	$y_2 = 175$
3	$200 \times 100 = 20{,}000$	$x_3 = 100$	$y_3 = 50$

$\Sigma A = 57{,}500$

{2

Centroids

$$\bar{x} = \frac{\Sigma A_i x_i}{\Sigma A} = \frac{A_1x_1 + A_2x_2 + A_3x_3}{A_1 + A_2 + A_3}$$

{3}

$$\bar{x} = 103.26\ mm$$

$$\bar{y} = \frac{A_1y_1 + A_2y_2 + A_3y_3}{A_1 + A_2 + A_3} = 157.61\ mm$$

$$\bar{y} = 157.61\ mm$$

(for 7a - P.T.O

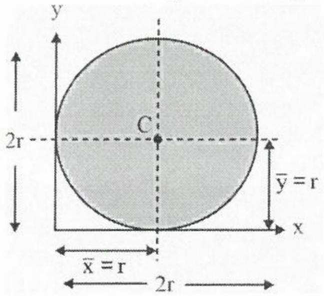
15

7a) Centroid of a Circle – Derivation

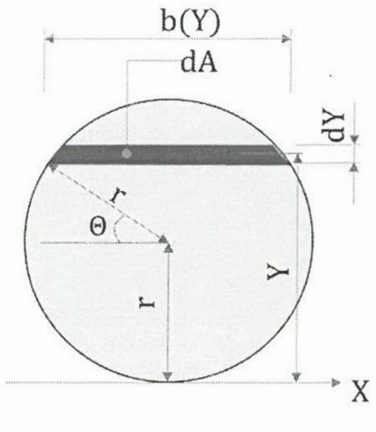
Statement:

To find the **centroid of a circular lamina** of radius R.

Neat Sketch (for exam):



{1}



Assumptions:

- Circle of radius **R** centered at origin **O**
- Area is symmetric about both **X-axis and Y-axis**

Consider: {1}

Take a small elemental area **dA** inside the circle at a distance *(x, y)*

Total area of circle:

$$A = \pi R^2$$

Centroid Coordinates:

X-coordinate of centroid:

$$\bar{x} = \frac{\int x\, dA}{\int dA}$$ (1}

Due to symmetry about Y-axis:

$$\int x\, dA = 0$$

$$\therefore \bar{x} = 0$$

16

Y-coordinate of centroid:

$$\bar{y} = \frac{\int y\, dA}{\int dA}$$

Due to symmetry about X-axis:

$$\int y\, dA = 0$$
$$\therefore \bar{y} = 0$$

{1}

Final Result:

$$\boxed{\bar{x} = 0, \bar{y} = 0}$$

Q8 (a) Work–Energy Principle (4 Marks)

Definition:

The **Work–Energy Principle** states that:

The work done by all forces acting on a particle is equal to the change in its kinetic energy.

Derivation:

Consider a particle of mass m moving under force **F**

Work done:

$$W = \int F\,ds$$

From Newton's 2nd law:

$$F = ma$$
$$W = \int ma\,ds$$

But,

$$a = \frac{dv}{dt}, ds = vdt$$
$$W = \int m\frac{dv}{dt} \cdot vdt$$
$$W = \int mv\,dv$$
$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

Final Governing Equation:

$$W = \Delta KE = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

Valuation Scheme (4 Marks):

- Definition → **1 Mark**
- Use of Newton's law → **1 Mark**
- Proper derivation steps → **1 Mark**
- Final equation → **1 Mark**

18

Q8 (b) Curvilinear Motion (6 Marks)

Definition:

Curvilinear motion is the motion of a particle along a **curved path**.

Position Vector:

$$\vec{r} = x\hat{\imath} + y\hat{\jmath}$$

Velocity in Rectangular Components:

{1}

$$\vec{v} = \frac{d\vec{r}}{dt}$$
$$\vec{v} = \frac{dx}{dt}\hat{\imath} + \frac{dy}{dt}\hat{\jmath}$$
$$\vec{v} = v_x\hat{\imath} + v_y\hat{\jmath}$$

Acceleration in Rectangular Components:

{2}

$$\vec{a} = \frac{d\vec{v}}{dt}$$
$$\vec{a} = \frac{d^2x}{dt^2}\hat{\imath} + \frac{d^2y}{dt^2}\hat{\jmath}$$
$$\vec{a} = a_x\hat{\imath} + a_y\hat{\jmath}$$

Type equation here.

Magnitude of Velocity:

{1}

$$v = \sqrt{v_x^2 + v_y^2}$$

Magnitude of Acceleration:

{2}

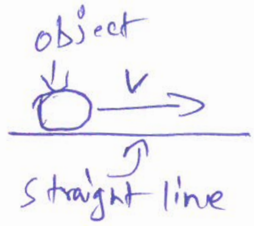
$$a = \sqrt{a_x^2 + a_y^2}$$

9(a)

1) Rectilinear motion.

Motion along a straight line.

Exm Car moving on straight Road.

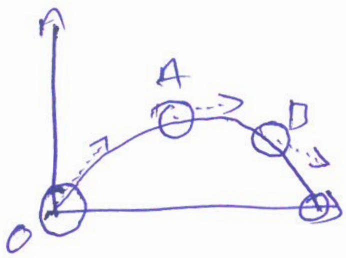


{1}

2) Curvillinear motion:-

Motion along curved path.

Ex:- Projectile motion

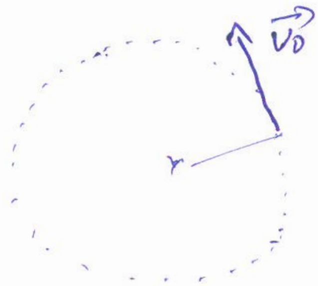


{1}

3) Circular motion:-

Motion along circular path

Ex: Rotation wheel

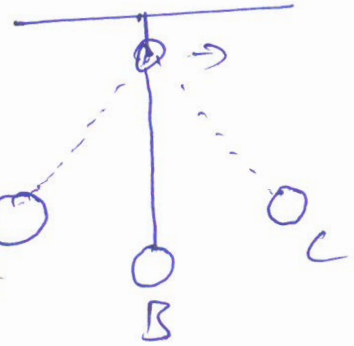


{1}

4) oscillary motion:-

To and fro motion about mean position.

Ex:- Pendulum



{1}

9(b)

Given

$$a = t^2 - 2t + 2$$

At $t = 1s$.

$S = 14.75m$, $V = 6.3m/s$.

Velocity equation

$$a = \frac{dv}{dt} = t^2 - 2t + 2$$

$\{1\}$

$$V = \int (t^2 - 2t + 2)\, dt$$

$$V = \frac{t^3}{3} - t^2 + 2t + C_1$$

at $t = 1$

$$6.3 = \frac{1}{3} - 1 + 2 + C_1$$

$$C_1 = 4.967$$

Velocity equation

$$V = \frac{t^3}{3} - t^2 + 2t + 4.967$$ $\{1\}$

Displacment equation

$$V = \frac{ds}{dt}$$

$$S = \int v\, dt$$ $\{1\}$

$$S = \frac{t^4}{12} - \frac{t^3}{3} + t^2 + 4.967t + C_2$$

$C_2 = 9.033$

Displacment equation

$$S = \frac{t^4}{12} - \frac{t^3}{3} + t^2 + 4.967t + 9.033 \quad \{1\}$$

at $t = 2s$

Acceleration

$$a = 2^2 - 2(2) + 2 \Rightarrow 2 m/s^2$$

Velocity:

$$V = \frac{8}{3} - 4 + 4 + 4.967$$

$$V = 7.634 m/s \quad \{1\}$$

Displacment

$$S = \frac{16}{12} - \frac{8}{3} + 4 + 9.934 + 9.033 \quad \{1\}$$

$$S = 21.633 m$$

1(a)

Rotation under Constant Torque

for a rigid body rotating about a fixed axis

$$\boxed{\tau = I \cdot \alpha}$$

{1}

τ = Torque

I = Moment of Inertia

α = Angular acceleration

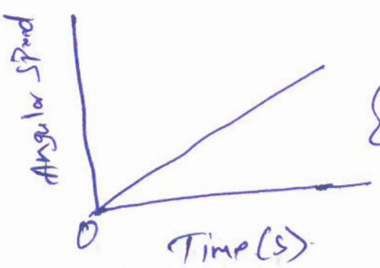
Since Torque is constant

α = constant.

Using rotational kinematics

1. Angular velocity equation

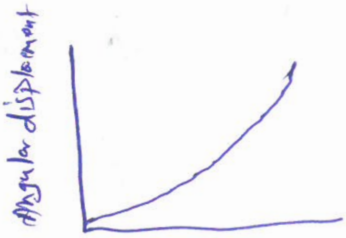
$\omega = \omega_0 + \alpha t$



{1}

2. Angular displacement

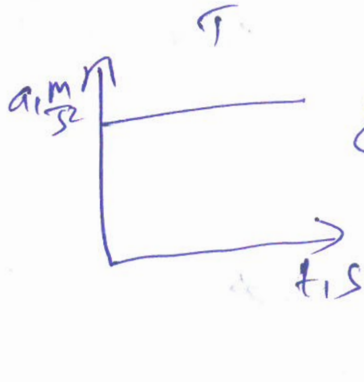
$\theta = \omega_0 t + \frac{1}{2} a t^2$



{1}

3. velocity-displacement.

$\omega^2 = \omega_0^2 + 2\alpha\theta$



{1}

10 b

Given

Intial speed $N = 1800$ rpm

Time $t = 6$ sec

final speed $\omega = 0$.

$$\omega_0 = \frac{2\pi N}{60} = \frac{2\pi \times 1800}{60} = 60\pi \text{ rad/sec} \quad -\{1\}$$

$$\omega_0 = 188.5 \text{ rad/sec} \quad -\{1\}$$

Angular Decleration.

$$\alpha = \frac{\omega - \omega_0}{t} \quad -\{1\}$$

$$\alpha = \frac{0 - 188.5}{6} = -31.42 \text{ rad/s}^2$$

$$\alpha = 31.42 \text{ rad/s}^2 \text{ (decleration)} \quad -\{1\}$$

Number of Revoutions

$$\theta = \omega_0 t + \frac{1}{2} a t^2 \quad -\{1\}$$

$$\theta = (188.5 \times 6) + \frac{1}{2}(-31.42)(36) = \underline{565.4 \text{ radians}}$$

Converts to revolutions

$-\{1\}$

$$n = \frac{\theta}{2\pi} = \frac{565.4}{2 \times (3.14)} = \underline{90 \text{ revolutions}}$$

11 a)

Kinetic's of Rotational motion & comparsion

Sol: Kinetic's of Rotational motion, deals with bodies rotation about a fixed axis

(Newton's 2^{nd} law of Rotation) — {1}

$$\tau = I \cdot \alpha$$

τ = Torque,

I = Moment of Inertia

α = Angular acceleration

for constant angular acceleration. — {1}

$$\omega = \omega_0 + \alpha t$$

$$\theta = \omega_0 t + \frac{1}{2} a t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

Comparsion with Rectilinear Motion — {2}

Rectilinear Motion	Rotational motion
Force (F)	Torque T
Mass (M)	Moment of Inertia (I)
Acceleration (a)	Angular Acceleration (α)
velocity (V)	Angular velocity (ω)
Displacment (S)	Angular displacment (θ)
$F = Ma$	$\tau = I\alpha$
$V = u + at$	$\omega = \omega_0 + \alpha t$

11 b

Given

Intial speed $\omega_0 = 0$

final speed $\omega = 120$ rad/se.

Time $= 20$ s

Constant speed $= 10$ s

Retardation Tim. $= 30$ s

Acceleration. (0 → 120 rad/s in 20s)

$$\alpha_1 = \frac{\omega - \omega_0}{t} = \frac{120 - 0}{20} = 6 \text{ rad/s}^2 \quad - ($$

Angular displacment

$$\theta_1 = \omega_0 t + \frac{1}{2} a t^2$$

$$\theta_1 = 0 + \frac{1}{2}(6)(20^2) = 1200 \text{ rad.} \quad - \{1\}$$

Speed 10s

$$\theta_2 = \omega t = 120 \times 10 = 1200 \text{ rad.} \quad - \{1\}$$

Retardation (120-0 in 30 sec)

$$\alpha_3 = \frac{0 - 120}{30} = -4 \text{ rad/s}^2 \quad - \{1\}$$

Angular displacment

$$\theta_3 = \omega_0 t + \frac{1}{2} a t^2$$

$$= 120(30) + \frac{1}{2}(-4)(30^2) = 1800 \text{ rad.} \quad \{1\}$$

Total displacment

$$\theta = \theta_1 + \theta_2 + \theta_3 \quad - \{1\}$$

$$= 1200 + 1200 + 1800$$

$$\Rightarrow 4200 \text{ rad}$$