UNIVERSITI TEKNOLOGI PETRONAS

FINAL EXAMINATION
JANUARY 2025 SEMESTER

COURSE	:	**MEB1043/MFB1043 - STATICS**
DATE	:	**12 APRIL 2025 (SATURDAY)**
TIME	:	**9.00 AM - 12.00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **EIGHT (8)** pages in this Question Booklet including the cover page and appendix.

ii. **DOUBLE-SIDED** Question Booklet.

1. a. Statics deals with the equilibrium of bodies that are either at rest or move with a constant velocity. Discuss the general procedure in analyzing problems related to statics.

[5 marks]

b. **FIGURE Q1** shows a free body diagram of bracket to hold the load of F_1 and F_3, respectively. If the F_1 and Φ is given 150 N and 30°, respectively.

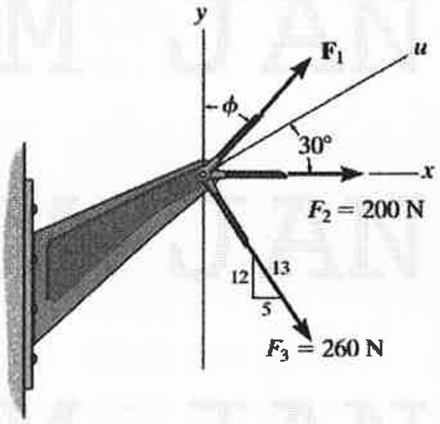


FIGURE Q1

i. Determine the magnitude of the resultant force acting on the bucket and its direction measured clockwise from the positive x axis.

[13 marks]

ii. From the finding **Part (i)**, develop the force diagram to shows the forces involved and the magitude of the resultant force.

[7 marks]

2. a. Discuss the procedure on how to develop the free body diagram of the particle.

[5 marks]

b. **FIGURE Q2** shows a tow truck model with struts *AB*, *AC* and *AD* mounted on the frame.

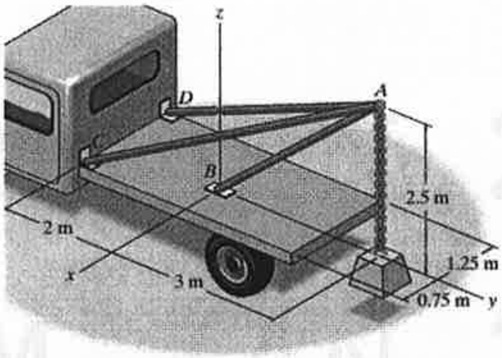


FIGURE Q2

i. Determine the force acting along the struts for them to support the 500 kg load.

[13 marks]

ii Develop a force diagram to show the forces acting along the truss by stating the magnitude and direction.

[7 marks]

3. The structural members shown in **FIGURE Q3** is subjected to force P_1 = 6 kN and P_2 = 4.5 kN at point D and point C, respectively.

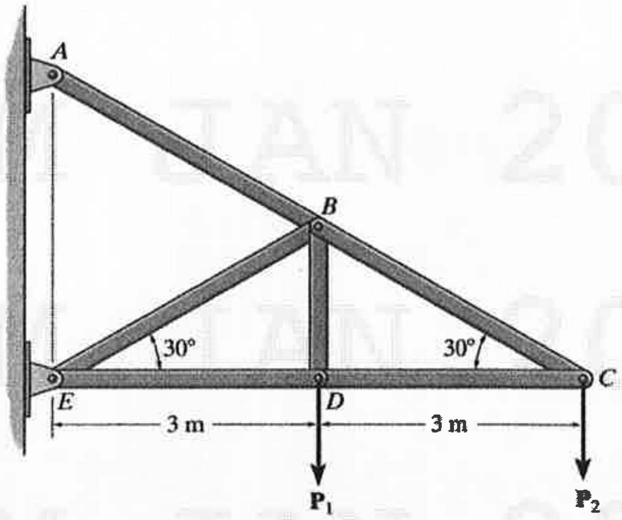


FIGURE Q3

a. Determine the forces in each truss member and state if the member is in tension or compression.

[18 marks]

b. Draw all the forces acting at joint E and determine the vertical force at point E. Then draw the free body diagram of the structure.

[7 marks]

4. For the beam shown in **FIGURE Q4**, *BC* is subjected to a uniformly distributed load of 2.4 kN/m:

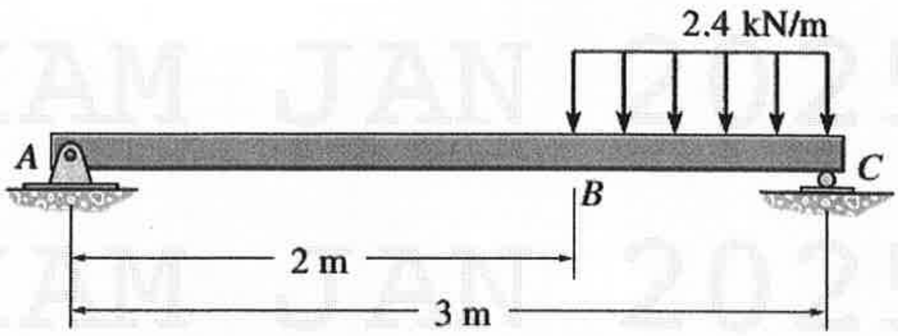


FIGURE Q4

a. Draw the free body diagram of the structure and calculate the support reactions at point *A* and point *C*.

[10 marks]

b. Develop the shear force diagram & bending moment diagram for the beam.

[15 marks]

- END OF PAPER –

APPENDIX

Cartesian Vector

$$\mathbf{A} = A_x\mathbf{i} + A_y\mathbf{j} + A_z\mathbf{k}$$

Magnitude

$$A = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

Directions

$$\mathbf{u}_A = \frac{\mathbf{A}}{A} = \frac{A_x}{A}\mathbf{i} + \frac{A_y}{A}\mathbf{j} + \frac{A_z}{A}\mathbf{k}$$
$$= \cos\alpha\mathbf{i} + \cos\beta\mathbf{j} + \cos\gamma\mathbf{k}$$
$$\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$$

Dot Product

$$\mathbf{A}\cdot\mathbf{B} = AB\cos\theta$$
$$= A_xB_x + A_yB_y + A_zB_z$$

Cross Product

$$\mathbf{C} = \mathbf{A}\times\mathbf{B} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

Cartesian Position Vector

$$\mathbf{r} = (x_2 - x_1)\mathbf{i} + (y_2 - y_1)\mathbf{j} + (z_2 - z_1)\mathbf{k}$$

Cartesian Force Vector

$$\mathbf{F} = F\mathbf{u} = F\left(\frac{\mathbf{r}}{r}\right)$$

Moment of a Force

$$M_o = Fd$$
$$\mathbf{M}_o = \mathbf{r}\times\mathbf{F} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$$

Moment of a Force About a Specified Axis

$$M_a = \mathbf{u}\cdot\mathbf{r}\times\mathbf{F} = \begin{vmatrix} u_x & u_y & u_z \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$$

Simplification of a Force and Couple System

$$\mathbf{F}_R = \Sigma\mathbf{F}$$
$$(\mathbf{M}_R)_O = \Sigma\mathbf{M} + \Sigma\mathbf{M}_O$$

Equilibrium

Particle

$$\Sigma F_x = 0,\ \Sigma F_y = 0,\ \Sigma F_z = 0$$

Rigid Body-Two Dimensions

$$\Sigma F_x = 0,\ \Sigma F_y = 0,\ \Sigma M_O = 0$$

Rigid Body-Three Dimensions

$$\Sigma F_x = 0,\ \Sigma F_y = 0,\ \Sigma F_z = 0$$
$$\Sigma M_{x'} = 0,\ \Sigma M_{y'} = 0,\ \Sigma M_{z'} = 0$$

Friction

Static (maximum) $F_s = \mu_s N$

Kinetic $F_k = \mu_k N$

Center of Gravity

Particles or Discrete Parts

$$\bar{r} = \frac{\Sigma\tilde{r}W}{\Sigma W}$$

Body

$$\bar{r} = \frac{\int \tilde{r}\,dW}{\int dW}$$

Area and Mass Moments of Inertia

$$I = \int r^2\,dA \qquad I = \int r^2\,dm$$

Parallel-Axis Theorem

$$I = \bar{I} + Ad^2 \qquad I = \bar{I} + md^2$$

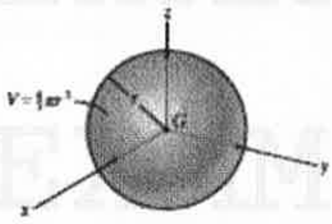
Radius of Gyration

$$k = \sqrt{\frac{I}{A}} \qquad k = \sqrt{\frac{I}{m}}$$

Virtual Work

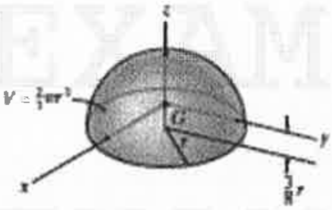
$$\delta U = 0$$

Center of Gravity and Mass Moment Inertia of Homogeneous Solids



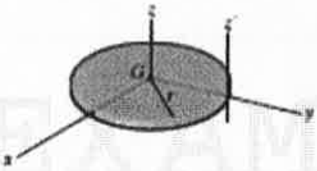
Sphere

$I_{xx} = I_{yy} = I_{zz} = \frac{2}{5}mr^2$



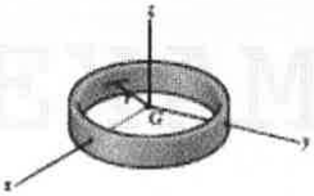
Hemisphere

$I_{xx} = I_{yy} = 0.259\, mr^2 \quad I_{zz} = \frac{2}{5}mr^2$



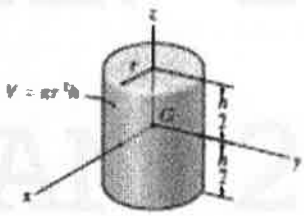
Thin Circular disk

$I_{xx} = I_{yy} = \frac{1}{4}mr^2 \quad I_{zz} = \frac{1}{2}mr^2 \quad I_{z'z'} = \frac{3}{2}mr^2$



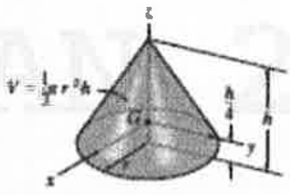
Thin ring

$I_{xx} = I_{yy} = \frac{1}{2}mr^2 \quad I_{zz} = mr^2$



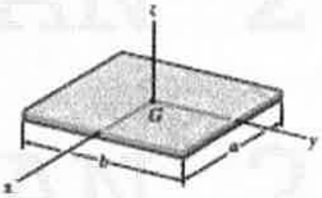
Cylinder

$I_{xx} = I_{yy} = \frac{1}{12}m(3r^2 + h^2) \quad I_{zz} = \frac{1}{2}mr^2$



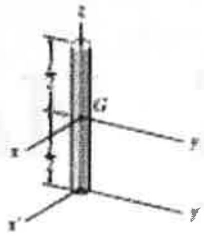
Cone

$I_{xx} = I_{yy} = \frac{3}{80}m(4r^2 + h^2) \quad I_{zz} = \frac{3}{10}mr^2$



Thin plate

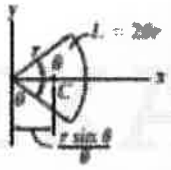
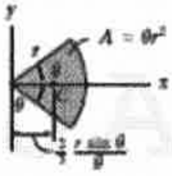
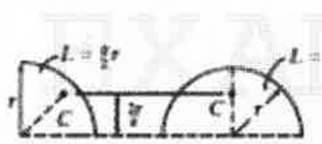
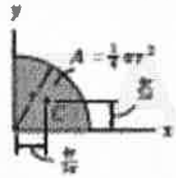
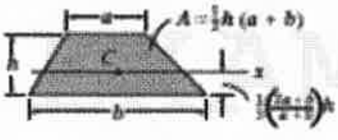
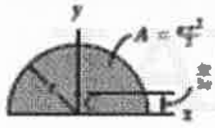
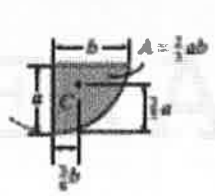
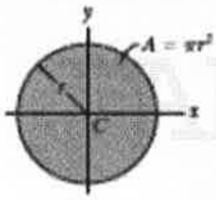
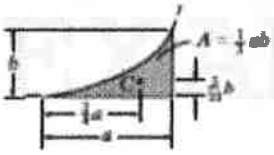
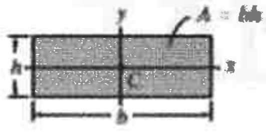
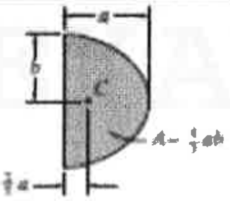
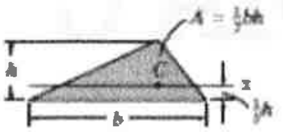
$I_{xx} = \frac{1}{12}mb^2 \quad I_{yy} = \frac{1}{12}ma^2 \quad I_{zz} = \frac{1}{12}m(a^2 + b^2)$



Slender Rod

$I_{xx} = I_{yy} = \frac{1}{12}ml^2 \quad I_{x'x'} = I_{y'y'} = \frac{1}{3}ml^2 \quad I_{z'z'} = 0$

Geometric Properties of Line and Area Elements

Centroid Location	Centroid Location	Area Moment of Inertia
 Circular arc segment	 Circular sector area	$I_x = \frac{1}{4} r^4 (\theta - \frac{1}{2} \sin 2\theta)$ $I_y = \frac{1}{4} r^4 (\theta + \frac{1}{2} \sin 2\theta)$
 Quarter and semicircle arcs	 Quarter circle area	$I_x = \frac{1}{16} \pi r^4$ $I_y = \frac{1}{16} \pi r^4$
 Trapezoidal area	 Semicircular area	$I_x = \frac{1}{8} \pi r^4$ $I_y = \frac{1}{8} \pi r^4$
 Semiparabolic area	 Circular area	$I_x = \frac{1}{4} \pi r^4$ $I_y = \frac{1}{4} \pi r^4$
 Exparabolic area	 Rectangular area	$I_x = \frac{1}{12} b h^3$ $I_y = \frac{1}{12} h b^3$
 Parabolic area	 Triangular area	$I_x = \frac{1}{36} b h^3$