UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BNJ 20103 / BNT 20103
PROGRAMME CODE	:	BNM / BNG / BNT
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER **ALL** QUESTIONS
		2. THIS FINAL EXAMINATION IS CONDUCTED VIA
		☐ Open book
		☒ Closed book
		3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **ELEVEN (11)** PAGES

Q1 Answer these questions on Kinematics of Particles.

(a) **Figure Q1.1** shows a ball K is thrown with an upward velocity of 7 m/s from the top of a 12 m high building. One second later, ball L is thrown vertically from the ground with a velocity of 11 m/s. Ball K and ball L will pass each other at time T and certain height of D from the ground.

(i) Express equation for vertical displacement of ball K from the ground.

(2 marks)

(ii) Express equation for vertical displacement of ball L.

(2 marks)

(iii) Calculate passing time T.

(2 marks)

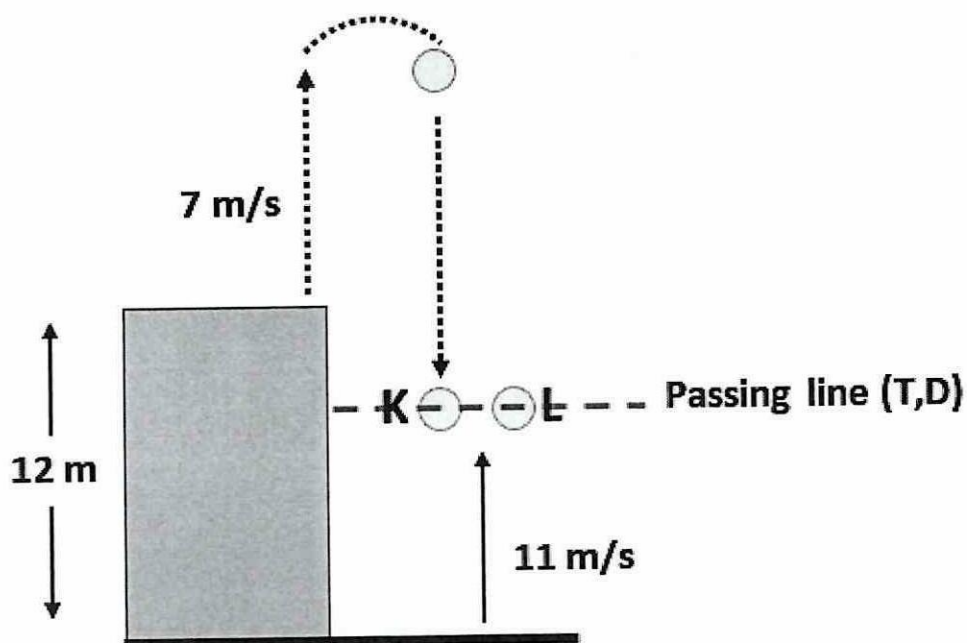(iv) Calculate passing height D.

(1 marks)

Figure Q1.1

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(b)   **Figure Q1.2** describes the position of a cyclist travelling along a straight road.

(i)   Describe what the slope of the *s-t* and *v-t* curves represent.

(2 marks)

(ii)   Describe what the area under the curve for *v-t* and *a-t* graph represent.

(2 marks)

(iii)   Construct a *v-t* graph for time interval of $0 < t < 20$ s. Include in your graph, the calculation of the maximum velocity and the final velocity.

(5 marks)

(iv)   Construct the *a-t* graph for time interval of $0 < t < 20$ s. Include in your graph, the calculation of the maximum acceleration and the final acceleration.
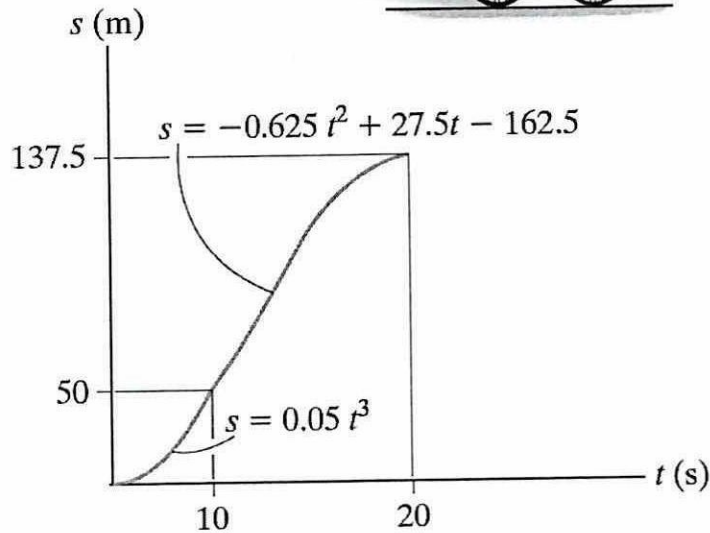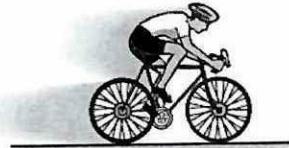
(3 marks)

Figure Q1.2

(c)   At a traffic junction, a motorcycle has a velocity of 5 m/s to the east and a car has a velocity 8 m/s to the north. Find the relative velocity of motorcycle with respect to car, $V_{M/C}$ using these methods.

   (i)   Rectangular components.

(3 marks)

   (ii)   Drawing vectors.

(3 marks)

Q2   Answer these questions on Kinematics of Particles and Kinetics of Particles.

(a)   **Figure Q2.1** shows collar B sliding smoothly on rod OA. Rod OA is pin joint at O and rotates freely. Given $\ddot{\theta} = 0.3$ radians/seconds^2 with initial conditions, $\dot{\theta}_0 = 0$ and $\theta_0 = 0$ while $r = 0.9 - 0.12t^2$ meters. Calculate the collar's acceleration magnitude when $t = 2$ seconds.

Given $|a| = \sqrt{\left(\ddot{r} - r\dot{\theta}^2\right)^2 + \left(r\ddot{\theta} + 2\dot{r}\dot{\theta}\right)^2}$.
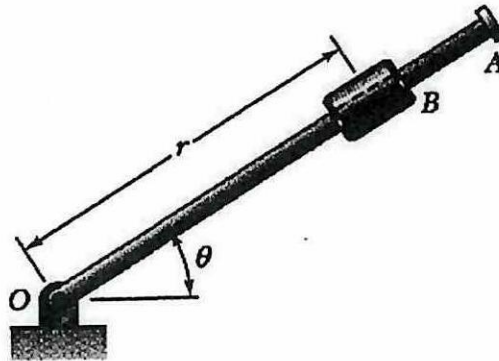

Figure Q2.1

(4 marks)

(b)   A man riding a sled down a slope has a total mass of 200 kg is as shown in **Figure Q2.2**. When he reaches point A, the velocity is 4 m/s and increasing at 2m/s^2. Determine the normal force and frictional force acting on the sled at point A. The radius of curvature equation is as given,
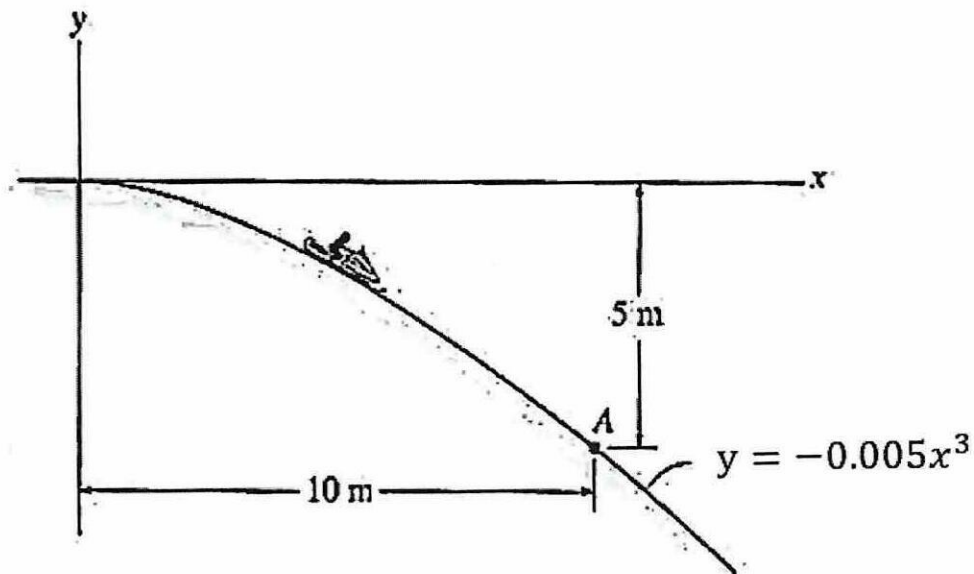
$$\rho = \frac{[1 + (dy/dx)^2]^{3/2}}{\left|d^2y/dx^2\right|}$$

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Figure Q2.2

(12 marks)

(c)   A motor pulls box C upwards using the pulley system as shown in **Figure Q2.3** has an efficiency of 0.85. If box C has a weight of 375 Newtons, the current velocity of point P is 0.6 m/s and the current acceleration of point P is 1.2 m/s², determine the input power to the motor.
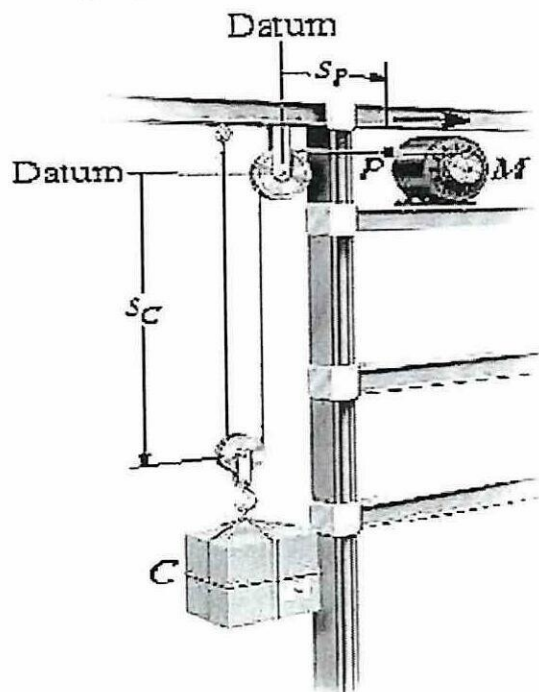

Figure Q2.3

(9 marks)

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Q3   Answer these questions on Kinetics of Particles and Kinematics of Rigid Bodies.

(a)   Collar A and B, slides smoothly on a rod as shown in **Figure Q3.1**. Collar B has a mass of 5 kg, initially at rest, is attached to an unstretched spring where $a = 0.9$ m. The coefficient of the spring is $k = 300$ N/m. The mass of collar A is 0.5 kg. If collar A collides with collar B causing **B** to move 1.2 m before momentarily stopping. The final position of collar B is as shown in **Figure Q3.2**.

(i)   Using Conservation of Energy equation between the spring and collar B, calculate the velocity of B after collision.

(5 marks)

(ii)   If the coefficient of restitution between is collar A and B is $e = 0.5$, using Conservation of Momentum equation, determine velocity of A after collision.
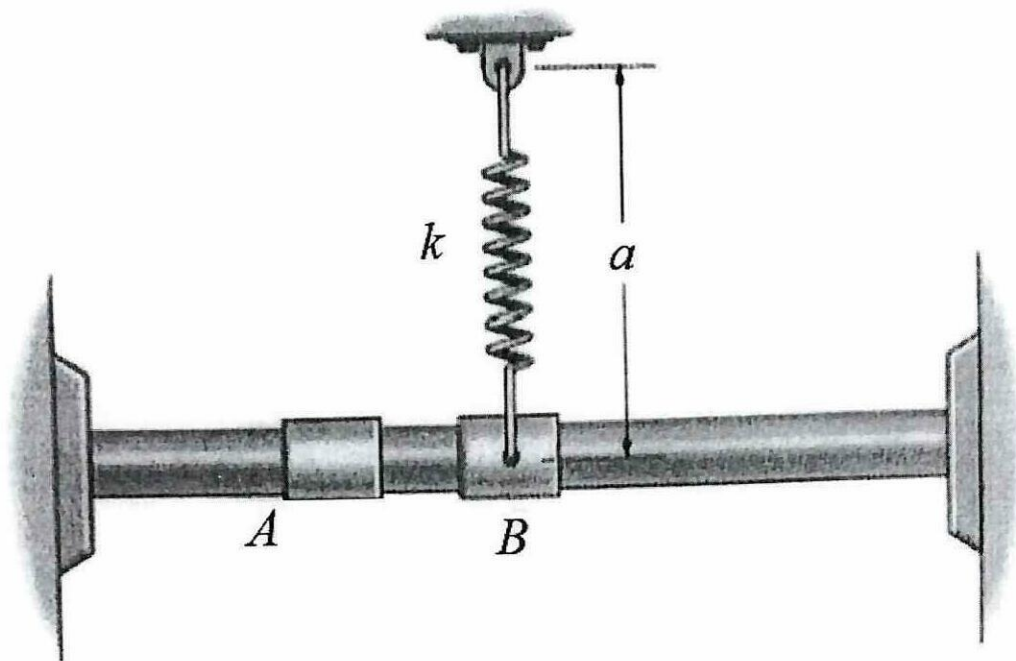
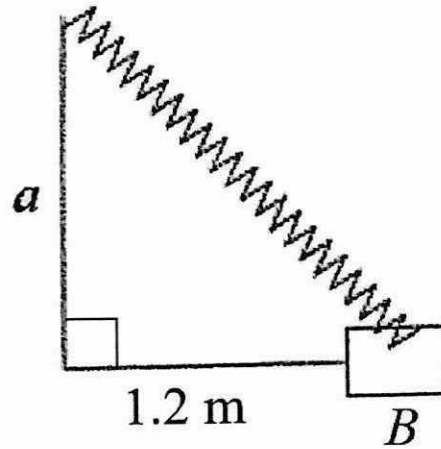(6 marks)

Figure Q3.1

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Figure Q3.2

(b) **Figure Q3.3** shows a set of gears. Given the radius of gear A, $r_A = 0.06$ m and radius of gear B, $r_B = 0.15$ m. If gear A starts from rest and has a constant angular acceleration $\alpha_A = 2$ rad/s, determine the time needed for gear B to attain an angular velocity $\omega_B = 50$ rad/s.
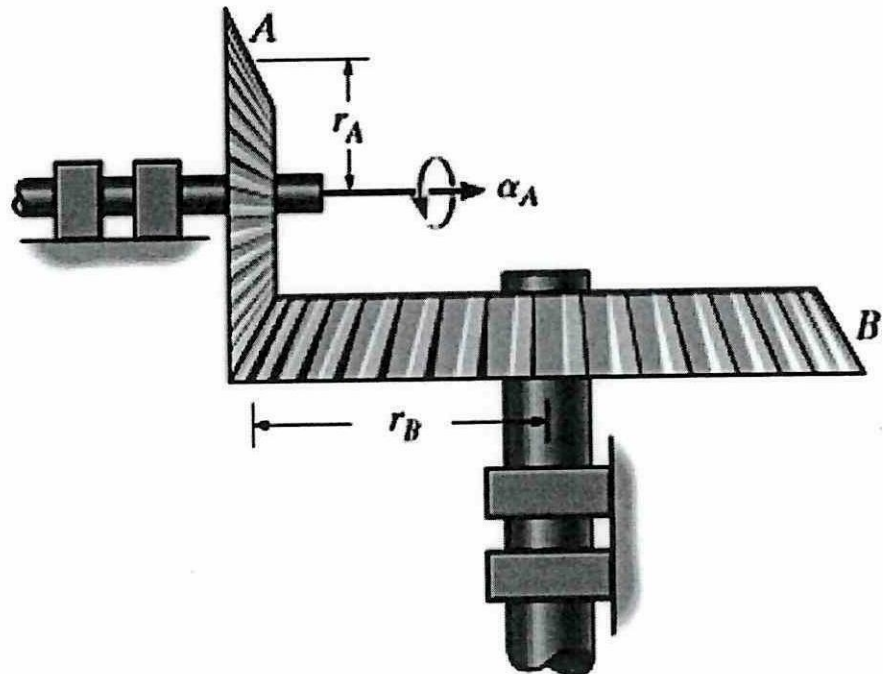

Figure Q3.3

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(7 marks)

(c)   **Figure Q3.4** shows the mechanism used in a marine engine consists of a single crank AB and two connecting rods BC and BD. The instant the crank is in the position shown, it has an angular velocity, $\omega_{AB} = 5$ rad/s. Determine the velocity of the piston at C, using the Instantaneous Centre of Zero Velocity method.

β = 45°

γ = 60°

0.4 m

φ = 35°

θ = 45°
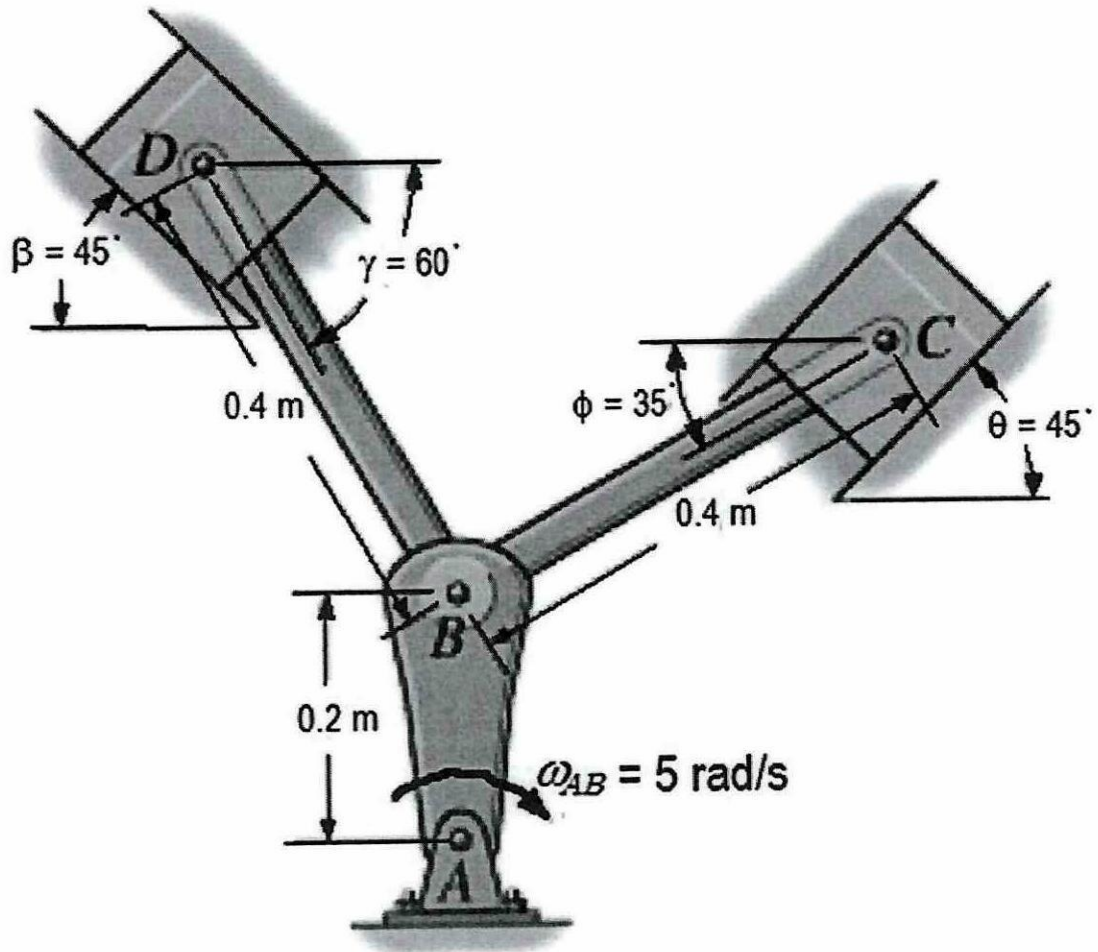
0.4 m

0.2 m

$\omega_{AB} = 5$ rad/s

Figure Q3.4

(7 marks)

Q4   Answer these questions on Kinetics of Rigid Bodies.

(a)   Explain why some objects in motion can be analysed as a particle and why others must be analysed as a rigid body. Then give examples to show the difference.

(4 marks)

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(b)   Kinetic of rigid body problems are shown in **Figure Q4.1** through **Figure Q4.4**. Draw the free-body diagram (FBD) and kinetic diagram (KD) of these rigid bodies in motions respectively.

(i)   Force P is applied to a cupboard as shown in **Figure Q4.1**. The cupboard does not tip. Draw the FBD and KD of the cupboard.
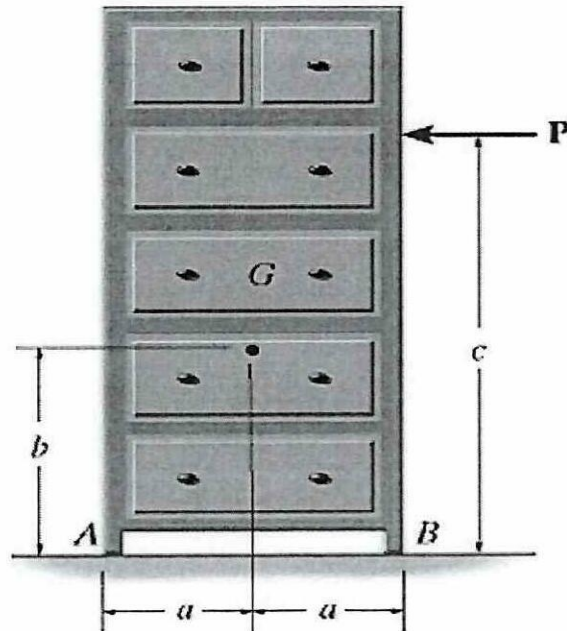

Figure Q4.1

(2 marks)

(ii)   **Figure Q4.2** shows a crate being raised. As the tractor raises the load, the forks do not rotate. Draw the FBD and KD of the crate.
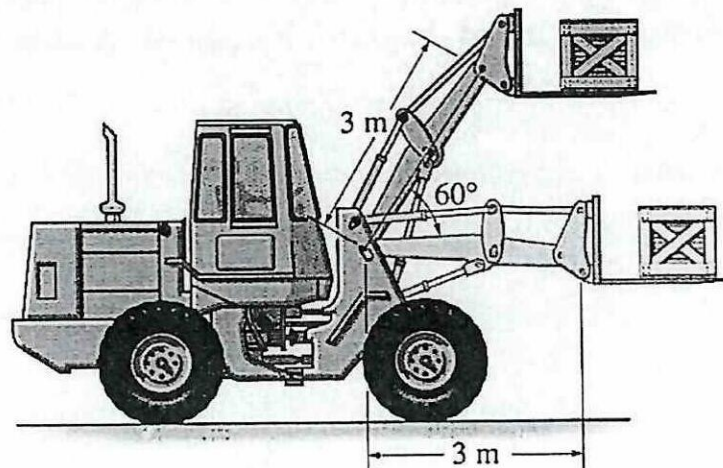

Figure Q4.2

(2 marks)

9

(iii)   In this pendulum system shown in **Figure Q4.3**, the rod and sphere are welded together. At this instant, an external moment is given to the system. Draw the FBD and KD of the pendulum system.
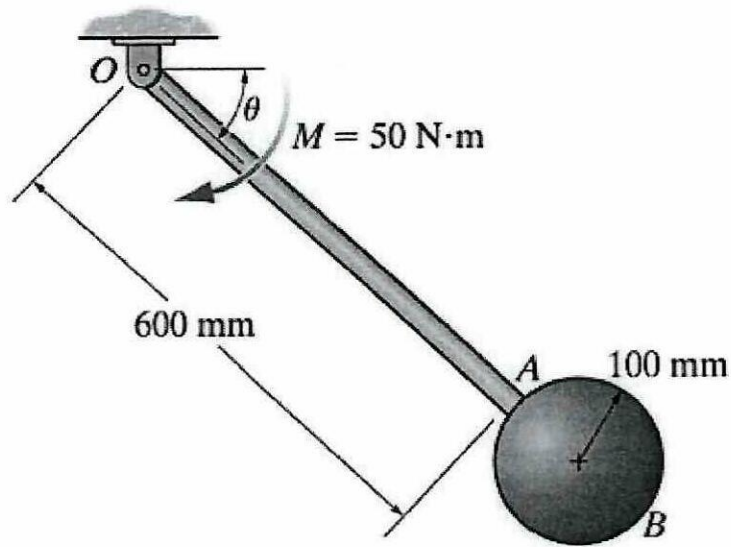

$M = 50 \text{ N·m}$

600 mm

100 mm

Figure Q4.3

(2 marks)

(iv)   In this system shown in **Figure Q4.4**, a bar leaning on the wall is slowly sliding down the wall. Draw the FBD and KD of the bar.
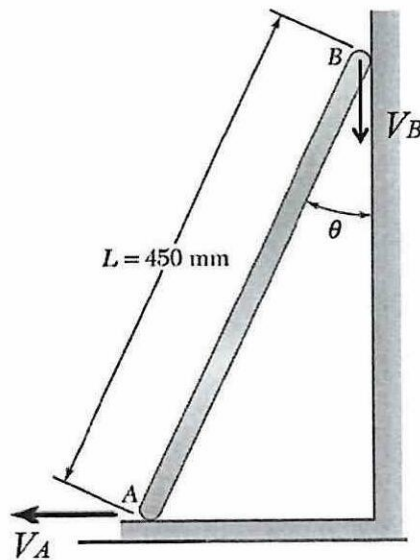

V_B

$L = 450$ mm

θ

V_A

Figure Q4.4

(2 marks)

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(c)   Give the Mass Moment of Inertia, Ixx, Iyy and Izz for a rod.

(3 marks)

(d)   A car with a new type of tyres has a coefficient of static friction of 0.8 is shown in **Figure Q4.5**. Determine the maximum achievable acceleration on the road assuming rear wheel drive. Mass of the car is 1000 kg. Hint: Solve simultaneous equations.
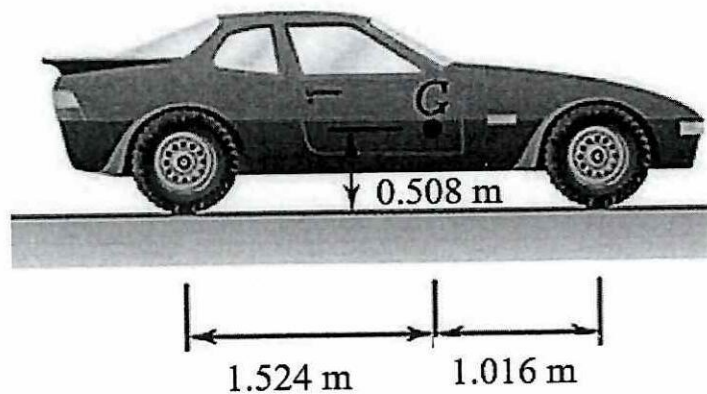

0.508 m

1.524 m   1.016 m

Figure Q4.5

(10 marks)

- END OF QUESTIONS -

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