Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BDA 20103
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER **FIVE (5)** QUESTIONS **ONLY**
		2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.**
		3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

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

Q1 (a) In **Figure Q1(a)**, it is observed that when the ball is thrown at A, it reaches its maximum height h at B when $t = 2$s.

(i) Calculate the required initial speed v_A.

(ii) Calculate the angle of release θ.

(iii) Determine the maximum height h.

(12 marks)

(b) A particle moves along a circular path of radius, 370 mm. If its angular velocity is $\dot{q} = (2t^2)$ rad/s, where t is in seconds. When $t = 2$ s,

(i) Determine the magnitude of the particle's velocity.

(ii) Determine the magnitude of the particle's acceleration.

(8 marks)

Q2 (a) A 50 kg crate as shown in **Figure Q2(a)** is projected along the floor with an initial speed of 8 m/s at $x = 0$. If the coefficient of kinetic friction is 0.40.

(i) Draw the free body diagram.

(ii) Calculate the time required for the crate to come to rest.

(iii) Calculate the corresponding distance x travelled.

(10 marks)

(b) A car of mass 1300 kg is travelling along a straight level road at 10 m/s when the traffic lights change from green to amber. The driver applies the brake 23 meters from the lights and just manage to stop on the line.

(i) Determine the kinetic energy of the car before braking.

(ii) Calculate the work done in bringing the car to rest.

(iii) Find the force due to the brake, friction, etc. against work is done

(10 marks)

Q3 (a) Sketch and explain 2 types of rigid body motions.

(4 marks)

(b) A three phase electric motor connected to a pairs of pulley *A* and *B* by belting system is used to turn a blower fan as shown in **Figure Q3(b)**. Radius of pulley *A* and *B* are *100 mm* and *450 mm* respectively. During the operational start-up, the motor has an angular acceleration of, $\alpha = 2\ rad/s^2$. At an instant where pulley *B* has turned one complete revolution with no belt slip occurred,

(i) Find how much has pulley *A* rotate compare to pulley *B*.

(ii) Calculate the angular velocity, ω of pulley *B*.

(iii) Find velocity, v of point P.

(iv) Calculate the acceleration of point *P*.

(16 marks)

Q4 **Figure Q4** shown crank AB has a constant clockwise angular velocity of 2000 rpm. For the crank AB position indicated.

(a) Determine the velocity of point B.

(2 marks)

(b) Calculate the angular velocity of the connecting rod BD.

(3 marks)

(c) Find the velocity of the piston P.

(3 marks)

(d) Compare and comment the velocity of piston P when crank AB rotate anticlockwise with same angular velocity.

(6 marks)

(e) Briefly explain velocity of piston A if the crank AB angular velocity increases to 3000 rpm at position angle of crank AB is 0.

(6 marks)

Q5 (a) The material of thin plate shown in **Figure Q5(a)** has a mass per unit area of 10 kg/m^2. Determine the mass moment of inertia of the thin plate about an axis perpendicular to the page and passing through point O.

(6 marks)

(b) A race car has a mass of 1200 kg and a centre of mass at G as shown in **Figure Q5(b)**. Neglect the mass of the wheels and assume the engine is disengaged so that the wheels are free to roll. If a braking parachute is attached at C and provides a horizontal braking force of $F = (1.6v^2)$ N , where v is in meters per second.

(i) Draw the free-body diagram and determine the critical speed the car can have upon releasing the parachute, such that the wheels at B are on the verge of leaving the ground that is the normal reaction at B is zero.

(7 marks)

(ii) If such a condition occurs, calculate the car's initial deceleration.

(1 marks)

(c) A motor supplies a constant torque $M = 2$ N.m to a 25 mm radius shaft O connected to the centre of the 30 kg flywheel as shown in **Figure Q5(c)**. The resultant bearing friction F, which the bearing exerts on the shaft, acts tangent to the shaft and has a magnitude of 50 N. Determine how long the torque must be applied to the shaft to increase the flywheel's angular velocity from 4 rad/s to 15 rad/s. The flywheel has a radius of gyration $k_O = 0.15$ m about its centre O.

(6 marks)

Q6 (a) **Figure Q6(a)** shows the mechanism system that consists of two links. Link AB has a weigh of 120 N while link BC has a weigh of 220 N. The 5 kg block is attached and fixed at point C. Calculate the kinetic energy of the mechanism system when the block is moving at 4 m/s to the rightwards at the instant shown.

(8 marks)

(b) The disk has a mass of 20 kg and a radius of gyration of $k_G = 0.24$ m as shown in **Figure Q6(b)**. It is attached to a spring and has a stiffness k = 70 N/m and the unstretched length of spring is 0.35 m. At the instant shown, the disk is released from rest in the position shown and rolls without slipping.

(i) Calculate the initial and final elastic potential energy of the spring.

(ii) Determine the angular velocity of the disk at the instant it moves 1 m to the right.

(iii) Find the final kinetic energy of the disk.

(12 marks)

-END OF QUESTION-

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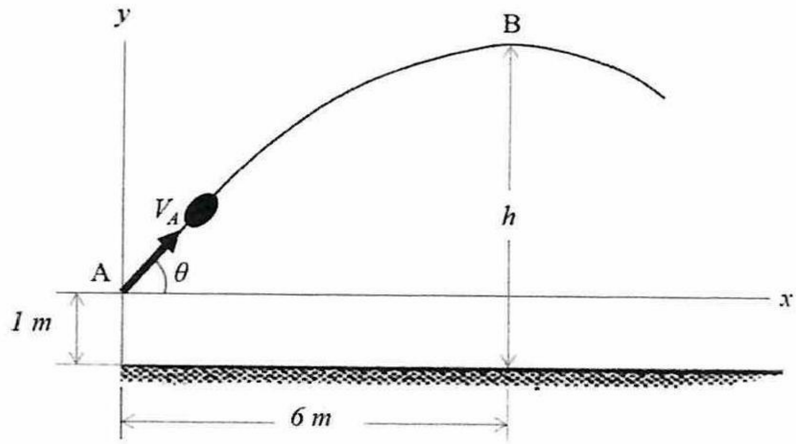

Figure Q1(a)

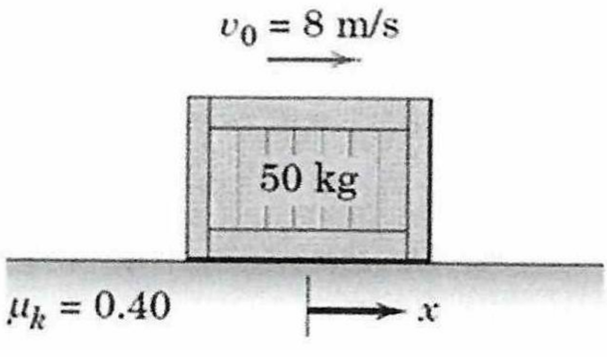

Figure Q2(a)

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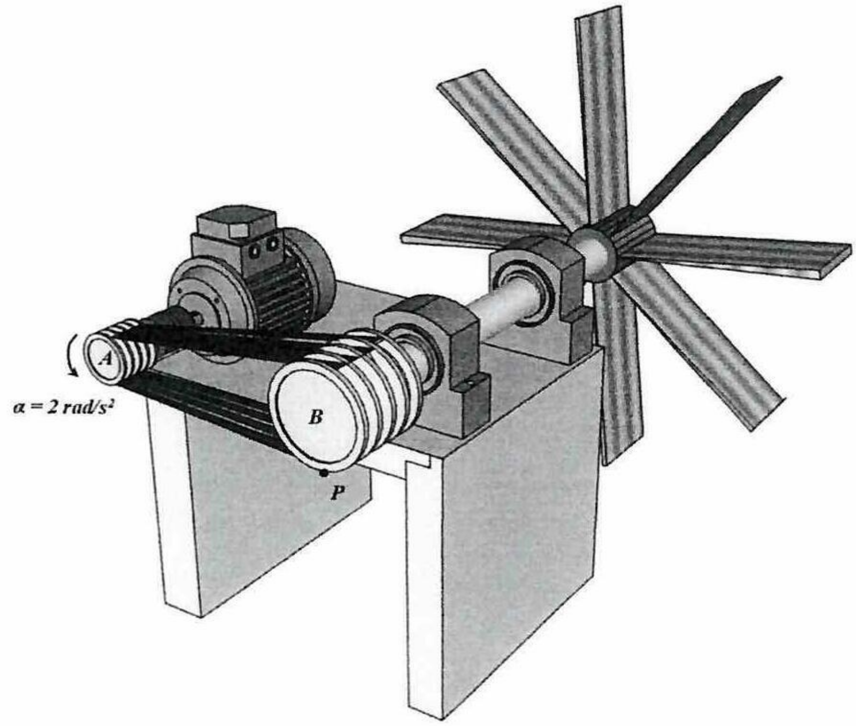

Figure Q3(b)

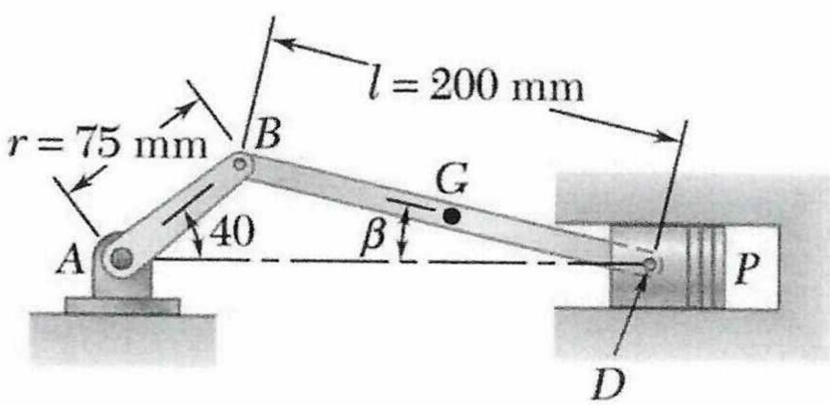

Figure Q4

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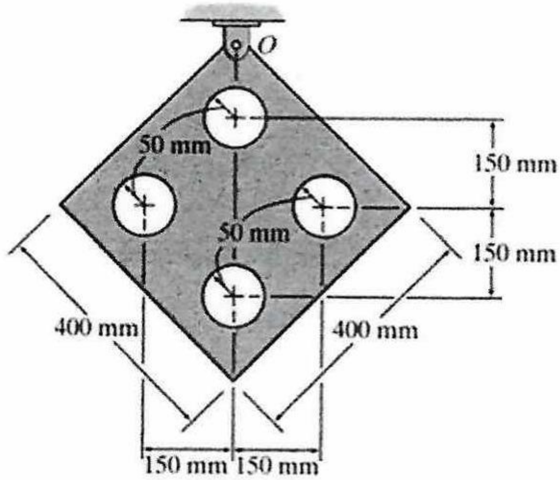

Figure Q5(a)

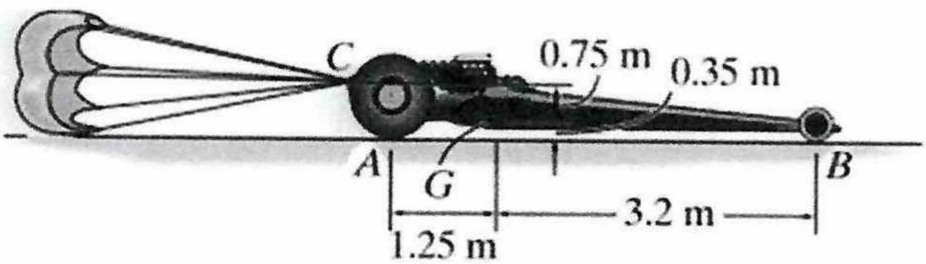

Figure Q5(b)

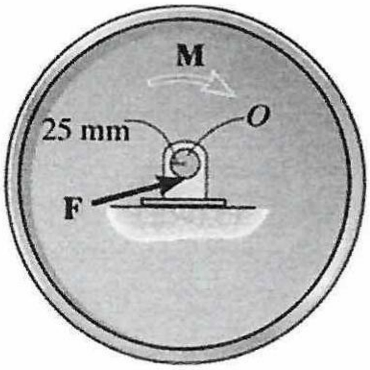

Figure Q5(c)

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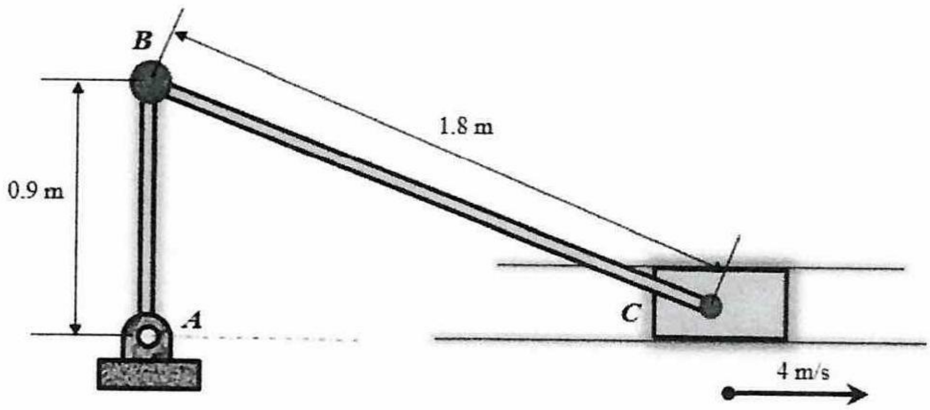

Figure Q6(a)

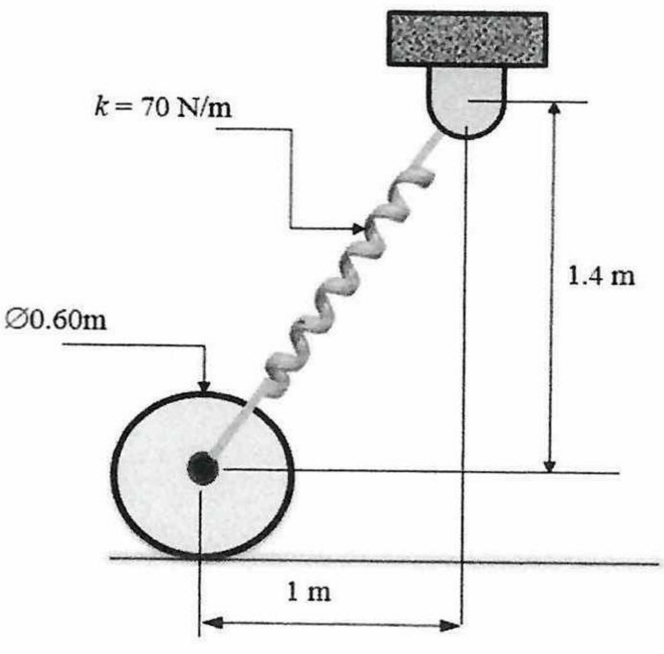

Figure Q6(b)

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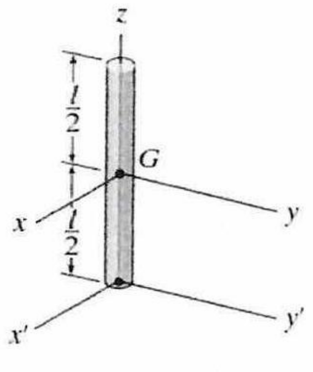
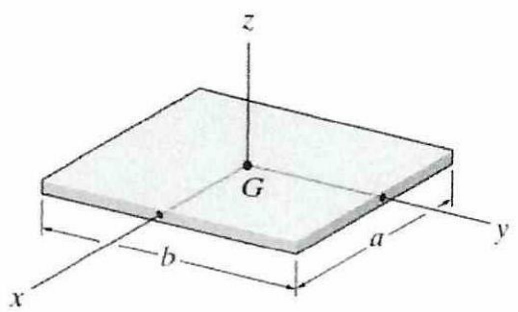


Slender Rod

$$I_{xx} = I_{yy} = \frac{1}{12}ml^2$$

$$I_{x'x'} = I_{y'y'} = \frac{1}{3}ml^2$$

$$I_{zz} = 0$$

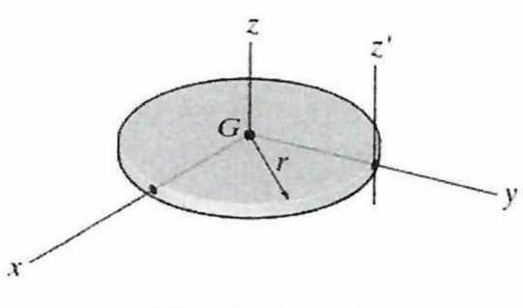


Thin plate

$$I_{xx} = \frac{1}{12}mb^2$$

$$I_{yy} = \frac{1}{12}ma^2$$

$$I_{zz} = \frac{1}{12}m(a^2 + b^2)$$



Thin Circular disk

$$I_{xx} = I_{yy} = \frac{1}{4}mr^2$$

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

$$I_{z'z'} = \frac{3}{2}mr^2$$

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KINEMATICS

Particle Rectilinear Motion

Variable a	*Constant* $a = a_c$
$a = dv/dt$	$v = v_0 + a_c t$
$v = ds/dt$	$s = s_0 + v_0 t + 0.5 a_c t^2$
$a\,ds = v\,dv$	$v^2 = v_0^2 + 2a_c(s - s_0)$

Particle Curvilinear Motion

x, y, z Coordinates		*r, θ, z Coordinates*	
$v_x = \dot{x}$	$a_x = \ddot{x}$	$v_r = \dot{r}$	$a_r = \ddot{r} - r\dot{\theta}^2$
$v_y = \dot{y}$	$a_y = \ddot{y}$	$v_\theta = r\dot{\theta}$	$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta}$
$v_z = \dot{z}$	$a_z = \ddot{z}$	$v_z = \dot{z}$	$a_z = \ddot{z}$

n, t, b Coordinates

$v = \dot{s}$ $\quad a_t = \dot{v} = v\dfrac{dv}{ds}$

$a_n = \dfrac{v^2}{\rho} \quad \rho = \dfrac{\left[1 + (dy/dx)^2\right]^{3/2}}{\left|d^2y/dx^2\right|}$

Relative Motion

$v_B = v_A + v_{B/A} \qquad a_B = a_A + a_{B/A}$

Rigid Body Motion About a Fixed Axis

Variable a	*Constant* $a = a_c$
$\alpha = d\omega/dt$	$\omega = \omega_0 + \alpha_c t$
$\omega = d\theta/dt$	$\theta = \theta_0 + \theta_0 t + 0.5\alpha_c t^2$
$\omega\,d\omega = \alpha\,d\theta$	$\omega^2 = \omega_0^2 + 2\alpha_c(\theta - \theta_0)$

For Point P

$s = \theta r \qquad \upsilon = \omega r \qquad a_t = \alpha r \qquad a_n = \omega^2 r$

Relative General Plane Motion – Translating Axis

$v_B = v_A + v_{B/A(pin)} \qquad a_B = a_A + a_{B/A(pin)}$

Relative General Plane Motion – Trans. & Rot. Axis

$v_B = v_A + \Omega \times r_{B/A} + (v_{B/A})_{xyz}$

$a_B = a_A + \dot{\Omega} \times r_{B/A} + \Omega \times (\Omega \times r_{B/A}) + 2\Omega \times (v_{B/A})_{xyz} \times (a_{B/A})_{xyz}$

KINETICS

Mass Moment of Inertia $\quad I = \int r^2 dm$

Parallel-Axis Theorem $\quad I = I_G + md^2$

Radius of Gyration $\quad k = \sqrt{I/m}$

Equations of Motion

Particle	$\sum F = ma$
Rigid Body (Plane Motion)	$\sum F_x = m(a_G)_x \quad \sum F_y = m(a_G)_y$ $\sum M_G = I_G a$ or $\sum M_P = \sum(\mu_k)_P$

Principle of Work and Energy : $T_1 + U_{1-2} = T_2$

Kinetic Energy

Particle	$T = (1/2)mv^2$
Rigid Body (Plane Motion)	$T = (1/2)mv_G^2 + (1/2)I_G\omega^2$

Work

Variable force	$U_F = \int F\cos\theta\,ds$
Constant force	$U_F = (F_c\cos\theta)\,\Delta s$
Weight	$U_W = -W\,\Delta y$
Spring	$U_s = -\left(0.5ks_2^2 - 0.5ks_1^2\right)$
Couple moment	$U_M = M\,\Delta\theta$

Power and Efficiency

$P = dU/dt = F.v \quad \varepsilon = P_{out}/P_{in} = U_{out}/U_{in}$

Conservation of Energy Theorem

$T_1 + V_1 = T_2 + V_2$

Potential Energy

$V = V_g + V_e$ where $V_g = \pm Wy, V_e = +0.5ks^2$

Principle of Linear Impulse and Momentum

Particle	$mv_1 + \sum\int F dt = mv_2$
Rigid Body	$m(v_G)_1 + \sum\int F dt = m(v_G)_2$

Conservation of Linear Momentum

$\sum(\text{syst. } mv)_1 = \sum(\text{syst. } mv)_2$

Coefficient of Restitution $\quad e = \dfrac{(v_B)_2 - (v_A)_2}{(v_A)_1 - (v_B)_1}$