UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BDA 20103
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JULY / AUGUST 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 **TEN (10)** PAGES

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Q1 (a) **Figure Q1(a)** shows the movement of block A upward which at the same time will cause a corresponding movement of block B downward. Block A and B are interconnected by inextensible cords which are wrapped around pulleys. Determine the position coordinates (S), velocity (v) and acceleration (a) equations that represent the absolute dependent motion of two particles.

(5 marks)

(b) A car A travelling at the speed of 25 km/h while a car B travelling at the speed of 70 km/h as shown in **Figure Q1 (b)**. The car B is accelerating at 1100 km/h^2 while car A maintain a constant speed as currently displayed. Considering the aforementioned factors,

(i) Find the magnitude and direction of velocity of car A with respect to car B, $v_{A/B}$,

(6 marks)

(ii) Determine the magnitude and direction of acceleration of car A relative to car B, $a_{A/B}$.

(9 marks)

Q2 The 30 kg block D rest on the horizontal plane as shown in **Figure Q2**. At initial position the spring is originally stretched 0.25 m. At the instant shown, the block is applied with a force P = 950 N which leads to the motion at final position for a distance of 3.5 m. The coefficient of kinetic friction between the block and the horizontal plane is $\mu_k = 0.5$.

(a) Draw the free body diagram of all forces exerted on the block D.

(4 marks)

(b) Find the total work done by all forces acting on the block D.

(8 marks)

(c) Determine the velocity and acceleration of the block when it reached final position.

(6 marks)

(d) Calculate the kinetic energy of block D at final position.

(2 marks)

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Q3 **Figure Q3** shows a structure that consist of link *AB*, link *BC* and link *CD*. Knowing the link *CD* has the angular velocity, $\omega = 2\ rad/s$ (counterclockwise direction) and the angular acceleration, $\alpha = 4\ rad/s^2$ (clockwise direction),

(a) draw the kinematic diagram of velocity for link *BC*,

(3 marks)

(b) determine the angular velocity of link *BC*, ω_{BC},

(2 marks)

(c) determine the velocity of point *B*, V_B, and point *C*, V_C,

(4 marks)

(d) draw the kinematic diagram of acceleration for link *BC*,

(4 marks)

(e) determine the angular acceleration of link *BC*, α_{BC},

(5 marks)

(f) determine the angular acceleration of link *AB*, α_{AB}.

(2 marks)

Q4 As shown in **Figure Q4**, end *A* of the hydraulic cylinder is moving at a velocity of $v_A =$ 3 m/s. At the instant illustrated,

(a) draw the kinematics diagram of rod *BC*, (3 marks)

(b) using instantaneous center of zero velocity method, draw the kinematics diagram and locate the instantaneous center (*IC*) of rod *AB*,

(6 marks)

(c) determine the angular velocity of rod *AB*, ω_{AB},

(5 marks)

(d) determine the angular velocity of rod *BC*, ω_{BC}.

(6 marks)

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Q5 **Figure Q5** shows the pendulum which is suspended at point O and consists of a thin rod having a mass of 7 kg. A rectangular thin plate with the hollow and triangle nose sections is welded at the end of slender rod OA with a mass of 10 kg/m^2. By examining on the above situation;

(a) Find moment of inertia of both slender bar and thin plate about its center of mass respectively. (7 marks)

(b) Determine the location of $\bar{y}$ of the mass center, G of the pendulum. (4 marks)

(c) Calculate the mass moment of inertia, I_G about the axis of rotation, O. (4 marks)

(d) If the velocity of its mass center of pendulum is 4 m/s, find the translational and rotational kinetic energy of the pendulum. (5 marks)

Q6 (a) The disk shown in **Figure Q6 (a)** has a mass of 50 kg and a radius of gyration k_o = 0.30 m. A cord with negligible mass is wrapped around the periphery of the disc and attached to a block having a mass of 25 kg.

(i) Find the moment of inertia of the disk when the block is released. (2 marks)

(ii) Determine acceleration and angular acceleration of the disc when the block is released. (6 marks)

(b) The 15 kg rod shown in **Figure Q6 (b)** is constrained so that its end of slider block B move along the fixed guide. The rod is initially at rest when $\theta = 0°$. If the slider block B is acted upon by a horizontal force P = 85 N;

(i) Draw kinematic diagram of the rod at $\theta = 0°$ and $\theta = 45°$ respectively. (3 marks)

(ii) Determine the initial and final kinetic energy. (5 marks)

(iii) Calculate the angular velocity of the rod at the instant $\theta = 45°$. (4 marks)

-END OF QUESTION-

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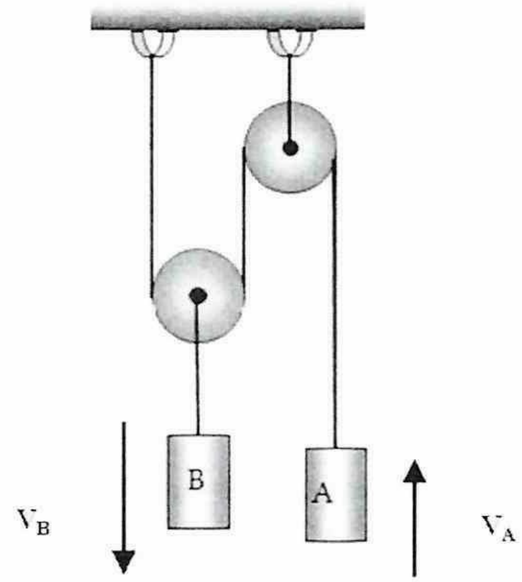

Figure Q1(a)

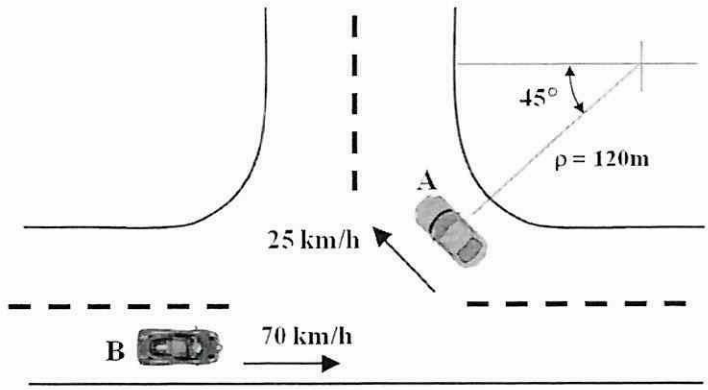

Figure Q1(b)

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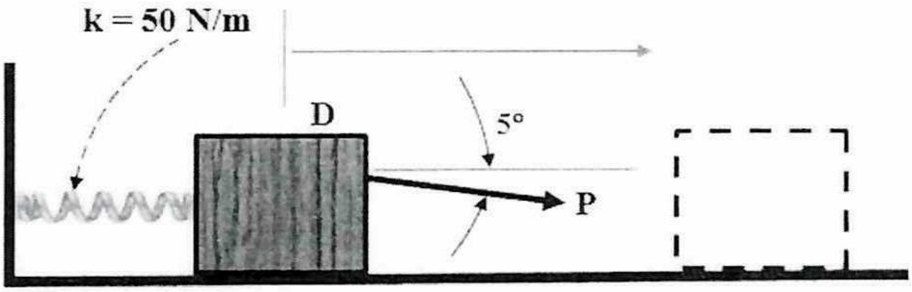

Figure Q2

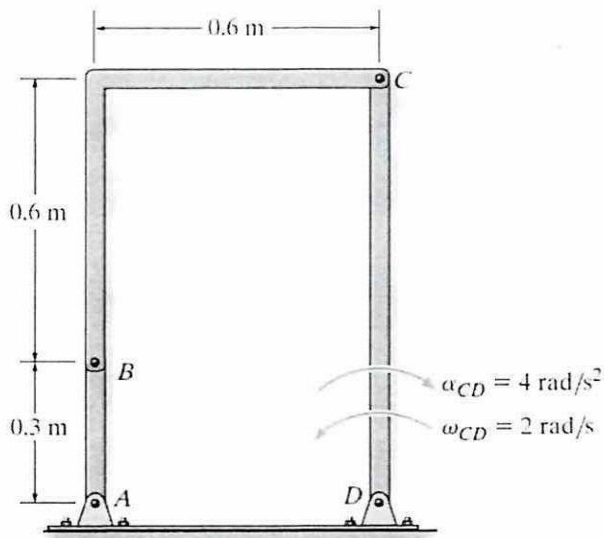

Figure Q3

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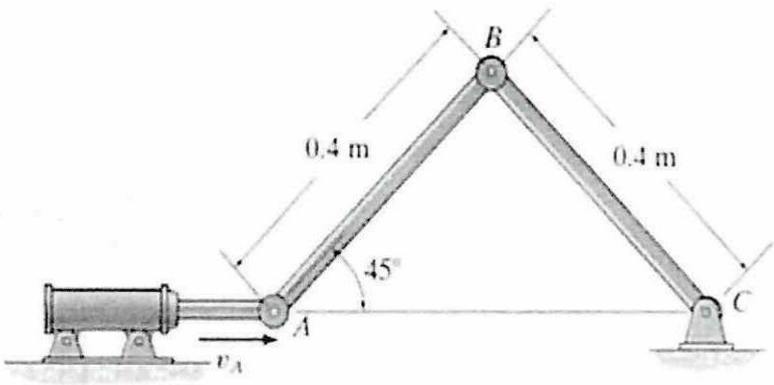

Figure Q4

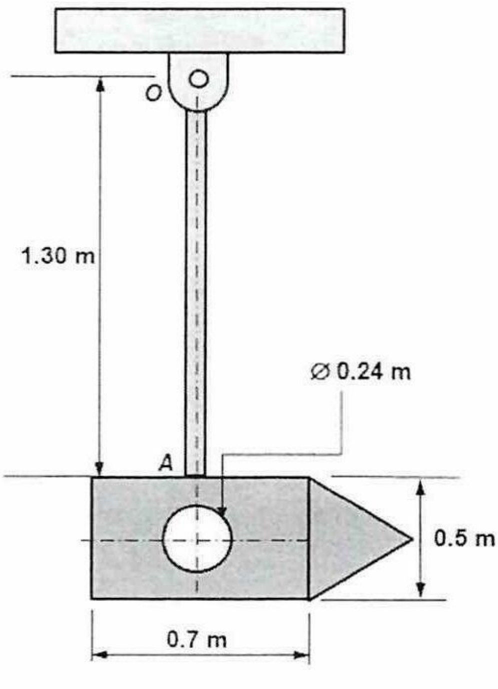

Figure Q5

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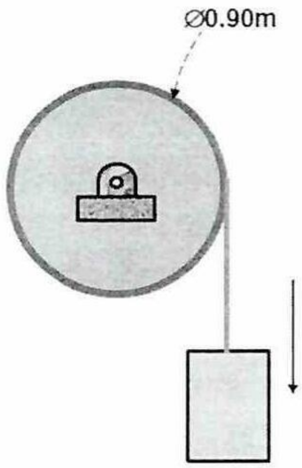

Figure Q6(a)

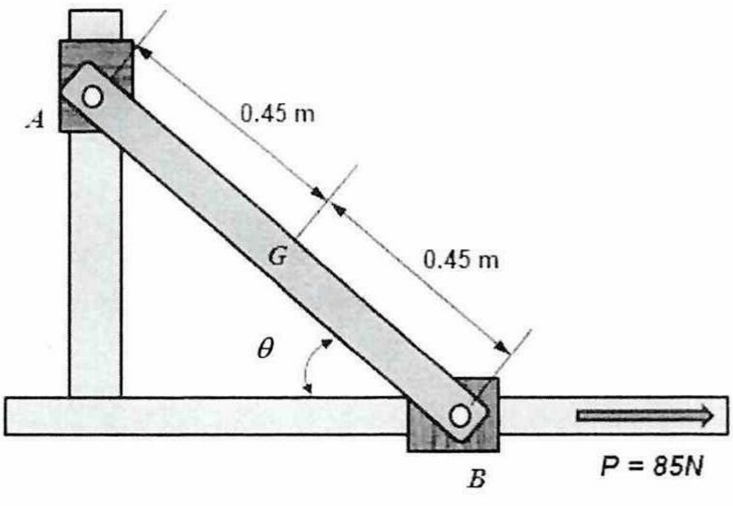

Figure Q6(b)

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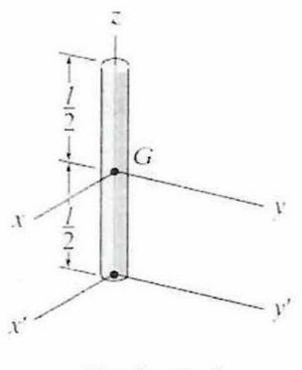
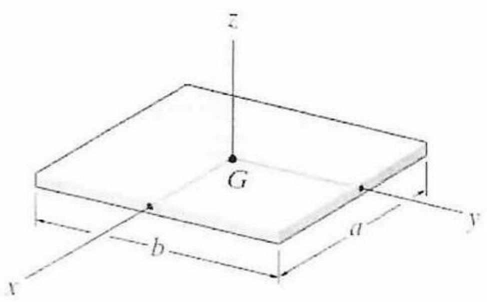


Slender Rod

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

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

$$I_{zz} = 0$$

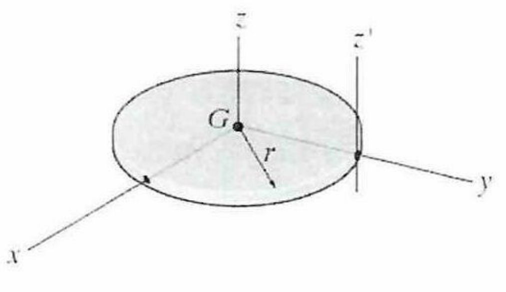


Thin plate

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

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

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



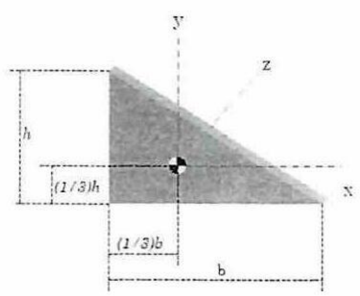
Thin Circular disk

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

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

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

THIN TRIANGULAR PLATE



$m = \rho\,(1/2)(bh)$

$$I_x = \frac{1}{18}mh^2$$

$$I_y = \frac{1}{18}mb^2$$

$$I_z = \frac{1}{18}m(b^2 + h^2)$$

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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	$U_s = -(0.5ks_2^2 - 0.5ks_1^2)$
Couple moment	$U_M = M\,\Delta\theta$

Power and Efficiency

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

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

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