Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER 2
SESSION 2018/2019

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BDA 20103
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1. A projectile is launched at a speed of 10 m/s from a sloping surface as shown in **Figure Q1**. Knowing that the angle α is 80°.

(a) Illustrate the kinematic diagram of free flight motion of the projectile.
(3 marks)

(b) Find the initial and final horizontal component of projectiles velocity.
(4 marks)

(c) Determine the time of flight of the projectile.
(8 marks)

(d) Determine the range of R.
(5 marks)

Q2. (a) In **Figure Q2 (a)**, the 100N crate is released from rest on the inclined surface at time t = 0. The coefficient of kinetic friction between the crate and the surface is μ_k = 0.18.

(i) Determine the magnitude of the linear impulse due to the forces acting on the crate from t = 0 to t = 2 s.
(3 marks)

(ii) Use the principle of impulse and momentum to determine how fast the crate is moving at t = 2 s.
(4 marks)

(b) A truck is hauling a 300kg log out of a ditch using a winch attached to the back of the truck as shown in **Figure Q2(b)**. The winch applies a constant force of 2500 N and the coefficient of kinetic friction between the ground and the log is μ_k =0.45. If the truck starts from rest, determine the time for the log to reach a speed of 0.5m/s.
(13 marks)

Q3. **Figure Q3** shows a rod AB which slide freely along the horizontal floor and the inclined plane. At the instant shown the velocity of point A is 1.4 m/s to the left. By examining the above circumstances;

(a) Draw the kinematic diagram for the motion of rod AB at this instant.
(4 marks)

(b) Determine the angular velocity of the rod AB.
(12 marks)

(c) Determine the velocity of point B of the rod.
(4 marks)

Q4. (a) The relative motion analysis of velocity is used to describe the motion of a rigid body which undergoing general plane motion. An equation that relates the velocity of two point A and B on a rigid body subjected to general plane motion may be determined by differentiating the position equation. Based on this statement, state the velocity equation of relative motion and illustrate the corresponding kinematic diagram to represent on the above mentioned of motion.

(4 marks)

(b) **Figure Q4 (b)** shows a link AB which is positioned vertically and is connected to link BC which is positioned horizontally. The end of link BC is pin connected with collar C and slide on the fixed shaft DE. If the collar C has a velocity of 6 m/s and deceleration of 4 m/s^2 as shown;

(i) Draw the kinematic diagram on the motion of link AB and link BC.

(2 marks)

(ii) Find the angular velocity of link BC, ω_{BC} rad/s and link AB, ω_{AB} rad/s.

(5 marks)

(iii) Determine the angular acceleration of link BC, α_{BC} rad/s^2 and link AB, α_{AB} rad/s^2.

(5 marks)

(iv) Calculate the magnitude and direction of acceleration of point B.

(4marks)

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

(i) Calculate moment of inertia of the pendulum about point *A*, $I_{pendulum}$.

(8 marks)

(ii) Determine the location of $\bar{y}$ of the mass center, *G* of the pendulum.

(3 marks)

(iii) Determine the moment of inertia, I_G.

(3 marks)

(b) The 15 kg slender bar shown in **Figure Q5 (b)** is rotating in the vertical plane and at the instant shown it has an angular velocity of 7 rad/s and couple moment of 80 N.m.

(i) Find the angular acceleration, α of the rod at this instant.

(3 marks)

(ii) Determine the translational and rotational kinetic energy, *T* of the rod.

(3 marks)

-END OF QUESTION-

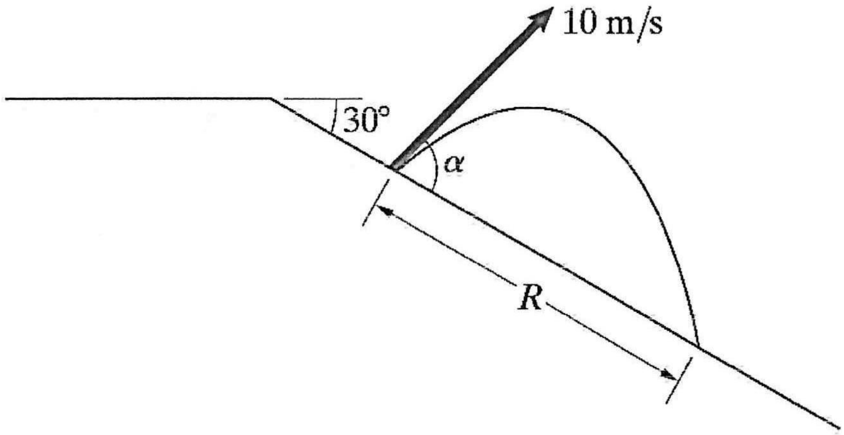

Figure Q1

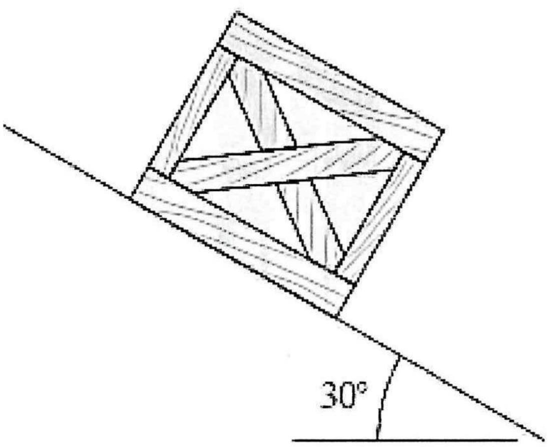

Figure Q2 (a)

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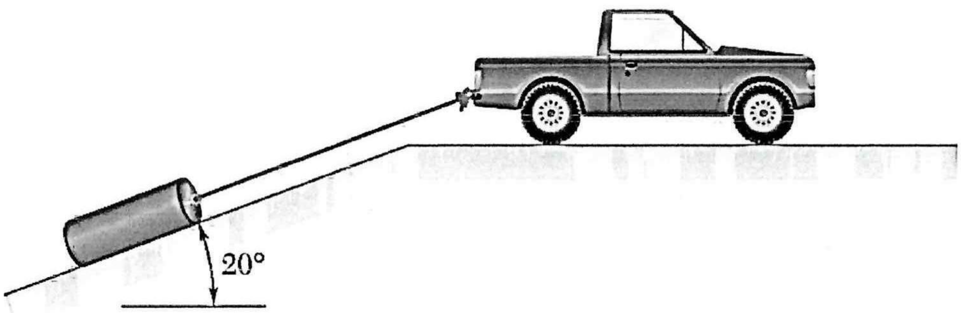

Figure Q2 (b)

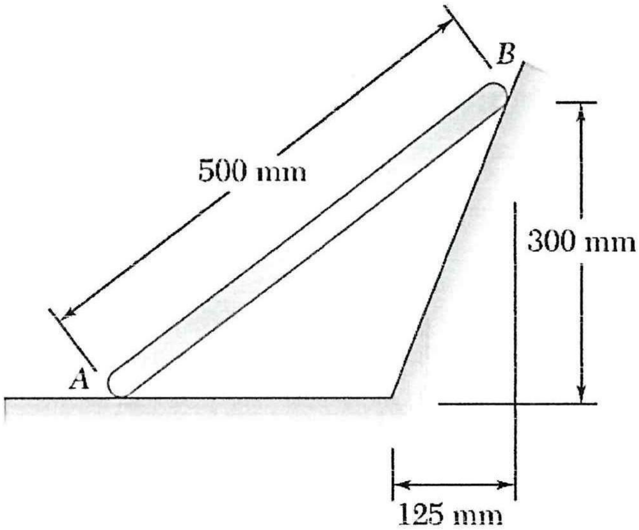

Figure Q3

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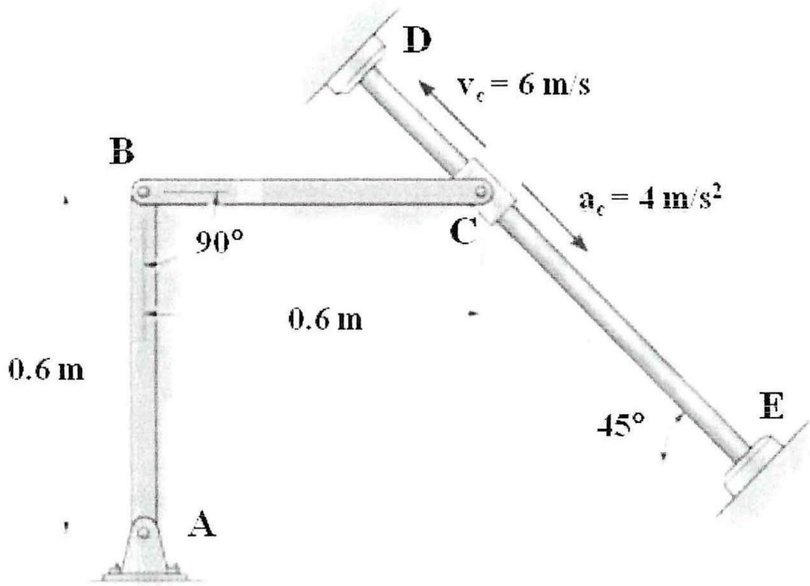

Figure Q4 (b)

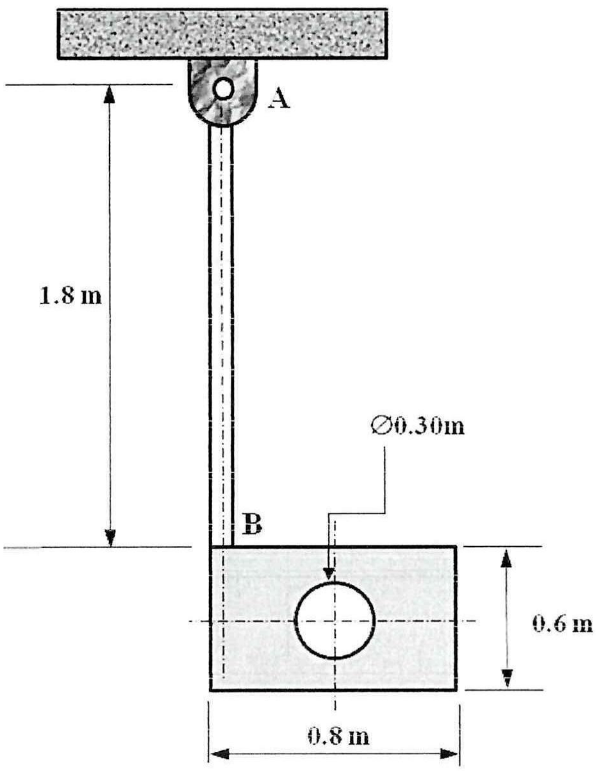

Figure Q5 (a)

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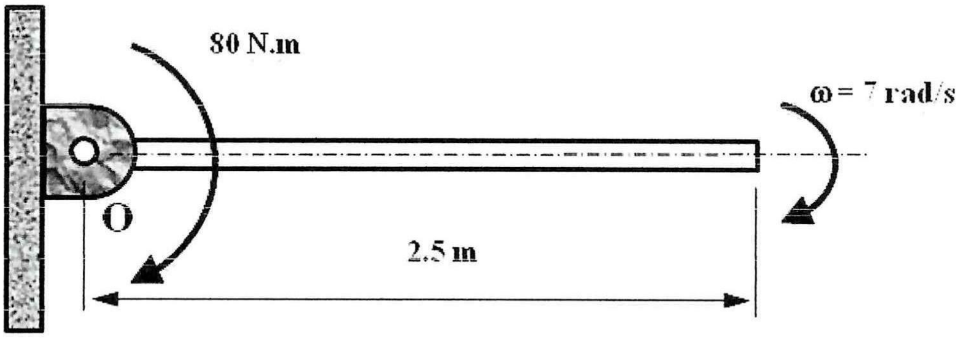

Figure Q5 (b)

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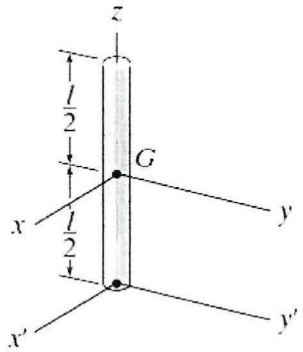
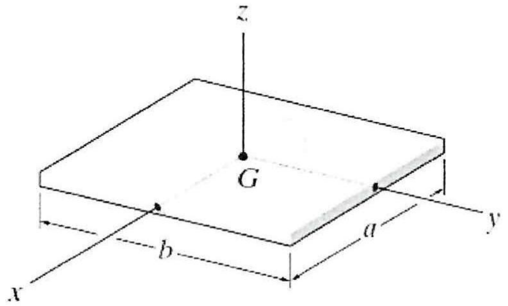


Slender Rod

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

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

$$I_{zz} = 0$$

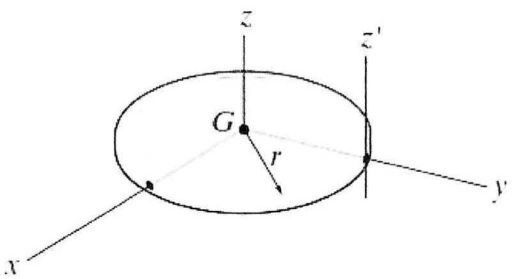


Thin plate

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

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

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



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*

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

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

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)	$\sum F_x = m(a_G)_x \quad \sum F_y = m(a_G)_y$ $\sum M_G = I_G \alpha$ 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 $e = \dfrac{(v_B)_2 - (v_A)_2}{(v_A)_1 - (v_B)_1}$