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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2016/2017

TERBUKA

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BDA 20103
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	DECEMBER 2016/JANUARY 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

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Q1 A suitcase of weight 400 N slides from rest a distance 5 m down the rough ramp as shown in **Figure Q1**. The coefficient of kinetic friction along ramp AB is $\mu_K = 0.2$. The suitcase has an initial velocity down the ramp, V_A = 2.5 m/s. By examining on the above mentioned scenario;

(a) Determine the point where it strikes the ground at C.

(15 marks)

(b) How long does it take to go from A to C?

(5 marks)

Q2 The 2 kg ball A is thrown at the suspended 20 kg block B with a velocity of 4 m/s as shown in **Figure Q2**. If the coefficient of restitution between the ball and the block is e = 0.8, and the time of impact between the ball and the block is 0.005 s. By examining on the stated situation;

(a) Determine the average normal force exerted on the block during this time.

(15 marks)

(b) Calculate the maximum height h to which the block will swing before it momentarily stops.

(5 marks)

Q3 The linkage of a machinery system consists of the bar AB, bar BC and a wheel as shown in **Figure Q3**. The link AB has a counter clockwise angular velocity of 45 rad/s when θ = 60°. By examining on the following circumstances,

(a) Calculate the velocity of link AB and BC at this instant.

(7 marks)

(b) Determine the angular velocities of member BC and the wheel at this instant. Show the method of solution by using vector analysis.

(6 marks)

(c) If point B has an acceleration of 350 m/s^2, find the angular acceleration of link AB at this instant.

(7 marks)

Q4 In a mechanism the slider block C travels along the path x-x. The Crankshaft AB rotates at a constant angular velocity of 995 rpm clockwise as shown in **Figure Q4**. For the position shown, the angular velocity BC, $\omega_{BC} = 45$ rad/s. By examining on this scenario;

(a) Draw a free body diagram for sliding block B, crankshaft AB and BC.

(6 marks)

(b) Determine the acceleration of the slider block B

(10 marks)

(c) Determine the acceleration of the crankshaft BC

(4 marks)

Q5 (a) The area bounded by the curve $y^3 = 8x$, the line x = 4, and the x axis is rotated about the x axis to generate a homogenous of solid mass density as shown in **Figure Q5(a).** By examining on the following graph, determine the mass of inertia of the solid with respect to the axis.

(5 marks)

(b) A pendulum consists of two main parts, a vertical slender bar and a thin plate with 4 holes is rigidly attached to the end of the slender bar as shown in **Figure Q5(b)**. The radius of the slender bar 5 mm and the plate has a mass per unit area of 20 kg/m^2. By examining on the above system, determine the center of mass of the pendulum structure and the mass moment of inertia about the rotation axis through the pin *O*.

(15 marks)

Q6 **Figure Q6** shows the disk which has a mass of 20 kg and a radius of gyration, $k_G = 0.18$ m. The disk is attached to a spring which has a stiffness *k*= 40 N/m. The spring has the unstretched length of 0.4 m. The disk is released from rest in the position shown and rolls without slipping and moves 1.2 m to the left. By examining on the above situation;

(a) Calculate the elastic potential energy of the spring in the initial and final position.

(6 marks)

(b) Determine the angular velocity at the instant G moves 1.2 m to the left.

(14 marks)

-END OF QUESTIONS-

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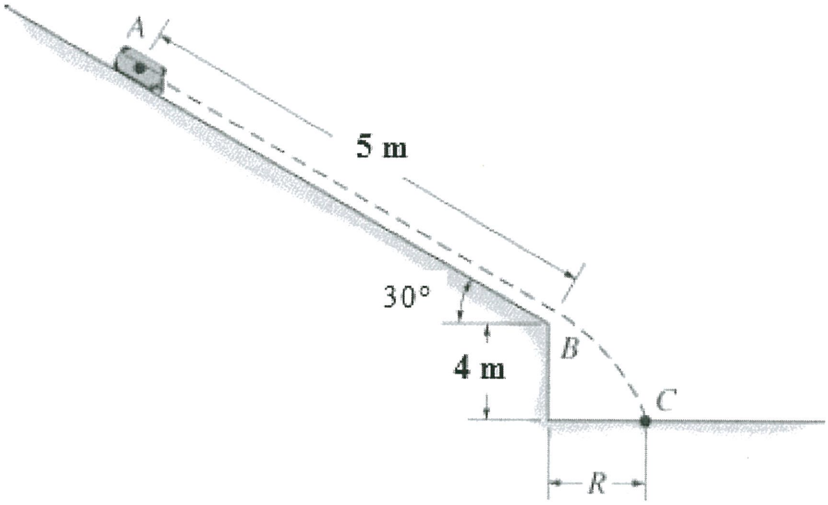

Figure Q1

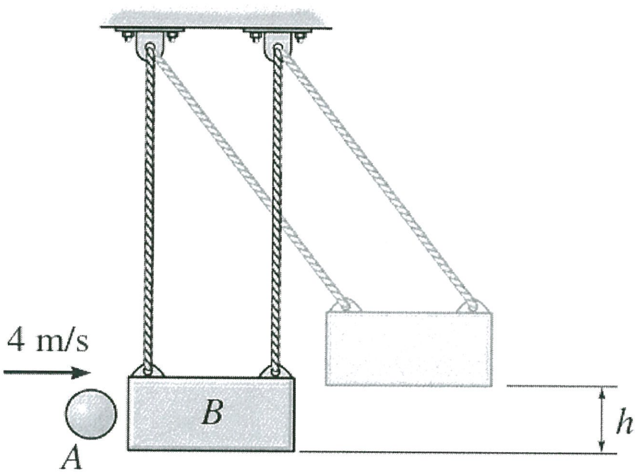

Figure Q2

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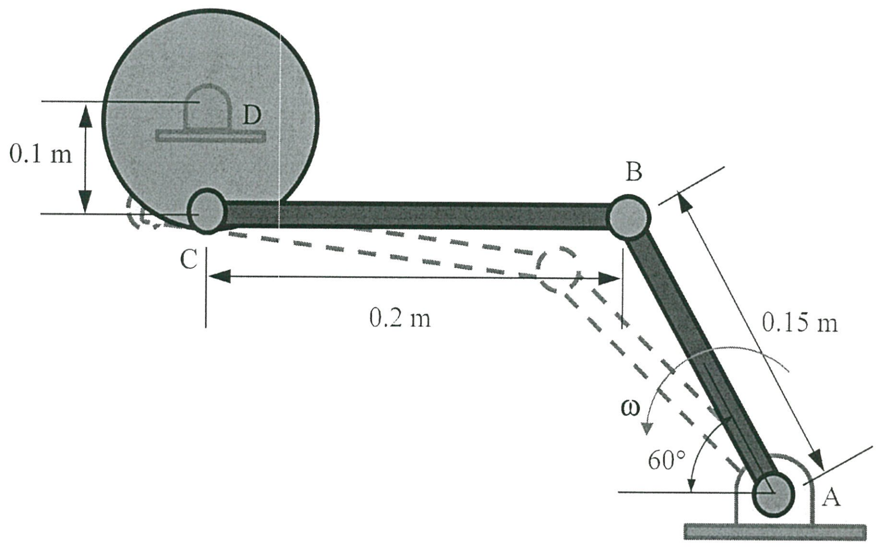

Figure Q3

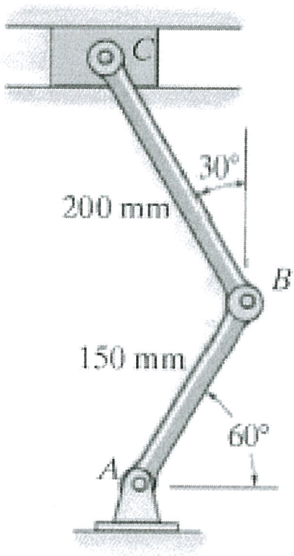

Figure Q4

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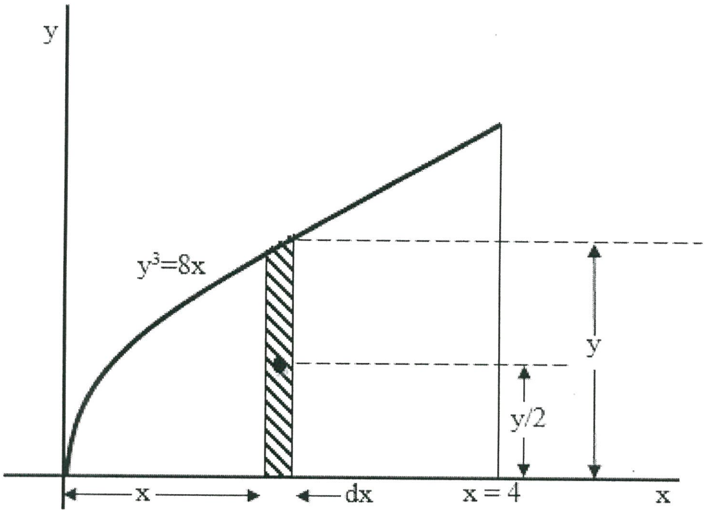

Figure Q5 (a)

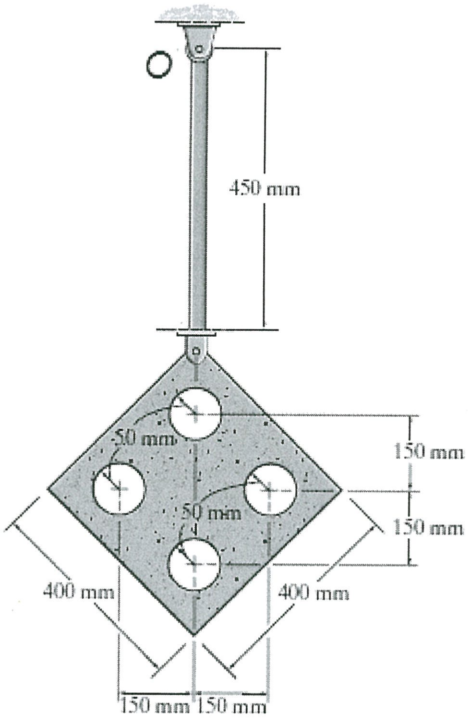

Figure Q5 (b)

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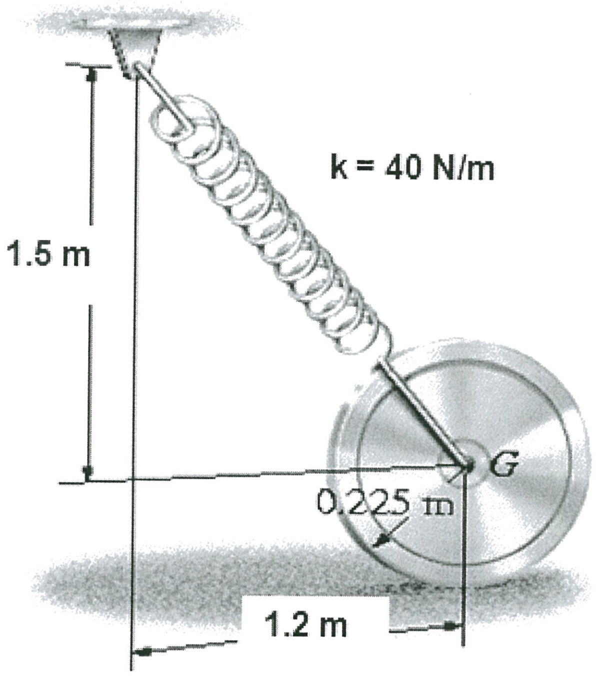

Figure Q6

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

Power and Efficiency

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

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

Principle of Angular Impulse and Momentum

Particle $\quad (H_O)_1 + \sum\int M_O dt = (H_O)_2$
where $H_O = (d)(mv)$

Rigid Body (Plane motion) $\quad (H_G)_1 + \sum\int M_G dt = (H_G)_2$
where $H_G = I_G\omega$
$(H_O)_1 + \sum\int M_O dt = (H_O)_2$
where $H_O = I_O\omega$

Conservation of Angular Momentum

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