Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BDA 20103
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JUNE 2017
DURATION	:	3 HOURS
INSTRUCTION	:	**PART A (OPTIONAL):** ANSWER **ONE (1)** QUESTION **ONLY** **PART B (COMPULSORY):** ANSWER **ALL** QUESTIONS

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

PART A (OPTIONAL): ANSWER ONE (1) QUESTION ONLY

Q1 In **Figure Q1,** the mechanism of sliding collar C moves along the shaft causing an oscillation of the constant angular velocity of bar AB is $\omega = 3$ rad/s clockwise. Using instant centers for velocities and the method of relative velocity,

(a) Draw a free body diagram to show an instantaneous center velocity.

(5 marks)

(b) Calculate the angular velocity of bar BC.

(11 marks)

(c) Determine the velocity of slider C.

(4 marks)

Q2 **Figure Q2** shows the pendulum which is suspended from point O and consists of two thin rods, each having a mass of 10 kg and 6 kg respectively. A thin plate with the hollow section is welded at one end of horizontal rod at point A. The thin plate has a mass per unit area of 6 kg/m^2. By examining on the above circumstances,

(a) Calculate moment of inertia of the pendulum about point O.

(12 marks)

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

(4 marks)

(c) Calculate the moment of inertia I_G.

(4 marks)

PART B (COMPULSORY): ANSWER ALL QUESTIONS

Q3 (a) In **Figure Q3(a)**, it is observed that the ball when thrown at A 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 300 mm. If its angular velocity is $\theta = (2t^2)$ rad/s, where t is in seconds, determine the magnitude of the particle's acceleration when $t = 2$s.

(8 marks)

Q4 (a) Explain the following terms;

i. Kinetic energy
ii. Conservative gravitational potential energy
iii. Conservative elastic potential energy

(6 marks)

(b) In **Figure Q4(b)**, a package is projected up a 15° incline at point A with an initial velocity of 8 m/s. Knowing that the coefficient of kinetic friction between the package and the incline is 0.12, calculate the maximum distance d that the package will move up the incline.

(14 marks)

Q5 In **Figure Q5,** at point A on the sliding collar has a constant velocity v = 0.3 m/s with corresponding lengthening of the hydraulic cylinder AC. For this same position BD is horizontal and DE is vertical.

(a) Draw a free body diagram and velocity diagram.

(3 marks)

(b) Calculate the acceleration of DE where $\theta = 30°$.

(14 marks)

(c) Illustrate the acceleration diagram.

(3 marks)

Q6 The 15 kg rod is constrained so that its ends of collar B move along the fixed guide as shown in **Figure Q6**. The rod is initially at rest when $\theta = 0°$. The collar B is acted upon by a horizontal force P = 80 N. By neglecting friction and mass of block A and collar B,

(a) Draw the free body diagram showing on the position of rod in initial and final position.

(3 marks)

(b) Write down the equation of initial and final kinetic energy (use instantaneous center of zero velocity to show on the relationship of final velocity and angular velocity).

(10 marks)

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

(4 marks)

(d) Find the final velocity of the collar B and its final kinetics energy.

(3 marks)

-END OF QUESTIONS-

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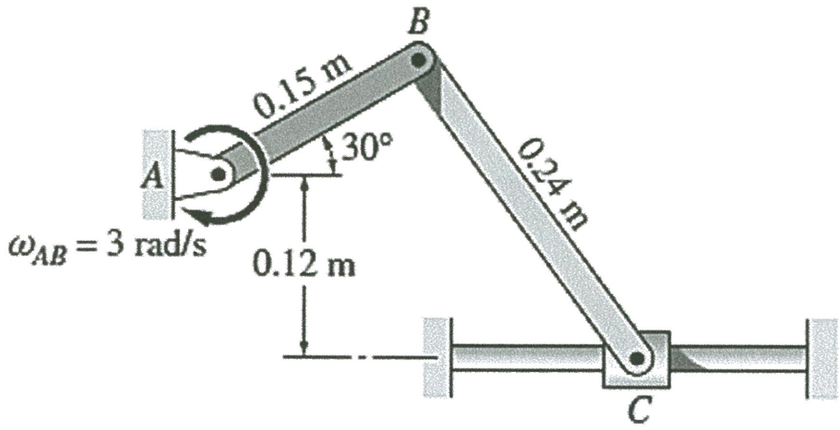

Figure Q1

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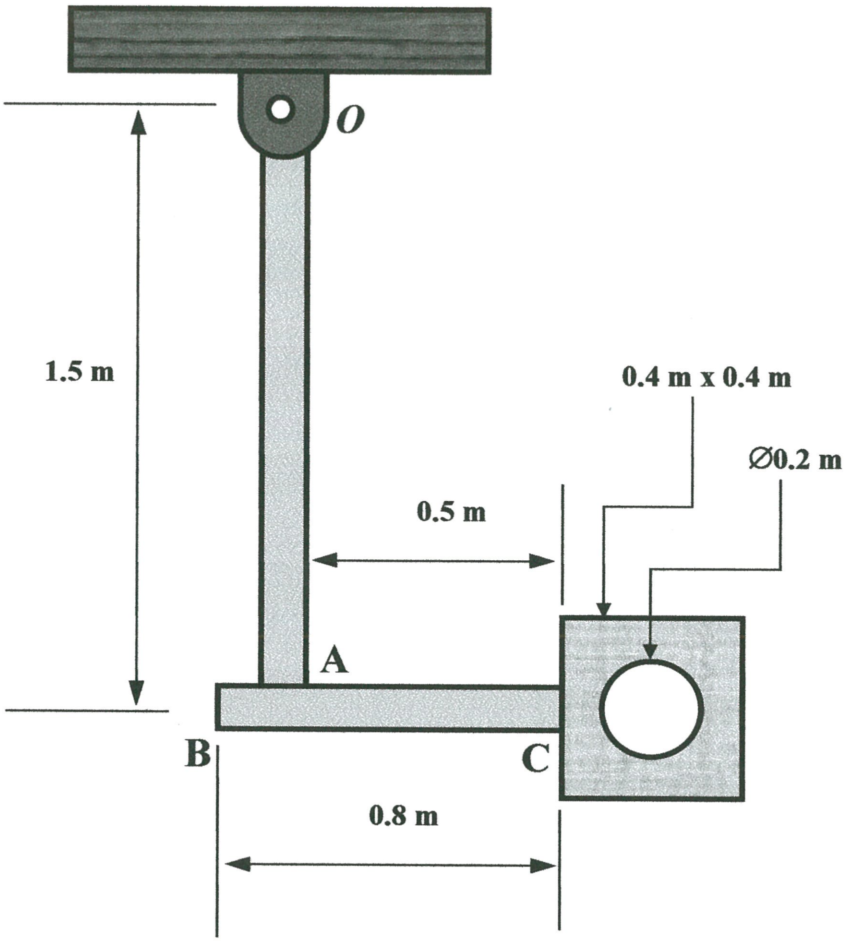

Figure Q2

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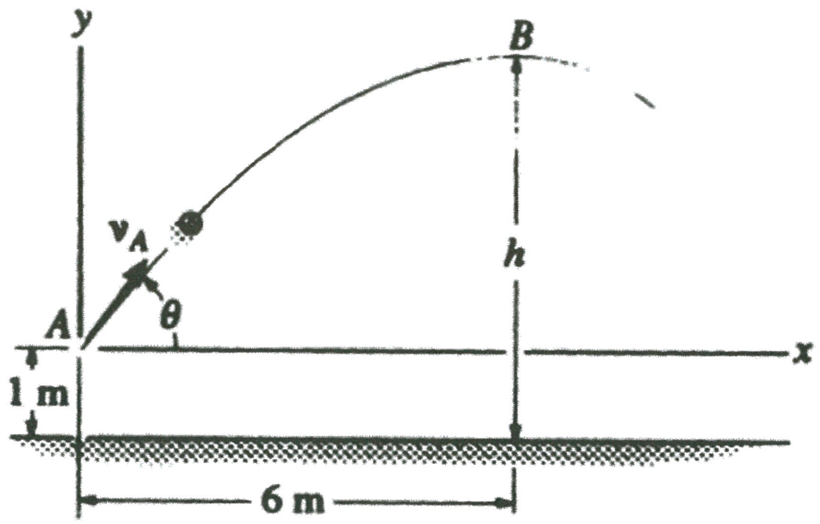

Figure Q3(a)

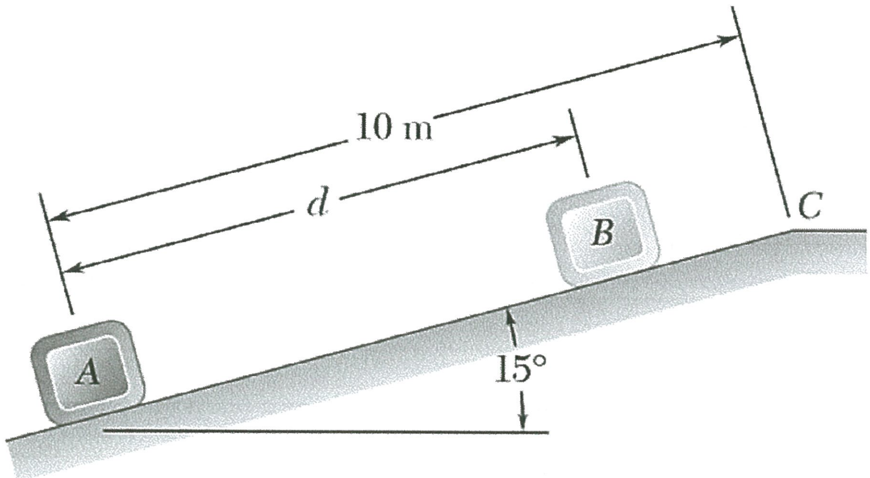

Figure Q4(b)

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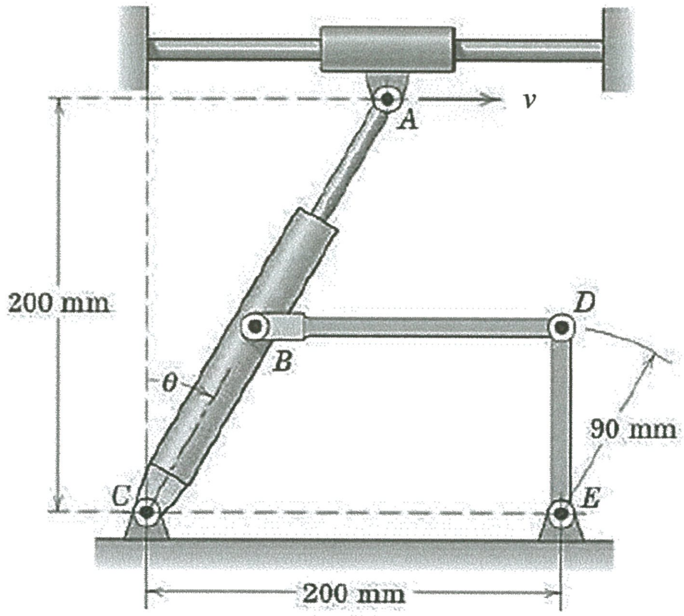

Figure Q5

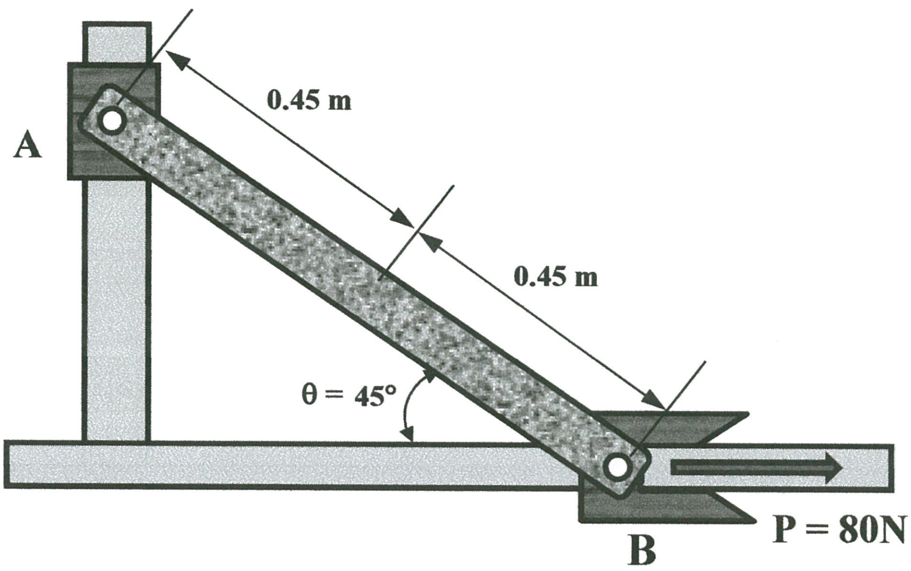

Figure Q6

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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

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

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

Relative Motion

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

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

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

Relative General Plane Motion – Translating Axis

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

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 $I = \int r^2 dm$

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

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

Equations of Motion

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

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

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

Principle of Angular Impulse and Momentum

Particle	$(H_O)_1 + \sum\int M_O dt = (H_O)_2$ where $H_O = (d)(mv)$
Rigid Body (Plane motion)	$(H_G)_1 + \sum\int M_G dt = (H_G)_2$ 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

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

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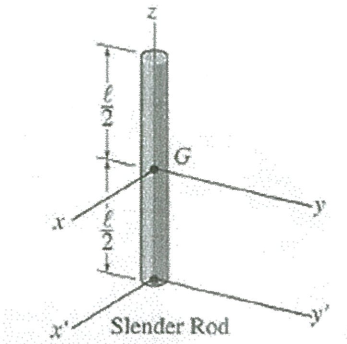
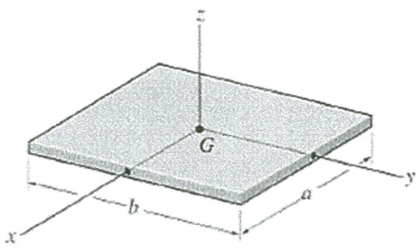


Slender Rod

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

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

$$I_{zz} = 0$$

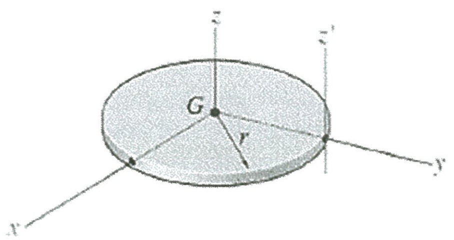


Thin plate

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

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

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



Thin Circular disk

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

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

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