CONFIDENTIAL

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2014/2015

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BDA 20103
PROGRAMME	:	BDD
DATE	:	DECEMBER 2014/ JANUARY 2015
DURATION	:	3 HOURS
INSTRUCTIONS	:	ANSWER FIVE (5) QUESTIONS ONLY

THIS PAPER CONTAINS EIGHT (8) PAGES

Q1 A hydraulic actuator shown in **FIGURE Q1** moves the pin P upward with constant velocity $v = 2\,\mathbf{j}$ (m/s). When $\theta = 35^o$,

a) Sketch the velocity of pin P, v_p in terms of polar coordinates, e_r and e_θ.

(3 marks)

b) Determine the value for $r, \dot{r}, y, \dot{y}$

(10 marks)

c) Express the velocity of pin *P*, v_p in terms of polar coordinates, e_r and e_θ.

(4 marks)

d) Find the angular velocity, ω of the slotted bar.

(3 marks)

Q2 A 30 kg box A is hung to the ceiling, and being initially at rest, as depicted in **FIGURE Q2**,. Then, a 60 g bullet B horizontally strikes the box with velocity of 2160 km/h. The bullet embedded into the box and moves together after the impact. Determine;

a) Velocity of the box and bullet after the impact.

(4 marks)

b) Angular velocity, ω of the pendulum.

(4 marks)

c) Maximum angle θ.

(12 marks)

Q3 a) Describe three types of planar rigid body motion and give example of each motion.

(9 marks)

b) **FIGURE Q3** shows a gear system configuration of jumping mechanism. Given an angular acceleration, α_A and initial angular velocity, $(\omega_A)_0$ of Gear A are $5t^3$ $rads^{-2}$ and 25 $rads^{-1}$ respectively where t is in seconds, determine:

i) the relation of angular motion (θ, ω) between Gear B and Gear A when $t = 2s$.

(9 marks)

ii) the angular displacement, θ_B and angular velocity, ω_B of Gear B when $t = 2s$

(2 marks)

Q4 (a) There are various way of analysing rigid-body motion. Describe the meaning of "instantaneous centers of rotation" in a rigid body .

(4 marks)

(b) **FIGURE Q4** shows the connecting link ABCD. If link AB is rotating with an angular velocity $\omega_{AB} = 3$ rad/s;

(i) Sketch the instantaneous center of zero velocity of link BC.

(2 marks)

(ii) Determine the velocity at point B, υ_B.

(2 marks)

(iii) Determine the distance of instantaneous radius of $r_{B/IC}$ and $r_{C/IC}$.

(4 marks)

(iv) Determine the angular velocity of link BC, ω_{BC}

(4 marks)

(v) Determine the angular velocity of link CD, ω_{CD}

(4 marks)

Q5 a) As shown in **FIGURE Q5 (a),** the pendulum consists of two slender rods AB and OC which have a mass of 3 kg. The thin circular plate has a mass of 12 kg. Determine:

i) The location of the $\bar{y}$, center of mass G of the pendulum.

(3 marks)

ii) The moment of inertia of the pendulum about an axis perpendicular to the page and passing through G.

(4 marks)

iii) The moment of inertia of the pendulum about an axis perpendicular to the page and passing through the pin at O.

(3 marks)

b) Determine the maximum acceleration that can be achieved by the car in **FIGURE Q5 (b)** without having the front wheels *A* leave the track or the rear drive wheels *B* slip on the track. The coefficient of static friction is $\mu_s = 0.9$. The car's mass center is at *G*, and the front wheels are free to roll. Neglect the mass of all the wheels.

(10 marks)

Q6 **FIGURE Q6** shows a system that consists of a 50 N bar and a spring of 12 N/m spring constant. Suppose the bar is rotating downward at 3 rad/s and the spring has an unstretched length of 2 m, determine:

a) The initial kinetic energy and potential energy, when ($\theta = 0^\circ$).

(8 marks)

b) The final kinetic energy and potential energy before the bar stops to rotate.

(8 marks)

c) The angle (measured down from the horizontal) to which the bar rotates before it stops its initial downward movement.

(4 marks)

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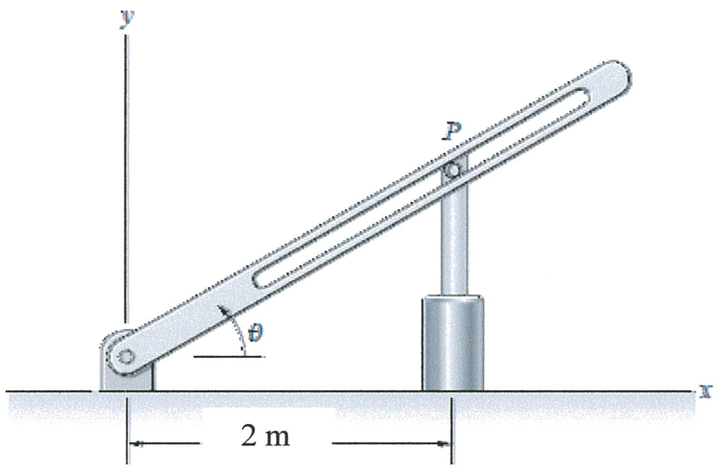

FIGURE Q1

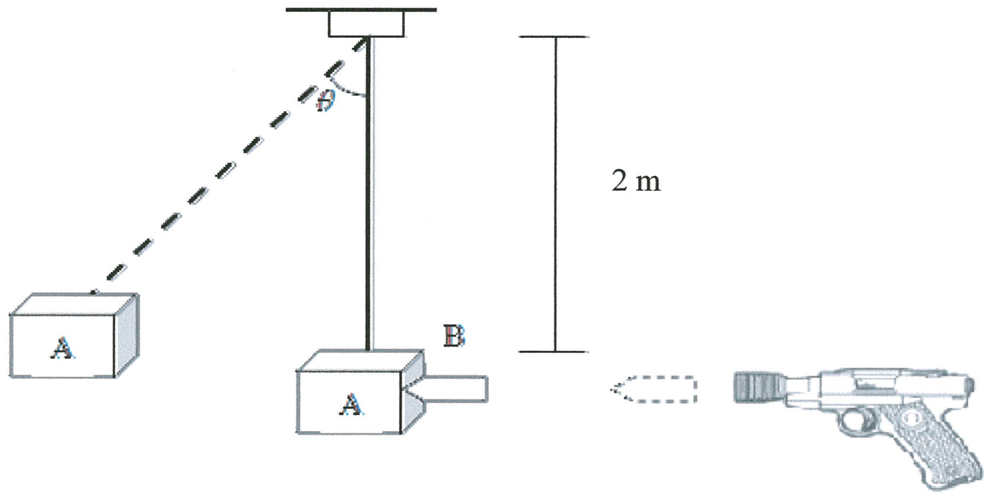

FIGURE Q2

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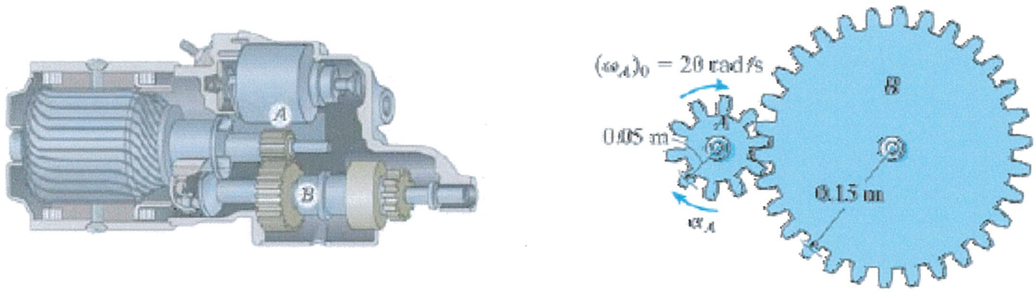

FIGURE Q3

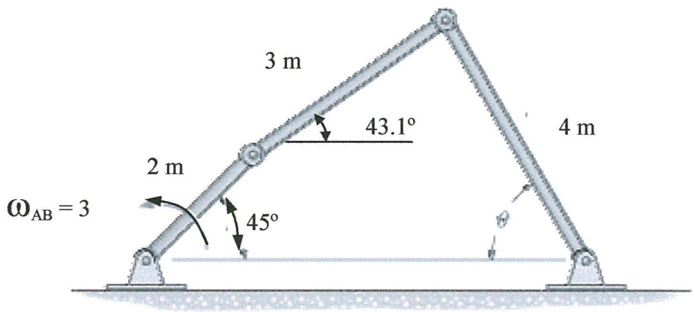

FIGURE Q4

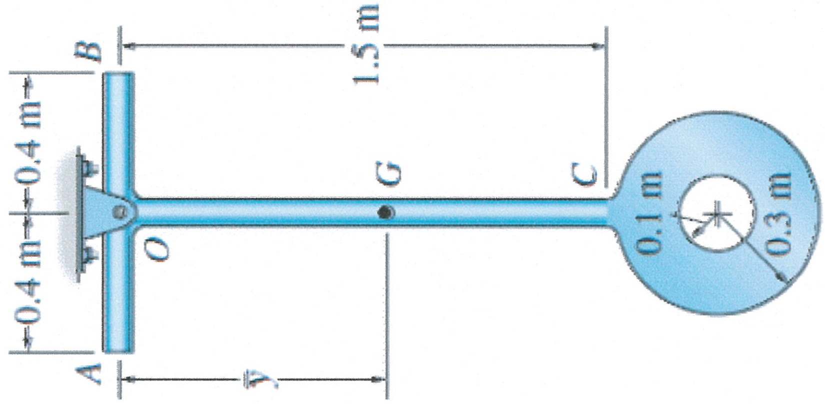

FIGURE Q5 (a)

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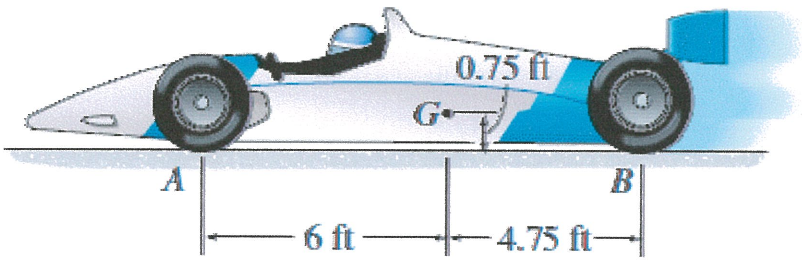

FIGURE Q5 (b)

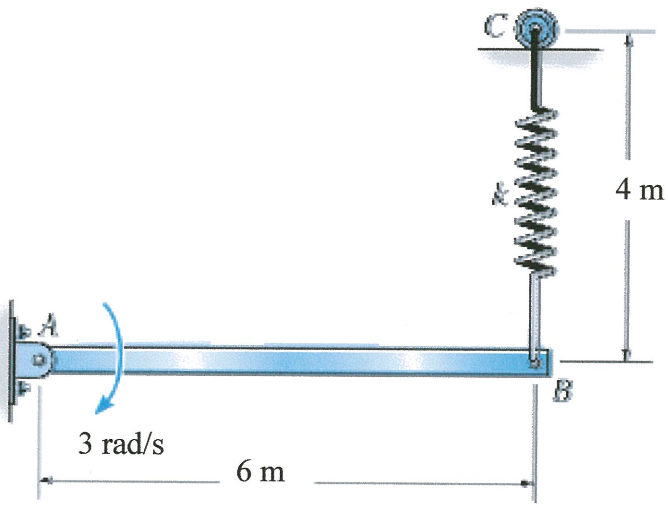

FIGURE Q6

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$$s = s_0 + v_0 t + \frac{1}{2} a t^2$$

$$v = v_0 + at$$

$$v^2 = v_0^2 + 2as$$

$$\theta = \theta_0 + \omega t + \frac{1}{2} \alpha t^2$$

$$\omega = \omega_0 + \alpha t$$

$$\omega^2 = \omega_0^2 + 2\alpha s$$

$$\mathbf{v} = \mathbf{v}^{\mathbf{r}} + \mathbf{v}^{\theta}$$

$$\mathbf{v}^{\theta} = r\omega \qquad \mathbf{v}^{r} = \dot{r}$$

$$\mathbf{a} = \mathbf{a}^{\mathbf{r}} + \mathbf{a}^{\boldsymbol{\theta}}$$

$$\mathbf{a}^{r} = \ddot{r} - \dot{\theta}^2 r$$

$$\mathbf{a}^{\boldsymbol{\theta}} = \ddot{\theta} r + 2\dot{\theta}\dot{r}$$

$$\mathbf{a} = \mathbf{a}^{\mathbf{n}} + \mathbf{a}^{\mathbf{t}}$$

$$\mathbf{a}^{\mathbf{n}} = r\omega^2 = \frac{v^2}{r}$$

$$U = \Delta T + \Delta V_g + \Delta V_e$$

$$\Delta T = \frac{1}{2} m\left(v_2^2 - v_1^2\right) + \frac{1}{2} I_G\left(\omega_2^2 - \omega_1^2\right)$$

$$\Delta V_g = mg\left(h_2 - h_1\right)$$

$$\Delta V_e = \frac{1}{2} k\left(x_2^2 - x_1^2\right)$$

$$mv_1 + \sum \int_{t_1}^{t_2} F\,dt = mv_2$$

$$\left(H_0\right)_1 + \sum \int_{t_1}^{t_2} M_0\,dt = \left(H_0\right)_2$$

$$m_A\left(v_A\right)_1 + m_B\left(v_B\right)_1 = m_A\left(v_A\right)_2 + m_B\left(v_B\right)_2$$

$$I_G\omega_1 + m\left(v_G\right)_1 d_1 + \sum \int M_A\,dt = I_G\omega_2 + m\left(v_G\right)_2 d_2$$

$$e = -\frac{\left(v_B\right)_2^n - \left(v_A\right)_2^n}{\left(v_B\right)_1^n - \left(v_A\right)_1^n}$$

$$\left(v_A\right)_1^t = \left(v_A\right)_2^t$$

$$\sum M_G = I_G \alpha$$

$$\sum F = ma$$

$$T_1 + V_1 = T_2 + V_2$$

$$\mathbf{v}_P = \mathbf{v}_{P'} + \mathbf{v}_{P/Oxy}$$

$$\mathbf{v}_P = (\ddot{\mathbf{r}})_{OXY} = \Omega \times \mathbf{r} + (\dot{\mathbf{r}})_{Oxy}$$

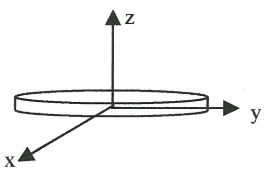
$$\mathbf{a}_P = \mathbf{a}_{P'} + \mathbf{a}_{\mathbf{P}/Oxy} + \mathbf{a}_C$$

$$\mathbf{a}_{\mathbf{P}} = \Omega \times (\Omega \times \mathbf{r}) + \dot{\Omega} \times \mathbf{r} + \mathbf{2}\left(\Omega \times (\dot{\mathbf{r}})_{Oxy}\right) + (\ddot{\mathbf{r}})_{Oxy}$$

$$I = mk_G^{\ 2}$$

$$I_{XX} = I_{YY} = \frac{1}{4} mr^2$$

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



$$I_{XX} = I_{YY} = \frac{1}{12} ml^2$$

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