# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESSION 2010/2011

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|---|---|---|
| NAME OF COURSE | : | DYNAMICS |
| COURSE CODE | : | BDA 2013 / BDA 20103 |
| PROGRAM | : | 2 BDD |
| DATE OF EXAMINATION | : | NOVEMBER/DECEMBER 2010 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | PART A: ANSWER **ALL** QUESTIONS.<br>PART B: ANSWER **TWO (2)** QUESTIONS ONLY. |

**THIS PAPER CONSISTS OF 8 PAGES**

**PART A : ANSWER ALL QUESTIONS**

**Q1** **Figure 1** shows the slotted guide which act as one of the mechanism used to translate and rotate the machinery component of the system. At an instant $\theta = 45°$, the slotted guide is moving upward with an acceleration of $4\ m/s^2$ and a velocity of $3\ m/s$. The upward motion of the guide is in the negative y direction.

(a) Illustrate the free body diagram of the system and find the position coordinate equation. [3 marks]

(b) Determine the angular velocity $(\omega)$ of link AB at this instant. [6 marks]

(c) Determine the angular acceleration $(\alpha)$ of link AB at this instant. [6 marks]

**Q2** A system is built and equipped with the links AB and BC as shown in **Figure 2**. The link BC is connected with the incline shaft at collar C. At a given instant the collar C is moving incline upward at an angle of $45°$ with the velocity of $v_c = 6\ m/s$ and it also undergoing the deceleration of $a_c = 4\ m/s^2$. By assuming that the angle $\theta = 90°$;

(a) Calculate the angular velocity of link AB and BC of the system. [8 marks]

(b) Determine the angular acceleration of link AB. [6 marks]

(c) Find the angular acceleration of link BC. [6marks]

**Q3** A uniform slender rod AB of length $90\ cm$ and mass of $10\ kg$ hangs freely from a hinge at O. The illustration of the hanging slender rod is shown in **Figure 3**. A horizontal force of magnitude $60\ N$ is applied at end B.

(a) Determine the mass moment of inertia of the slender rod about the hinge at O. [6marks]

(b) Find the angular acceleration about the hinge O. [5marks]

(c) Calculate the components of reaction force at the hinge O. [4marks]

**PART B : ANSWER TWO (2) QUESTIONS ONLY**

**Q4** The crank CD revolves anti clockwise with an angular velocity, $\omega = 0.5\ rad/s$ and acceleration, $\alpha = 0.1\ rad/s^2$ as shown in **Figure 4**. The pin P is fixed to rod CD and can only slide along the slot of link AE. For the position $\theta = 45^o$;

(a) Determine the angular velocity of slotted link AE. [13marks]

(b) Calculate the angular acceleration of slotted link AE. [12marks]

**Q5** A signboard consists of slender rod AB (60 cm) and an aluminium plate. The mass of the slender rod is *5 kg*. This slender rod and the plate are welded at B so that the connection is fixed. The thickness of the plate is 1 cm and the mass density of the aluminium material is $7000\ kg/m^3$. The attachment of the signboard is illustrated in **Figure 5**. This signboard has a hinge at A that enable the structure to rotate about point A.

By looking at the structure as illustrated in the following figure;

(a) Determine the center of mass of the signboard structure, measured from the hinge at A. [5 marks]

(b) Calculate the mass moment of inertia of the signboard structure about the hinge at A. [5 marks]

If the support at C is cut;

(c) Draw an illustration when the signboard structure has a maximum angular speed. Your illustration must be clear, visible and readable. [5 marks]

(d) Calculate the value of maximum angular speed. [5 marks]

(e) Calculate the moment required at A to stop the signboard at the condition as you have described in (c). [5 marks]

**Q6** **Figure 6** shows the cross section of a uniform *110 kg* ventilator door hinged about its upper horizontal edge at O. The door is controlled by the spring-loaded cable that passes over the small pulley at A. The spring has a stiffness of *200 N/m* of stretch and is undeformed when $\theta = 0$. If the door is released from rest in the horizontal position;

(a) Find the angular velocity, $\omega$ *in rad/s* reached by the door at $\theta = 60^o$. [12 marks]

(b) Determine the suitable spring stiffness $k$ (*N/m*) that can be used so that the angular velocity at $\theta = 90^o$ is $\omega = 0$ *rad/s.* [13 marks]

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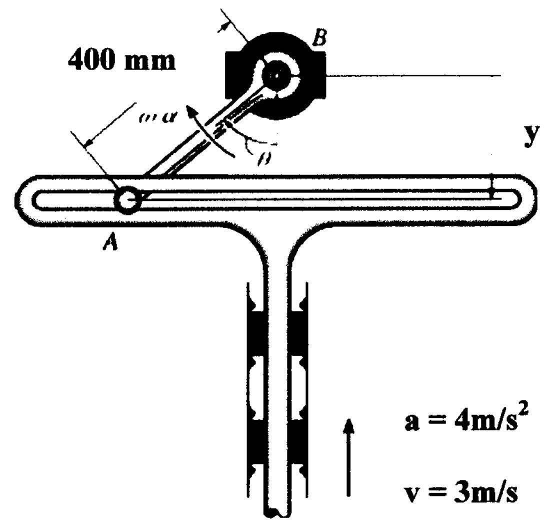


**FIGURE 1: SLOTTED GUIDE AND LINK MECHANISM**

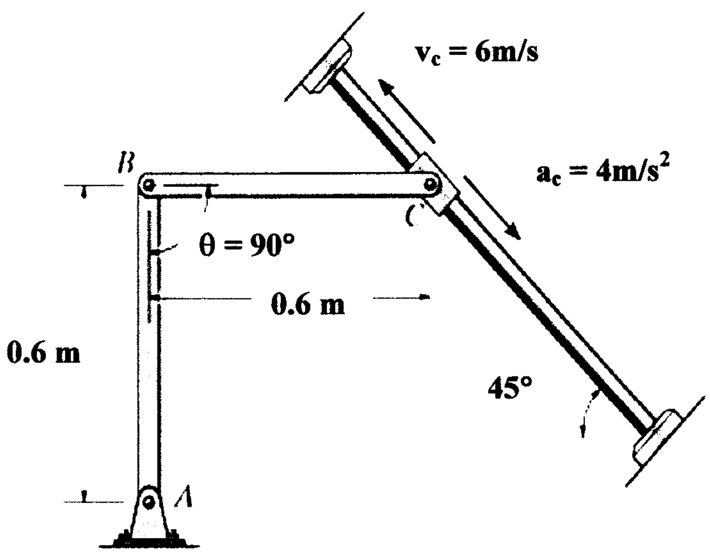


**FIGURE 2: LINKS AND COLLAR**

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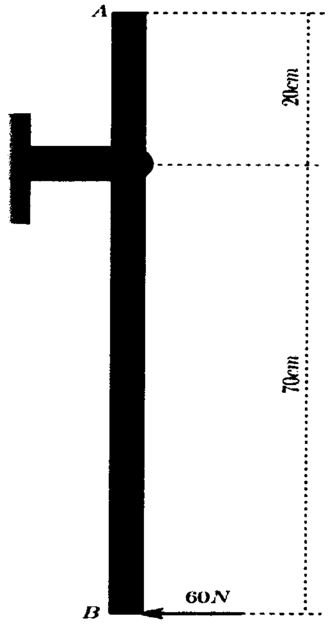


**FIGURE 3 : UNIFORM SLENDER ROD**

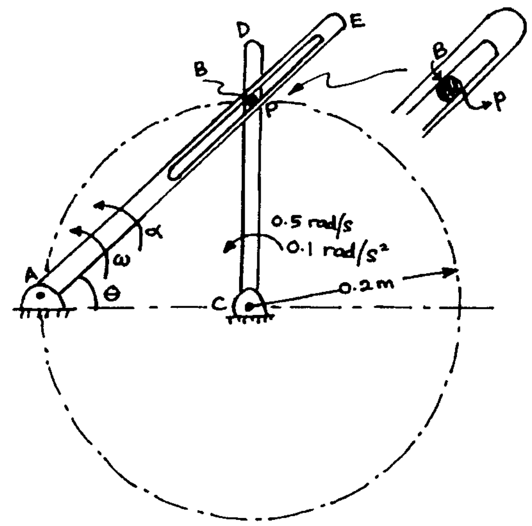


**FIGURE 4: CRANK AND SLOTTED LINK**

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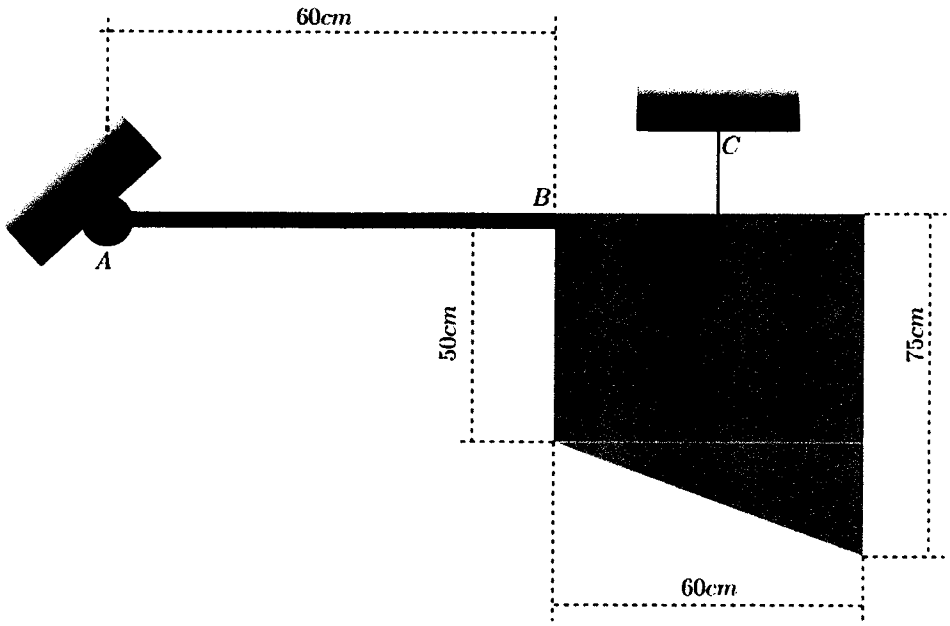


**FIGURE 5: A SIGNBOARD STRUCTURE**

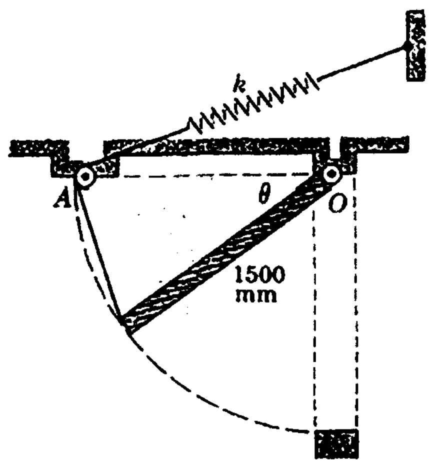


**FIGURE 6: VENTILATOR DOOR**

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

$$v = v_0 + at$$

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

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

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

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

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

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

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

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

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

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

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

$$\mathbf{a}^t = r\alpha$$

$$T_1 + U_{1\to 2} = T_2$$

$$T_1 + V_1 = T_2 + V_2$$

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

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

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

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

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

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

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

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

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

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

$$\sum M_G = I_G\alpha$$

$$\sum F = ma$$

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

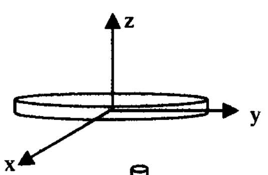
$$\mathbf{v}_P = (\dot{\mathbf{r}})_{OXY} = \mathbf{\Omega}\times\mathbf{r} + (\dot{\mathbf{r}})_{Oxy}$$

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

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

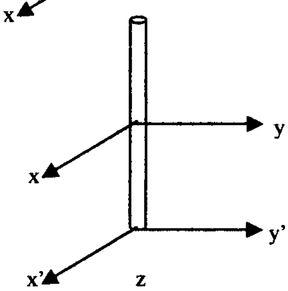
$$I = mk_G^{\,2}$$

$$I = \int_m r^2\,dm$$



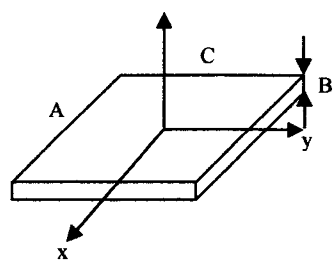

$$I_{XX} = I_{YY} = \frac{1}{4}mr^2$$

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




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

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




$$I_{XX} = \frac{1}{12}m\left(B^2 + C^2\right)$$

$$I_{YY} = \frac{1}{12}m\left(A^2 + B^2\right)$$

$$I_{ZZ} = \frac{1}{12}m\left(A^2 + C^2\right)$$