جامعة البعث
كلية الهندسة الميكانيكية والكهربائية
قسم هندسة التصميم والإنتاج

امتحانات الفصل الثاني للعام الدراسي 2023-2024
سلم تصحيح مادة ديناميك الآلات والاهتزازات
الدرجة: 80 درجة

السؤال الأول: (18 درجة)

1- عزم العطالة الكتلي المرجع على الحد القائد:

$$J(\varphi_2) = J_2\dot{\varphi}_2^2 + J_3\dot{\varphi}_3^2 + J_6\dot{\varphi}_6^2 + m_{34}r^2\dot{\varphi}_3^2 + (m_{45}+m_5)\acute{x}_5^2$$

$$\dot{\varphi}_2 = \frac{d\varphi_2}{d\varphi_2} = 1 \ , \ r_2\varphi_2 = r_3\varphi_3 \Rightarrow \varphi_3 = \frac{r_2}{r_3}\varphi_2 \ \Rightarrow \ \dot{\varphi}_3 = \frac{r_2}{r_3} = \frac{0.1}{0.4} = \frac{1}{4} = \mathbf{0.25}$$

$$r_3\varphi_3 = -r_6\varphi_6 \Rightarrow \varphi_6 = -\frac{r_3}{r_6}\varphi_3 = -\frac{r_3}{r_6}\frac{r_2}{r_3}\varphi_2 \ \Rightarrow \ \dot{\varphi}_6 = -\frac{r_2}{r_6} = -\frac{0.1}{0.3} = -\frac{1}{3}$$

$$X_5 \cong L + r\cdot cos\,\varphi_3 = L + r\cdot cos\frac{r_2}{r_3}\varphi_2 \ \Rightarrow \ \acute{X}_5 = -r\cdot\frac{r_2}{r_3}\sin\frac{r_2}{r_3}\varphi_2 \ \Rightarrow \ \acute{X}_5 = -0.2(0.25)\sin\frac{\varphi_2}{4} \quad (6)$$

$$\acute{\boldsymbol{X}}_{\mathbf{5}} = \mathbf{-0.05\sin\frac{\varphi_2}{4}}$$

$$m_{34} + m_{45} = m_4 = 8\,. \ m_{34}l = m_{45}(L-l) \ \Rightarrow m_{34}(0.2) = m_{45}(0.8-0.2) \ \Rightarrow m_{34} = 3m_{45}$$

$$\boldsymbol{m_{45} = 2\ kg \ , \ m_{34} = 6\ kg} \quad (4)$$

$$J(\varphi_2) = 0.15 + 0.5(0.25)^2 + 0.4\left(-\frac{1}{3}\right)^2 + 6(0.2)^2(0.25)^2 + (2+10)\left(-0.05\sin\frac{\varphi_2}{4}\right)^2$$

$$J(\varphi_2) = \mathbf{0.240694 + 0.03\sin^2\left(\frac{\varphi_2}{4}\right)}$$

$$J(\varphi_2) = 0.240694 + 0.03\left(\frac{1-\cos\left(\frac{\varphi_2}{2}\right)}{2}\right) \ \Rightarrow \ J(\varphi_2) = \mathbf{0.255694 - 0.015\cos\left(\frac{\varphi_2}{2}\right)} \quad (6)$$

$$J(\varphi_2) = J_m \mp \Delta J \ \Rightarrow \ \delta_J = \frac{\Delta J}{J_m} = \frac{0.015}{0.255694} = \mathbf{0.05866} \quad (2)$$

السؤال الثاني: (22 درجة)

1- حساب عزم مقاومة العمل المرجع على الحد القائد:

$$Q = \sum_{i=2}^{n}\left[F_{Xi}\cdot\acute{X}_i + F_{Yi}\cdot\acute{Y}_i + M_i\cdot\acute{\varphi}_i\right]$$

$$\varphi_2 = 4\varphi_5 \ \Rightarrow \ \varphi_5 = \frac{1}{4}\varphi_2 \ \Rightarrow \ \Rightarrow \ \acute{\varphi}_5 = \frac{1}{4} = 0.25$$

دورة العمل: $2\pi i = 2\pi\frac{1}{0.25} = 8\pi$

$$M_w = M_5 \times \acute{\varphi}_5 = \begin{cases} 0 & 0 \le \varphi_2 \le 2\pi \\ -2400\times 0.25 = -600\ N\cdot m & 2\pi \le \varphi_2 \le 4\pi \\ -4800\times 0.25 = -1200\ N\cdot m & 4\pi \le \varphi_2 \le 6\pi \\ 0 & \varphi_2 = 8\pi \end{cases} \quad (5)$$

- حساب عزم المحرك الضروري في حالة التشغيل المستقر

$$W_W = -W_M$$

$$W_M = \int_0^{8\pi} M_M d\varphi_2 = 8\pi M_M$$

$$W_W = \int_0^{8\pi} M_W d\varphi_2 = (2\pi)(-600) + (2\pi)(-1200) + \frac{1}{2}(2\pi)(-1200) =$$

$$= \mathbf{-4800\pi = -15079.6447} \ \ [N.m]$$

$$8\pi M_M = 4800\pi \ \Rightarrow \ M_M = \frac{4800}{8} = \mathbf{600}\ [N.m] \quad (5)$$

- حساب العزم المحصل والعمل المحصل:

$$M_{eq} = \begin{cases} 600 & [N\cdot m] & 0 \le \varphi_2 \le 4\pi \\ 0 & [N\cdot m] & 2\pi \le \varphi_2 \le 4\pi \\ -600 & [N\cdot m] & 4\pi \le \varphi_2 \le 6\pi \\ 600 & [N\cdot m] & \varphi_2 = 8\pi \end{cases}$$

$$a + b = 2\pi \ , \quad \frac{a}{b} = \frac{600}{600} = 1 \ \Rightarrow b = a$$

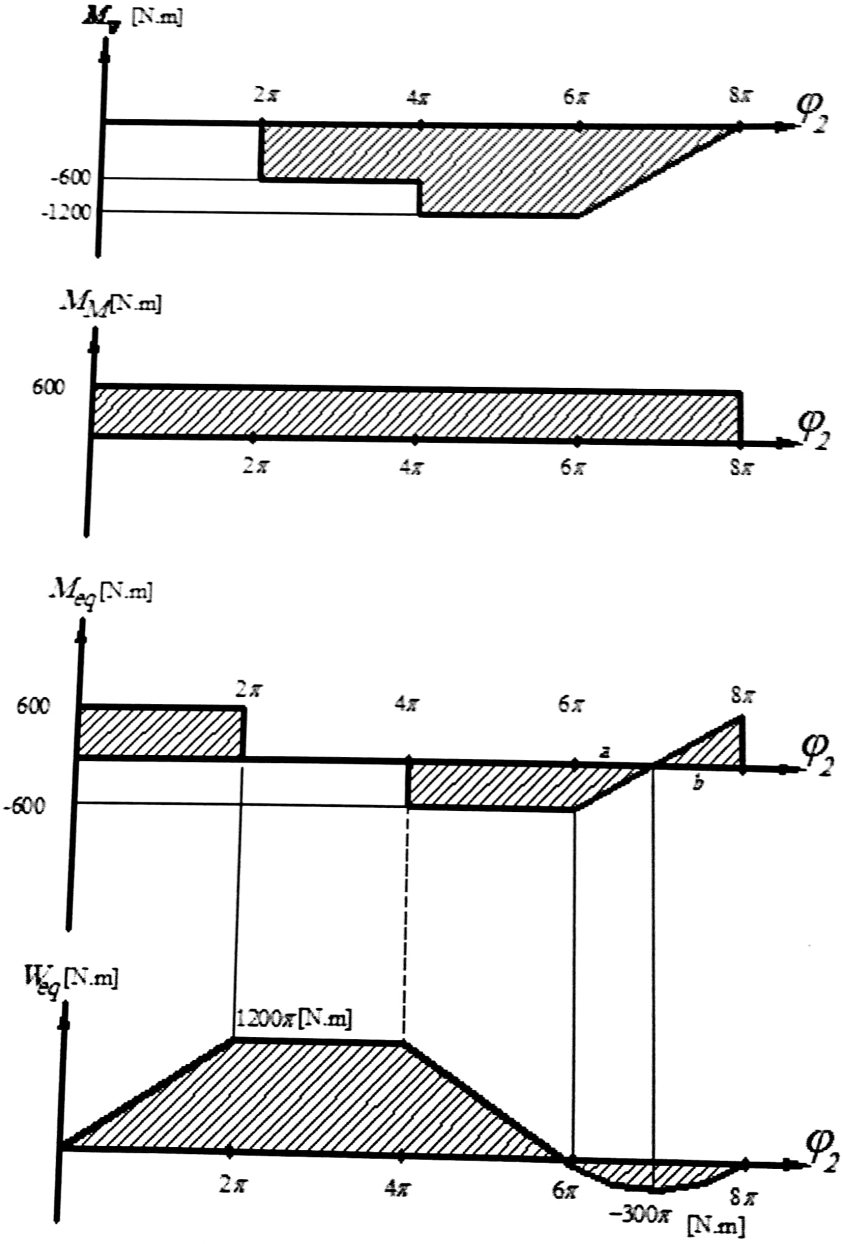
$$\boldsymbol{a = \pi}, \quad \boldsymbol{b = \pi}$$

(8)

$$W_{max} = \int_0^{\bar{\varphi}_2} M_{eq}\, d\varphi_2 = 600(2\pi) = \mathbf{1200\pi = 3769.91}\ [N.m]$$

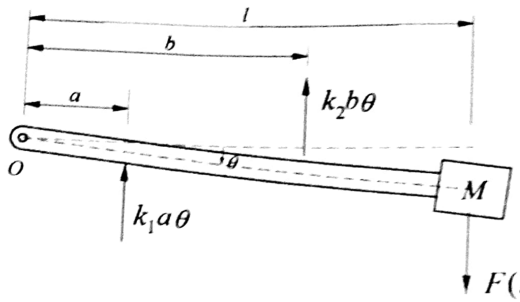
$$W_{min} = \int_0^{\bar{\varphi}_2} M_{eq}\, d\varphi_2 = 600(2\pi) - 600(2\pi) - \frac{1}{2}(\pi)(600)$$

$$= \mathbf{-300\pi = -942.478}\ [N.m]$$



(4)

السؤال الثالث: (20 درجة)



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$$\omega = \frac{2\pi(1000)}{60} = \frac{100\pi}{3} = 104.7197551 \left[\frac{rad}{sec}\right] \quad (2)$$

للعارضة $J_o = \frac{1}{12}ml^2 + m\left(\frac{l}{2}\right)^2 = \frac{1}{3}ml^2 = \frac{1}{3}(10)(1)^2 = 3.3333\ [kg.m^2]$ (2)

$$(J_o + Ml^2)\ddot{\theta} = -k_1a^2\theta - k_2b^2\theta + F(t) \times l$$

$$\ddot{\theta} + \frac{k_1a^2+k_2b^2}{J_o+Ml^2}\theta = \frac{F_0 l}{J_o+Ml^2}\sin\omega t \Rightarrow \ddot{\theta} + \frac{5000(0.25^2+0.5^2)}{\frac{10}{3}+50(1)^2}\theta = \frac{500(1)}{\frac{10}{3}+50(1)^2}\sin\left(\frac{2\pi(1000)}{60}t\right)$$

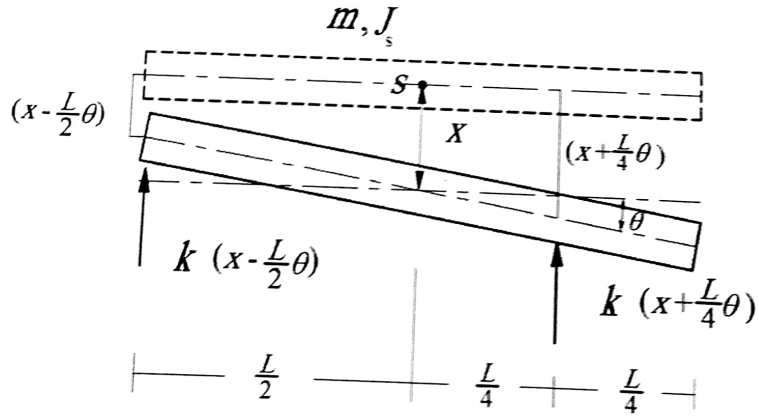
$$\ddot{\theta} + 29.296875\theta = 9.375\sin\frac{100\pi}{3}t \quad (6)$$

$$\omega_n^2 = 29.296875 \Rightarrow \omega_n = 5.412658774 \left[\frac{rad}{sec}\right] \quad (2)$$

$$\theta_{stat} = \frac{\bar{Q}}{\omega_n^2} = \frac{9.375}{29.296875} = 0.32$$

$$\theta = A\sin\omega t \Rightarrow A = \frac{\theta_{stat}}{\sqrt{\left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)^2}} = \frac{0.32}{\sqrt{\left(1-\left(\frac{104.7197551}{5.412658774}\right)^2\right)^2}} = 8.571875 \times 10^{-4}\ [rad] \quad (5)$$

السؤال الرابع : (20 درجة)



(4)

$$m\ddot{x} = -k\left(x-\frac{L}{2}\theta\right) - k\left(x+\frac{L}{4}\theta\right) \Rightarrow \ddot{x} + \frac{2k}{m}x - \frac{kL}{4m}\theta = 0 \quad (4)$$

$$J_s\ddot{\theta} = k\left(x-\frac{L}{2}\theta\right)\left(\frac{L}{2}\right) - k\left(x+\frac{L}{4}\theta\right)\left(\frac{L}{4}\right) \Rightarrow \frac{1}{12}ml^2\ddot{\theta} = \frac{kL}{4}x - \frac{5kL^2}{16}\theta \Rightarrow \ddot{\theta} - 3\frac{k}{mL}x + \frac{15k}{4m}\theta = 0 \quad (6)$$

$$a_{11} = \frac{2k}{m}\left[\frac{1}{s^2}\right] \quad . a_{12} = -\frac{kL}{4m}\left[\frac{m}{s^2}\right] \quad . a_{21} = -3\frac{k}{mL}\left[\frac{1}{m\cdot s^2}\right] \quad . a_{22} = \frac{15k}{4m}\left[\frac{1}{s^2}\right] \quad (6)$$

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