حل ورقة النشاط المطورة لنواس الفتل

نشاط (1):

س1) $\sum \Gamma_\Delta = I_\Delta \cdot \alpha$ (c)

س2) $K = K' \frac{(2r)^4}{\ell}$ (c)

س3) $T_0 = 2\pi\sqrt{\frac{I_\Delta}{K}}$

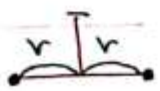
نربع

$0.5 = 2\pi\sqrt{\frac{\frac{3}{4}\times 10^{-2}}{K}}$

$\frac{1}{4} = 40\,\frac{\frac{3}{4}\times 10^{-2}}{K} \Rightarrow$

$K = 4\times 40\times \frac{3}{4}\times 10^{-2} = 1.2\ m\,N\,rad^{-1}$

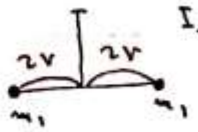
س4) عندما يكون البعد بين الكتلتين 2r



$m_1 = m_2$ $\quad I_\Delta = m_1 r_1^2 + m_2 r_1^2 = 2m_1 r_1^2$

$T_0 = 2\pi\sqrt{\frac{2m_1 r_1^2}{K}}$

عندما يكون البعد بين الكتلتين 4r



$I_\Delta = m_1(2r)^2 + m_1(2r)^2 = 2m_1(2r)^2$

$T_0' = 2\pi\sqrt{\frac{2m_1(2r_1)^2}{K}}$

$T_0' = 2\pi\sqrt{\frac{4\times 2m_1 r_1^2}{K}}$

$T_0' = 2\times 2\pi\sqrt{\frac{2m_1 r_1^2}{K}} = 2T_0$

س5) $T_0 = 2\pi\sqrt{\frac{I_\Delta}{K}}$

$T_0' = 2\pi\sqrt{\frac{4I_\Delta}{K}} = 2\times 2\pi\sqrt{\frac{I_\Delta}{K}}$

$T_0' = 2T_0$

س6) $\alpha = -\omega_0^2\theta \qquad \omega_0 = \frac{2\pi}{T_0} = \frac{2\pi}{0.5}$

$\alpha = -(4\pi)^2\times -\frac{\pi}{4} \qquad \omega_0 = 4\pi\ rad.s^{-1}$

$\alpha = +160\times\frac{\pi}{4} = 40\pi = 125\ rad.s^{-2}$

س7) $E_{tot} = E_p + E_K \Rightarrow$

$E_K = E_{tot} - E_p = \frac{1}{2}K\theta_{max}^2 - \frac{1}{2}K\theta^2$

$= \frac{1}{2}K\theta_{max}^2 - \frac{1}{2}K\left(\frac{\theta_{max}}{\sqrt{5}}\right)^2$

$= \frac{1}{2}K\theta_{max}^2 - \frac{1}{2}K\frac{\theta_{max}^2}{5}$

$= \underset{(5)}{\frac{1}{2}K\theta_{max}^2} - \underset{(1)}{\frac{1}{10}K\theta_{max}^2}$

$= \frac{4}{10}K\theta_{max}^2 = \frac{2}{5}K\theta_{max}^2$

س8)

$$T_0 = 2\pi\sqrt{\frac{I_\Delta}{k}}$$

$$I_{\Delta\,(\text{جملة})} = I_{\Delta\,(\text{ساق})} + I_{\Delta\,(\text{قرص})} \quad ---- (1)$$

$$I_{\Delta\,(\text{قرص})} = \frac{1}{2}M_1R^2 = \frac{1}{2}(0.12)(0.05)^2$$

$$= 0.06 \times 25\times10^{-4} = 150\times10^{-6}$$

$$= 15\times10^{-5}\ kg\,m^2$$

$$I_{\Delta\,(\text{ساق})} = \frac{1}{12}M_2L^2 = \frac{1}{12}\times0.012\times(0.1)^2$$

$$= 1\times10^{-3}\times10^{-2} = 1\times10^{-5}\ kg\,m^2$$

$$I_{\Delta\,(\text{جملة})} = 15\times10^{-5} + 1\times10^{-5} = 16\times10^{-5}\ kg\,m^2$$

$$\Rightarrow T_0 = 2\pi\sqrt{\frac{16\times10^{-5}}{8\times10^{-4}}} = 2\sqrt{2}\ s$$

س9)

$$\omega = -\omega_0\,\theta_{max}\sin(\omega_0 t + \bar\varphi)$$

من التابع θ: نلاحظ أنه $\theta_{max} = \pi\ rad$ ، $\bar\varphi = \pi\ rad$

$\Leftarrow$ $\omega_0 = 2\pi\ rad.s^{-1}$

$$\omega = -2\pi\times\pi\sin(2\pi t + \pi)$$

$$\omega = -20\sin(2\pi t + \pi)$$

لأنه لحظة المرور الأول بوضع التوازن $t = \frac{T_0}{4}\ s$

$$\omega = -20\sin\left(2\pi\times\frac{T_0}{4} + \pi\right)$$

2/

$$\omega = -20\sin\left(\frac{\pi}{2} + \pi\right)$$

$$\omega = -20\sin\left(\frac{3\pi}{2}\right) = 20\ rad.s^{-1}$$

س10)

$$T_0 = 2\pi\sqrt{\frac{I_\Delta}{k}} \qquad K = K'\frac{(2r)^4}{l}$$

لأنه عندما يصبح طول السلك $2l$

$$K^* = \overbrace{K'\frac{(2r)^4}{2l}}^{K} = \frac{K}{2}$$

$\Leftarrow$

$$T_0' = 2\pi\sqrt{\frac{I_\Delta}{\frac{K}{2}}} = 2\pi\sqrt{\frac{2I_\Delta}{K}}$$

$$T_0' = \sqrt{2}\times2\pi\sqrt{\frac{I_\Delta}{K}}$$

$$T_0' = \sqrt{2}\ T_0$$

نشاط (2):

1) ثقل الساق $\vec{w}$ ، توتر السلك $\vec{T}$ ، مزدوجة الفتل $\vec{\Gamma}$

2) السلك - الساق - تمانع (تقاوم)

3) $\Gamma_{\Delta/0} = -K\theta$ - زاوية الفتل - بإشارة

نشاط (3): الجدول صفحة 24 من الكتاب

نشاط (4) 1) لأنه يعمل على إعادة السلك إلى وضع التوازن.

2) لأن الدور لا علاقة له بالسعة الزاوية θ_{max}

3) لأن حامل القوتين تنطبقان على محور الدوران.

نشاط (5)

1) الاستنتاج صفحة 22 من الكتاب

2)

$$T_0 = 2\pi\sqrt{\frac{I_{\Delta/m_1} + I_{\Delta/m_2}}{k}}$$

$$T_0 = 2\pi\sqrt{\frac{2m_1 r_1^2}{k}} = 2\pi\sqrt{\frac{2m_1\left(\frac{\ell}{2}\right)^2}{k}}$$

نربع الطرفين ونستنتج قيمة ℓ :

$$T_0^2 = 40\,\frac{2m_1\frac{\ell^2}{4}}{K} \Rightarrow$$

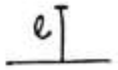
$$\ell^2 = \frac{T_0^2 \times K \times 4}{40 \times 2m_1}$$

$$\ell^2 = \frac{T_0^2 \times k}{20\, m_1} \Rightarrow \ell = T_0\sqrt{\frac{K}{20 m_1}}$$

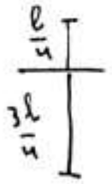
$$\ell = 1\sqrt{\frac{15\times 10^{-2}}{20 \times 75 \times 10^{-3}}}$$

$$\ell = \sqrt{\frac{15 \times 10^{-2}}{1.5}} = \sqrt{\frac{1}{10}} = \frac{1}{\pi}\,m$$

3)



$$K = k'\frac{(2r)^4}{\ell} \qquad T_0 = 2\pi\sqrt{\frac{I_\Delta}{k}} = 1\,s$$



$$K^* = K_1 + K_2 = k'\frac{(2r)^4}{\frac{\ell}{4}} + k'\frac{(2r)^4}{\frac{3\ell}{4}}$$

$$K^* = 4k'\frac{(2r)^4}{\ell} + \frac{4}{3}k'\frac{(2r)^4}{\ell}$$

$$= \underset{(3)}{\frac{4}{1}}k + \underset{(1)}{\frac{4}{3}}k = \frac{16}{3}k$$

$$\Rightarrow T_0' = 2\pi\sqrt{\frac{I_\Delta}{k^*}} = 2\pi\sqrt{\frac{I_\Delta}{\frac{16}{3}k}}$$

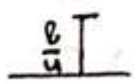
$$T_0' = 2\pi\sqrt{\frac{3}{16}\frac{I_\Delta}{K}}$$

$$T_0' = \frac{\sqrt{3}}{4} \times 2\pi\sqrt{\frac{I_\Delta}{k}} = \frac{\sqrt{3}}{4}T_0$$

نشاط (6):

1)

$$K = k'\frac{(2r)^4}{\ell} \qquad T_0 = 2\pi\sqrt{\frac{I_\Delta}{k}}$$



$$K^* = k'\frac{(2r)^4}{\frac{\ell}{4}} = 4k'\frac{(2r)^4}{\ell} = 4K$$

$$T_0' = 2\pi\sqrt{\frac{I_0}{k^*}} = 2\pi\sqrt{\frac{I_0}{4k}}$$

$$T_0' = \frac{1}{2}\times 2\pi\sqrt{\frac{I_0}{k}} = \frac{1}{2}T_0 = \frac{1}{2}\times 4$$

$$T_0' = 2\,s$$

2) بدون وجود الكتلتين

$$T_0 = 2\pi\sqrt{\frac{I_{0\,\text{ساق}}}{k}}$$

بوجود كتلتين

$$T_0' = 2\pi\sqrt{\frac{I_{0\,\text{ساق}} + I_{0/m_1} + I_{0/m_2}}{k}}$$

$$T_0' = 2\pi\sqrt{\frac{I_{0\,\text{ساق}} + 2m_1 r_1^2}{k}}$$

نقسم العلاقتين:

$$\frac{T_0'}{T_0} = \frac{\cancel{2\pi}\sqrt{\frac{I_{0\,\text{ساق}} + 2m_1 r_1^2}{\cancel{k}}}}{\cancel{2\pi}\sqrt{\frac{I_{0\,\text{ساق}}}{\cancel{k}}}}$$

$$\frac{T_0'}{T_0} = \sqrt{\frac{I_{0\,\text{ساق}} + 2m_1 r_1^2}{I_{0\,\text{ساق}}}} = \sqrt{1 + \frac{2m_1 r_1^2}{I_{0\,\text{ساق}}}}$$

$$T_0' = T_0\sqrt{1 + \frac{2m_1 r_1^2}{I_{0\,\text{ساق}}}} \qquad r = \frac{l}{2}$$

$$T_0' = \frac{1}{2}\sqrt{1 + \frac{2\times 20\times 10^{-3}\times\left(\frac{3}{4}\right)^2}{\frac{3}{4}\times 10^{-2}}}$$

$$= \frac{1}{2}\sqrt{1 + \frac{40\times 10^{-3}\times\frac{3}{4}}{10^{-2}}}$$

$$T_0' = \frac{1}{2}\sqrt{1+3} = \frac{1}{2}\sqrt{4} = 1\,s$$

3)

$$T_0 = 2\pi\sqrt{\frac{I_{0\,\text{ساق}} + I_{0/m_1} + I_{0/m_2}}{k}}$$

$$T_0 = 2\pi\sqrt{\frac{0 + 2m_1 r_1^2}{k}}$$

$$T_0 = 2\pi\sqrt{\frac{2m_1 r_1^2}{k}}$$

$$T_0' = 2\pi\sqrt{\frac{2m_1 r_1'^2}{k}}$$

$$\frac{T_0'}{T_0} = \frac{\cancel{2\pi}\sqrt{\frac{2m_1 r_1'^2}{\cancel{k}}}}{\cancel{2\pi}\sqrt{\frac{2m_1 r_1^2}{\cancel{k}}}}$$

$$\frac{T_0'}{T_0} = \sqrt{\frac{r_1'^2}{r_1^2}} = \frac{r_1'}{r_1}$$

$$T_0' = T_0\times\frac{r_1'}{r_1} = 2\times\frac{1\times 10^{-2}}{5\times 10^{-2}} = \frac{2}{5} = 0.4\,s$$

نشاط (٦

1)

$$E_{tot} = E_p + E_K$$

$$\frac{1}{2} K \theta_{max}^2 = \frac{1}{2} K \theta^2 + \frac{1}{2} I_0 \omega^2$$

نشتق طرفي العلاقة بالنسبة للزمن

$$0 = \frac{1}{2} K \, 2 \theta \theta' + \frac{1}{2} I_0 \, 2 \omega \omega'$$

$$0 = K \theta \omega + I_0 \omega \alpha$$

$$0 = \omega (K\theta + I_0 \alpha)$$ $\omega \neq 0$ لأن

$$K \theta + I_0 (\theta)''_t = 0 \Rightarrow$$

$$(\theta)''_t = -\frac{K}{I_0} \theta \qquad (1)$$

وهي معادلة تفاضلية من المرتبة الثانية تقبل حلاً جيبياً من الشكل

$$\bar{\theta} = \theta_{max} \cos(\omega_0 t + \bar{\varphi}) \qquad (2)$$

نشتق المعادلة (2) مرتين بالنسبة للزمن

$$(\theta)'_t = -\omega_0 \theta_{max} \sin(\omega_0 t + \bar{\varphi})$$

$$(\theta)''_t = -\omega_0^2 \theta_{max} \cos(\omega_0 t + \bar{\varphi})$$

$$(\theta)''_t = -\omega_0^2 \theta \quad \dots (3)$$

بمقارنة (1) و (3):

$$-\omega_0^2 \theta = -\frac{K}{I_0} \bar{\theta} \Rightarrow$$

$$\omega_0^2 = \frac{K}{I_0} \Rightarrow \omega_0 = \sqrt{\frac{K}{I_0}} > 0$$

وهذا محقق لأن K ، I_0 موجبتان دوماً

$$\frac{2\pi}{T_0} = \sqrt{\frac{K}{I_0}} \Rightarrow$$

$$T_0 = 2\pi \sqrt{\frac{I_0}{K}}$$

و حركة نواس الفتل حركة جيبية انسحابية دورانية بسيطة

2)

$$\omega_0 = \sqrt{\frac{K}{I_0}} \Rightarrow \omega_0^2 = \frac{K}{I_0}$$

$$\Rightarrow K = \omega_0^2 I_0$$

3)

$$T_{0_1} = 2\pi \sqrt{\frac{I_0}{K_1}} = 2\pi \sqrt{\frac{I_0}{K' \frac{(2r)^4}{\ell_1}}}$$

$$T_{0_1} = 2\pi \sqrt{\frac{I_0 \times \ell_1}{K' (2r)^4}}$$

$$T_{0_1} = const \sqrt{\ell_1}$$

$$T_{0_2} = const \sqrt{\ell_2}$$

$$\frac{T_{0_2}}{T_{0_1}} = \frac{const \sqrt{\ell_2}}{const \sqrt{\ell_1}} \Rightarrow \frac{T'_{0_2}}{T'_{0_1}} = \sqrt{\frac{\ell_2}{\ell_1}}$$

$$\frac{4 T_{0_1}}{T_0} = \sqrt{\frac{\ell_2}{\ell_1}} \Rightarrow 16 = \frac{\ell_2}{\ell_1} \Rightarrow$$

$$\ell_2 = 16 \ell_1$$

نشاط 8) 1،

عزم عطالة نقطة مادية $I_0 = m r^2$

عزم عطالة قرص متجانس $I_{0/c} = \frac{1}{2} m r^2$

عزم عطالة ساق متجانسة $I_{0/c} = \frac{1}{12} m L^2$

2) بدون وجود كتلتين

$$T_0 = 2\pi\sqrt{\frac{I_{0\,\text{ساق}}}{k}}$$

بوجود كتلتين

$$T_0' = 2\pi\sqrt{\frac{I_{0\,\text{ساق}} + 2 m_1 r_1^2}{k}}$$

نشاط (9):

1) $\omega = -\omega_0 \theta_{max} \sin(\omega_0 t + \bar{\varphi})$

واضح من الشكل أنه: $2T_0 = 8\,s \Rightarrow$

$T_0 = 4\,s \Rightarrow \omega_0 = \frac{2\pi}{T_0} = \frac{2\pi}{4} = \frac{\pi}{2}\ rad.s^{-1}$

من الشكل: $\mp \omega_0 \theta_{max} = \mp \frac{\pi^2}{4} \Rightarrow$

$$\theta_{max} = \frac{\frac{\pi^2}{4}}{\omega_0} = \frac{\frac{\pi^2}{4}}{\frac{\pi}{2}} = \frac{2\pi^2}{4\pi} = \frac{\pi}{2}\ rad.s^{-1}$$

حساب $\bar{\varphi}$ من شروط البدء:

$\left.\begin{matrix} t=0 \\ \omega=0 \end{matrix}\right\} \Rightarrow \omega = -\omega_0 \theta_{max} \sin(\omega_0 t + \bar{\varphi})$

$0 = -\omega_0 \theta_{max} \sin\bar{\varphi}$

لأنه $\theta_{max} \neq 0$ $\omega_0 \neq 0$

$\Rightarrow \sin\bar{\varphi} = 0 \Rightarrow \bar{\varphi} = \left\langle \begin{matrix} 0 \\ \pi \end{matrix} \right.\ rad$

نختار الحل الذي يجعل السرعة سالبة بعد ربع دور

$\varphi = 0 \Rightarrow \omega = -\frac{\pi^2}{4}\sin\left(\frac{\pi}{2} \times \frac{T_0}{4} + 0\right)$

حل مقبول

$\omega = -\frac{\pi^2}{4}\sin\frac{\pi}{2} = -\frac{\pi^2}{4}\ rad.s^{-1}$

$\varphi = \pi \Rightarrow \omega = -\frac{\pi^2}{4}\sin\left(\frac{\pi}{2} \times \frac{T_0}{4} + \frac{\pi}{2}\right)$

حل مرفوض

$\omega = -\frac{\pi^2}{4}\sin\left(\frac{\pi}{2} + \frac{\pi}{2}\right) = -\frac{\pi^2}{4}\sin\pi$

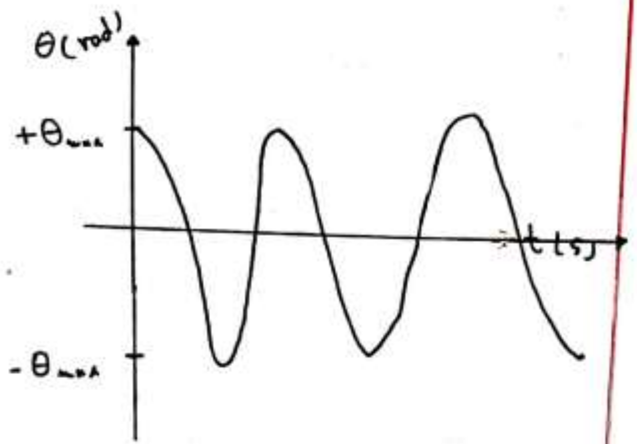
$\omega = 0\ rad.s^{-1}$

$\Rightarrow \omega = -\frac{\pi^2}{4}\sin\left(\frac{\pi}{2}t\right)$

2) دور النواس بوجود الكتلتين

$$T_0 = 2\pi\sqrt{\frac{2 m_1 r_1^2}{K}}$$

بازدياد البعد بين الكتلتين يزداد دور النواس



نشاط (10):

$\alpha\,(rad\,s^{-2})$ ، $\Gamma_{\vec{F}/\Delta}\,(m.N)$ ،

$K\,(m.N.rad^{-1})$ ، $E_p\,(J)$ ، $\omega\,(rad.s^{-1})$

$I_\Delta\,(kg.m^2)$

نشاط (11):

1) يتناسب دور النواس طرداً مع الجذر التربيعي لعزم عطالة جملة النواس

يتناسب دور النواس عكساً مع الجذر التربيعي لثابت فتل السلك

لا علاقة للدور بالسعة الزاوية θ_{max}

2) إنقاص طول سلك الفتل بشكل مناسب.

3) جسم صلب متجانس (ساق أو قرص) معلق من مركزه يتزن في مستوٍ أفقي حول سلك فتل شاقولي ثابتة فتله K بتأثير عزم مزدوجة الفتل.

حركة النواس حركة جيبية دورانية توافقية بسيطة

4)

$$K = \omega_0^2 I_\Delta$$

$$K = \left(\frac{2\pi}{T_0}\right)^2 \times I_\Delta = \left(\frac{2\pi}{1}\right)^2 \times 2\times10^{-3}$$

$$K = 40\times2\times10^{-3} = 8\times10^{-2}\ m\,N\,rad^{-1}$$

المسألة الأولى:

1)

$$T_0 = 2\pi\sqrt{\frac{I_{\Delta/rod}+I_{\Delta/m_1}+I_{\Delta/m_2}}{K}}$$

$$T_0 = 2\pi\sqrt{\frac{0 + m_1 r_1^2 + m_2 r_2^2}{K}}$$

$$T_0 = 2\pi\sqrt{\frac{2 m_1 r_1^2}{K}} \qquad r = \frac{l}{2}$$

$$T_0 = 2\pi\sqrt{\frac{2\times0.2\times(0.1)^2}{0.1}}$$

$$T_0 = 2\pi\sqrt{4\times10^{-2}} = 2\pi\times2\times10^{-1}$$

$$T_0 = 0.4\pi\ s = 1.256\ s$$

لا علاقة للدور بالسعة الزاوية θ_{max} لأنه لا يوجد في علاقة الدور سعة زاوية θ_{max}

2)

$$\bar\theta = \theta_{max}\cos(\omega_0 t + \bar\varphi)$$

نحسب الثوابت: ω_0 ، θ_{max} ، $\bar\varphi$:

$$\omega_0 = \frac{2\pi}{T_0} = \frac{2\pi}{0.4\pi} = \frac{20}{4} = 5\ rad.s^{-1}$$

$$\theta_{max} = 1\ rad$$

حساب $\bar\varphi$ من شروط البدء:

$$\left.\begin{matrix} t=0 \\ \theta=\theta_{max} \end{matrix}\right\} \quad \bar\theta = \theta_{max}\cos(\omega_0 t + \bar\varphi)$$

$$\theta_{max} = \theta_{max}\cos\bar\varphi$$

$$\cos\bar\varphi = 1 \Rightarrow \bar\varphi = 0\ rad$$

$$\Rightarrow \bar\theta = 1\cos 5t$$

(3

$$\omega_{max} = \left|\mp \omega_0 \theta_{max}\right|$$
$$= 5 \times 1 = 5\ rad.s^{-1}$$

(4

$$\alpha = -\omega_0^2 \theta = -(5)^2 \times -\theta_{max}$$
$$= -(5)^2 \times -1 = +25\ rad.s^{-2}$$

(5

$$E_p = \frac{1}{2} K \theta_{max}^2 = \frac{1}{2}(0.1)(1)^2$$
$$= 0.05\ J$$

المسألة الثانية: (1

$$\bar{\theta} = \theta_{max} \cos(\omega_0 t + \bar{\varphi})$$

نحسب الثوابت ω_0 ، θ_{max} ، $\bar{\varphi}$:

$$\omega_0 = \frac{2\pi}{T_0} = \frac{2\pi}{1} = 2\pi\ rad.s^{-1}$$

بدءاً:

$$\left.\begin{matrix} t=0 \\ \omega=0 \end{matrix}\right\} \theta = \theta_{max} = \frac{\pi}{2}\ rad.$$

حساب $\bar{\varphi}$ من شروط البدء:

$$\left.\begin{matrix} t=0 \\ \theta=\theta_{max} \end{matrix}\right\} \begin{matrix} \bar{\theta} = \theta_{max}\cos(\omega_0 t + \bar{\varphi}) \\ \theta_{max} = \theta_{max}\cos\bar{\varphi} \Rightarrow \end{matrix}$$

$$\cos\bar{\varphi} = 1 \Rightarrow \bar{\varphi} = 0\ rad$$

$$\bar{\theta} = \frac{\pi}{2}\cos 2\pi t$$

(2

$$\omega = -\omega_0 \theta_{max} \sin(\omega_0 t + \bar{\varphi})$$

$$\omega = -2\pi \times \frac{\pi}{2} \sin(2\pi t)$$

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$$\omega = -10 \sin 2\pi t$$

لحظة المرور الأول بوضع التوازن

$$t = \frac{T_0}{4} = \frac{1}{4} s \Rightarrow$$

$$\omega = -10 \sin 2\pi \times \frac{1}{4} = -10 \sin\frac{\pi}{2}$$

$$\omega = -10\ rad.s^{-1}$$

$$E_k = \frac{1}{2} I_0 \omega^2 = \frac{1}{2} \times 2\times10^{-3} \times (-10)^2$$

$$E_k = 0.1\ J$$

(3

$$\alpha = -\omega_0^2 \theta = -(2\pi)^2 \times -\frac{\pi}{4}$$

$$\alpha = 40 \times \frac{\pi}{4} = 10\pi\ rad.s^{-2}$$

4) الدور بدون وجود كتلتين

$$T_0 = 2\pi\sqrt{\frac{I_{0\,\text{ساق}}}{K}}$$

الدور بوجود كتلتين

$$T_0' = 2\pi\sqrt{\frac{I_{0\,\text{ساق}} + I_{0/m_1} + I_{0/m_2}}{K}}$$

$$T_0' = 2\pi\sqrt{\frac{I_{0\,\text{ساق}} + 2 m_1 r_1^2}{K}}$$

$$\frac{T_0'}{T_0} = \frac{\cancel{2\pi}\sqrt{\frac{I_{0\,\text{ساق}} + 2m_1 r_1^2}{\cancel{K}}}}{\cancel{2\pi}\sqrt{\frac{I_{0\,\text{ساق}}}{\cancel{K}}}}$$

$$\frac{T_0'}{T_0} = \sqrt{\frac{I_{0\,\text{ساق}} + 2m_1 r_1^2}{I_{0\,\text{ساق}}}}$$

9/

$r = \frac{\ell}{2}$

$$T_0' = T_0 \sqrt{1 + \frac{2 m_1 r_1^2}{I_{0_{\text{جل}}}}}$$

$$T_0' = 1 \sqrt{1 + \frac{2 \times 20 \times 10^{-3} \times (\frac{1}{2})^2}{2 \times 10^{-3}}}$$

$$T_0' = \sqrt{1 + 5} = \sqrt{6}\ s$$

حساب k:

$$K = \omega_0^2 I_0 = \left(\frac{2\pi}{T_0}\right)^2 I_0$$

$$K = \left(\frac{2\pi}{1}\right)^2 \times 2 \times 10^{-3} = 40 \times 2 \times 10^{-3}$$

$$= 8 \times 10^{-2}\ m\,N\,rad^{-1}$$

المسألة الثالثة:

1)
$$T_0 = 2\pi \sqrt{\frac{I_0}{K}} = 2\pi \sqrt{\frac{2 \times 10^{-3}}{8 \times 10^{-2}}}$$

$$T_0 = 2\pi \sqrt{\frac{1 \times 10^{-1}}{4 \times 1}} = 2\pi \sqrt{\frac{1}{40}}$$

$$T_0 = 2\pi \sqrt{\frac{1}{4\pi^2}} = 1\ s$$

2)
$$\bar{\theta} = \theta_{max} \cos(\omega_0 t + \bar{\varphi})$$

حساب الثوابت ω_0 ، θ_{max} ، $\bar{\varphi}$:

$$\omega_0 = \frac{2\pi}{T_0} = \frac{2\pi}{1} = 2\pi\ rad.s^{-1}$$

بدأ:

$$\left.\begin{array}{l} t = 0 \\ \omega = 0 \end{array}\right\} \theta = \theta_{max} = \frac{\pi}{2}\ rad$$

حساب $\bar{\varphi}$:

$$\left.\begin{array}{l} t = 0 \\ \theta = \theta_{max} \end{array}\right\} \begin{array}{l} \theta = \theta_{max} \cos(\omega_0 t + \bar{\varphi}) \\ \theta_{max} = \theta_{max} \cos\bar{\varphi} \end{array}$$

$$\cos\bar{\varphi} = 1 \Rightarrow \bar{\varphi} = 0\ rad$$

$$\Rightarrow \bar{\theta} = \frac{\pi}{2} \cos(2\pi t)$$

3)
$$E_p = \frac{1}{2} k \theta^2$$

$$= \frac{1}{2} \times 8 \times 10^{-2} \times \left(\frac{\pi}{4}\right)^2$$

$$= 4 \times 10^{-2} \times \frac{10}{16} = \frac{10}{4} \times 10^{-2}\ J$$

$$= 2.5 \times 10^{-2}\ J$$

$$E = \frac{1}{2} K \theta_{max}^2 = \frac{1}{2} \times 8 \times 10^{-2} \times \left(\frac{\pi}{2}\right)^2$$

$$= 4 \times 10^{-2} \times \frac{10}{4} = 10 \times 10^{-2}\ J$$

$$E_k = E - E_p = 10 \times 10^{-2} - 2.5 \times 10^{-2}$$

$$= 7.5 \times 10^{-2}\ J$$

4)

ℓ

$$K = K' \frac{(2r)^4}{\ell} \qquad T_0 = 2\pi \sqrt{\frac{I_0}{K}}$$

$\frac{\ell}{2}$

$$K^* = K' \frac{(2r)^4}{\frac{\ell}{2}} \qquad T_0' = 2\pi \sqrt{\frac{I_0}{K^*}}$$

$$K^* = 2K' \frac{(2r)^4}{\ell} = 2K$$

$$\Rightarrow T_0' = 2\pi \sqrt{\frac{I_0}{2K}} = \frac{1}{\sqrt{2}} \times 2\pi \sqrt{\frac{I_0}{K}} = \frac{1}{\sqrt{2}} T_0 = \frac{1}{\sqrt{2}} \times 1 = \frac{1}{\sqrt{2}}\ s$$

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أ. $T_o' = T_o - 1.25 = 6.25 - 1.25$

$T_o' = 5\ s$

$$T_o' = 2\pi\sqrt{\frac{I_{o_{\text{قضيب}}} + 2m_1 r_1'^2}{K}}$$

$$5 = 2\pi\sqrt{\frac{2\times10^{-2} + 2\times0.75\, r_1'^2}{8\times10^{-2}}}$$

$$5 = 2\pi\sqrt{\frac{2\times10^{-2} + 1.5\, r_1'^2}{8\times10^{-2}}}$$

نربع الطرفين

$$25 = 40\,\frac{2\times10^{-2} + 1.5\, r_1'^2}{8\times10^{-2}}$$

$$\frac{25\times8\times10^{-2}}{40} = 2\times10^{-2} + 1.5\, r_1'^2$$

$$5\times10^{-2} - 2\times10^{-2} = 1.5\, r_1'^2$$

$$3\times10^{-2} = 1.5\, r_1'^2 \Rightarrow$$

$$r_1'^2 = 2\times10^{-2} \Rightarrow r_1 = 0.1\sqrt{2} \simeq 0.14\,m$$

15) $I_o = \frac{1}{2} m r^2 \Rightarrow 2I_o = m r^2$

$$m = \frac{2I_o}{r^2} = \frac{2\times2\times10^{-3}}{(0.2)^2} = \frac{4\times10^{-3}}{4\times10^{-2}}$$

$m = 0.1\ Kg$

المسألة الرابعة:

1) $T_o = 2\pi\sqrt{\frac{I_o}{K}}$

$I_{o_{\text{جملة}}} = I_{o_{\text{قرص}}} + I_{o/m_1} + I_{o/m_2}$

$I_{o_{\text{جملة}}} = \frac{1}{2} m r^2 + 2m_1 r_1^2$

$= \frac{1}{2}(1)(20\times10^{-2})^2 + 2\times0.75\times(20\times10^{-2})^2$

$= \frac{1}{2}\times400\times10^{-4} + 1.5\times400\times10^{-4}$

$= 2\times10^{-2} + 6\times10^{-2}$

$= 8\times10^{-2}\ kg.m^2$

$$T_o = 2\pi\sqrt{\frac{8\times10^{-2}}{8\times10^{-2}}} = 2\pi\ s$$

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