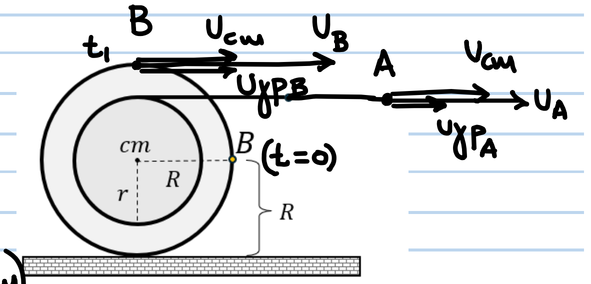
Λύσεις διαγωνίσματος φυσικής Γ' λυκείου 4/9/2024

ΘΕΜΑ Α

A1 – α A2 – β A3 – β A4 – δ A5 – Σ Λ Λ Λ Λ

ΘΕΜΑ Β

$\boxed{B1\ \ I-β,\ II-α}$



I) t_1: $\vec{υ}_B = \vec{υ}_{cm} + \vec{υ}_{γρB}$

$υ_B = υ_{cm} + υ_{γρB}$ (και $υ_{γρB} = Rω = υ_{cm}$)

$υ_B = 2υ_{cm} \Rightarrow υ_{cm} = \frac{υ_B}{2}$ (1)

$\vec{υ}_A = \vec{υ}_{cm} + \vec{υ}_{γρA}$

$υ_A = υ_{cm} + υ_{γρA}$ όπου $υ_{γρA} = rω = 0,6Rω = 0,6υ_{cm}$

$υ_A = 1,6υ_{cm} \xRightarrow{(1)} υ_A = 1,6\frac{υ_B}{2} \Rightarrow υ_B = \frac{υ_A}{0,8} \Rightarrow \boxed{υ_B = 1,25υ_A}$ (β)

II) Για τη μετατόπιση του σημείου Α ισχύει:

$Δx_A = Δx_{cm} + Δ\ell_{νημ} = Rθ + rθ = Rθ + 0,6Rθ = 1,6Rθ$

όμως $θ = \frac{3π}{2} rad \rightarrow Δx_A = 1,6R\frac{3π}{2} \Rightarrow \boxed{Δx_A = 2,4πR}$ (α)

ή $υ_A = 1,6υ_{cm} \rightarrow \frac{dυ_A}{dt} = 1,6\frac{dυ_{cm}}{dt} \Rightarrow α_A = 1,6α_{cm}$

$Δx_A = \frac{1}{2}α_A Δt^2 = \frac{1}{2}1,6α_{cm}Δt^2 = 1,6\frac{1}{2}α_{cm}Δt^2 = 1,6Δx_{cm}$

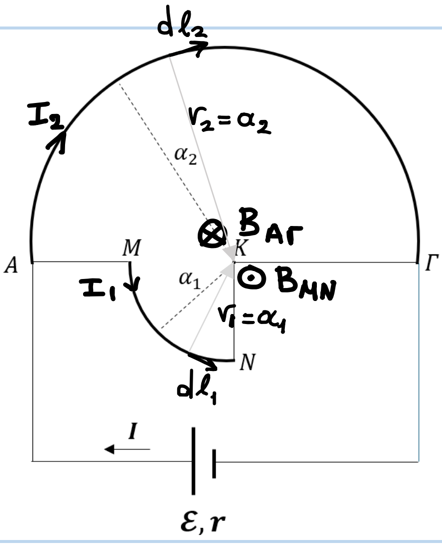
$Δx_A = 1,6Δx_{cm} = 1,6RΔθ = 1,6R\frac{3π}{2} \Rightarrow \boxed{Δx_A = 2,4πR}$ (α)

$\boxed{B2 - α}$ $R_1 = R$, $R_2 = 4R$ $\mathcal{E}, r$

$R_{1,2} = \frac{R_1 R_2}{R_1 + R_2} = \frac{4R^2}{5R} = 0,8R$

$R_{ολ} = r + R_{1,2}$

$I = \frac{\mathcal{E}}{R_{ολ}}$



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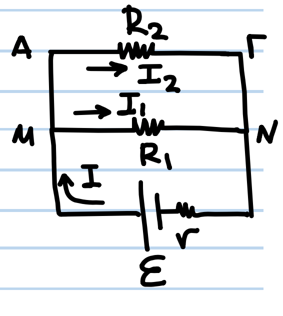


$V_{R_1} = V_{R_2} \Rightarrow I_1 R_1 = I_2 R_2$

$I_1 R = 4I_2 R \Rightarrow I_1 = 4I_2$

Ισχύει $I = I_1 + I_2 = 5I_2 \Rightarrow I_2 = \frac{I}{5}, \; I_1 = \frac{4}{5}I$

$$B_{A\Gamma} = B_2 = \sum dB_{A\Gamma} = \sum \frac{\mu_0}{4\pi}\frac{I_2\, dl_2}{r_2^2} = \frac{\mu_0 I_2}{4\pi r_2}\sum dl_2 = \frac{\mu_0 I_2}{4\pi r_2^2}\pi r_2 = \frac{\mu_0 I_2}{4 r_2}$$

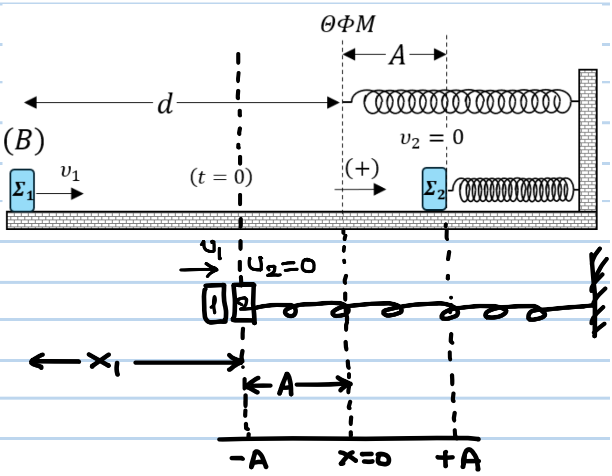
$$B_{MN} = B_1 = \sum dB_{MN} = \sum \frac{\mu_0}{4\pi}\frac{I_1\, dl_1}{r_1^2} = \frac{\mu_0 I_1}{4\pi r_1}\sum dl_1 = \frac{\mu_0 I_1}{4\pi r_1^2}\frac{\pi}{2} r_1 = \frac{\mu_0 I_1}{8 r_1}$$

όπου $r_2 = \alpha_2 = 2\alpha, \; I_2 = \frac{I}{5} \rightarrow B_{A\Gamma} = \frac{\mu_0 I/5}{4\cdot 2\alpha} \Rightarrow B_{A\Gamma} = \frac{\mu_0 I}{40\alpha} \otimes$

$r_1 = \alpha_1 = \alpha, \; I_1 = \frac{4I}{5} \rightarrow B_{MN} = \frac{\mu_0 4I/5}{8\cdot\alpha} \Rightarrow B_{MN} = \frac{4\mu_0 I}{40\alpha} \odot$

$$\underset{}{\vec{B}_K} = \underset{\odot}{\vec{B}_{MN}} + \underset{\otimes}{\vec{B}_{A\Gamma}} \longrightarrow B_K = \frac{4\mu_0 I}{40\alpha} - \frac{\mu_0 I}{\alpha} \Rightarrow \boxed{B_K = \frac{3\mu_0 I}{40\alpha}} \; (\alpha)$$

$\boxed{\text{B3 I-β, II-γ}}$



I) Τα σώματα κινούνται ταυτόχρονα για χρονικό διάστημα $\Delta t = \frac{3T}{2}$

Ισχύει $d = x_1 + A = u_1 \Delta t + A$

$\Rightarrow d = 2u_{max}\Delta t + A = 2\omega A\cdot\Delta t + A$

$\Rightarrow d = 2\frac{2\pi}{T}A\frac{3T}{2} + A$

$\Rightarrow d = 6\pi A + A \Rightarrow \boxed{d = (6\pi + 1)A} \; (\beta)$

II) Κεντρική ελαστική κρούση στην ακραία θέση της ατ του σώματος Σ_2, άρα $\upsilon_2 = 0$

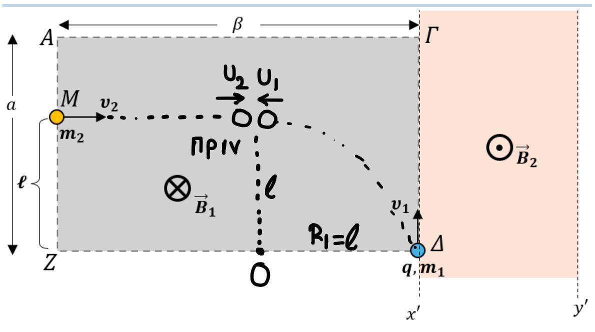
$$\upsilon_2' = \frac{2m_1}{m_1+m_2}\upsilon_1 = \frac{2m}{4m}2\omega A \Rightarrow \upsilon_2' = \omega A$$

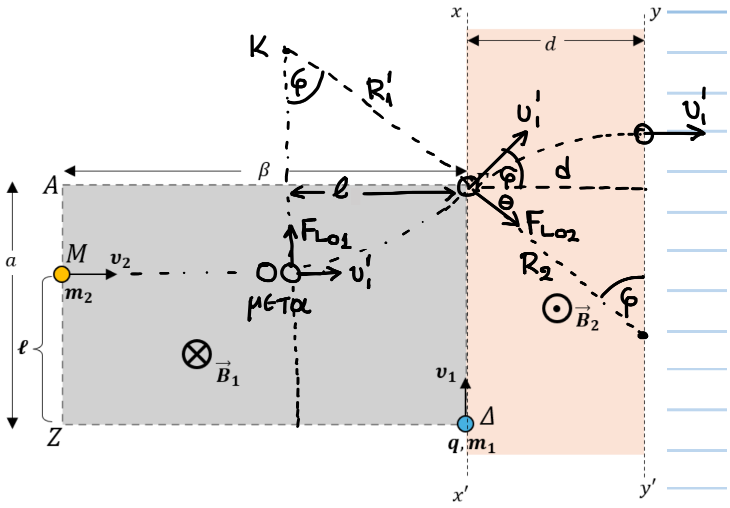
Ισχύει $E' = K + U \Rightarrow \frac{1}{2}kA'^2 = \frac{1}{2}m_2\upsilon_2'^2 + \frac{1}{2}kA^2$

$A'^2 = \frac{m_2}{k}\upsilon_2'^2 + A^2$ όπου $D = k = m_2\omega^2 \Rightarrow \frac{m_2}{k} = \frac{1}{\omega^2}$

$A'^2 = \frac{1}{\omega^2}\omega^2 A^2 + A^2 = 2A^2 \Rightarrow \boxed{A' = \sqrt{2}A} \; (\gamma)$

ΘΕΜΑ Γ





Γ1) Το αφόρτιστο σωματίδιο δε δέχεται δύναμη από το πεδίο έντασης $\vec{B}_1$: $\boxed{F_{Lo2} = 0}$

Το τρίτιο έχει φορτίο $q = +e = +1{,}6\cdot 10^{-19}$ και μάζα $m_1 = 3m$

$\Rightarrow m_1 = 3\cdot 1{,}6\cdot 10^{-27}\,kg$ και δέχεται από το πεδίο $\vec{B}_1$ δύναμη

Lorentz : $F_{Lo1} = B_1 v_1 q = 10^{-2}\cdot 2\sqrt{2}\cdot 10^4\cdot 1{,}6\cdot 10^{-19}\,N \Rightarrow \boxed{F_{Lo1} = 3{,}2\sqrt{2}\cdot 10^{-17}\,N}$

Γ2) Κεντρική ελαστική κρούση

$$v_1' = \frac{m_1 - m_2}{m_1 + m_2} v_1 + \frac{2m_2}{m_1 + m_2} v_2 \quad (\overset{+}{\leftarrow})$$

$$-4\sqrt{2}\cdot 10^4 = \frac{m_1 - m_2}{m_1 + m_2}\, 2\sqrt{2}\cdot 10^4 + \frac{2m_2}{m_1 + m_2}\left(-10\sqrt{2}\cdot 10^4\right)$$

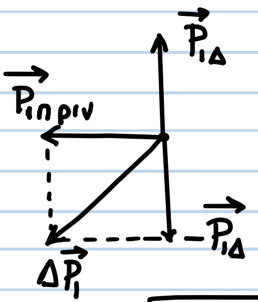
$$-2 = \frac{m_1 - m_2}{m_1 + m_2} - \frac{10m_2}{m_1 + m_2} \Rightarrow -2m_1 - 2m_2 = m_1 - 11m_2$$

$$3m_1 = 9m_2 \Rightarrow m_2 = \frac{m_1}{3} = \frac{3m}{3} \Rightarrow \boxed{m_2 = m = 1{,}6\cdot 10^{-27}\,kg} \text{ (νετρόνιο)}$$

Ισχύει $v_1 + v_1' = v_2' + v_2 \quad (\overset{+}{\leftarrow})$

$$2\sqrt{2}\cdot 10^4 - 4\sqrt{2}\cdot 10^4 = v_2' - 10\sqrt{2}\cdot 10^4 \Rightarrow \boxed{v_2' = 8\sqrt{2}\cdot 10^4\,m/s}$$

Γ3) $\Delta\vec{P}_1 = \vec{P}_{1\pi\rho\iota\nu} - \vec{P}_{1\Delta} = \vec{P}_{1\pi\rho\iota\nu} + (-\vec{P}_{1\Delta})$



$P_{1\pi\rho\iota\nu} = P_{1\Delta} = m_1 v_1$

$$|\Delta\vec{P}_1| = \sqrt{P_{1\pi\rho\iota\nu}^2 + P_{1\Delta}^2} = \sqrt{(m_1 v_1)^2 + (m_1 v_1)^2}$$

$$|\Delta\vec{P}_1| = \sqrt{2}\, m_1 v_1 = \sqrt{2}\cdot 3\cdot 1{,}6\cdot 10^{-27}\cdot 2\sqrt{2}\cdot 10^4\ kg\,m/s \Rightarrow \boxed{|\Delta\vec{P}_1| = 19{,}2\cdot 10^{-23}\ kg\,m/s}$$

Γ4) Μετά την κρούση: $R_1' = \dfrac{m_1 v_1'}{B_1 q_1} = \dfrac{3\cdot 1{,}6\cdot 10^{-27}\cdot 4\sqrt{2}\cdot 10^{4}}{10^{-2}\cdot 1{,}6\cdot 10^{-19}}\, m$

$$R_1' = 12\sqrt{2}\cdot 10^{-2}\, m = 12\sqrt{2}\, cm$$

Εντός του ομπ $\vec{B}_1$ διαγράφει γωνία φ για την οποία ισχύει:

$$\eta\mu\varphi = \frac{\ell}{R_1} = \frac{6\sqrt{2}}{12\sqrt{2}} = \frac{1}{2} \longrightarrow \varphi = \pi/6\ rad$$

Ισχύει $\varphi = \omega_1 \Delta t \Rightarrow \dfrac{\pi}{6} = \dfrac{2\pi}{T_1}\Delta t \Rightarrow \Delta t = \dfrac{T_1}{12} = \dfrac{1}{12}\,\dfrac{2\pi m_1}{B_1 q_1}$

$$\Rightarrow \Delta t = \frac{1}{6}\,\frac{\pi\cdot 3\cdot 1{,}6\cdot 10^{-27}}{10^{-2}\cdot 1{,}6\cdot 10^{-19}}\ sec \Rightarrow \boxed{\Delta t = \frac{\pi}{2}\cdot 10^{-6} sec = 5\pi\cdot 10^{-7} sec}$$

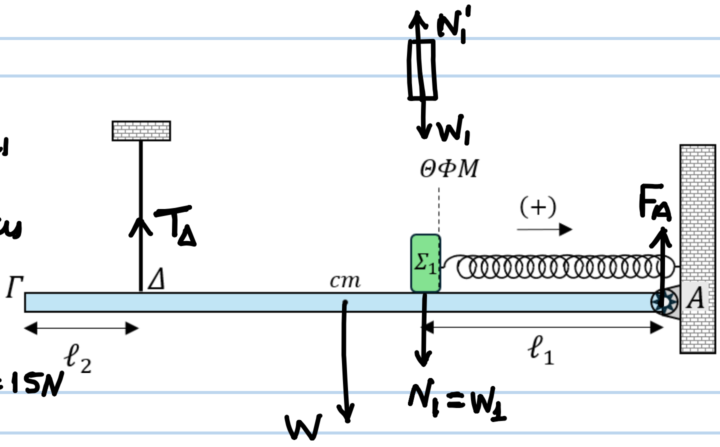
Γ5) α) $\boxed{W_{F_{L_{o2}}} = 0}$ αφού $\vec{F}_{L_{o2}} \perp \vec{v}_1'$

β) Ισχύει $R_2 = \dfrac{m_1 v_1'}{B_2 q_1}$

$$\eta\mu\varphi = \frac{d}{R_2} \Rightarrow \frac{1}{2} = \frac{d}{R_2} \Rightarrow R_2 = 2d \Rightarrow \frac{m_1 v_1'}{B_2 q_1} = 2d \Rightarrow B_2 = \frac{m_1 v_1'}{2 q_1 d}$$

$$\Rightarrow B_2 = \frac{3\cdot 1{,}6\cdot 10^{-27}\cdot 4\sqrt{2}\cdot 10^{4}}{2\cdot 1{,}6\cdot 10^{-19}\cdot 5\sqrt{2}\cdot 10^{-2}}\ T \Rightarrow \boxed{B_2 = 1{,}2\cdot 10^{-2}\, T}$$

ΘΕΜΑ Δ



Δ1) Στο σώμα $Σ_1$ ασκούνται το βάρος του $\vec{W}_1$ και η κάθετη δύναμη $\vec{N}_1'$ από τη δοκό.

Ισχύει $\Sigma F_{1y} = 0 \Rightarrow N_1' = W_1 = m_1 g = 15N$

Στη δοκό ασκούνται το βάρος της $\vec{W}$ ($W = Mg = 20N$), η τάση νήματος $\vec{T}_\Delta$ η κάθετη δύναμη $\vec{N}_1$ από το σώμα (αντίδραση της $N_1' \to N_1' = N_1 = 15N$) και η δύναμη $\vec{F}_A$ από την άρθρωση.

Ισχύουν: $\Sigma\tau_A = 0 \Rightarrow \tau_W + \tau_{N_1} - \tau_{T_\Delta} = 0 \Rightarrow W\dfrac{\ell}{2} + N_1 \ell_1 = T_\Delta(\ell - \ell_2)$

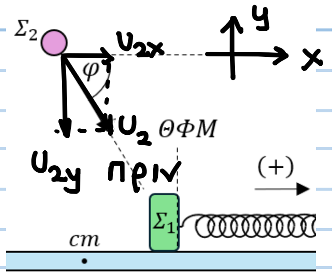
$$20\frac{5}{2} + 15\cdot 2 = T_\Delta \cdot 4 \Rightarrow \boxed{T_\Delta = 20N}$$

και $\Sigma F_y = 0 \Rightarrow T_\Delta + F_A = W + N_1 \Rightarrow 20 + F_A = 20 + 15 \Rightarrow \boxed{F_A = 15N}$

Δ2) ΑΔΟ x : $\vec{P}_{x\pi\rho\iota\nu} = \vec{P}_{x\mu\varepsilon\tau\alpha} \Rightarrow P_{2x} = P_{\kappa}$

$\Rightarrow m_2 U_{2x} = m_{o\lambda} U_{\kappa} \Rightarrow m_2 U_2 \sigma\upsilon\nu\varphi = (m_1 + m_2) U_{\kappa}$

$\Rightarrow U_{\kappa} = \dfrac{m_2 U_2 \sigma\upsilon\nu\varphi}{m_1 + m_2} = \dfrac{0{,}5 \cdot 20 \cdot 1/2}{2}\, m/s \Rightarrow \boxed{U_{\kappa} = 2{,}5\, m/s}$

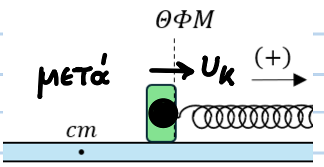


Δ3) $K_{\pi\rho\iota\nu} = \frac{1}{2} m_2 U_2^2 = \frac{1}{2} 0{,}5 \cdot 400\, J = 100\, J$

$K_{\mu\varepsilon\tau\alpha} = \frac{1}{2}(m_1 + m_2) U_{\kappa}^2 = \frac{1}{2} 2 \cdot 6{,}25\, J = 6{,}25\, J$

ΑΔΕ στην κρούση: $E_{o\lambda\,\pi\rho\iota\nu} = E_{o\lambda\,\mu\varepsilon\tau\alpha}$

$K_{\pi\rho\iota\nu} = K_{\mu\varepsilon\tau\alpha} + E_{\alpha\pi\omega\lambda\varepsilon\iota\acute{\omega}\nu}$



$E_{\alpha\pi\omega\lambda\varepsilon\iota\acute{\omega}\nu} = K_{\pi\rho\iota\nu} - K_{\mu\varepsilon\tau\alpha} = 100\, J - 6{,}25\, J = 93{,}75\, J$

$\Pi = \dfrac{E_{\alpha\pi\omega\lambda\varepsilon\iota\acute{\omega}\nu}}{K_{\pi\rho\iota\nu}} 100\,\% = \dfrac{93{,}75}{100} 100\,\% \Rightarrow \boxed{\Pi = 93{,}75\,\%}$

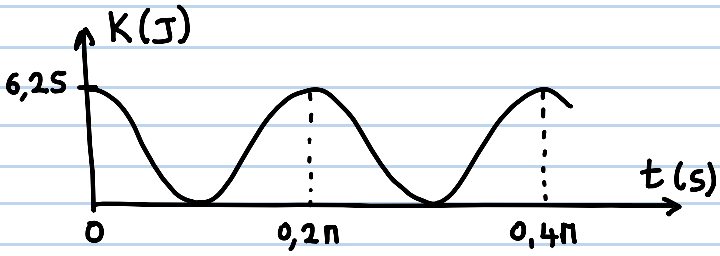
Δ4) Στην ΘΙΤ για το συσσωμάτωμα $U_{\kappa} = U_{max}$.

Άρα $K_{\mu\varepsilon\tau\alpha} = K_{max} = E_{\tau\alpha\lambda\acute{\alpha}\nu\tau\omega\sigma\eta\varsigma} = E = 6{,}25\, J$.

Ισχύει $K = E\,\sigma\upsilon\nu^2(\omega t + \varphi_0)$ όμως $\varphi_0 = 0$ αφού $t=0$, $x=0$, $\upsilon>0$

$D = k = m_{o\lambda}\omega^2 \Rightarrow \omega = \sqrt{k/m_{o\lambda}} = 5\, rad/s$, $T = \dfrac{2\pi}{\omega} = 0{,}4\pi\ sec$.

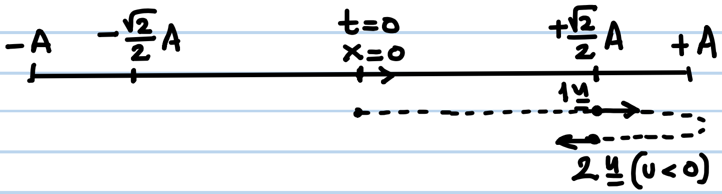
Άρα $\boxed{K = 6{,}25\,\sigma\upsilon\nu^2(5t)\ SI}$



Δ5) Όταν $K = U \rightarrow E = K + U = 2U \Rightarrow U = \frac{E}{2} \Rightarrow \frac{1}{2}kx^2 = \frac{1}{2}\frac{1}{2}kA^2$

$x = \pm\frac{\sqrt{2}}{2}A$

Αντίστοιχα $K = \frac{E}{2} \Rightarrow \frac{1}{2}m\upsilon^2 = \frac{1}{2}\frac{1}{2}m\upsilon_{max}^2 \Rightarrow \upsilon = \pm\frac{\sqrt{2}}{2}\upsilon_{max}$.



2η φορά $K = U$ είναι όταν το συσσωμάτωμα διέρχεται από τη θέση $x = +\frac{\sqrt{2}}{2}A$ έχοντας $\upsilon < 0 \rightarrow \upsilon = -\frac{\sqrt{2}}{2}\upsilon_{max}$

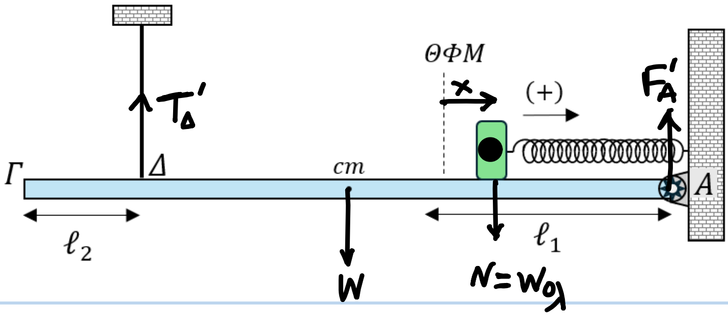
Ισχύει $υ_κ = υ_{max} = ωA \Rightarrow 2,5 = 5A \Rightarrow A = 0,5m$

Έχουμε: $dK = dW_{ΣF} \to \frac{dK}{dt} = \frac{dW_{ΣF}}{dt} = \frac{ΣF\,dx}{dt} = ΣF\cdot υ = -Kx\cdot υ$

$$\frac{dK}{dt} = -Kxυ = -K\left(+\frac{\sqrt{2}}{2}A\right)\left(-\frac{\sqrt{2}}{2}υ_{max}\right) = +\frac{1}{2}KAυ_{max}$$

$$\frac{dK}{dt} = +\frac{1}{2}50\cdot 0,5\cdot 2,5\ J/s \Rightarrow \boxed{\frac{dK}{dt} = +31,25\ J/s}$$

Δ6) Για την ισορροπία της δοκού ισχύουν:



$ΣF_y = 0 \Rightarrow T'_Δ + F'_A = w + w_{ολ}$

Όμως $T'_Δ = F'_A$

οπότε $2T'_Δ = w + w_{ολ}$

$$2T'_Δ = Mg + (m_1+m_2)g \Rightarrow 2T'_Δ = 20+20 \Rightarrow T'_Δ = 20N$$

Για μια τυχαία θέση του συσσωματώματος πάνω στη δοκό έχουμε:

$$Στ'_A = 0 \Rightarrow τ_W + τ_N - τ_{T'_Δ} = 0 \Rightarrow w\frac{\ell}{2} + N(\ell_1 - x) = T'_Δ\cdot(\ell - \ell_2)$$

όπου $N = w_{ολ} = (m_1+m_2)g = 20N$ $\quad 20\frac{5}{2} + 20(2-x) = 20\cdot 4$

$\Rightarrow 50 + 40 - 20x = 80 \Rightarrow 20x = 10 \Rightarrow \underline{x = 0,5m = +A}$

Άρα όταν $T'_Δ = F'_A$ το σώμα βρίσκεται στην ακραία θέση $x = +A$. Για δεύτερη φορά μετά την κρούση θα βρίσκεται τη χρονική στιγμή $t = T + \frac{T}{4} = \frac{5T}{4} = \frac{5\cdot 0,4π}{4} sec \Rightarrow \boxed{t = 0,5π\ sec}$