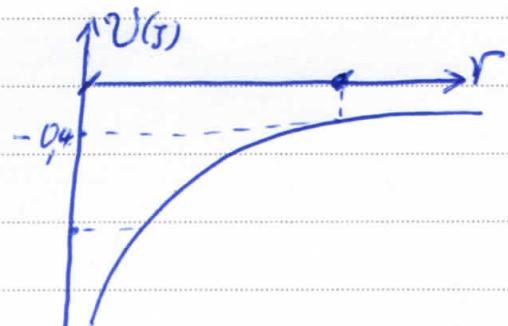


Kef. F. Διναγιντηλεπειρη' Ευσπεργε  
- Απαντηγεις -  
Ερωτησης Σ-1

7.1  $U = k \frac{q_1 q_2}{r} = 0,4J \Rightarrow q_1 q_2 < 0$



α-1x90°, β-1x90°  
γ-8000J, δ-2x800J



$$E_{\text{pot}} + E_{\text{kin}} = E_{\infty} \Rightarrow U + E_{\text{kin}} = 0 + 0$$

$$\Rightarrow E_{\text{pot}} = -U \Rightarrow E_{\text{pot}} = 0,40J$$

$$\therefore W_{\text{kin}} = -\Delta U = -[U_{\infty} - U] = -[0 - U] = U = -0,40 \text{ Joule}$$

7.2.  $q_1 q_2 < 0, U < 0$

α-1x90°, β-1x90°, γ-8000J, δ-2x800J

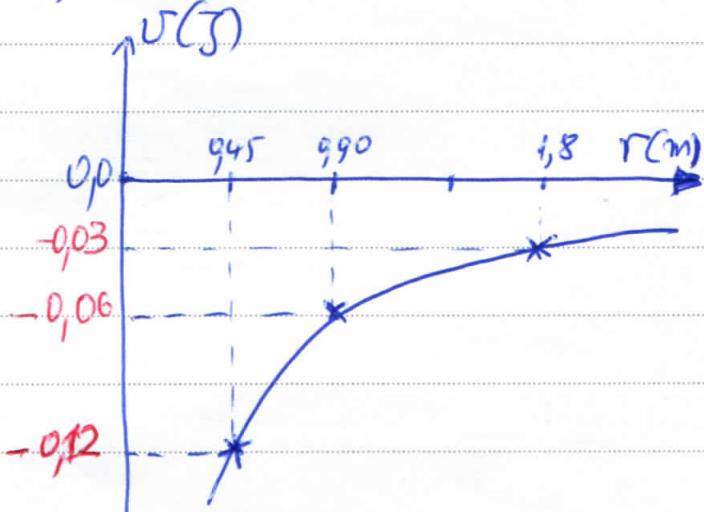
7.3 α-1x90°, β-6006J

$$U_0 + K = U' + K'$$

$$\Rightarrow -0,06J + 0 = -0,12J + K'$$

$$\Rightarrow K' = 0,06J$$

γ-2x90°, δ-6006J



7.4  $U = 0,04 \text{ Joule}$

α-1x90°, β-1x90°, γ-1x90°, δ-Σωσηρ'

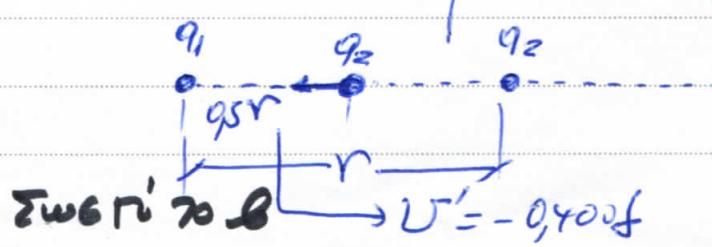


7.5

$$U + 0 = U' + K'$$

$$\Rightarrow -0,200J = -0,400J + K'$$

$$\Rightarrow K' = 0,200J$$



$$\Sigma \omega \sigma \approx 0,8$$

$$U = -0,200J$$



$$U' = -0,400J$$

F.6  $F_C = k_c \frac{|q_1 q_2|}{r^2}$

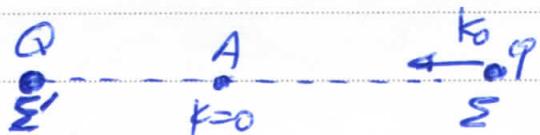


$$U = k_c \frac{q_1 q_2}{r} \xrightarrow{q_1 q_2 < 0} U = -k_c \frac{|q_1 q_2|}{r}$$

$$\frac{F_C}{U} = \frac{k_c \frac{|q_1 q_2|}{r}}{-k_c \frac{|q_1 q_2|}{r}} = -\frac{r}{r^2} = -\frac{1}{r} \Rightarrow U = -F_C \cdot r$$

Apa sebabnya?

F.7



$\alpha = 60^\circ$

$$U_A + F_0 = U_{\infty} + F_0 \Rightarrow U_A + 0 = 0 + F_0 \Rightarrow U_A = F_0$$

B -  $72000 \text{ N}$

R -  $72000 \text{ m}$

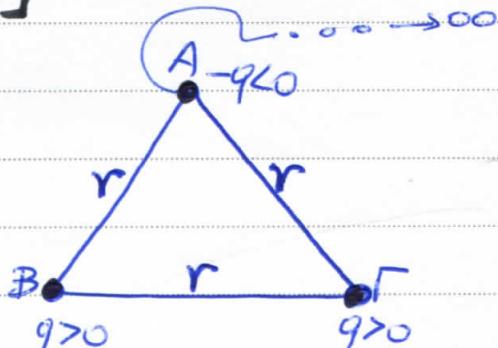
$\delta = 72000 \text{ N}$

EQUASIESTI KARANGAN

F.8

Aproximasi  $U_{\text{ext}} = k_c \frac{q \cdot q}{r} + k_c \frac{-q \cdot q}{r} + k_c \frac{q \cdot q}{r}$

$$\Rightarrow U_{\text{ext}} = -k_c \frac{q^2}{r}$$

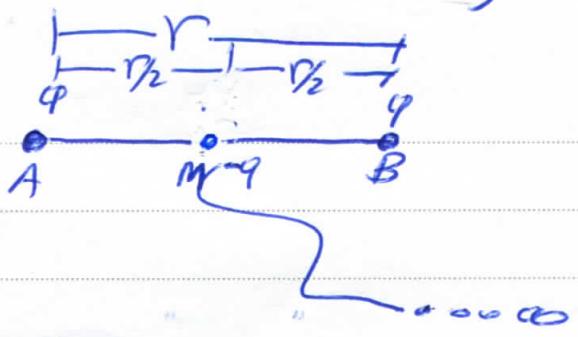


Tentukan  $U_{TEF} = k_c \frac{q^2}{r}$

$$\Delta U = U_{\infty} - U_{\text{ext}} = k_c \frac{q^2}{r} - \left( -k_c \frac{q^2}{r} \right) \Rightarrow \Delta U = 2k_c \frac{q^2}{r}$$

Apa sebabnya?

7.9



$$\text{a. } U = k_e \frac{q \cdot q}{r} + k_e \frac{q(-q)}{r_1} + k_e \frac{(-q)q}{r_2}$$

$$\Rightarrow U = k_e \frac{q^2}{r} - 2k_e \frac{q^2}{r_1} - 2k_e \frac{q^2}{r_2} \Rightarrow U = -3k_e \frac{q^2}{r} \quad \alpha - 6006 \text{ N}$$

$$\text{b. } U = k_e \frac{(-q) \cdot q}{r_1} + k_e \frac{(-q)q}{r_2} = -2k_e \frac{q^2}{r} - 2k_e \frac{q^2}{r} = -4k_e \frac{q^2}{r} \quad \theta - 71905$$

$$\text{c. } W = (-q)(V_{\infty} - V_{\infty}) = -q \cdot V_M = -q \left[ k_e \frac{q}{r_1} + k_e \frac{q}{r_2} \right] = -q4k_e \frac{q}{r} = -4k_e \frac{q^2}{r}$$

J-6006N'

$$\text{d. } U_{\text{ex}} = -3k_e \frac{q^2}{r} \quad \left. \begin{array}{l} \\ U_{TEI} = k_e \frac{q^2}{r} \end{array} \right\} \Delta U = U_{TEI} - U_{\text{ex}} \Rightarrow \Delta U = 4k_e \frac{q^2}{r}$$

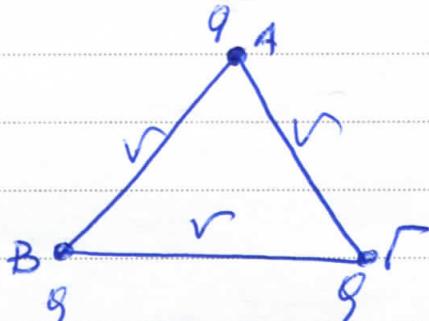
Δ-GWGN'

'Alpha α-Σ, θ-1, J-Σ, Δ-Σ

7.10

$$U = k_e \frac{q \cdot q}{r} + k_e \frac{q \cdot q}{r} = 2k_e \frac{q^2}{r}$$

$$U' = 3k_e \frac{q^2}{r}$$



$$\frac{U'}{U} = \frac{3}{2} \Rightarrow U' = 1.5U$$

swertn n (α)

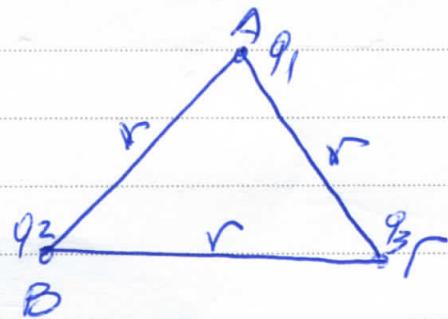
$$\text{7.11 } U = -F \cdot r = -0,6 \cdot 0,2 \Rightarrow U = -0,12 \text{ J}$$

swertn n (α)

7.12

$$U = k \frac{q_1 q_2}{r} + k \frac{q_2 q_3}{r} + k \frac{q_3 q_1}{r} = 0$$

$$\Rightarrow q_1 q_2 + q_2 q_3 + q_3 q_1 = 0$$



$$\Rightarrow \frac{1}{q_3} + \frac{1}{q_1} + \frac{1}{q_2} = 0 \Rightarrow \frac{1}{q_1} = -\frac{1}{q_2} - \frac{1}{q_3}$$

Άριθμοι σωστοί στην (f)

7.13

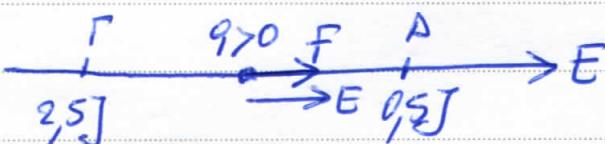
(α)



$$U_B > U_A : \vec{F} : B \rightarrow A$$

$$\underline{q20} \quad \vec{E} : A \rightarrow B$$

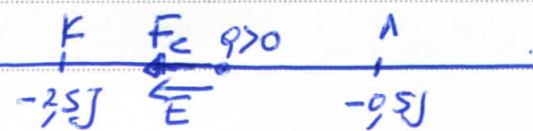
(β)



$$U_E > U_\Delta : \vec{F} : E \rightarrow \Delta$$

$$\underline{q20} \quad \vec{E} : \Gamma \rightarrow \Delta$$

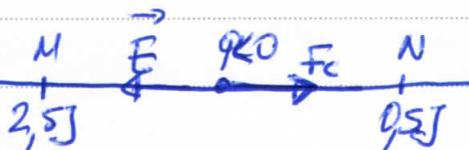
(γ)



$$U_h > U_k : \vec{F} : h \rightarrow k$$

$$\underline{q20} \quad \vec{E} : 1 \rightarrow K$$

(δ)



$$U_M > U_N : \vec{F} : M \rightarrow N$$

$$\underline{q20} \quad \vec{E} : N \rightarrow M$$

Περικάρ πρέπει να έχει την ιδέα της εργασίας  
αλλά δεν έχει θέληση για την εργασία  
προς περιόδους ψείτην για κατέργαση δύναμης  
για σύρμα... δρα μαζί σε αυτήν την κατάντη  
ενώ για την άλλην η παραγόμενη εργασία  
δεν έχει θέληση για την εργασία της μάζας  
φορτού με γύναις  $\vec{E}$  τον η στόμιο

7.14



$$\begin{aligned} U_{00} + k_{00} &= U_A + K_A \Rightarrow \frac{1}{2} m u_0^2 = k_c \frac{q q}{d} + \frac{1}{2} m \frac{u_0^2}{4} \quad \left. \begin{array}{l} \text{at } A: \frac{2}{4} m \frac{u_0^2}{2} = k_c \frac{q q}{d} \\ \text{at } A: U_A = k_c \frac{q q}{x_{min}} \end{array} \right\} \\ U_{00} + k_{00} &= U_R + O \Rightarrow \frac{1}{2} m u_0^2 = k_c \frac{q q}{x_{min}} \end{aligned}$$

$$\frac{3}{4} k_c \frac{q q}{x_{min}} = k_c \frac{q q}{d} \Rightarrow \boxed{x_{min} = \frac{3}{4} d} \quad \text{Aper Gwari n (g)}$$

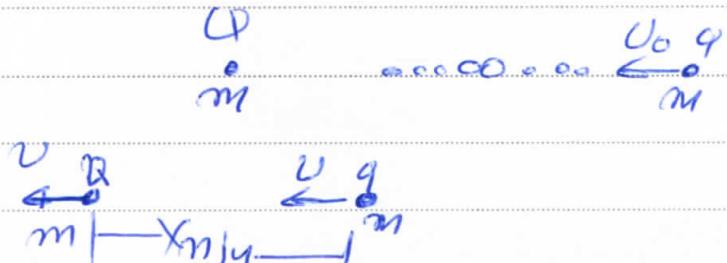
7.15

13 TFE in way



$$k_{00} + U_{00} = K_A + U_A \Rightarrow k_0 = U_A \Rightarrow \frac{1}{2} m u_0^2 = k_c \frac{q q}{d_{min}} \quad (1)$$

$$2 = \pi f \rho / (\pi) \omega_0$$



$$m u_0 = m u + m v \Rightarrow u = \frac{u_0}{2}$$

$$U_{00} + k_{00} = U + K \Rightarrow 0 + k_0 = k_c \frac{q q}{x_{min}} + 2 \frac{1}{2} m u^2 \Rightarrow$$

$$\Rightarrow \frac{1}{2} m u^2 = k_c \frac{q q}{x_{min}} + 2 \frac{1}{2} m \frac{u_0^2}{4} \Rightarrow \frac{1}{2} m u^2 - \frac{1}{2} \cdot \frac{1}{2} m u_0^2 = k_c \frac{q q}{x_{min}}$$

$$\Rightarrow \frac{1}{2} \cdot \frac{1}{2} m u^2 = k_c \frac{q q}{x_{min}} \xrightarrow{(1)} \frac{1}{2} k_c \frac{q q}{d_{min}} = k_c \frac{q q}{x_{min}} \Rightarrow \underline{\underline{x_{min} = 2 d_{min}}}$$

Aper Gwari n (g)

-1. 6

7.16

$q_1 \frac{q_2}{m} r \quad U = k_c \frac{q_1 q_2}{r}$

$$U = -k_c \frac{q_1 q_2}{r}$$

$$U' = -2k_c \frac{q_1 q_2}{r}$$

$$U' = 2U$$

$$0 = m_1 v_1 - m_2 v_2 \Rightarrow m_1 v_1 = m_2 v_2 \Rightarrow v_1 = v_2$$

$$K_1 = \frac{1}{2} m_1 v_1^2$$

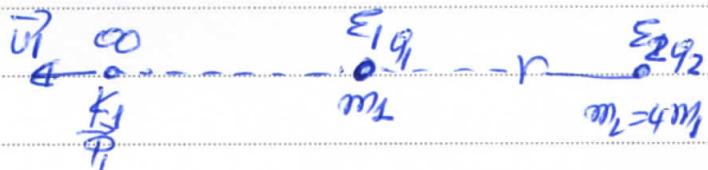
$$K_2 = \frac{1}{2} m_2 v_2^2 \Rightarrow K_1 = K_2 = K.$$

$$U + 0 = U' + K + K \Rightarrow K = -U$$

$$\hookrightarrow U = 2U + 2K \Rightarrow -U = 2K \Rightarrow \boxed{K = -\frac{U}{2}}$$

Σωστινή σχέση (δ)

7.17



$$\frac{\Sigma q_1}{m_1} = \vec{r} \quad \frac{\Sigma q_2}{m_2 = 4m_1} = \vec{r}$$

$$\frac{m_2 q_2}{P_2} = \vec{v}'$$

1) Εξειδικωση  $U = K_1 \Rightarrow k_c \frac{q_1 q_1}{r} = \frac{1}{2} m_1 v_1^2$

2) Εξειδικωση  $U_{\text{ex}} = K_2 \Rightarrow k_c \frac{q_1 q_1}{r} = \frac{1}{2} m_2 v_2^2$

α)  $K_1 = K_2 \quad \alpha = \sqrt{\omega G T}$

β)  $\frac{1}{2} m_1 v_1^2 = \frac{1}{2} m_2 v_2^2 \Rightarrow m_1 v_1^2 = 4m_2 v_2^2 \Rightarrow v_1 = 2v_2 \quad \beta = \sqrt{\omega G T'}$

γ)  $P_2 = m_2 v_2 \quad \frac{P_2}{P_1} = \frac{4m_2 v_2}{m_1 \cdot 2v_2} = 2 \Rightarrow P_2 = 2P_1$

δ)  $K_1 = \frac{P_1^2}{2m_1} \quad \frac{P_1^2}{2m_1} = \frac{P_2^2}{2 \cdot 4m_1} \Rightarrow 4P_1^2 = P_2^2 \Rightarrow P_2 = 2P_1 \quad \delta = \sqrt{\omega G T'}$

-7-

7.18



$$\vec{P}_{\text{Gesamt}1+2} = e_0 q_1 \partial_{q_2} \vec{r} \Rightarrow 0 = \vec{P}_1 + \vec{P}_2 \Rightarrow \vec{P}_1 = -\vec{P}_2 \Rightarrow P_1 = P_2 \quad (\text{nach rechts})$$

$$\frac{k_1}{k_2} = \frac{\frac{P_1^2}{2m_1}}{\frac{P_2^2}{2m_2}} = \frac{m_2}{m_1} = \frac{2m_1}{m_1} = 2 \Rightarrow \frac{k_1}{k_2} = 2 \quad \text{doppelte Ladung}$$

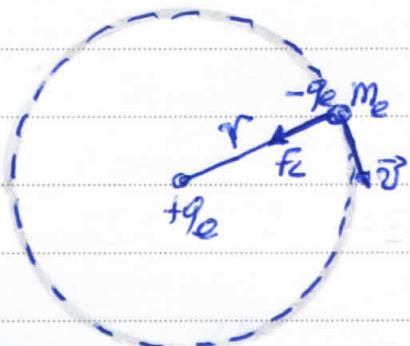
7.19.  $E = U + K$  (1)

$$U = k_c \frac{(+q_e)(-q_e)}{r} = -k_c \frac{q_e^2}{r} \quad (2)$$

$$K = \frac{1}{2} m_e v^2 \quad (3)$$

$$\sum F = m_e a \Rightarrow F_c = m \frac{v^2}{r} \Rightarrow k_c \frac{|q_e| |q_e|}{r^2} = m \frac{v^2}{r}$$

$$\Rightarrow m_e v^2 = k_c \frac{q_e^2}{r} \xrightarrow{(3)} K = \frac{1}{2} k_c \frac{q_e^2}{r} \quad (3)$$



$$(1), (2), (3) \Rightarrow E = -k_c \frac{q_e^2}{r} + \frac{1}{2} k_c \frac{q_e^2}{r} \Rightarrow E = \frac{1}{2} k_c \frac{q_e^2}{r}$$

Αριθμητική (2)

7.20

	A	B	C	D
Απόσταση	r	2r	4r	$r \rightarrow \infty$
Κίνητη Ενέργεια (K)	0	$8 \cdot 10^6 \text{ J}$	$12 \cdot 10^6 \text{ J}$	$16 \cdot 10^6 \text{ J}$
Διαρροή (U)	$16 \cdot 10^6 \text{ J}$	$8 \cdot 10^6 \text{ J}$	$4 \cdot 10^6 \text{ J}$	0
Μηχανική (E)	$16 \cdot 10^6 \text{ J}$			

7.21

$$\frac{Q}{r} = \frac{q}{r}$$

$$U_A = 36J$$

$$V_A = -18 \cdot 10^5 V$$

$$\left. \begin{array}{l} U = k_c \frac{Qq}{r} \\ V = k_c \frac{Q}{r} \end{array} \right\} \frac{U}{V} = q \Rightarrow q = \frac{U}{V}$$

$\hookrightarrow U = qV$

$$\hookrightarrow q = \frac{36J}{-18 \cdot 10^5 V} \Rightarrow q = -0,2 \cdot 10^{-5} C$$

$$\Rightarrow q = -2 \cdot 10^{-6} C$$

$$V = k_c \frac{Q}{r} \Rightarrow Q = \frac{V \cdot r}{k_c} = \frac{-18 \cdot 10^5 V \cdot 10^1 m}{8 \cdot 10^8 Nm^2/C} \Rightarrow Q = -2 \cdot 10^{-5} C$$

	A	B	C	D
Abstand	r	2r	4r	$r \rightarrow \infty$
Kinetische E	0,0	1,8J	3,7J	3,6J
Drehenergie	3,6J	1,8J	0,9J	0,0J
Mechanische E	3,6J	3,6J	3,0J	3,6J
Drehimpuls	-18 \cdot 10^5 V	-9 \cdot 10^5 V	-4,5 \cdot 10^5 V	0
Zentralkr. $\pi F/r$	$18 \cdot 10^6 V/m$	$4,5 \cdot 10^6 V/m$	$1,125 \cdot 10^6 V/m$	0

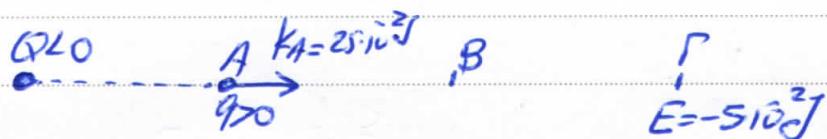
$$\left. \begin{array}{l} E = k_c \frac{|Q|}{r^2} \\ V = k_c \frac{|Q|}{r} \end{array} \right\} \Rightarrow \frac{E}{V} = \frac{k_c \frac{|Q|}{r^2}}{-k_c \frac{|Q|}{r}} = -\frac{1}{r} \Rightarrow E = -\frac{V}{r} \Rightarrow E = -\frac{-18 \cdot 10^5}{0,1}$$

$$\Rightarrow E = 180 \cdot 10^5 \text{ und } E = 18 \cdot 10^6 V/m$$

7.22

a)

	A	B	C	D
Απόσταση	r	2r	3r	x
Κίρκιτεργία Σ	$25 \cdot 10^2 J$	$10 \cdot 10^2 J$	$5 \cdot 10^2 J$	0
Συνάρτηση Σ	$-30 \cdot 10^2 J$	$-15 \cdot 10^2 J$	$-10 \cdot 10^2 J$	$-5 \cdot 10^2 J$
Μηχανική Σ	$-5 \cdot 10^2 J$	$-5 \cdot 10^2 J$	$-5 \cdot 10^2 J$	$-5 \cdot 10^2 J$



b)  $U + K = U_{00} + K_{00} \Rightarrow -5 \cdot 10^2 = 0 + K_{00} \Rightarrow K_{00} = -5 \cdot 10^2 J < 0$  θετικό

αρχικής κίρκιτεργίας στο σημείο της πλήρους

c)  $\frac{U_A}{U_0} = \frac{k_c \frac{|Qq|}{x}}{k_c \frac{|Qq|}{r}} = \frac{r}{x} \Rightarrow \frac{-5 \cdot 10^2 J}{-30 \cdot 10^2 J} = \frac{r}{x} \Rightarrow x = 6r \Rightarrow \boxed{x = 9,6 m}$

d)  $\frac{U}{F} = \frac{-k_c \frac{|Qq|}{r'}}{k_c \frac{|Qq|}{r^2}} = -r' \Rightarrow F = -\frac{U}{r'} = -\frac{-15 \cdot 10^2}{2 \cdot 0,1} \Rightarrow F = 0,75 N$

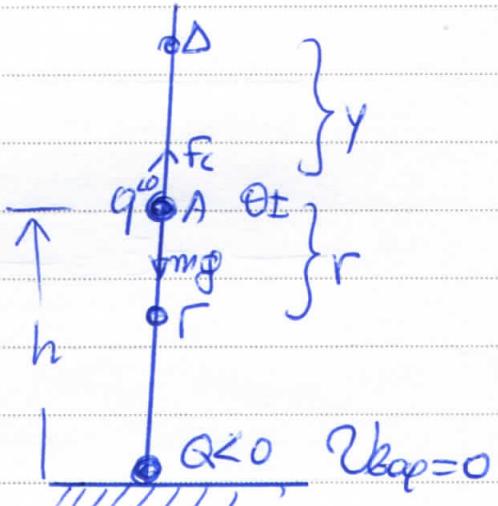
7.23

a)  $F_c = mg \Rightarrow k_c \frac{|Qq|}{h^2} = mg \Rightarrow k_c |Qq| = mg h^2 \quad (1)$

$$U = k_c \frac{|Qq|}{h} \Rightarrow U = k_c \frac{|Qq|}{h} \quad (2)$$

$$U = \frac{mg h^2}{h} \Rightarrow U = mgh$$

δύναμης αρχικής



b)

$$U_{syst}(r) + U_{el}(r) + Kr = U_{syst} + U_{el}(CA) + K_{max} \Rightarrow mg(h-r) + k_c \frac{|Qq|}{h-r} + 0 = mg(h-r) + k_c \frac{|Qq|}{h-r} + k_{max}$$

$$\Rightarrow mg(h-r) + \frac{mg h^2}{h-r} = 2mg h + k_{max} \Rightarrow \frac{mg(h-r)^2 + mg h^2}{h-r} = 2mg h + k_{max}$$

$$\Rightarrow \frac{m\varphi \frac{h^2}{4} + m\varphi h^2}{\frac{h}{2}} - 2m\varphi h = k_{max} \Rightarrow \frac{\frac{5}{4}m\varphi h^2}{\frac{h}{2}} - 2m\varphi h = k_{max}$$

$$\Rightarrow k_{max} = \frac{5}{2}m\varphi h \quad \text{oder } 8-6000 \text{ N}$$

8)  $m\varphi(h-r) + k_e \frac{Qy}{h-r} = m\varphi(h+y) + k_e \frac{Qy}{h+y} \quad (1)$

$$m\varphi(h-r) + \frac{m\varphi h^2}{h-r} = m\varphi(h+y) + \frac{m\varphi h^2}{h+y} \Rightarrow h-r + \frac{h^2}{h-r} = h+y + \frac{h^2}{h+y}$$

$$+ \frac{h^2}{h-r} - r = \frac{h^2}{h+y} + y \Rightarrow \frac{h^2}{h-h} - h = \frac{h^2}{h+y} + y$$

$$\Rightarrow 2h - \frac{h}{2} = \frac{h^2}{h+y} + y \Rightarrow \frac{3}{2}h = \frac{h^2}{h+y} + y \Rightarrow \frac{3}{2}h(h+y) = h^2 + y(h+y)$$

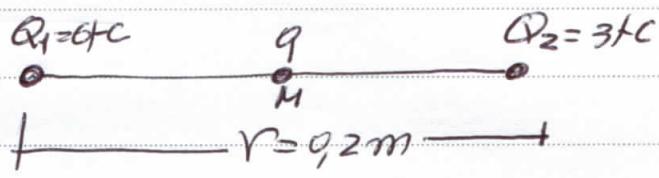
$$\Rightarrow \frac{3}{2}h^2 + \frac{3}{2}hy = h^2 + yh + y^2 \Rightarrow y^2 - \frac{1}{2}hy + \frac{h^2}{2} = 0 \quad \text{und } y^2 - hy + h^2 = 0$$

$$\Delta = h^2 + 8h^2 = 9h^2 \quad \sqrt{\Delta} = \pm 3h$$

$$y = \frac{h \mp 3h}{4} \quad \begin{cases} y = \frac{4h}{4} = h & \text{Seri} \\ y = -\frac{2h}{4} = -0.5h \end{cases}$$

Agor moet in f-ord

7.24



$$d) U_{1,2} = k_e \frac{Q_1 Q_2}{r} = 8 \cdot 10^8 \cdot \frac{6 \cdot 10^{-6} \cdot 3 \cdot 10^{-6}}{2 \cdot 10^1} \Rightarrow U = 81 \cdot \frac{10^3}{10^1} \Rightarrow U = 0.81\text{J}$$

$$e) \frac{U}{q} = k_e \frac{Q_1 q}{r} + k_e \frac{Q_2 q}{r} + k_e \frac{q_1 q}{r_1} + k_e \frac{q_2 q}{r_2} = 0 \Rightarrow \frac{2k_e Q_2}{r} + \frac{2k_e Q_1}{r} + \frac{2k_e q_1 q_2}{r_1 r_2} = 0 \\ \Rightarrow 2q(Q_1 + Q_2) = -Q_1 Q_2 \Rightarrow q = -\frac{Q_1 Q_2}{2(Q_1 + Q_2)} \Rightarrow q = -\frac{6\text{fC} \cdot 3\text{fC}}{2 \cdot 9.2\text{m}} = -1.4\text{fC}$$

$$\exists q = -1.4$$

$$f) U = q V_M = q \left( k_e \frac{q_1}{r_1} + k_e \frac{q_2}{r_2} \right) = q \frac{2k_e q_1 + 2k_e q_2}{r} \Rightarrow U = 2k_e \frac{q(Q_1 + Q_2)}{r} \\ \Rightarrow U = 2 \cdot 9 \cdot 10^9 \frac{(-10^6) \cdot 3 \cdot 10^{-6}}{2 \cdot 10^1} \Rightarrow U = -0.81\text{J}$$

...  $\partial \mathcal{W}_{\text{OTF}}$   $U_{1,2} + U = 0 \dots$

$$g) \frac{\partial U_{0,2}}{\partial x} + E_{\text{pot0,6}} = \frac{U_{0,2}}{r_{0,2}} + K_{F_{0,6}} \Rightarrow 0 + E_{\text{pot0,6}} = 0.81\text{J}$$

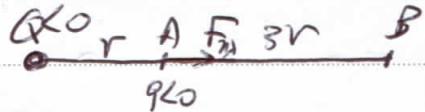
$$\Rightarrow E_{\text{pot0,6}} = 0.81\text{J} \quad W_{21} = U_2 = -0.81\text{J}$$

$$\text{... и ср } \Delta K = W_F + W_{21} = 0 = W_F - 0.81\text{J} \text{ ...}$$

$$\exists W_{F_{0,6}} = 0.81\text{ Joule} \Leftrightarrow E_{\text{pot0,6}} = 0.81\text{J}$$

$$h) \frac{\partial U_{0,2}}{\partial x} + E_{\text{pot0,6}} = \frac{U_{0,2}}{r_{0,2}} \Rightarrow 0 + E_{\text{pot0,6}} = 0 \Rightarrow E_{\text{pot0,6}} = 0$$

7.25



$$\alpha) U_A = k \frac{q}{r} = U$$

$$U_B = k \frac{q}{3r} = \frac{U_A}{3} = \frac{U}{3}$$

$$W_{AB} = -\Delta U = -[U_B - U_A] = -\left[\frac{U}{3} - U\right] = -\left[-\frac{2}{3}U\right] \Rightarrow W = \frac{2}{3}U$$

$$\Rightarrow U = \frac{3}{2}W = \frac{3}{2} \cdot 0,30J \Rightarrow U = 0,45J$$

$$\text{Aprox } U_A = 0,45J \quad \text{and } U_B = 0,15J$$

$$\beta) \Delta K_B = WF_{AB} \Rightarrow K_B - 0 = W_{AB} \Rightarrow K_B = 0,30J$$

$$\gamma) \Delta K = W_{AB} \Rightarrow |k_{10}| - k_A = W_{AB} \text{ kann } 0 \text{ oder } \infty$$

$$U_A + K_A = U_{10} + k_{10} \Rightarrow 0,45J + 0 = 0 + k_{10}$$

$$\Rightarrow k_{\max} = 0,45J$$

7.26

$$Q = 8 \text{ fC}$$

$$q = 1 \text{ fC}, m = 10^3 \text{ kg}$$



a) ... επιταχνότευν ότε φέρειν τσυ σηταχνωσ

$$\text{e)} \quad U + K = 6100 \Rightarrow k_e \frac{Qq}{R} + 0 = k_e \frac{Qq}{r} + \frac{1}{2} mv^2 \Rightarrow k_e Qq \left( \frac{1}{R} - \frac{1}{r} \right) = \frac{1}{2} mv^2$$

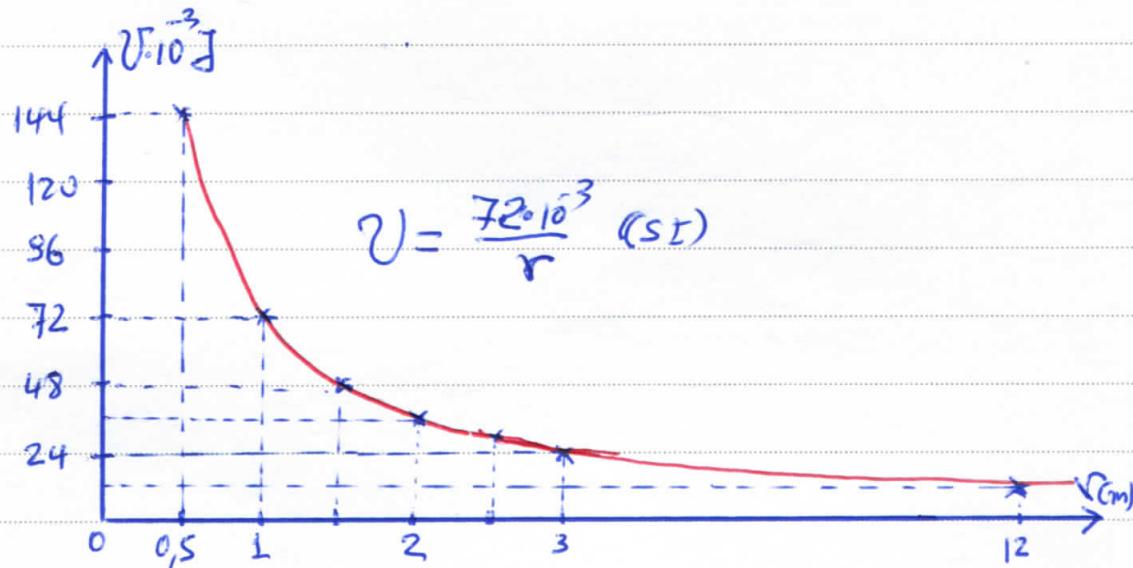
$$\Rightarrow U = \sqrt{\frac{2k_e Qq}{m} \left( \frac{1}{R} - \frac{1}{r} \right)} = \sqrt{\frac{2 \cdot 8 \cdot 10^9 \cdot 8 \cdot 10^{-6} \cdot 1 \cdot 10^6}{10^{-3}} \left( \frac{1}{0,5} - 1 \right)} \Rightarrow U = 12 \text{ m/s}$$

$$\delta) \quad U + K = 6100 \Rightarrow k_e \frac{Qq}{R} + 0 = U_{\max} + K_{\max} \Rightarrow k_e \frac{Qq}{R} = L_{\max} v_{\max}^2$$

$$\Rightarrow v_{\max} = \sqrt{\frac{2k_e Qq}{mR}} \Rightarrow v_{\max} = 12\sqrt{2} \text{ m/s}$$

$$\delta) \quad U = k_e \frac{Qq}{r} = 8 \cdot 10^9 \cdot \frac{8 \cdot 10^{-6} \cdot 1 \cdot 10^6}{r} = \frac{72 \cdot 10^3}{r} \text{ J}$$

$r$	0,5	1	1,5	2	2,5	3
$U$	$144 \cdot 10^3$	$72 \cdot 10^3$	$48 \cdot 10^3$	$36 \cdot 10^3$	$28,8 \cdot 10^3$	$24 \cdot 10^3$

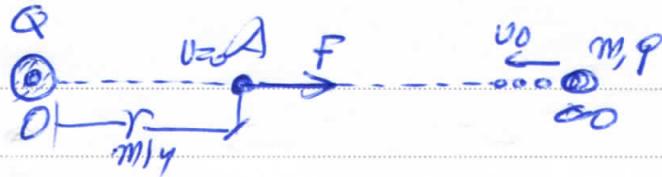


7.27

$$Q = -20 \text{ fC}$$

$$q = -1 \text{ fC}$$

$$V_0 = 10 \text{ mV}$$



a)  $E_{kin} + k_{el} V_0 + qV_0$  us der für rotorschleife

$$b) V_{\infty} + k_{eo} = V_A + k_A \Rightarrow 0 + \frac{1}{2} m V_0^2 = k \frac{Q q}{m V_0} + 0$$

$$\Rightarrow V_{mly} = \frac{2 k c Q q}{m V_0^2} = \frac{2 \cdot 8 \cdot 10^8 (-20 \cdot 10^{-9})(-1 \cdot 10^{-9})}{10 \cdot 10^3 \cdot 10^2} \Rightarrow V_{mly} = 0,36 \text{ mV}$$

$$c) V_{\infty} + k_{eo} = V_f + k_f \xrightarrow{U=k} \frac{1}{2} m V_0^2 = 2 V_f \Rightarrow$$

$$\Rightarrow \frac{1}{2} m V_0^2 = 2 \cdot k \frac{Q q}{x} \Rightarrow x = \frac{4 k c Q q}{m V_0^2} \Rightarrow x = 0,72 \text{ m}$$

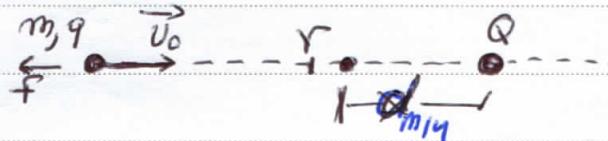
7.28

$$Q = -50 \text{ fC}$$

$$q = -\frac{10^6}{3} \text{ C}, V_0 = 10 \text{ mV}$$

$$m = 10 \text{ Ry}$$

$$r = 1 \text{ m}$$



$$d) \frac{1}{2} m V_0^2 + k \frac{q Q}{r} = \frac{1}{2} m V^2 + k \frac{q Q}{r'} \Rightarrow \frac{1}{2} m V^2 = \frac{1}{2} m V_0^2 + k q Q \left( \frac{1}{r} - \frac{1}{r'} \right)$$

$$\Rightarrow V^2 = V_0^2 + \frac{2 k q Q}{m} \left( \frac{1}{r} - \frac{1}{r'} \right) \Rightarrow V^2 = 100 + 2 \cdot 8 \cdot 10^9 \cdot 50 \cdot 10^{-6} \frac{10^6}{3} \left( \frac{1}{1} - \frac{1}{0,25} \right)$$

$$\Rightarrow V^2 = 100 + 100 \left( \frac{1}{0,25} \right) \Rightarrow V^2 = 100 - 25 = 75 \Rightarrow V = 5\sqrt{3} \text{ m/s}$$

$$e) \frac{1}{2} m V_0^2 + k \frac{q Q}{r} = 0 + k \frac{q Q}{dmly} \Rightarrow \frac{1}{2} \cdot 10^{-3} \cdot 100 + 9 \cdot 10^9 \frac{\left(\frac{-10^6}{3}\right) \left(-50 \cdot 10^{-6}\right)}{1} = 9 \cdot 10^9 \frac{\left(-\frac{10^6}{3} \cdot -50 \cdot 10^{-6}\right)}{dmly}$$

$$\Rightarrow 50 \cdot 10^{-3} + 50 \cdot 10^{-3} = \frac{50 \cdot 10^3}{dmly} \Rightarrow 100 = \frac{50}{dmly} \Rightarrow dmly = 0,5 \text{ m}$$



f)  $1000 \text{ m/s}$  Gm q q oq reflexions

$$\Rightarrow k_{max} = \frac{1}{2} 10^3 \cdot 100 + 9 \cdot 10^9 \frac{-\frac{10^6}{3} \cdot (-50 \cdot 10^{-6})}{dmly} = \frac{k_{eo}}{max} \Rightarrow k_{eo} = 100 \cdot 10^3 \text{ J} \Rightarrow k_{max} = 0,100 \text{ J}$$

$$g) V_{max} = k \frac{q Q}{dmly} = 8 \cdot 10^9 \frac{9 \cdot -\frac{10^6}{3} \cdot -50 \cdot 10^{-6}}{0,5 \text{ m}} \Rightarrow V_{max} = \frac{50 \cdot 10^3}{9 \cdot 5} \Rightarrow V_{max} = 0,100 \text{ J} \text{ broesvole}$$

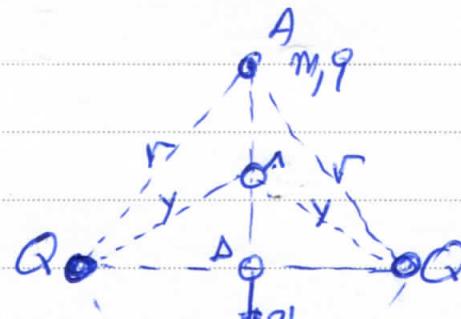
7.29

$$Q = 10 \cdot 10^6 C = 10^7 C$$

$$q = -10^6 C \quad m = 10^1 kg$$

$$r = 0,1m = 10^1$$

d) B) Elektrostatik S7.



$$\delta) q \cdot V_A = q V_1 + \frac{1}{2} m v^2$$

$$\Rightarrow q \left[ k_e \frac{qQ}{r} + k_e \frac{qQ}{r} \right] = q \left[ k_e \frac{qQ}{r_1} + k_e \frac{qQ}{r_2} \right] + \frac{1}{2} m v^2$$

$$\Rightarrow 2k_e \frac{qQ}{r} = 4k_e \frac{qQ}{r} + \frac{1}{2} m v^2 \Rightarrow \frac{1}{2} m v^2 = -2k_e \frac{qQ}{r} \Rightarrow v = \sqrt{-\frac{4k_e qQ}{m r}}$$

$$\Rightarrow v = \sqrt{-\frac{4 \cdot 8 \cdot 10^9 \cdot (-10^6) \cdot 10^5}{10^1 \cdot 10^1}} \Rightarrow v = \sqrt{36} \Rightarrow v = 6 m/s$$

$$\delta) q V_A + 0 = q V_2 + 0 \Rightarrow V_A = V_2 \Rightarrow 2k_e \frac{qQ}{r} = 2k_e \frac{qQ}{x} \Rightarrow x = r$$

$$\Rightarrow x = 0,1m$$

$$\epsilon) k_{max} \sim 670 \Delta \quad (\zeta f = 0)$$

$$\text{approx 670} \quad \text{at } 670 \Delta \quad k_x = \frac{k_{max}}{2} = \frac{\frac{1}{2} m v^2}{2} = \frac{1}{4} \cdot 10^1 \cdot 6^2 = 9,08$$

$$V_A + k_A = V_1 + k_1 \Rightarrow 2k_e \frac{qQ}{r} + 0 = 2k_e \frac{qQ}{y} + k_1$$

$$\Rightarrow 2 \cdot 8 \cdot 10^9 \frac{(-10^6) \cdot 10^5}{9,1} = 2 \cdot 8 \cdot 10^9 \frac{(-10^6) \cdot (10^5)}{y} + 0,9$$

$$\Rightarrow -1,8 = -\frac{18 \cdot 10^2}{y} + 0,9 \Rightarrow \frac{18 \cdot 10^2}{y} = 2,7 \Rightarrow y = \frac{0,18}{2,7} = \frac{18 \cdot 10^2}{3 \cdot 10^1} = \frac{2}{3} \cdot 10^1$$

$$\Rightarrow y = \frac{2}{3} m \quad \boxed{y = \frac{2}{30} m} \quad \Rightarrow y = \frac{1}{15} m$$

7.30

$$Q = -2\alpha + c \quad R = 0,1 \text{ m} = 10 \text{ cm}$$

$$q = -1 + c \quad m = 2,1 \text{ kg}$$

$$\text{a) } F_C = k_C \frac{|q, Q|}{r^2} = 8 \cdot 10^8 \cdot \frac{20 \cdot 10^{12}}{10^2}$$

$$\Rightarrow F_C = 18 \text{ N} \quad m_f = 2 \cdot 10 \cdot 10 = 2 \text{ N}$$

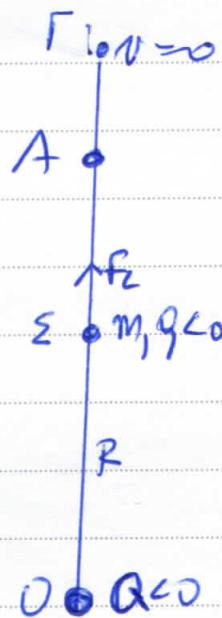
$$\alpha = \frac{F_C - m_f}{m} = \frac{18 - 2}{2 \cdot 10} = \frac{16}{2} \cdot 10 = 80 \text{ m/s}^2 \Rightarrow \alpha = 80 \text{ m/s}^2$$

$$\alpha = 80 \text{ m/s}^2$$

$$\text{b) } \frac{U}{q} = k_C \frac{Q}{R} = 8 \cdot 10^8 \cdot \frac{-20 \cdot 10^{12}}{10^1} \Rightarrow \frac{U}{q} = -18 \cdot 10^{47} \text{ J/C} \Rightarrow \boxed{\frac{U}{q} = -18 \cdot 10^{47} \text{ J/C}}$$

$$\text{c) } \text{Effy} = 0 \Rightarrow F_C = m_f \Rightarrow k_C \frac{|q, Q|}{r^2} = m_f \Rightarrow 8 \cdot 10^8 \frac{20 \cdot 10^{12}}{r^2} = 2$$

$$\Rightarrow \frac{180 \cdot 10^3}{r^2} = 2 \Rightarrow \frac{918}{r^2} = 2 \Rightarrow r^2 = \frac{918}{2} = \frac{34908}{2} = 909 \Rightarrow \boxed{r = 93 \text{ m}}$$



$$k_C \frac{qQ}{r} + m_f g R = k_C \frac{qQ}{r} + m_f g R + \frac{1}{2} m v_{max}^2 \Rightarrow k_C \frac{qQ}{r} \left( \frac{1}{R} - \frac{1}{r} \right) + m_f g (R - r) = \frac{1}{2} m v_{max}^2$$

$$\Rightarrow 8 \cdot 10^8 \cdot 20 \cdot 10^{12} \left( \frac{1}{0,1} - \frac{1}{0,3} \right) + 2 \cdot 10^1 \cdot 10 (0,1 - 0,3) = \frac{1}{2} \cdot 2 \cdot 10^1 v_{max}^2$$

$$\Rightarrow 180 \cdot 10^3 \frac{92}{0,03} + 2 \cdot (-0,2) = 10^1 v_{max}^2 \Rightarrow 180 \cdot 10^{-3} \frac{2 \cdot 10^8}{3 \cdot 10^2} - 2 \cdot 10^1 = 10^1 v_{max}^2$$

$$12 - 4 = v_{max}^2 \Rightarrow v_{max} = \sqrt{8} \Rightarrow v_{max} = 2\sqrt{2} \text{ m/s}$$

$$\delta) \quad k_e \frac{qQ}{R} + mgR = k_e \frac{qQ}{y} + mgy \Rightarrow 8 \cdot 10^9 \cdot \frac{20 \cdot 10^{-12}}{10^1} + 2 \cdot 10^3 \cdot 10 \cdot 10^1 = 8 \cdot 10^9 \frac{20 \cdot 10^{-12}}{y} + 2y$$

$$\Rightarrow 180 \cdot \frac{10^3}{10^1} + 9,2 = \frac{180 \cdot 10^3}{y} + 2y \Rightarrow Q = \frac{918}{y} + 2y$$

$$\Rightarrow 2y = 0,18 + 2y^2 \Rightarrow 2y^2 - 2y + 918 = 0 \Rightarrow y^2 - y + 459 = 0$$

$$\Delta = 1 - 0,36 = 0,64$$

$\Delta p_{\alpha} \quad y = \frac{1 \pm \sqrt{0,64}}{2}$       0,9 Feuer .  
                                   \ 0,1

$$\Delta p_{\alpha} \quad y = 0,9 \text{ m} .$$

$R=0,1$        $v_{m_j} = k_e \frac{qQ}{R} = 8 \cdot 10^9 \frac{20 \cdot 10^{-12}}{0,1} = 180 \cdot \frac{10^{-3}}{10^1} = 1,8 \text{ J}$        $+ 3,0 \text{ J}$

$$v_{max} = mpr = 2 \cdot 10^3 \cdot 10 \cdot 0,1 = 0,2 \text{ J}$$

$R=0,3$        $v_{m_j} = k_e \frac{qQ}{R} = 8 \cdot 10^9 \frac{20 \cdot 10^{-12}}{3 \cdot 10^1} = 60 \cdot \frac{10^{-3}}{10^1} = 0,6 \text{ J}$

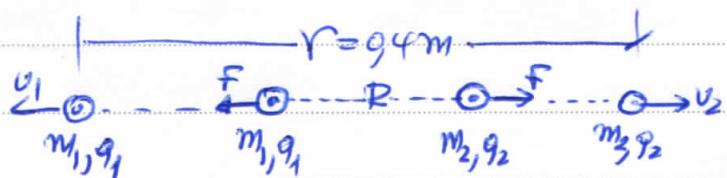
$$v_{max} = mpr = 2 \cdot 10^3 \cdot 10 \cdot 0,3 = 0,6 \text{ J}$$

$$\sum K_{max} = 0,8 \text{ J} = \frac{1}{2} \cdot 2 \cdot 10^3 \cdot v_{max}^2 \Rightarrow v_{max} = \underline{\underline{18 \text{ m/s}}}$$

7.31  $R=0,1m$   $r=0,4m$

$$q_1 = 4tC \quad q_2 = 12tC$$

$$m_1 = 0,03kg \quad m_2 = 0,06kg$$



$$0) \vec{P}_A = 6rad \Rightarrow m_2 v_2 - m_1 v_1 = 0 \Rightarrow \frac{v_1}{v_2} = \frac{m_2}{m_1} \Rightarrow v_1 = \frac{m_2}{m_1} v_2 \Rightarrow v_1 = 2v_2$$

$$\frac{k c q_1 q_2}{R} = k \frac{q_1 q_1}{r} + \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 \Rightarrow k q_1 q_2 \left( \frac{1}{R} - \frac{1}{r} \right) = \frac{1}{2} m_1 \frac{m_2^2}{m_1^2} v_2^2 + \frac{1}{2} m_2 v_2^2$$

$$\Rightarrow k q_1 q_2 \left( \frac{1}{0,1} - \frac{1}{0,4} \right) = \frac{1}{2} m_2 v_2^2 \cdot \left( \frac{m_2}{m_1} + 1 \right) \Rightarrow k q_1 q_2 \left( \frac{1}{0,1} - \frac{1}{0,4} \right) = \frac{1}{2} \frac{m_2}{m_1} (m_1 + m_2) v_2^2$$

$$\Rightarrow v_2^2 = \frac{2 m_1}{m_2 (m_1 + m_2)} k q_1 q_2 \left( \frac{1}{0,1} - \frac{1}{0,4} \right) \xrightarrow{\text{SF}} v_2^2 = \frac{2 \cdot 3 \cdot 10^2}{6 \cdot 10^2 \cdot 9 \cdot 10^2} 9 \cdot 10^9 \cdot 48 \cdot 10^{12} \left( \frac{1}{0,1} - \frac{1}{0,4} \right)$$

$$\Rightarrow v_2^2 = 48 \cdot 10^1 \cdot \frac{0,3}{0,04} = 48 \cdot 10^1 \cdot \frac{3 \cdot 10^1}{4 \cdot 10^2} = 36 \Rightarrow v_2 = 6 \frac{m}{s} \quad \wedge \quad v_1 = 12 \frac{m}{s}$$

$$8) \frac{v_1}{v_2} = \frac{m_2}{m_1} = \frac{2}{1} \Rightarrow \frac{dx_1/dt}{dx_2/dt} = \frac{2}{1} \Rightarrow \frac{dx_1}{dx_2} = \frac{2}{1} \quad \dots \Rightarrow \frac{\Delta x_1}{\Delta x_2} = \frac{2}{1}$$

$$\Rightarrow \Delta x_1 = 2 \Delta x_2 \quad \Delta x_1 + \Delta x_2 = R - r = 0,3 \Rightarrow 3 \Delta x_2 = 0,3$$

$$\Rightarrow \Delta x_2 = 0,1m \quad \wedge \quad \Delta x_1 = 0,2m$$

8)  $v_{max} \Rightarrow r \rightarrow \infty$

$$v_{2,max}^2 = \frac{2 m_1}{m_2 (m_1 + m_2)} \frac{k c q_1 q_2}{R} = \frac{2 \cdot 3 \cdot 10^2}{6 \cdot 10^2 \cdot 9 \cdot 10^2} \frac{9 \cdot 10^9 \cdot 48 \cdot 10^{12}}{10^1} \Rightarrow v_{2,max}^2 = 48$$

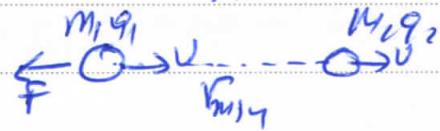
$$\Rightarrow v_{2,max} = 4\sqrt{3} \frac{m}{s} \quad \wedge \quad v_{1,max} = 8\sqrt{3} \frac{m}{s}$$

7.32

$$m_2 = 9,24 \text{ kg}, R = 0,6 \text{ m}, q_1 > 0$$

$$m_1 = 0,08 \text{ kg}, q_1 > 0$$

$$v_0 = 10 \text{ m/s} \quad F = k_c \frac{|q_1 q_2|}{R^2} = 1 \text{ N} \Rightarrow k_c |q_1 q_2| = F \cdot R^2$$



$$\text{a)} \quad U = k_c \frac{q_1 q_2}{R} = k_c \frac{|q_1 q_2|}{R} = \frac{F R^2}{R} = F R \Rightarrow U = 0,6 \text{ J}$$

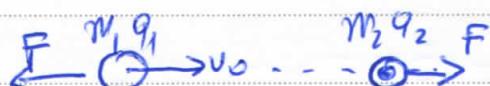
$$\text{b)} \quad m_1 v_0 = m_1 v + m_2 v \Rightarrow v = \frac{m_1 v_0}{m_1 + m_2} \Rightarrow v = \frac{0,08 \cdot 10}{0,32} \Rightarrow v = 25 \text{ m/s}$$

$$\text{b.2)} \quad U' = U + K_1 + K_2 \Rightarrow k_c \frac{q_1 q_2}{R} = k_c \frac{\frac{1}{2} m_1 v_0^2}{r} + \frac{1}{2} m_1 v^2 + \frac{1}{2} m_2 v^2$$

$$\Rightarrow 4,6 = \frac{F \cdot R^2}{R} + \frac{1}{2} (m_1 + m_2) v^2 \Rightarrow 4,6 = \frac{1 \cdot 0,6^2}{R} + \frac{1}{2} \cdot 0,32 \cdot 25^2$$

$$4,6 - 1 = \frac{0,36}{R} \Rightarrow 3,6 = \frac{0,36}{R} \Rightarrow R = 0,10 \text{ m}$$

8)

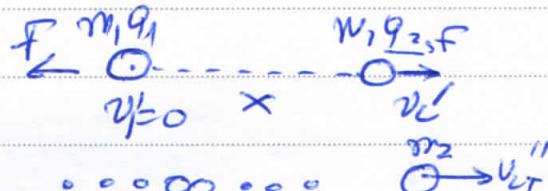


$$m_1 v_0 = m_1 v_1 + m_2 v_2'$$

$$0,08 \cdot 10 = 0 + 0,24 \cdot v_2' \Rightarrow v_2' = \frac{9,8}{0,24}$$

$$\Rightarrow v_2' = \frac{80}{24} = \frac{10}{3} \text{ m/s}$$

$$v_2'' = 0$$



$$\frac{1}{2} m_1 v_0^2 + k_c \frac{q_1 q_2}{R} = \frac{1}{2} m_2 v_2'^2 + k_c \frac{q_1 q_2}{x} \Rightarrow \frac{1}{2} 0,08 \cdot 100 + 0,6 = \frac{1}{2} 0,24 \frac{100}{9} + \frac{F R^2}{x}$$

$$\Rightarrow 4,6 = \frac{4}{3} + \frac{1,036}{x} \Rightarrow \frac{9,8}{3} = \frac{9,36}{x} \Rightarrow x = \frac{3 \cdot 0,36}{9,8} = \frac{1,08}{9,8} \Rightarrow x = 0,11 \text{ m}$$

8)

$$m_1 v_0 = -m_1 v_{1T} + m_1 v_{2T} \Rightarrow 0,08 \cdot 10 = -0,08 v_{1T} + 0,24 v_{2T}$$

$$10 = -v_{1T} + 3v_{2T} \Rightarrow 3v_{2T} - v_{1T} = 10 \quad (1)$$

$$U_{\text{apex}} + K_{\text{ex}} = \frac{1}{2} m_1 v_{1T}^2 + \frac{1}{2} m_2 v_{2T}^2 \Rightarrow 4,6 = \frac{1}{2} 0,08 v_{1T}^2 + \frac{1}{2} 0,24 v_{2T}^2$$

$$\Rightarrow 115 = U_{1T}^2 + 3U_{2T}^2 \quad (7)$$

$$3U_{2T} - U_{1T} = 10 \Rightarrow U_{1T} = 3U_{2T} - 10 \quad (8) \quad 115 = (3U_{2T} - 10)^2 + 3U_{2T}^2$$

$$\Rightarrow 115 = 9U_{2T}^2 + 100 - 60U_{2T} + 3U_{2T}^2 \Rightarrow 12U_{2T}^2 - 60U_{2T} - 15 = 0$$

$$\Rightarrow U_{2T}^2 - 5U_{2T} - 1,25 = 0 \Rightarrow \Delta = 25 + 4 \cdot 1,25 = 30$$

$$U_{2T} = \frac{5 \pm 5,48}{2} \quad \begin{matrix} /5,24 \\ \backslash (-) \end{matrix}$$

$$\underline{U_{1T} = 5,72 \text{ m/s}}$$

dpa  $U_{1T} = 5,72 \text{ m/s}$ , woei  $U_{2T} = 5,24 \text{ m/s}$

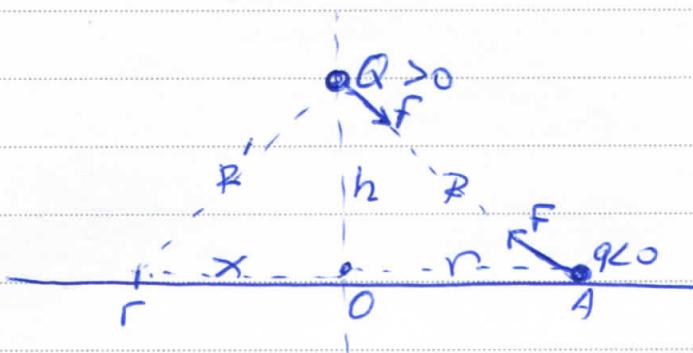
7.33

$$Q=4 \text{ tC}$$

$$h=0,8 \text{ m}, r=0,6 \text{ m}$$

$$m=0,01 \text{ kg}$$

$$q=-1 \text{ tC}$$



$$\alpha) U_{\text{apex}} = U_{\text{ES}}$$

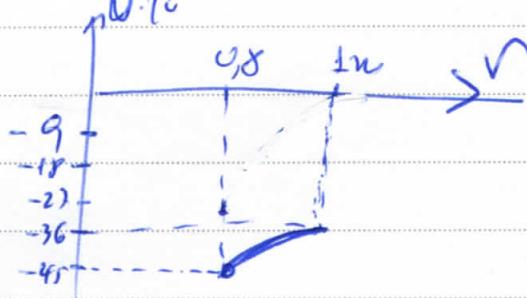
$$\Rightarrow k_e \frac{qQ}{R} = k_e \frac{qQ}{R'} \Rightarrow R' = R \Rightarrow x^2 + h^2 = h^2 + r^2 \Rightarrow x = r \Rightarrow x = 0,6 \text{ m}$$

b)

$$R=1,0 \text{ m} \quad U_A = k_e \frac{qQ}{R} = 9 \cdot 10^9 \cdot \frac{-1 \cdot 10^{-6} \cdot 4 \cdot 10^{-6}}{1} = -36 \cdot 10^3 \text{ J}$$

$$U_0 = k_e \frac{qQ}{h} = 9 \cdot 10^9 \cdot \frac{-1 \cdot 10^{-6} \cdot 4 \cdot 10^{-6}}{0,8} = -45 \cdot 10^3 \text{ J}$$

$$U_{\text{min}} = U_0 = -45 \cdot 10^3 \text{ J}$$



$$\gamma) U_A + K_A = U_0 + K_0$$

$$\Rightarrow -36 \cdot 10^3 + 0 = -45 \cdot 10^3 + K_0$$

$$\Rightarrow K_0 = 9 \cdot 10^3 \text{ J} \Rightarrow K_{\text{max}} = 9 \cdot 10^3 \text{ J}$$

c)

$$F < mg \Rightarrow$$

$$k_e \frac{|qQ|}{H^2} < mg$$

$$Q > 0$$

$$H$$

$$F$$

$$q > 0$$

$$mg$$

$$\Rightarrow k_e |qQ| \leq mg H^2 = 9 \cdot 10^9 \cdot 4 \cdot 10^{-12} \leq 0,01 \cdot 10 \cdot 1,4^2 \Rightarrow 36 \cdot 10^3 \leq 0,1 \cdot 1,96$$

$$\Rightarrow H^2 \geq 36 \cdot 10^2 \Rightarrow H \geq 0,6 \text{ m} \Rightarrow \boxed{H_{\text{min}} = 0,6 \text{ m}}$$

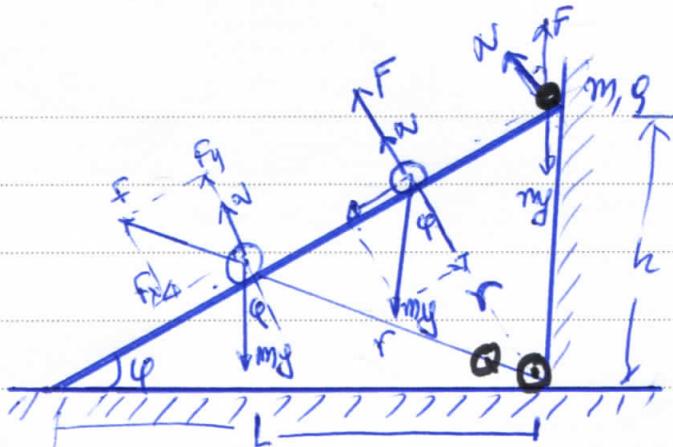
7.34

$$\varphi = 37^\circ \quad h = 0,75 \text{ m}$$

$$Q = 8 \text{ t} \cdot \text{C} \quad \left| \begin{array}{l} \vartheta = 45^\circ \\ m = 0,1 \text{ kg} \end{array} \right.$$

$$\tan \varphi = \frac{h}{L} \Rightarrow \frac{3}{4} = \frac{0,75}{L}$$

$$\Rightarrow 3L = 4 \cdot 0,75 \Rightarrow L = 1 \text{ m}$$



$$\text{Applikation: } F = k_c \frac{Q \cdot g}{h^2} = g \cdot 10^3 \cdot \frac{32 \cdot 10^{12}}{0,75^2} = 0,192 \text{ N}$$

$$\left. \begin{array}{l} \exists x > f_x \\ B_m + \varphi > f_u + \varphi \end{array} \right\}$$

$$m_f = 0,1 \cdot 10 = 1 \text{ N}$$

$$mg > f$$

$$F_{max} = k_c \frac{Q \cdot g}{r^2} = g \cdot 10^3 \cdot \frac{32 \cdot 10^{12}}{0,36} = 75 \cdot 10^3 \text{ N} = 0,8 \text{ MN}$$

$$r = L \sin \varphi = 0,6 \text{ m}$$

$$B_y = m_f \sin \varphi = 1 \cdot 0,8 = 0,8 \text{ N}$$

$$F_{max} \leq R_y$$

Naepatmnyj s  $F_{max} \leq R_y$  do o svyazane n stopy

$$e) U_{max} = k_c \frac{Q \cdot g}{r} = g \cdot 10^3 \cdot \frac{32 \cdot 10^{12}}{0,6} = \underline{\underline{0,4807}}$$

( $k_{max}$  &  $T_{fmax}$ ) do w'vnuu auxx en, faxnopen

$$s) U_{apx} + U_{aex} + k_{aex} = U_{rel} + U_{sys} + k_{sys}$$

$$k_c \frac{Q \cdot g}{h^2} + m_f H + 0 = k_c \frac{Q \cdot g}{L^2} + k_{max}$$

$$g \cdot 10^3 \cdot \frac{32 \cdot 10^{12}}{0,75^2} + 0,1 \cdot 10 \cdot 0,75 = g \cdot 10^3 \cdot \frac{32 \cdot 10^{12}}{1} + k_{max} \Rightarrow 0,384 + 0,770 = 0,788 + k_{max}$$

$$\underline{\underline{k_{max} = 0,8467}}$$

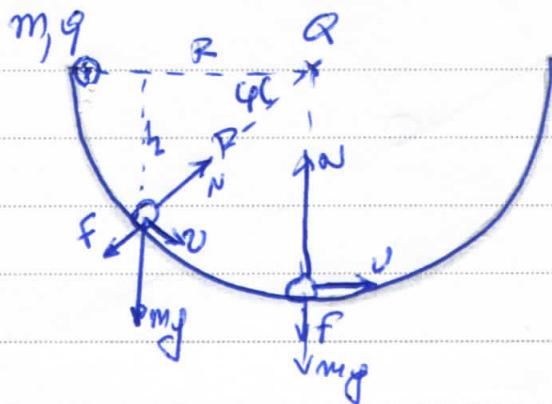
F35

$$R = 0,2 \text{ m} \quad d) U = k_c \frac{Qq}{R}$$

$$Q = 4 \mu \text{C}$$

$$q = 1 \mu \text{C} \quad \Rightarrow U = 9 \cdot 10^9 \cdot \frac{4 \cdot 10^{-12}}{0,2} = \frac{36}{2} \cdot 10^{-3}$$

$$\Rightarrow U = 18 \cdot 10^{-3} \Rightarrow U = 0,18 \text{ J}$$



$$e) k_c \frac{qU}{R} + mgR = k_c \frac{qQ}{R} + \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2gR} = \sqrt{2 \cdot 10 \cdot 0,2} \Rightarrow v = 2 \text{ m/s}$$

$$f) \tau F_F = ma_F = m \frac{v^2}{R} \Rightarrow \tau F_F = 0,05 \cdot \frac{4}{0,2} \Rightarrow \tau F_F = 1 \text{ N}$$

$$g) \tau F_F = N - F - mg \Rightarrow 1 = N - 0,9 - 0,05 \cdot 10 \Rightarrow N = 1 + 0,9 + 0,5 \Rightarrow N = 2,4 \text{ N}$$

$$F = k_c \frac{qQ}{R^2} = 9 \cdot 10^9 \cdot \frac{4 \cdot 10^{-12}}{0,04} = \frac{36 \cdot 10^{-3}}{4 \cdot 10^{-2}} = 0,9 \text{ N}$$

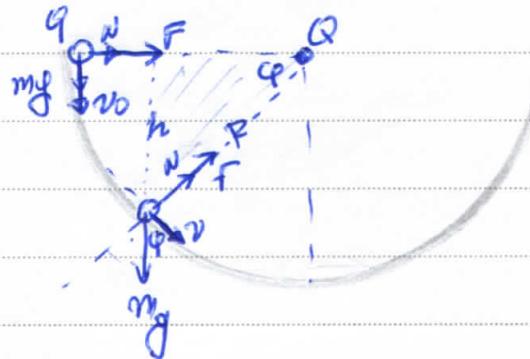
$\therefore mg h = \frac{1}{2}mv^2 \Rightarrow ghg R n t \varphi = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2ghRn t \varphi}$

$$\Rightarrow v = \sqrt{2 \cdot 10 \cdot 0,2 \cdot \frac{1}{2}} \Rightarrow v = \sqrt{2} \text{ m/s}$$

7.36

a) Für  $\varphi = 20^\circ$   $\lambda = 10$   $\text{deg}^{\circ}$ 

$$\frac{1}{2}mv_0^2 + \frac{1}{2}k_c \frac{Q^2}{R} + mgh = k_c \frac{Q^2}{R} + \frac{1}{2}mv^2$$



$$\Rightarrow V = \sqrt{v_0^2 + 2gR\mu + \varphi}$$

$$\Rightarrow V^2 = v_0^2 + 2gR\mu + \varphi$$

$$\sum F_F = m a_F \Rightarrow F + N - mg \sin \varphi = m \frac{v^2}{R^2} \Rightarrow F + N - mg \sin \varphi = m \cdot \frac{v_0^2 + 2gR\mu + \varphi}{R^2}$$

$$F = k_c \frac{|QQ|}{R^2} = 9 \cdot 10^9 \cdot \frac{40 \cdot 10^{-12}}{4 \cdot 10^2} = 90 \cdot \frac{10^{-3}}{10^2} = 9 \text{ N}$$

$$\Rightarrow 9 + N - 0,01 \cdot 10 \cdot \sin \varphi = 0,01 \cdot \frac{36 + 2 \cdot 10 \cdot g + \varphi}{0,04}$$

$$\Rightarrow 9 + N - 0,1 \sin \varphi = \frac{36 + 4 \cdot 10 \cdot \varphi}{4} = 9 + 10 \cdot \sin \varphi \Rightarrow N = \underline{\underline{7,1 \text{ N}}}$$

$N = 7,1 \text{ N} \sin \varphi$   $0 < \varphi < 180^\circ \Rightarrow \sin \varphi > 0 \quad N > 0$   
der Wert ist der maximale

$$V_{m1} = k_c \frac{Q^2}{R} = 9 \cdot 10^9 \frac{2 \cdot 10^{-6}}{0,2} = 90 \cdot 10^6 \Rightarrow V_{m1} = \frac{360}{2} \cdot \frac{10^3}{10^1}$$

$$\Rightarrow V_{m2} = \underline{\underline{18 \text{ Joule}}}$$

b)

$$N = 7,1 \text{ N} \sin \varphi \xrightarrow{\varphi = 90^\circ} \boxed{N = 8 \text{ N}} \rightsquigarrow N = \underline{\underline{8 \text{ N}}}$$

$$\gamma) 000 \cdot g + N - 0,1 \sin \varphi = 0,01 \frac{v_0^2 + 2 \cdot 10 \cdot g \cdot 2 \sin \varphi}{0,04}$$

$$\Rightarrow 8 + N - 0,1 \sin \varphi = 0 \frac{v_0^2 + 4 \sin \varphi}{4}$$

$$N = 9 + 0,1 \sin \varphi + \frac{v_0^2}{4} + 1 \sin \varphi$$

$$\Rightarrow N = 9 + 1,1 \sin \varphi + \frac{v_0^2}{4}$$

ooo kofolyo opeiv maxxi

24-2

Beslungs + gemaq  $q \geq 0$   $N \geq 0$

$$q=0 \rightarrow N = -8 + \frac{v_0^2}{4} \geq 0 \Rightarrow v_0^2 \geq 32 \Rightarrow \underline{v_0 \geq 6 \text{ m/s}}$$

$$-9 + 1,1m + q + \frac{v_0^2}{4} \geq 0 \Rightarrow \frac{v_0^2}{4} \geq 9 - 1,1m - q$$

$$\Rightarrow v_0^2 \geq 36 - 4,4m + q$$

$$q_0 = 0 \quad v_0 \geq 6 \text{ m/s}$$

$$q = 80 \quad v_0 \geq \dots \text{ s.t.}$$

$$v_0 \geq 6 \text{ m/s}$$

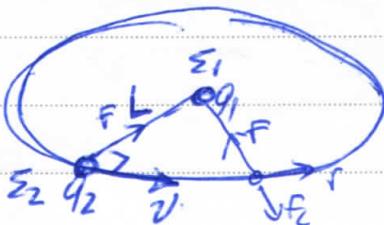
$$\boxed{v_{0\text{min}} = 6 \text{ m/s}}$$

7.37

d)

$$U = k_c \frac{q_1 q_2}{L} = 8J \quad F_C = 16N$$

$$F_{\text{app}} = F_C = k_c \frac{q_1 q_2}{L^2} = \frac{U}{L} = \frac{8J}{0,5m} = 16N$$



$$\text{e)} \quad k = \frac{1}{2} m v^2 = 17J \Rightarrow m v^2 = 2k$$

$$F - F_C = \frac{m v^2}{L} \Rightarrow F - F_C = \frac{2k}{L}$$

$$\Rightarrow F - 16 = \frac{2 \cdot 11}{0,5} \Rightarrow \underline{\underline{F = 60N}}$$

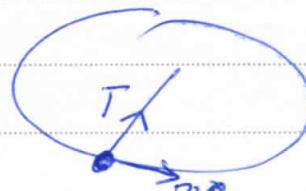
$$\text{f)} \quad F = F_C + \frac{2k}{L} = 16 + 4k \leq 100 \text{ N} \quad 4k \leq 84 \Rightarrow k \leq 21J$$

$$\alpha_0 \propto k_{\max} = 21J$$

g)

$$T = m \frac{v^2}{L} = \frac{2k}{L}$$

$$\Rightarrow T = \frac{2 \cdot 11}{0,5} \Rightarrow \underline{\underline{T = 44N}}$$



## 7.38

α) Το δυναμικό στο σύνθετο πεδίο της άσκησης για  $0 < x < 3m$  δίνεται από τη σχέση  $V = K_c \frac{Q_1}{x} + K_c \frac{Q_2}{3-x}$  (S.I). Από τη σχέση αυτή και τη μορφή της καμπύλης  $V = f(x)$  για να έχουμε μόνο θετικές τιμές για το δυναμικό πρέπει  $Q_1 > 0$  και  $Q_2 > 0$ .

β) Ένα φορτίο  $q$  όταν αφεθεί ελεύθερο χωρίς αρχική ταχύτητα μέσα σε ένα ηλεκτροστατικό πεδίο και η μόνη δύναμη που ασκείται σε αυτό είναι η δύναμη του πεδίου θα κινηθεί - αυθόρυμητα-

- ⊕ προς την κατεύθυνση της δύναμης που δέχεται από το ηλεκτροστατικό πεδίο,
- ⊕ προς την κατεύθυνση που το έργο της ηλεκτροστατικής δύναμης είναι θετικό,
- ⊕ σε κάθε περίπτωση προς περιοχές που μειώνεται η δυναμική ηλεκτρική ενέργεια που έχει το φορτίο λόγω αλληλεπίδρασης με το πεδίο,
- ⊕ αν είναι θετικό προς περιοχές με μικρότερα δυναμικά,
- ⊕ αν είναι αρνητικό προς περιοχές με μεγαλύτερα δυναμικά.

Στην άσκηση το φορτισμένο σωματίδιο έχει θετικό φορτίο ( $q > 0$ ) άρα αρχικά - αφού δεν έχει ταχύτητα -θα κινηθεί προς μικρότερα δυναμικά, δηλαδή από τη θέση  $x = 2m$  προς τη θέση  $x = 1m$

Στην κίνηση αυτή η μηχανική ενέργεια παραμένει σταθερή.

$U + K = \sigma t a \theta$  και επειδή η δυναμική ενέργεια μειώνεται η κινητική ενέργεια αυξάνεται και θα γίνει μέγιστη όταν γίνει ελάχιστη η δυναμική ενέργεια, και επειδή  $U = qV > 0$  αυτή

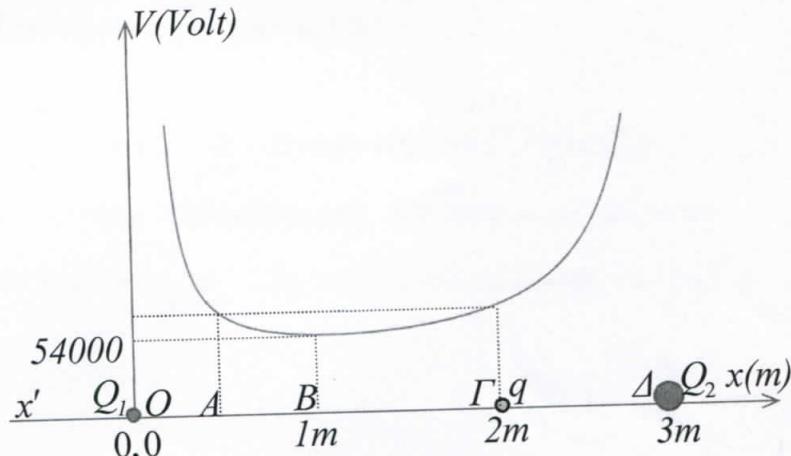
γίνεται ελάχιστη στη θέση που το δυναμικό παίρνει τη ελάχιστη τιμή ... στη θέση  $B(x = 1m)$ .

$$\gamma) U + K = \sigma t a \theta \Rightarrow U_{\Gamma} + K_{\Gamma} = U_B + K_B \xrightarrow{K_{\Gamma}=0} U_{\Gamma} = qV_B + K_{max}$$

$$\xrightarrow{S.I} U_{\Gamma} = 2 \cdot 10^{-7} \cdot 54000 + 5,4 \cdot 10^{-3} \Rightarrow U_{\Gamma} = 16,2 \cdot 10^{-3} J.$$

$$\delta) U_{\Gamma} = qV_{\Gamma} \Rightarrow V_{\Gamma} = \frac{U_{\Gamma}}{q} \xrightarrow{S.I} V_{\Gamma} = \frac{16,2 \cdot 10^{-3} J}{2 \cdot 10^{-7} C} \Rightarrow V_{\Gamma} = 81000 V.$$

$$\varepsilon) \text{Το δυναμικό στο } B \text{ είναι } V = K_c \frac{Q_1}{x} + K_c \frac{Q_2}{3-x} \Rightarrow$$



$$54000 = 9 \cdot 10^9 \frac{Q_1}{1} + 9 \cdot 10^9 \frac{Q_2}{2} \Rightarrow Q_1 + 0,5Q_2 = 6 \cdot 10^{-6} C \quad (1)$$

$$\text{Το δυναμικό στο } \Gamma \text{ είναι } V = K_c \frac{Q_1}{x} + K_c \frac{Q_2}{3-x} \Rightarrow$$

$$81000 = 9 \cdot 10^9 \frac{Q_1}{2} + 9 \cdot 10^9 \frac{Q_2}{1} \Rightarrow 0,5Q_1 + Q_2 = 9 \cdot 10^{-6} C \quad (2)$$

Από το σύστημα των (1) και (2) παίρνουμε  $Q_1 = 2 \cdot 10^{-6} C$  και  $Q_2 = 8 \cdot 10^{-6} C$ .

στ) Η κίνηση από το  $\Gamma$  μέχρι το  $B$  είναι επιταχυνόμενη και λόγω της ταχύτητας περνάει από το  $B$  αλλά κινείται προς μεγαλύτερα δυναμικά όπου η δυναμική ενέργεια αυξάνεται και προφανώς η κινητική μειώνεται...και έστω ότι θα μηδενισθεί σε ένα σημείο  $A$ .

$$U_{\Gamma} + K_{\Gamma} = U_A + K_A \xrightarrow{K_{\Gamma}=0, K_A=0} U_{\Gamma} = U_A \Rightarrow U_{\Gamma} = qV_A \Rightarrow$$

$$16,2 \cdot 10^{-3} = 2 \cdot 10^{-7} \left( K_c \frac{Q_1}{x} + K_c \frac{Q_2}{3-x} \right) \Rightarrow K_c \frac{Q_1}{x} + K_c \frac{Q_2}{3-x} = 81000V \Rightarrow$$

$$81000 = 9 \cdot 10^9 \frac{2 \cdot 10^{-6}}{x} + 9 \cdot 10^9 \frac{8 \cdot 10^{-6}}{3-x} \Rightarrow \dots 9x^2 - 21x + 6 = 0 \dots \text{οι λύσεις}$$

αυτής είναι  $x = \frac{1}{3}m$  και  $x = 2m$ . Προφανώς δεκτή είναι η  $x = \frac{1}{3}m$ .

$$\zeta) E = K_c \frac{Q_1}{x^2} - K_c \frac{Q_2}{(3-x)^2} \text{ ( αντίρροπες εντάσεις) } \Rightarrow$$

$$E_B = 9 \cdot 10^9 \frac{2 \cdot 10^{-6}}{1} - 9 \cdot 10^9 \frac{8 \cdot 10^{-6}}{4} \Rightarrow E_B = 0 \dots \text{αναμενόμενο !! ( γιατί;)}$$

η) Το φορτίο εκτελεί μια συνεχή παλινδρομική κίνηση - ταλάντωση μεταξύ των θέσεων  $x = 2m$  και  $x = \frac{1}{3}m$  ...δηλαδή εγκλωβίζεται σε ένα "πηγάδι" δυναμικών.....

α) Το δυναμικό στο σύνθετο πεδίο της άσκησης για  $0 < x < 3m$  δίνεται από τη σχέση  $V = K_c \frac{Q_1}{x} + K_c \frac{Q_2}{3-x}$  (S.I). Από τη σχέση αυτή και τη μορφή της καμπύλης  $V = f(x)$

$Q_1 > 0$  και  $Q_2 < 0$ .

$$V = K_c \frac{Q_1}{x} + K_c \frac{Q_2}{3-x} \xrightarrow[V=0]{x=0,6m} 0 = K_c \frac{Q_1}{0,6} + K_c \frac{Q_2}{2,4} \Rightarrow Q_2 = -4Q_1 \xrightarrow[Q_2 < 0]{Q_1 > 0}$$

$$|Q_2| = 4Q_1$$

β) Το φορτίο  $q_1$  κινείται από αρνητική τιμή δυναμικού προς μηδενική τιμή ... δηλαδή από μικρότερα προς μεγαλύτερα δυναμικά άρα έχει αρνητικό φορτίο,  $q_1 < 0$ .

Το φορτίο  $q_2$  κινείται από θετική τιμή δυναμικού προς μηδενική τιμή ... δηλαδή από μεγαλύτερα προς μικρότερα δυναμικά άρα έχει θετικό φορτίο,  $q_2 > 0$ .

γ) Τα δυναμικά στις θέσεις  $x_1 = 1m$  και  $x_2 = 0,5m$  αντίστοιχα είναι

$$\text{Θέση } x_1 = 1m: V = K_c \frac{Q_1}{x} + K_c \frac{Q_2}{3-x} \xrightarrow{x=x_1=1m} V_1 = K_c \frac{Q_1}{x_1} + K_c \frac{Q_2}{3-x_1}$$

$$\xrightarrow[Q_2=-4Q_1]{Q_1=4Q_1} V_1 = 9 \cdot 10^9 \frac{Q_1}{1} - 9 \cdot 10^9 \frac{4Q_1}{2} \Rightarrow V_1 = -9 \cdot 10^9 Q_1$$

$$\text{Θέση } x_2 = 0,5m: V = K_c \frac{Q_1}{x} + K_c \frac{Q_2}{3-x} \xrightarrow{x=x_2=0,5m} V_2 = K_c \frac{Q_1}{x_2} + K_c \frac{Q_2}{3-x_2}$$

$$\xrightarrow[Q_2=-4Q_1]{Q_1=4Q_1} V_2 = 9 \cdot 10^9 \frac{Q_1}{0,5} - 9 \cdot 10^9 \frac{4Q_1}{2,5} \Rightarrow V_2 = +3,6 \cdot 10^9 Q_1$$

Το φορτισμένο σωματίδιο  $q_1$  κατά την μετακίνησή του από την θέση  $x_1 = 1m$  στη θέση  $x = 0,6m$  αποκτά κινητική ενέργεια  $K_1$  που υπολογίζεται από το ΘΜΚΕ  $K_1 - 0 = q_1(V_1 - 0) \xrightarrow[q_1 < 0]{q_1 = -|q|} K_1 = -|q|(-9 \cdot 10^9 Q_1) \Rightarrow$

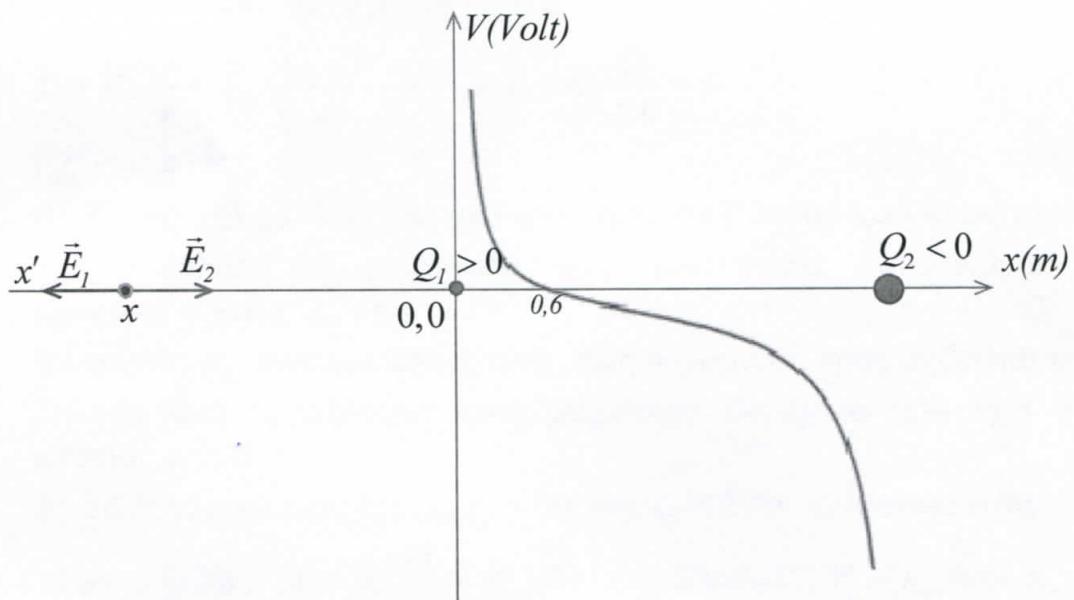
$$K_1 = 9 \cdot 10^9 Q_1 |q|$$

Το φορτισμένο σωματίδιο  $q_2$  κατά την μετακίνησή του από την θέση  $x_2 = 0,5m$  στη θέση  $x = 0,6m$  αποκτά κινητική ενέργεια  $K_2$  που υπολογίζεται από το ΘΜΚΕ  $K_2 - 0 = q_2(V_2 - 0) \xrightarrow[q_2 > 0]{q_2 = |q|} K_2 = |q|(3,6 \cdot 10^9 Q_1) \Rightarrow$

$$K_2 = |q|(3,6 \cdot 10^9 Q_1) \Rightarrow K_2 = 3,6 \cdot 10^9 Q_1 |q|$$

Παρατηρούμε ότι μεγαλύτερη κινητική ενέργεια αποκτά το φορτισμένο σωματίδιο  $q_1$

δ) Για να παραμείνει ακίνητο ένα φορτισμένο σωματίδιο πρέπει να το αφήσουμε στην θέση που η ένταση του πεδίου είναι μηδέν  $E = 0$ , που σημαίνει ότι οι επιμέρους εντάσεις από τις πηγές  $Q_1$  και  $Q_2$  να είναι αντίθετες. Αυτό όμως μπορεί να γίνει μόνο πάνω στην  $x'x$  και για  $x < 0$  (γιατί;)...



$$E_1 = E_2 \Rightarrow Kc \frac{|Q_1|}{|x|^2} = Kc \frac{|Q_2|}{(3+|x|)^2} \Rightarrow \frac{|Q_1|}{|x|^2} = \frac{|4Q_1|}{(3+|x|)^2} \Rightarrow \frac{(3+|x|)^2}{|x|^2} = 4 \Rightarrow$$

$$\frac{3+|x|}{|x|} = 2 \Rightarrow |x| = 3 \Rightarrow x = -3m$$

V

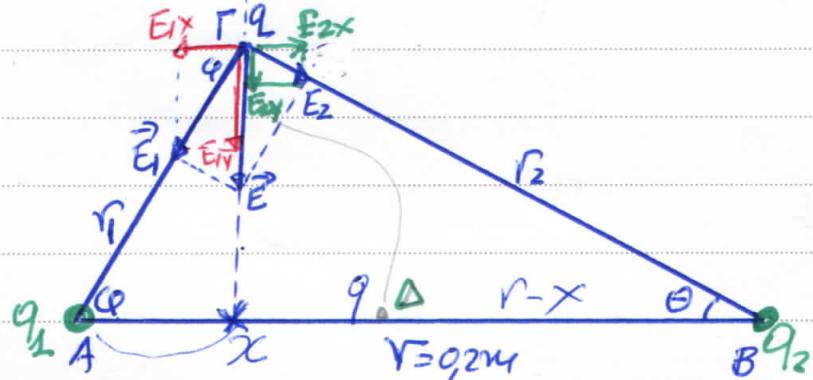
7.40

$$r_1 = 12 \text{ cm}$$

$$r_2 = 16 \text{ cm}$$

$$q_1 = -12 \text{ kN}$$

$$q_2 =$$



a) Για να είναι  $\vec{E} = \vec{E}_1 + \vec{E}_2 \perp AB$  πρέπει να είναι

πρόσθια στο μέσον της γέφυρας  $q_1 < 0, q_2 < 0$  και  $\sum F_x = 0$  και  $\sum F_y = 0$

$$\sum F_x = 0 \Rightarrow F_{1x} = F_{2x} \Rightarrow E_1 \sin \varphi = E_2 \cos \varphi \Rightarrow k_c \frac{|q_1|}{r_1^2} \frac{r_1}{r} = k_c \frac{|q_2|}{r_2^2} \frac{r_2}{r}$$

$$\Rightarrow \frac{|q_1|}{r_1} = \frac{|q_2|}{r_2} \Rightarrow |q_2| = |q_1| \cdot \frac{r_2}{r_1} = 12 \text{ kN} \cdot \frac{16 \text{ cm}}{12 \text{ cm}} \Rightarrow |q_2| = -16 \text{ kN}$$

Ωπού  $q_1 = -12 \text{ kN}$  πρέπει  $q_2 = -16 \text{ kN}$

$$\text{b) } U_f = k_c \frac{q_1 q_2}{r} = 9 \cdot 10^8 \frac{(-12 \cdot 10^6)(-16 \cdot 10^6)}{2 \cdot 10^1} = U = 8,64 \text{ J}$$

$$\text{c) } U_f = k_c \frac{q_1 q_1}{r_1} + k_c \frac{q_2 q_2}{r_2} = 9 \cdot 10^8 \frac{-12 \cdot 10^6 \cdot 10^6}{12 \cdot 10^2} + 9 \cdot 10^8 \frac{-16 \cdot 10^6 \cdot 10^6}{16 \cdot 10^2}$$

$$\Rightarrow U_f = -0,9 - 0,9 \Rightarrow U_f = -1,8 \text{ J}$$

$$\text{d) } W_{\text{pot}} = -\Delta U_f = -(-0,72 \text{ J}) = +0,72 \text{ J}$$

7.41

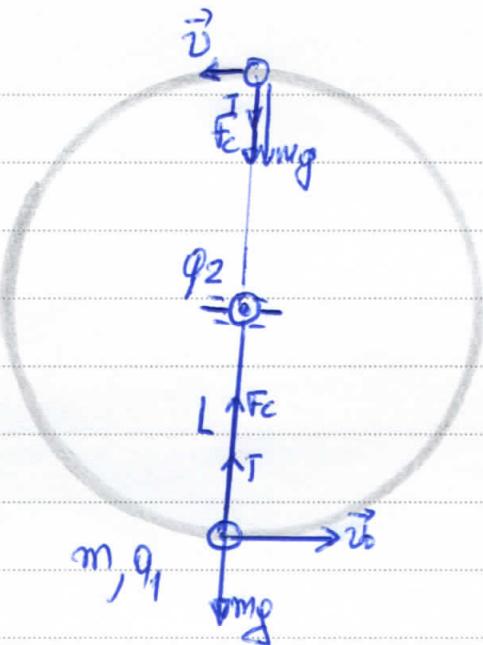
$$m = 0,25 \text{ kg} \quad q_1 = +\frac{50}{g} \cdot 10^6 \text{ C}$$

$$\alpha) U = k_c \frac{q_1 q_2}{L} \Rightarrow q_2 = \frac{U L}{k_c q_1}$$

$$\Rightarrow q_2 = \frac{-1 \cdot 0,5 \text{ N}}{8 \cdot 10^8 \frac{\text{Nm}^2}{C} \cdot \frac{50}{g} \cdot 10^6}$$

$$\Rightarrow q_2 = -9,01 \cdot 10^{-3} = -10^{-1} = -10 \text{ nC}$$

$$\Rightarrow q_2 = -10 \text{ nC}$$



$$\beta) U = k_c \frac{q_1 q_2}{2} \quad F_c = k_c \frac{|q_1 q_2|}{L^2} = \frac{-U L}{L^2} = -\frac{U}{L} = -\frac{-1}{0,5} = 2 \text{ N}$$

$$\left. \begin{aligned} U &= -k_c \frac{|q_1 q_2|}{L} \\ &\Rightarrow F_c = 2 \text{ N} \end{aligned} \right.$$

$$\left. \begin{aligned} \sum F_k &= m \ddot{r}_k \Rightarrow F_c + T - mg = m \frac{v^2}{L} \\ k &= \frac{1}{2} m v^2 \Rightarrow m v^2 = 2 k_0 \end{aligned} \right\} \quad \left. \begin{aligned} F_c + T - mg &= \frac{2 k_0}{L} \\ \Rightarrow 2 + T - 0,3 \cdot 10 &= \frac{2 \cdot 5}{0,5} \Rightarrow 2 + T - 3 = 20 \Rightarrow T = 21 \text{ N} \end{aligned} \right.$$

$$\gamma) \sum F_T \neq 0 \text{ but } \sum F_k = m \ddot{r}_k \Rightarrow F_c + T + mg = m \frac{v^2}{L} \Rightarrow F_c + T + mg = \frac{2 k}{L}$$

$$\Rightarrow T = \frac{2 k}{L} - F_c - mg \geq 0 \Rightarrow \frac{2 k}{L} \geq F_c + mg \Rightarrow \frac{2 \cdot k}{0,5} \geq 2 \cdot 0,3 \cdot 10 \Rightarrow k \geq 12,5 \text{ N}$$

$$\Rightarrow k \geq 12,5 \text{ N}$$

$$\Delta k = N_B + N_f + \Delta N_F \Rightarrow k - k_0 = -mg \cdot 2L \Rightarrow k = k_0 - 2mgL$$

$$\Rightarrow k = k_0 - 2 \cdot 0,3 \cdot 10 \cdot 0,5 = 12,5 \text{ N}$$

$$\therefore \boxed{k \geq 12,5 \text{ N}}$$

$$\Rightarrow \boxed{k_0 \geq 25 \text{ N}}$$

$$\boxed{k_{\min} = 4,75 \text{ N}}$$

$$\boxed{k = k_0 - 3J \geq 12,5 \text{ N} \Rightarrow k_0 \geq 4,25 \text{ J}}$$

742

$$d) U = k_c \frac{q^2}{L} \Rightarrow q = \sqrt{\frac{U L}{k_c}}$$

$$\Rightarrow q = \sqrt{\frac{3,24 \cdot 0,9}{9,81 \cdot 10^6}} \Rightarrow q = 18 \cdot 10^{-6} C$$

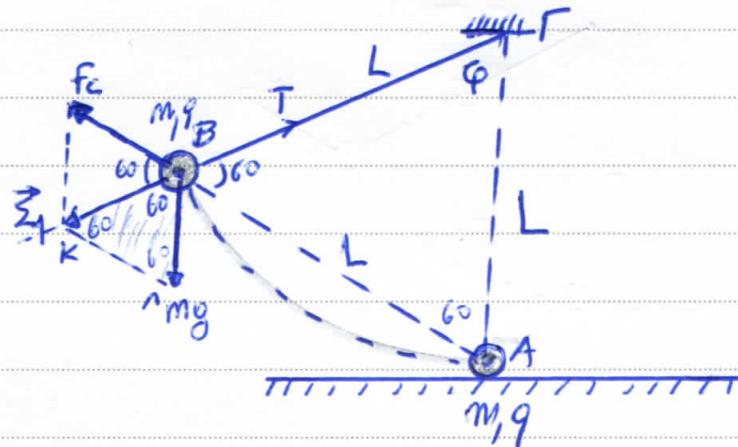
$$\Rightarrow q = 18 \mu C$$

BKA  $\hat{\gamma}$  δένεινευρο  $\Rightarrow mg = F_C = \Sigma_1 = T$

$$\hookrightarrow mg = k_c \frac{q^2}{L^2} \Rightarrow mg = \frac{U}{L} \Rightarrow m = 0,36 kg$$

b)

$$T = \Sigma_1 \Rightarrow T = mg \Rightarrow T = 3,6 N$$

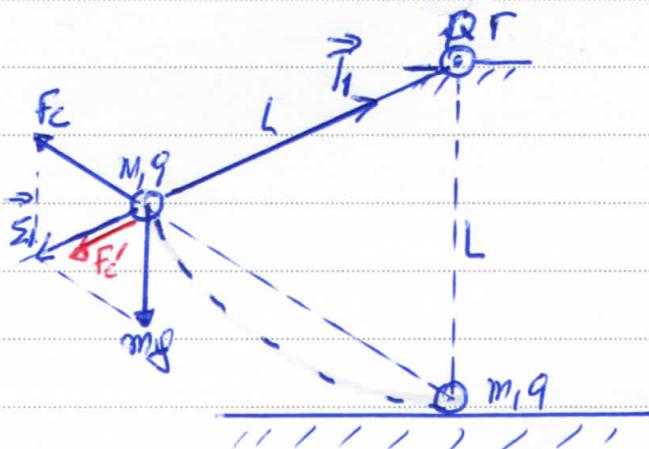


$$\Sigma_1 = \vec{T}_1 + \vec{F}_C'$$

$$\Sigma_1 = T_1 - F_C'$$

$$mg = T_1 - F_C' \Rightarrow 3,6 = 5,6 - F_C'$$

$$\Rightarrow F_C' = 2N \Rightarrow k_c \frac{q^2}{L^2} = F_C'$$



$$\Rightarrow k_c \frac{q^2}{L} = F_C' \cdot L = 2 \cdot 0,9 = 1,8 J \quad (1)$$

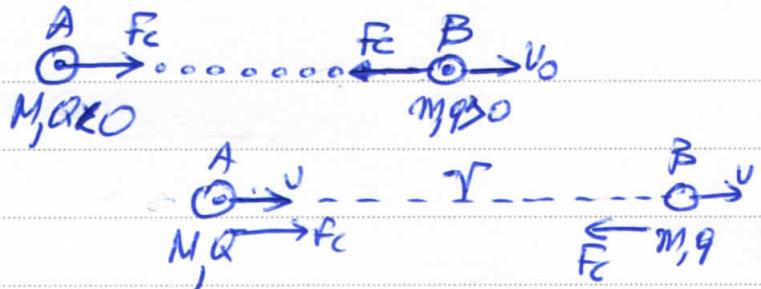
$$U_{02} = k_c \frac{q^2}{L} + k_c \frac{q^2}{L} + k_c \frac{q^2}{L} = k_c \frac{q^2}{L} + 2k_c \frac{q^2}{L} \xrightarrow{(1)} U_{02} = 3,24 + 2 \cdot 1,8 \Rightarrow U_{02} = 6,84 J$$

7.43

$$Q = -5 \cdot 10^6 \text{ C} \quad M = 20 \cdot 10^3 \text{ kg}$$

$$q = +2 \cdot 10^6 \text{ C} \quad m = 10 \cdot 10^3 \text{ kg}$$

$$k_0 = 0,045 \text{ N/m}, \quad r = 1 \text{ m}$$



$$\text{d) } p_{\text{ext}} = m v_0 \Rightarrow m v_0 = (m+M) v \Rightarrow v = \frac{m v_0}{m+M}$$

$$U_{\text{ext}} + k_0 = k_A + k_B + U \Rightarrow k_c \frac{qQ}{r} + k_0 = \frac{1}{2} M v^2 + \frac{1}{2} m v^2 + k_c \frac{qQ}{r}$$

$$\Rightarrow k_c \frac{qQ}{r} + k_0 = \frac{1}{2} (m+M) v^2 + k_c \frac{qQ}{r} \Rightarrow k_c \frac{qQ}{r} + k_0 = \frac{m}{m+M} k_0 + k_c \frac{qQ}{r}$$

$$\Rightarrow 9 \cdot 10^9 \frac{-10 \cdot 10^{12}}{1} + 0,045 = 0,015 + 9 \cdot 10^9 \frac{-10 \cdot 10^{12}}{r} \Rightarrow -0,090 + 0,045 - 0,015 = \frac{-990}{r}$$

$$\frac{0,090}{r} = 0,060 \Rightarrow r = 1,5 \text{ m}$$

$$\text{B) } U = k_c \frac{qQ}{r} = 9 \cdot 10^9 \frac{-10 \cdot 10^{12}}{1,5} \Rightarrow U = -0,060 \text{ J}$$

$$\text{C) } \left[ k_0 = \frac{1}{2} m v_0^2 \Rightarrow v_0 = \sqrt{\frac{2 k_0}{m}} = \sqrt{\frac{2 \cdot 0,045}{10 \cdot 10^3}} = v_0 = 3 \text{ m/s} \right. \quad , \quad v = \frac{m v_0}{m+M} \Rightarrow v = 1 \text{ m/s} \quad ]$$

$$F_c = k_c \frac{|qQ|}{r^2} = 9 \cdot 10^9 \frac{10 \cdot 10^{12}}{1,5^2} \Rightarrow F_c = 0,040 \text{ N}$$

$$\frac{dP_A}{dt} = \sum F = F_c \Rightarrow = (+0,040 \text{ N}) \Rightarrow \frac{dP_A}{dt} = +0,040 \text{ N m/s}^2$$

$$\frac{dP_B}{dt} = \sum F = F_c \Rightarrow (-0,040 \text{ N}) \Rightarrow \frac{dP_B}{dt} = -0,040 \text{ N m/s}^2$$

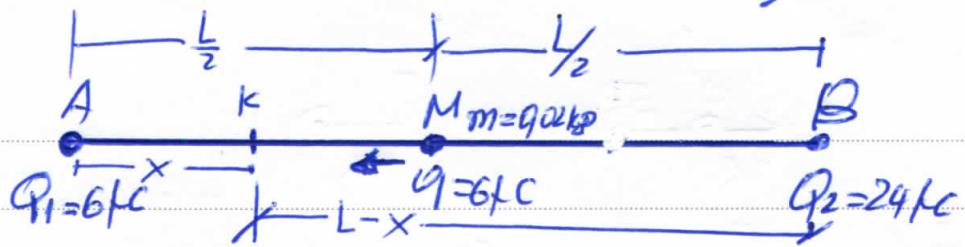
$$\text{D) } dV_{\text{ext}} = F_c \cdot r \quad U + k = 6 \text{ mJ} \Rightarrow dV = -dk \Rightarrow \frac{dV}{dt} = \frac{dk}{dt}$$

$$\Rightarrow \frac{dV}{dt} = -\frac{dk_A}{dt} = \frac{dP_B}{dt} = -[(+F_c)(+r)] + (-F_c)(-v) = 0$$

$$\Rightarrow \frac{dV}{dt} = 0$$

7.44

$$L=1,2 \text{ m}$$



d)

$$\frac{U_{\text{Ges}}}{M} + K = \frac{U_{\text{Ges}}}{M} + K_k$$

$$\sum K_c \frac{Q_1 q}{y_1} + K_c \frac{Q_2 q}{y_2} = K_c \frac{Q_1 q}{x} + K_c \frac{Q_2 q}{L-x} + \text{S}$$

$$\Rightarrow \frac{36 \cdot 10^3}{0,6} + \frac{144 \cdot 10^3}{0,6} = \frac{36 \cdot 10^3}{x} + \frac{144 \cdot 10^3}{1,2-x} = 60 + 240 = \frac{36}{x} + \frac{144}{1,2-x}$$

$$\Rightarrow 300 = \frac{36}{x} + \frac{144}{1,2-x} \Rightarrow 25 = \frac{3}{x} + \frac{12}{1,2-x}$$

$$\Rightarrow 25 \times (1,2-x) = 3(1,2-x) + 12x \Rightarrow 30x - 25x^2 = 3,6 - 3x + 12x$$

$$\Rightarrow 25x^2 - 21x + 3,6 = 0 \quad \Rightarrow x = \frac{21 \pm 9}{50} \quad x = 0,6 \text{ m}$$

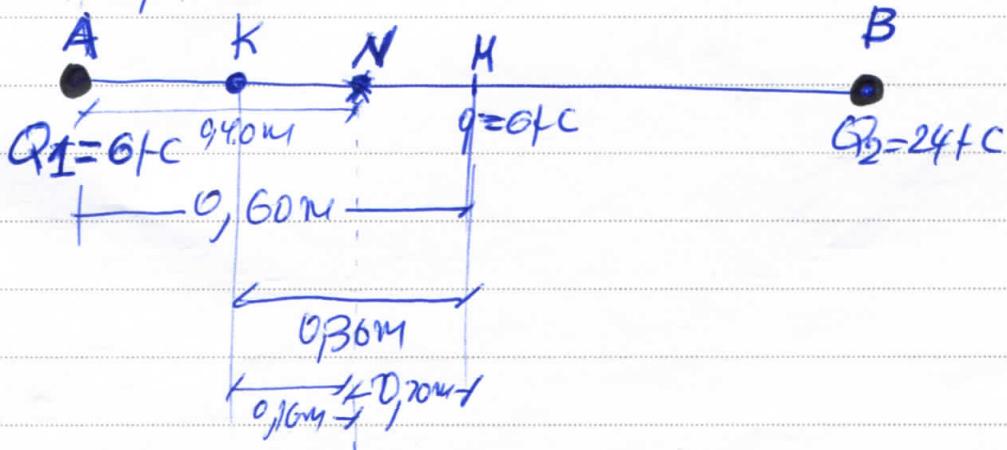
$$K_c \frac{q' Q_1}{y^2} = K_c \frac{q' Q_2}{(L-y)^2} \Rightarrow \left(\frac{L-y}{y}\right)^2 = \frac{Q_2}{Q_1}$$

$$\Rightarrow \left(\frac{L-y}{y}\right)^2 = 4 \Rightarrow \frac{1,2-y}{y} = \pm 2$$

$$1,2-y = 2y \Rightarrow 1,2 = 3y \Rightarrow y = 0,4 \text{ m}$$

$$1,2-y = -2y \Rightarrow 1,2 = -y \Rightarrow y = -1,2 \text{ m}$$

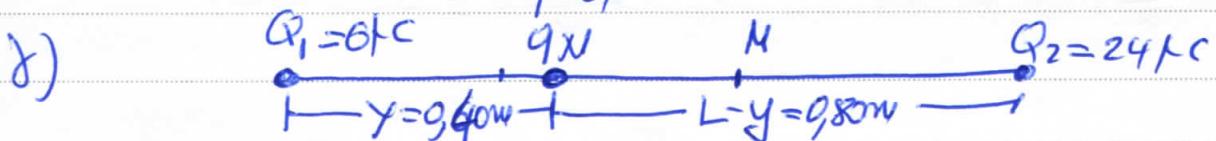
k924m



$$K + U = \text{Grad}$$

\* HE70x16M ស្ថាបីលិក និង ស្ថាបីលិក  
ធម្មតាសម និង រឿងទឹក ស្ថាបីលិក  
និង ពិនិត្យ និង ស្ថាបីលិក ស្ថាបីលិក  
 $\delta f = 0$

$$\rightarrow \text{ដោន្លេ} \quad \frac{df}{dt} = \delta F \cdot V$$



$$U_m|_u = k_c \frac{Q_1 y}{y} + k_c \frac{Q_2 y}{L-y} = 9 \cdot 10^9 \cdot \frac{36 \cdot 10^{12}}{0,4} + 9 \cdot 10^9 \cdot \frac{144 \cdot 10^{12}}{0,8}$$

$$\Rightarrow U_m|_u = 0,810 + 1,620 \Rightarrow U_m|_u = 2,430 \text{f}$$

8)  $U_N = k_c \frac{Q_1 y_1}{y_1} + k_c \frac{Q_2 y_2}{y_2} = 9 \cdot 10^9 \frac{36 \cdot 10^{12}}{0,6} + 9 \cdot 10^9 \frac{144 \cdot 10^{12}}{0,6}$

$$\Rightarrow U_N = 0,540 + 3,160 = 3,700 \text{f}$$

$$U_M + K_M = U_N + K_N \Rightarrow 2,7 + 0 = 2,43 + K_N$$

$$\Rightarrow K_{max} = 0,27 \text{f} = \frac{1}{2} m u_{max}^2 \Rightarrow u_{max} = \sqrt{\frac{2 K_{max}}{m}}$$

$$\Rightarrow u_{max} = \sqrt{\frac{2 \cdot 0,27}{0,102}} \Rightarrow u_{max} = 3\sqrt{3} \text{ m/s}$$

7.45

$$L = 0,6 \text{ m} \quad Q = -6 \text{ kN}$$

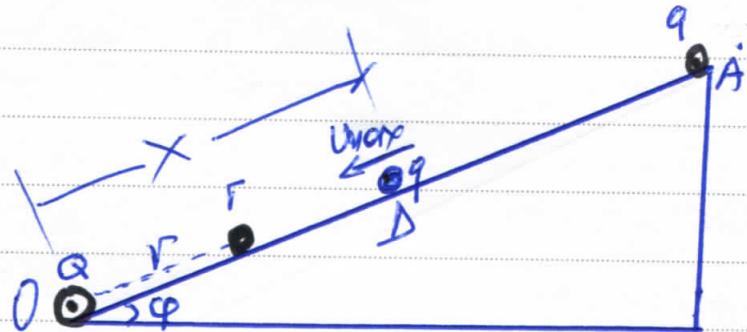
$$\varphi = 37^\circ \quad q = -2 \text{ kN}$$

$$m = 92 \text{ kg}$$

d)

$$\text{Drehmoment } m_f \cdot \varphi = 0,2 \cdot 10 \cdot 0,6 = 120 \text{ N}$$

$$F_c = k_c \frac{|Q|}{L^2} = \frac{9 \cdot 12 \cdot 10^3}{0,36} = 0,30 \text{ N}$$



$$m_f \cdot \varphi > F_c \quad \Rightarrow \quad U_A + U_{A\perp} + K_A = U_r + U_{r\perp} + K_r$$

$$\Rightarrow mg \cdot (L-r) \sin \varphi + k_c \frac{q q}{L} + 0 = 0 + k_c \frac{q q}{r} + 0$$

$$\Rightarrow 0,2 \cdot 10 (0,6 - r) 0,6 + \frac{9 \cdot 12 \cdot 10^3}{0,6} = \frac{9 \cdot 12 \cdot 10^3}{r}$$

$$\Rightarrow 1,2 (0,6 - r) + 0,18 = \frac{9108}{r} \Rightarrow 0,90 - 1,2r - \frac{9108}{r} = 0$$

$$\Rightarrow 1,2r^2 - 0,90r + 0,108 = 0 \quad \begin{cases} r = 0,6 \text{ m} \quad (\text{zu gro\ss}) \\ r = 0,15 \text{ m} \end{cases}$$

$$r^2 - 0,75r + 0,09 = 0 \Rightarrow r = \frac{0,75 \pm 0,45}{2}$$

B)  $k_{\max}$  d\tau\_{av}  $\sum F_x = 0 \Rightarrow F_c = m_f \cdot \varphi \Rightarrow k_c \frac{q Q}{x^2} = m_f \cdot \varphi$

$$\Rightarrow x = \sqrt{\frac{k_c q Q}{m_f \cdot \varphi}} \Rightarrow x = \sqrt{\frac{9 \cdot 12 \cdot 10^3}{0,2 \cdot 10 \cdot 0,6}} = \sqrt{\frac{9 \cdot 12 \cdot 10^3}{12 \cdot 10 \cdot 10^2}} = 0,3 \text{ m}$$

$$\Rightarrow x = 0,3 \text{ m}$$

d)  $U_{mb} = k_c \frac{q Q}{x} = 9 \cdot 10 \frac{12 \cdot 10^3}{0,3} = \frac{8012 \cdot 10^3}{3 \cdot 10^1} = 3610^2 = 936 \text{ f}$

$\hat{\Delta} X_L \dots U_{Bop} + U_{mb} + K = 6789$

$$\Rightarrow \delta_{\text{av}} \text{ know } \text{ note } (V_{\text{max}} + U_{\text{ex}}) = m/y$$

$$\dots u_{\text{ex}} / \delta x L \quad U_{\text{ex}} = m/y.$$

8)

$$k_A + \frac{U_A}{m} + \frac{U_A}{\delta x e} = k_A + \frac{U_A}{m} + \frac{U_A}{\delta x e} \Rightarrow 0 + k_c \frac{qQ}{L^2} + mg(L-x)m/y$$

$$= k_{A,\text{max}} + k_c \frac{qQ}{x} + 0 \Rightarrow$$

$$\Rightarrow 8 \cdot 10^9 \frac{12 \cdot 10^{-12}}{0,6} + 0,2 \cdot 10(0,3) \cdot 0,6 = k_{A,\text{max}} + 8 \cdot 10^9 \frac{12 \cdot 10^{-12}}{0,3}$$

$$\Rightarrow 0,180 + 0,36 = k_{A,\text{max}} + 0,360$$

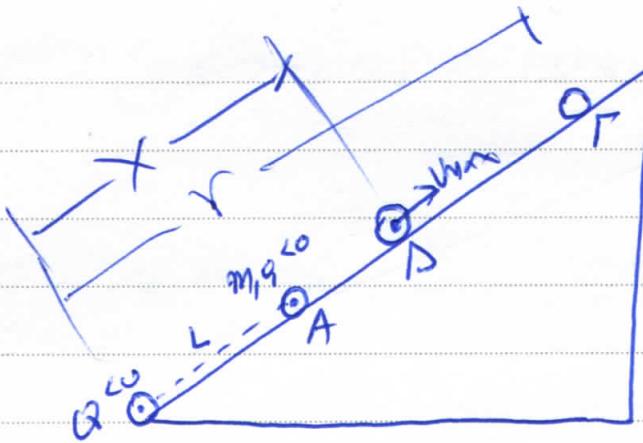
$$\Rightarrow k_{A,\text{max}} = 0,18 \text{ J/m}^2$$

7.46

$$\text{a) } f_c = k_c \frac{|q_a|}{L^2} = 9,10 \cdot \frac{10 \cdot 10^3}{0,16}$$

$$\Rightarrow f_c = 0,5625 N$$

$$m g \sin \varphi = 0,05 \cdot 10 \cdot 0,16 = 0,25 N$$



$$f_c > m g \sin \varphi, k_c \frac{q_a}{L} + m g \sin \varphi = k_c \frac{q_a}{r} + m g \sin \varphi$$

$$\Rightarrow \frac{90 \cdot 10^3}{0,4} + 0,05 \cdot 10 \cdot 0,4 \cdot 0,5 = \frac{90 \cdot 10^3}{r} + 0,05 \cdot 10 \cdot 1 \cdot 0,5$$

$$\Rightarrow 0,225 + 0,100 = \frac{909}{r} + 0,25r$$

$$\Rightarrow 0,325 = \frac{909}{r} + 0,25r \Rightarrow 0,325r = 0,09 + 0,25r^2$$

$$0,25r^2 - 0,325r + 0,09 = 0 \Rightarrow r^2 - 1,3r + 0,36 = 0$$

$$r = \frac{1,3 \pm \sqrt{0,5}}{2} \quad \begin{array}{l} 0,99 \text{ m} \\ 0,4 \text{ m} \end{array} \quad (\text{only positive root}) \quad \Delta r = 0,50 \text{ m}$$

b)  $k_c \alpha x, \alpha_{\max}, \delta \tan \alpha \leq f_c = m g \sin \varphi$

$$\Rightarrow k_c \frac{|q_a|}{x^2} = m g \sin \varphi \Rightarrow \frac{90 \cdot 10^3}{x^2} = 0,25 \Rightarrow x = \sqrt{\frac{90 \cdot 10^3}{0,25}}$$

$$\Rightarrow x = \sqrt{\frac{9 \cdot 10^3}{25 \cdot 10^3}} = x = \frac{3}{5} \Rightarrow \boxed{x = 0,6 \text{ m}}$$

$$\text{c) } k_c \frac{q_a}{L} + 0 + 0 = k_c \frac{q_a}{x} + m g (x - L) \sin \varphi + \alpha_{\max}$$

$$\frac{80 \cdot 10^3}{0,4} = \frac{80 \cdot 10^3}{0,6} + 0,05 \cdot 10 (0,6 - 0,4) \cdot 0,5 + k_{max}$$

$$\Rightarrow 0,125 = 0,150 + 0,050 + k_{max} \Rightarrow k_{max} = 0,025 \text{ N/mm}^2$$

$$k_{max} = \frac{1}{2} m_{max}^2 \quad m_{max} = \sqrt{\frac{2 k_{max}}{m}} = \sqrt{\frac{2 \cdot 25 \cdot 10^3}{5 \cdot 5^2}} = \sqrt{40 \cdot 10^1} = 1 \text{ m/s}$$

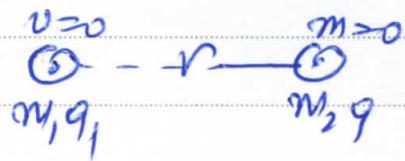
$$\delta) \quad dU_{hj} = -dW_{hj} = -F_c \cdot dx \Rightarrow \frac{dU_{hj}}{dt} = -F_c \cdot \frac{dx}{dt} \Rightarrow \frac{dU_{hj}}{dt} = -F_c \cdot v \quad \text{at release}$$

$$\Rightarrow \frac{dU_{hj}}{dt} = -0,25 \text{ N} \cdot 1 \text{ m/s} = \frac{dU_{hj}}{dt} = -0,25 \frac{\text{J}}{\text{s}}$$

7.47



$$\begin{aligned}m_1 &= 0,9 \text{ kg} \\m_2 &= 0,3 \text{ kg} \\q_1 &= -3 \mu\text{C} \\q_2 &= -6 \mu\text{C}\end{aligned}$$



a)  $U_{\max} = k_e \frac{q_1 q_2}{r} = 8 \cdot 10^9 \frac{18 \cdot 10^{-12}}{10^{-2}} \Rightarrow U_{\max} = 1,8 \text{ Joule}$

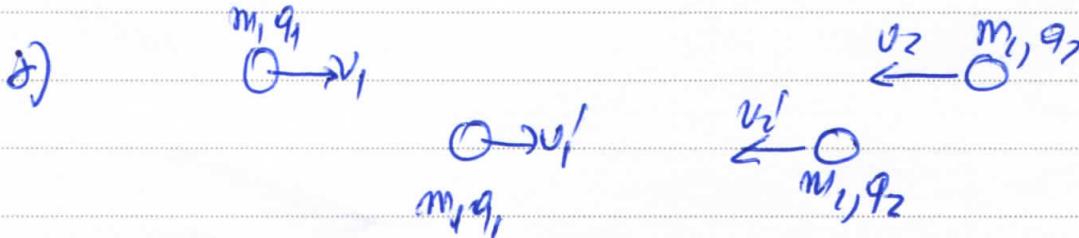
b)  $m_1 v_1 - m_2 v_2 = 0 \Rightarrow m_1 v_1 = m_2 v_2 \Rightarrow v_2 = \frac{m_1 v_1}{m_2}$

$$\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = k_e \frac{q_1 q_2}{r} \Rightarrow v_2 = 3 v_1 \quad (1)$$

$$\Rightarrow \frac{1}{2} \cdot 0,9 v_1^2 + \frac{1}{2} \cdot 0,3 v_2^2 = 1,8 \Rightarrow 0,9 v_1^2 + 0,3 v_2^2 = 3,6$$

$$0,9 v_1^2 + 3 v_1^2 = 3,6 \Rightarrow 3 v_1^2 + v_1^2 = 12 \quad (2)$$

$$3 v_1^2 + 9 v_1^2 = 12 \Rightarrow 12 v_1^2 = 12 \Rightarrow v_1 = 1 \text{ m/s} \quad 1 v_2 = 3 \text{ m/s}$$



$$m_1 v_1 - m_2 v_2 = m_1 v_1' - m_2 v_2' \Rightarrow 0,9 \cdot 1 - 0,3 \cdot 3 = 0,9 v_1' - 0,3 v_2'$$

$$\Rightarrow 0,9 v_1' = 0,3 v_2' \Rightarrow v_2' = 3 v_1' \quad (3)$$

$$\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = k_e \frac{q_1 q_2}{r} + \frac{1}{2} m_1 v_1'^2 + \frac{1}{2} m_2 v_2'^2$$

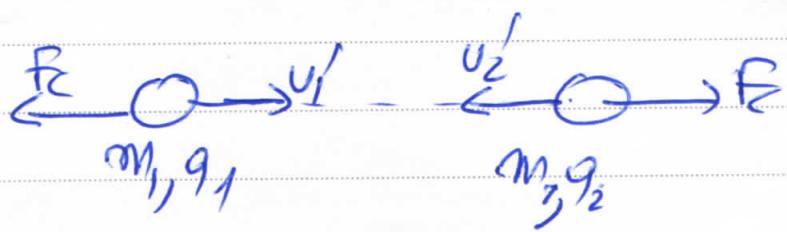
$$\Rightarrow 1,8 = 8 \cdot 10^9 \frac{18 \cdot 10^{-12}}{12 \cdot 10^{-2}} + \frac{1}{2} \cdot 0,9 v_1'^2 + \frac{1}{2} \cdot 0,3 v_2'^2$$

$$1,8 = 1,35 + 0,45 \cdot v_1'^2 + 0,15 \cdot v_2'^2 \Rightarrow 0,45 v_1'^2 + 0,15 v_2'^2 = 0,45$$

$$3U_1'^2 + U_2'^2 = 3 \xrightarrow{\textcircled{2}} 3U_1'^2 + 8U_1'^2 = 3 \Rightarrow 12U_1'^2 = 3$$

$$\Rightarrow U_1' = \frac{1}{\sqrt{4}} = 0,75 \Rightarrow U_1' = 0,5 \text{ m/s}, \quad U_2' = 1,5 \text{ m/s}$$

$$5) F_c = k_c \frac{g_1 g_2}{r^{12}} = 8 \cdot 10^3 \cdot \frac{18 \cdot 10^{-12}}{144 \cdot 10^9} \text{ at } F_c = 11,25 N$$



$$U + k_1 + k_2 = 0 \text{ or } U = -[k_1 + k_2]$$

$$\Rightarrow \frac{dU}{dt} = -\left[ \frac{dk_1}{dt} + \frac{dk_2}{dt} \right] \quad (3)$$

$$\frac{dk_1}{dt} = F_c \cdot v_1' = (-11,25)(+0,5) = -5,625 \text{ J/s} \quad \} = -27,5 \text{ J/s}$$

$$\frac{dk_2}{dt} = F_c \cdot v_2' = (-11,25)(+1,5) = -16,875 \text{ J/s} \quad \}$$

$$(3) \quad \frac{dU}{dt} = -(-27,5 \text{ J/s}) \Rightarrow \frac{dU}{dt} = +27,5 \text{ J/s}$$

7.4B

$$m_1 = 10^3 \text{ kg}, q_1 = 2 \mu\text{C} \quad \text{d) } m_2, q_2 > 0$$

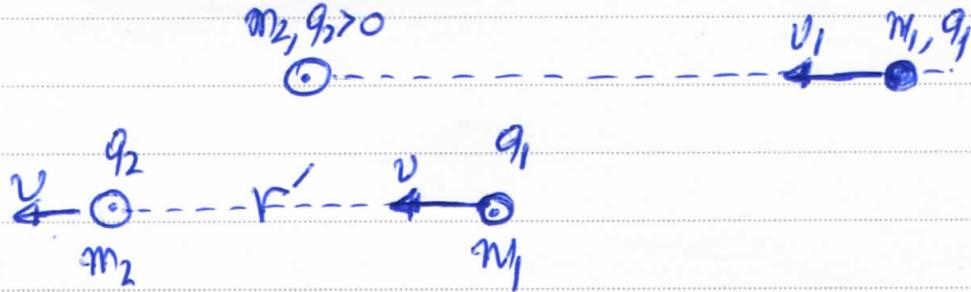
$$m_1, q_2 = 5 \mu\text{C}$$

$$v_1 = 30 \text{ m/s}$$

$$\frac{1}{2}m_1v_1^2 + 0 = k_c \frac{q_1 q_2}{R} \Rightarrow R = \frac{2k_c q_1 q_2}{m_1 v_1^2} = \frac{2 \cdot 90 \cdot 10 \cdot 10^3}{10^3 \cdot 30^2} = 0,2 \text{ m}$$

$$\Rightarrow R = 0,2 \text{ m}$$

b)



$$\frac{1}{2}m_1v_1^2 + 0 = k_c \frac{q_1 q_2}{R'} + \frac{1}{2}m_2v^2 + \frac{1}{2}m_1v^2$$

$$m_1v_1 = (m_1 + m_2)v \Rightarrow v = \frac{m_1v_1}{m_1 + m_2} \quad (1)$$

$$\frac{1}{2}m_1v_1^2 - k_c \frac{q_1 q_2}{R'} = \frac{1}{2}(m_1 + m_2) \frac{m_1^2 v_1^2}{(m_1 + m_2)^2}$$

$$\Rightarrow \frac{1}{2}m_1v_1^2 - k_c \frac{q_1 q_2}{R'} = \frac{1}{2}m_1v_1^2 \frac{m_1}{m_1 + m_2} \Rightarrow \frac{1}{2}10 \cdot 900 - \frac{9 \cdot 10 \cdot 10^3}{0,4} = \frac{1}{2}10 \cdot 900 \frac{m_1}{m_1 + m_2}$$

$$450 - 225 = 450 \frac{m_1}{m_1 + m_2} \Rightarrow \frac{m_1}{m_1 + m_2} = 0,5$$

$$\Rightarrow m_1 = 0,5m_1 + 0,5m_2 \Rightarrow 0,5m_1 = 0,5m_2 \Rightarrow m_2 = m_1$$

$$\Rightarrow m_2 = 10^3 \text{ kg}$$

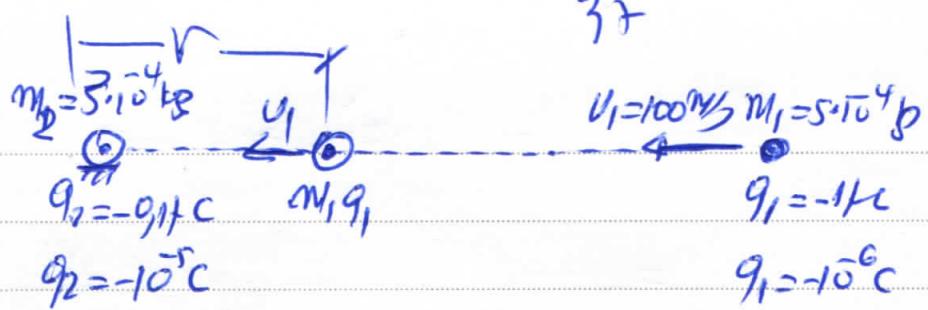
$$\text{d) } v = \frac{10^3 \cdot 30}{2 \cdot 10^3} \Rightarrow v = 15 \text{ m/s}$$

$$\delta) k_{1,20x} = \frac{1}{2} m_1 v_1^2 = \frac{1}{2} 10^3 \cdot 30^2 = 9450 \text{ J}$$

$$U_{\max} = k_e \frac{q_1 q_2}{r'} = \frac{910^3 \cdot 10 \cdot 10^2}{0,40} \Rightarrow U_{\max} = 0,725 \text{ J}$$

$$\eta \% = \frac{U_{\max}}{k_{1,20x}} \cdot 100 = 50 \% \Rightarrow \eta \% = 50 \%$$

7.49

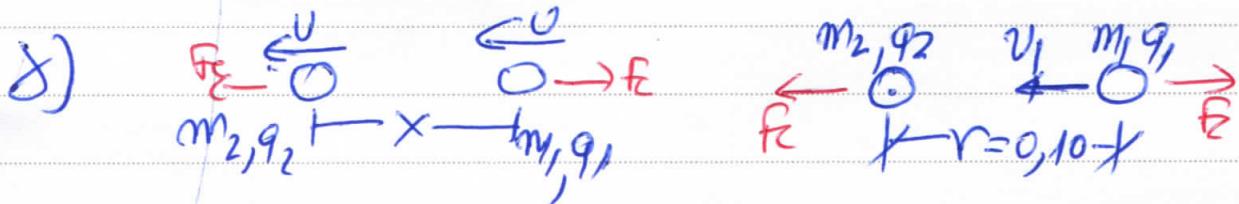


$$\alpha) F_C = k_C \frac{|q_1 q_2|}{r^2} \Rightarrow r = \sqrt{k_C \frac{q_1 q_2}{F_C}} \Rightarrow r = \sqrt{8 \cdot 10^9 \frac{10^{-11}}{8}} \Rightarrow r = 0,1 \text{ m}$$

$$\text{B)} \frac{1}{2} m_1 v_0^2 = \frac{1}{2} m_1 v_1^2 + k_C \frac{q_1 q_2}{r} \Rightarrow \frac{1}{2} \cdot 5 \cdot 10^{-4} \cdot 10^4 = \frac{1}{2} \cdot 5 \cdot 10^{-4} \cdot \frac{9 \cdot 10^{-11}}{0,1}$$

$$\Rightarrow 2,5 = 2,5 v_1^2 + 0,9 \Rightarrow 2,5 v_1^2 = 1,6 \Rightarrow v_1^2 = \frac{16}{25} \Rightarrow v_1 = \frac{4}{5} \cdot 100 \text{ m/s} = 80 \text{ m/s}$$

$$2,5 \cdot 10^{-4} v_1^2 = 1,6 \Rightarrow v_1^2 = \frac{16}{25} \cdot 10^4 \text{ m/s} \Rightarrow v_1 = \frac{4}{5} \cdot 100 \text{ m/s} = 80 \text{ m/s}$$



$$m_1 v_1 = (m_1 + m_2) v \Rightarrow v = \frac{m_1 v_1}{m_1 + m_2} = \frac{5 \cdot 10^{-4} \cdot 80}{8 \cdot 10^{-4}} = 50 \text{ m/s}$$

$$\delta) \frac{\frac{1}{2} m_1 v_1^2 + k_C \frac{q_1 q_2}{r}}{x} = \frac{1}{2} (m_1 + m_2) v^2 + k_C \frac{q_1 q_2}{x}$$

$$\Rightarrow 2,5 = \frac{1}{2} \cdot 8 \cdot 10^9 \cdot 2500 + \frac{8 \cdot 10^9 \cdot 10^{-11}}{x}$$

$$1,5 = \frac{9 \cdot 10^{-2}}{x} \Rightarrow x = \frac{9 \cdot 10^{-2}}{1,5} \text{ m} = 6 \cdot 10^{-3} \text{ m} \Rightarrow x = 6 \text{ cm}$$

$$\epsilon) F_C = k_C \frac{|q_1 q_2|}{x^2} = 8 \cdot 10^9 \cdot \frac{10^{-11}}{36 \cdot 10^{-6}} \Rightarrow F_C = 25 \text{ N}, v = 50 \text{ m/s}$$

$$\frac{dP_1}{dt} = F_C \cdot v = -25 \cdot 50 \cdot -\frac{1}{2} m_1 v_1^2 \quad \frac{dP_2}{dt} = +25 \cdot 50 \cdot \frac{1}{2} m_1 v_1^2$$

$$67) \frac{dy}{dt} = \alpha_1 = \frac{F_c}{m_1} = \frac{-25}{3 \cdot 10^4} = -5 \cdot 10^4 m/s^2$$

$$\frac{dU_2}{dt} = \alpha_2 = \frac{F_c}{m_2} = \frac{+25}{3 \cdot 10^4} = +\frac{25}{3} \cdot 10^4 m/s^2$$

$$J) \frac{dE}{dt} = F_c \cdot v = -25 \cdot (+50) = -1250 J/s$$

$$\frac{dE}{dt} = F_c \cdot v = +25 \cdot (+50) = +1250 J/s$$

$$J1) U_{Ges} + k_{aus} = 0 \Rightarrow \frac{dU_{Ges}}{dt} = -\frac{dk_{aus}}{dt} = 0$$

$$\Rightarrow \frac{dU_{Ges}}{dt} = 0.$$

7.50

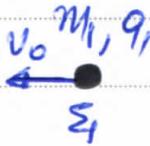
$$m_1 = 2 \cdot 10^7 \text{ kg}$$

$$\frac{dp_2}{dt} = F_c = 0,8 \text{ N}$$

$$\frac{du_2}{dt} = a_2 = 30 \text{ m/s}^2$$

$$\frac{du_2}{dt} = 18 \text{ f/s}$$

$$\frac{dU}{dt} = 45 \text{ f/s}$$

 $m_2, q_2$ 

d)  $F_c = 0,8 \text{ N}, a_2 = 30 \text{ m/s}^2 \Rightarrow \vec{F}_{x,2} = m_2 \vec{a}_2 \Rightarrow m_2 = \frac{F_c}{a_2} = \frac{0,8 \text{ N}}{30 \text{ m/s}^2} = 0,0267 \text{ kg}$

$\Rightarrow m_2 = 3 \cdot 10^{-2} \text{ kg}$  ✓

b)  $\frac{dk_2}{dt} = F_c \cdot v_2 \Rightarrow 18 = 0,9 \cdot v_2 \Rightarrow v_2 = 20 \text{ m/s}$

$$\frac{dv}{dt} = -\frac{dk_{avg}}{dt} = -\left[ \frac{dk_1}{dt} + \frac{dk_2}{dt} \right] \Rightarrow 4,5 = -\left[ \frac{dk_1}{dt} + 18 \right]$$

$$\Rightarrow 4,5 = -\frac{dk_1}{dt} - 18 \Rightarrow \frac{dk_1}{dt} = -63 \text{ f/s}$$

$$\frac{dk_1}{dt} = F_c \cdot v_1 \Rightarrow -63 = (-0,9) \cdot v_1 \Rightarrow v_1 = 70 \text{ m/s}$$

c)  $m_1 v_0 = m_1 v_1 + m_2 v_2 \Rightarrow v_0 = \frac{m_1 v_1 + m_2 v_2}{m_1}$

$$\Rightarrow v_0 = v_1 + \frac{m_2}{m_1} v_2 \Rightarrow v_0 = 70 + \frac{3 \cdot 10^{-2}}{2 \cdot 10^7} \cdot 20 \Rightarrow v_0 = 100 \text{ m/s}$$

d)

$$\frac{1}{2} m_1 v_0^2 = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 + Q \Rightarrow \frac{1}{2} \cdot 2 \cdot 10^7 \cdot 10^2 = \frac{1}{2} \cdot 2 \cdot 10^7 \cdot 70^2 + \frac{1}{2} \cdot 3 \cdot 10^{-2} \cdot 20^2 + Q$$

$$\Rightarrow 1 = 0,49 + 0,06 + Q \Rightarrow Q = +0,45 \text{ J}$$

$$\left. \begin{array}{l} F_C = k_C \frac{q_1 q_2}{r^2} \\ U = k_C \frac{q_1 q_2}{r} \end{array} \right\} \quad \frac{F_C}{U} = \frac{k_C \frac{q_1 q_2}{r^2}}{k_C \frac{q_1 q_2}{r}} = \frac{1}{r} \Rightarrow F_C r = U \Rightarrow r = \frac{U}{F_C}$$

$$\Rightarrow r = \frac{0,45}{0,9} \Rightarrow r = 0,5 \text{ m}$$

E)  $m_1 v_0 = m_1 v + m_2 v \Rightarrow v = \frac{m_1 v_0}{m_1 + m_2} = \frac{2 \cdot 0,1^2 \cdot 10}{5 \cdot 0,1^2} \Rightarrow v = 4 \text{ m/s}$

$$\frac{1}{2} m_1 v_0^2 = \frac{1}{2} m_1 v^2 + \frac{1}{2} m_2 v^2 + U_{\max} \Rightarrow$$

$$\Rightarrow \frac{1}{2} \cdot 2 \cdot 0,1^2 \cdot 10^2 = \frac{1}{2} \cdot 2 \cdot 0,1^2 + \frac{1}{2} \cdot 3 \cdot 0,1^2 \cdot 4^2 + U_{\max}$$

$$\Rightarrow 1 = 0,16 + 0,24 + U_{\max} \Rightarrow U_{\max} = 0,60 \text{ Joule}$$

$$\left. \begin{array}{l} r = 0,5 \text{ m}; \quad U = k_C \frac{q_1 q_2}{r} \\ r_{min} =; \quad U_{\max} = k_C \frac{q_1 q_2}{r_{min}} \end{array} \right\} \quad \frac{U}{U_{\max}} = \frac{r_{min}}{r} \Rightarrow r_{min} = \frac{U}{U_{\max}} \cdot r$$

$$\Rightarrow r_{min} = \frac{0,45}{0,60} \cdot 0,5 \approx \boxed{r_{min} = 0,375 \text{ m}}$$

### Κεφάλαιο 8<sup>ο</sup>. Ορισμένες Ηλεκτρικές πεδία

#### A. Ερωτήσεις 6ωρων - 2020

$$8.1 \quad \alpha, \beta, \delta$$

$$8.2 \quad B$$

$$8.3 \quad \alpha$$

$$8.4 \quad B$$

$$8.5 \quad B$$

$$8.6 \quad \alpha$$

$$8.7 \quad \beta, \delta$$

$$8.8 \quad B$$

#### B. Ερωτήσεις μεταπόντιους

8.9

$$\begin{aligned} V_A - V_M &= E(CAM) \\ V_N - V_B &= E(MB) \end{aligned} \quad \left\{ \Rightarrow \begin{aligned} X_A - X_M &= E(CAM) \\ -X_M + V_B &= -E(MB) \end{aligned} \right\} \Rightarrow \begin{array}{c} A \\ M \\ B \end{array} \xrightarrow{x>0} \vec{E} \xrightarrow{x} \begin{array}{c} X_A = 100V \\ V_B = 40V \end{array}$$

$$\Rightarrow V_A - 2V_M + V_B = 0 \Rightarrow V_M = \frac{V_A + V_B}{2} = \frac{100V - 40V}{2} \Rightarrow V_M = 30V, \text{ διαφορά } n(α)$$

• • • Κατ' αρχήν θα προβεπτικό.

Η Ρεσίγιαν των Διανομών είναι σύναριθμητικής

Εξαριθμητικής πηγούφυσης  $V = V_A - \alpha \cdot x / \alpha = \text{const}$  (α. γνήσια)

Παρ  $x=0 \Rightarrow V = V_A = 100V$ , παρ  $x=L \Rightarrow V_B = 100 - \alpha \cdot L \Rightarrow -40 = 100 - \alpha \cdot L$

$$\Rightarrow \alpha = \frac{140}{L}, \text{ οπότε } x = 100 - \frac{140}{L}x \quad \text{Με } x_M = \frac{L}{2} \Rightarrow X_M = 100 - \frac{140}{L} \cdot \frac{L}{2}$$

$$\Rightarrow X_M = +30 \text{ Volt}$$

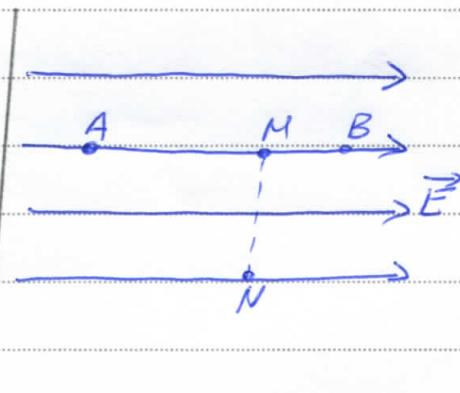
8.10

$$V_B - V_N = -200V \Rightarrow V_N - V_B = +200V$$

$$V_N = V_M \Rightarrow V_M - V_B = 200V$$

$$V_A - V_N = E(CAM) \quad \left\{ \frac{V_A - V_B}{V_M - V_B} = \frac{2(MB)}{(MB)}$$

$$V_M - V_B = E(MB) \quad \left\{ \Rightarrow \frac{V_M - V_B}{V_B} = \frac{2(CAM)}{(CAM)}$$



$$\Rightarrow \frac{V_A - V_M}{V_M - V_B} = 2 \Rightarrow V_A - V_M = 2(V_M - V_B) \Rightarrow V_A - V_M = 400V$$

$$V_A - V_N = 400V$$

$$V_M - V_B = 200V$$

$$V_A - V_B = 600V$$

Αερ αναριθμητικής

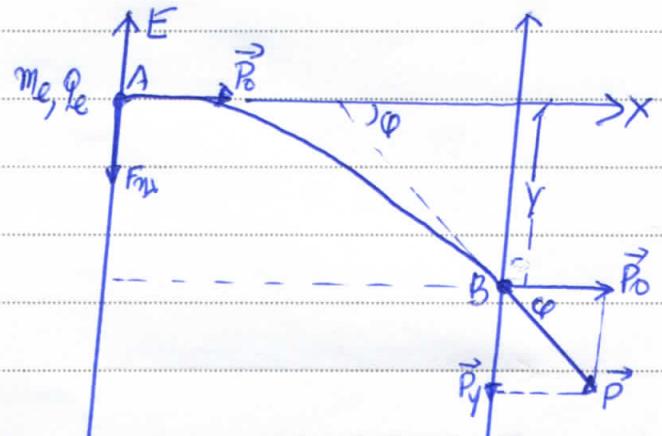
8.11

$$a) \Delta K = W_{\text{y1}} \Rightarrow \dots$$

$$W_{\text{y1}} = k_B - k_A = \frac{P_0^2}{2m_e} - \frac{P_0^2}{2m_e} = \frac{P_0^2}{2m_e}$$

$$\text{Eq } \varphi = \frac{P_0}{P_0} \Rightarrow \text{Eq45} = \frac{P_0}{P_0} \Rightarrow 1 = \frac{P_0}{P_0}$$

$$\Rightarrow W_{\text{y1}} = \frac{P_0^2}{2m_e} \quad \text{OP - 600610'}$$



$$b) \vec{DP} = \vec{P} - \vec{P}_0 = (P_x + \vec{P}') - \vec{P}_0 \Rightarrow \vec{DP} = \vec{P}' \quad \left. \begin{array}{l} \text{Eq } \varphi = \frac{P_0}{P_0} \Rightarrow P_y = P_0 \\ \Rightarrow \vec{DP} = P_0 \end{array} \right\} \text{ (4 E Tera)}$$

B-70000

$$f.) \Delta p = P_y = ?$$

$$\vec{SF} = \frac{\vec{DP}}{Dt} \Rightarrow F_{\text{y1}} Dt = -\frac{P_y}{Dt} \Rightarrow F_{\text{y1}} Dt = -\frac{P_0}{Dt} \quad \left. \begin{array}{l} P_0 > P_0 \\ E/q_e / Dt = P_0 \end{array} \right\} \Rightarrow \Delta t = \frac{P_0}{E/q_e}$$

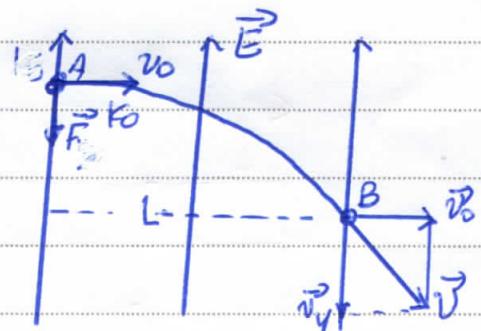
f-70000

8.12

$$\Delta K = W_F = F_y = F \cdot \frac{1}{2} \alpha t^2 = \frac{1}{2} F \cdot \frac{E}{m} L^2$$

$$x = v_0 t \quad \rightarrow \quad L = v_0 t \Rightarrow t = \frac{L}{v_0}$$

$$K_0 = \frac{1}{2} m v_0^2 \Rightarrow m v_0^2 = 2 K_0$$



$$\Delta K = \frac{1}{2} \frac{F^2 L^2}{m v_0^2} \Rightarrow \Delta K = \frac{F^2 L^2}{4 K_0}$$

AOP 600610 in (a)

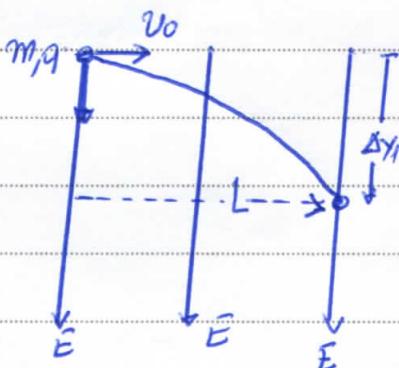
8.13

$$\text{neutro} : \Delta Y_1 = \frac{1}{2} \alpha t^2 = \frac{1}{2} \frac{F}{m} \left( \frac{L}{v_0} \right)^2 = \frac{E q L^2}{2 m v_0^2} \quad (1)$$

$$\text{neutra} : \Delta Y_2 = \frac{1}{2} \alpha' t'^2 = \frac{1}{2} \frac{F'}{m} \left( \frac{L}{v_0} \right)^2 = \frac{1}{2} \frac{E 4 q}{2 m} \frac{L^2}{v_0^2} \Rightarrow$$

$$\Rightarrow \Delta Y_2 = 2 \frac{E q L^2}{2 m v_0^2} = 2 \Delta Y_1 \Rightarrow \Delta Y_2 = 2 \Delta Y_1$$

AOP 600610 in (b)



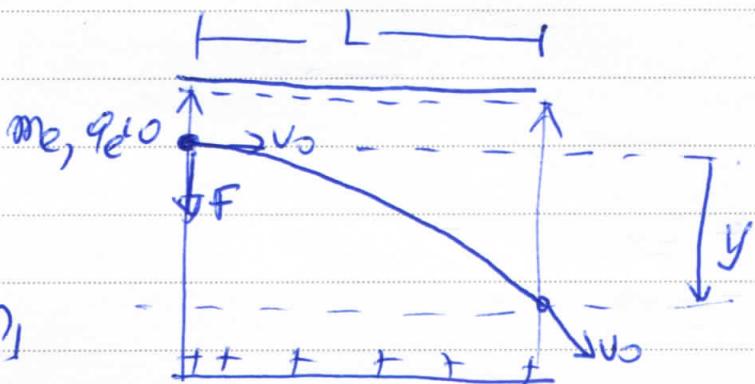
B.14

$$d) y = \frac{1}{2} \alpha t^2$$

$$x = v_0 t \Rightarrow t = \frac{x}{v_0} \quad (\text{vergleichen})$$

aus  $\Delta F = m \cdot a$

$$\partial \rho \alpha + f' = f$$



$$Gesucht$$

$$e) y = \frac{1}{2} \alpha t^2 = \frac{1}{2} \frac{F}{m} \left( \frac{x}{v_0} \right)^2 = \frac{1}{2} \frac{E I q_e}{m} \left( \frac{x}{v_0} \right)^2 = \frac{1}{2} \frac{V}{\alpha} \frac{q_e}{m} \left( \frac{x}{v_0} \right)^2$$

$$\rightarrow y \text{ proportional to } V$$

$$y = G \cdot a \cdot V$$

Aber  $G$  ist proportional  $V$  nach Sinfleisch-Boussinesq

$$y' = 2y, \\ G \text{ proportional}$$

f)

$$\Delta U = -W_{\text{ext}} = -F y = -E I q_e \cdot y = -\frac{V}{\alpha} I q_e \cdot y$$

$$\Delta U' = -\frac{V}{\alpha} I q_e \cdot y' =$$

$$= -\frac{2V}{\alpha} I q_e \cdot 2y$$

$$\Rightarrow \Delta U' = 4 \Delta U$$

Spur  $\delta = 1 \text{ m}$

$$g) \Delta K = W_{\text{ext}, \infty} \quad \Delta U' = 4 \Delta K$$

$\delta = 1 \text{ m}$

8.15



$$d. \sum \vec{F}_x = m\vec{a} \Rightarrow -F_{y1} = m\alpha \Rightarrow -E/|q_e| = m_e\alpha \Rightarrow \alpha = -\frac{E/|q_e|}{m_e} \text{ or } |\alpha| = \frac{E/|q_e|}{m_e}$$

$$U = U_0 - \alpha / t$$

$$x = v_0 t - \frac{1}{2} a x t^2 \Rightarrow 0 = (2v_0 + at)t \Rightarrow t = 0 \text{ or } t = \frac{-2v_0}{ax}$$

$$\Rightarrow t_{0R} = \frac{2V_0}{E|q_0|} = \frac{2m_e v_b}{E|q_e|} \Rightarrow t_{0L} = \frac{2P_0}{E|q_e|} \quad \text{Q-6006b}$$

$$\theta_3 \quad v = v_0 - |d| \frac{2v_0}{|d|} = v = -v_0 \quad (d) \text{ f. B. p. 144 T. p. 1}$$

$$P_2 \cdot m \cdot V = m(-V_0) = -P_0$$

$$K = \frac{P^2}{2m_B} = \frac{P_B^2}{2m_B} = K_0 \quad B = 64000 N/m$$

$$\text{J. } \vec{DP} = \vec{P} - \vec{P}_0 \Rightarrow DP = -P - (-P_0) = -2P_0 \Rightarrow DP = -2P_0 \Rightarrow AP = 2P_0$$

J-600670

8.16

Aproximativ ( $\approx$  erstat yar)  $\Sigma F_y = 0 \Rightarrow E_g - mg \quad (1)$

$$N_{E\rightarrow i} \quad (\geq 0 \forall i) \quad F_i = E' q = \frac{E}{2} q = \frac{mg}{2} \quad (7)$$

See no good we sold xury.

1903 Կը որդութեա Տիրացիկու

Parity of  $\pi_0 D \rightarrow A$

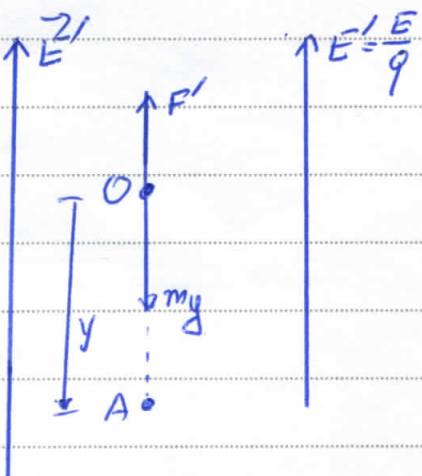
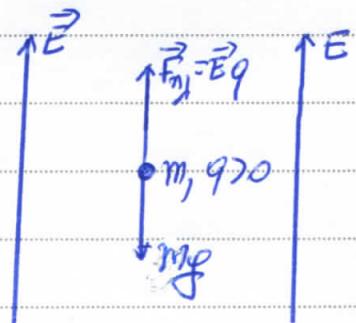
$$V_A - V_0 = E \frac{y}{s} y \Rightarrow \Delta V_{A_0} = \frac{E}{2} Y \quad (3)$$

$$\Theta \cdot K E_{(0-A)} \Rightarrow K_A - K_0 = (mg - F') / y$$

$$\Rightarrow \Delta F = (m g - \frac{m g}{3}) y = \frac{2}{3} m g y$$

$$SK = \frac{1}{2} Eq y = g \cdot \frac{E}{2} y \stackrel{?}{=}$$

$$\Delta F = q \cdot \Delta V \quad \text{decrease in energy}$$



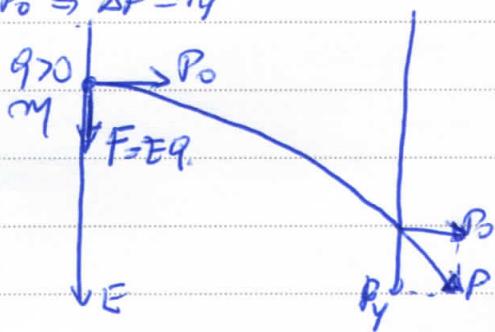
B.17

$$\text{Antó zo } \Delta P = \vec{P} - \vec{P}_0 = (\vec{P}_y + \vec{P}_0) - \vec{P}_0 \Rightarrow \Delta P = \vec{P}_y$$

$$\Delta P = P_y = m v_y = m \alpha t = m \frac{Eg}{m} t$$

$$\Rightarrow \Delta P = Eg t \quad \text{Anto zo dôvod}$$

$$\Delta P = f(t) \quad \text{... o n' uhliai elva!}$$



$$Eg t = Eg = \frac{0,51}{0,85} = \frac{51}{85} = \frac{3}{5} = 0,6 \text{ sT}$$

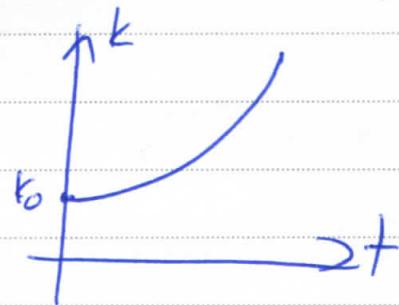
$$\Rightarrow E = \frac{0,6}{9} = \frac{0,6}{2 \cdot 10^6} = 0,3 \cdot 10^5 \text{ N/m}$$

Zložené účinky (d)

B.18

$$\text{a) } \Delta k = WF = P_y = Eg \frac{1}{2} \alpha t^2 = Eg \frac{1}{2} \frac{Eg}{m} t^2 = \frac{Eg^2}{2m} t^2$$

$$k = k_0 + \frac{Eg^2}{2m} t^2$$



b)



$$\Delta P = m a = Eg t$$

b - Gelenk

$$\text{c) } \Delta k = F \cdot y = Eg y \rightarrow k = k_0 + Eg y$$

c - Gelenk

8.19

$$v_0 = 8 \cdot 10^6 \text{ m/s}$$

$$\sum F_x = m \alpha \Rightarrow -E/|q_e| = m \alpha \quad (1)$$

$$x = v_0 t - \frac{1}{2} |\alpha| t^2$$

$$V = v_0 - |\alpha| t$$

$$\text{d)} \quad x=0 \Rightarrow t = \frac{2v_0}{|\alpha|} \Rightarrow |\alpha| = \frac{2v_0}{t_{\text{f}}} = \frac{2 \cdot 8 \cdot 10^6}{50 \cdot 10^9} \text{ m/s} = 0,32 \cdot 10^{15} \text{ m/s}^2$$

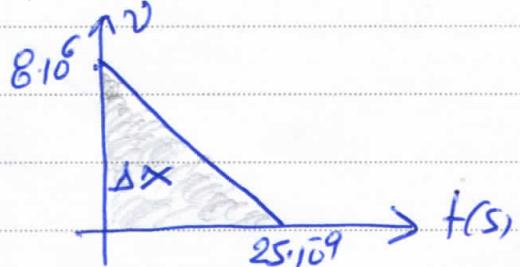
$$\Rightarrow \alpha = -32 \cdot 10^{13} \text{ m/s}^2$$

$$(1) \Rightarrow E = \frac{m \alpha}{|q_e|} = \frac{9 \cdot 10^{-31} \cdot (-32 \cdot 10^{13})}{1,6 \cdot 10^{-19} \text{ C}} \Rightarrow \underline{\underline{E = 1800 \text{ N/C}}}$$

$$\text{d)} \quad V = v_0 - |\alpha| t = v_0 - |\alpha| \frac{x_0}{|\alpha|} = -v_0 \Rightarrow V = -8 \cdot 10^6 \text{ m/s}$$

$$\text{B)} \quad V = v_0 - |\alpha| t' \Rightarrow 0 = v_0 - |\alpha| t' \Rightarrow t' = \frac{v_0}{|\alpha|} = 25 \text{ ns}$$

$$\Delta x = \frac{v_0^2}{2|\alpha|} = \frac{64 \cdot 10^{12}}{2 \cdot 32 \cdot 10^{13}} \Rightarrow \Delta x = 0,1 \text{ m}$$



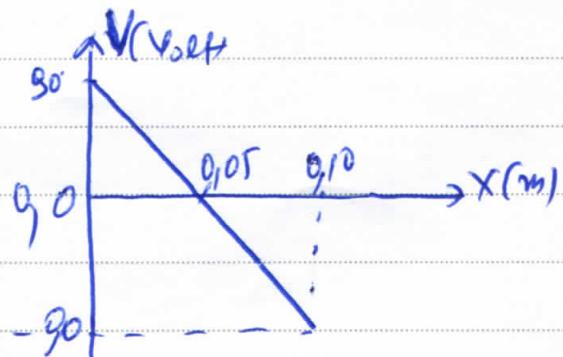
$$\text{d)} \quad \Delta V = E \cdot \Delta x = 1800 \cdot 0,1 = 180 \text{ V} \Rightarrow \underline{\underline{\Delta V = 180 \text{ V}}}$$

$$\text{E)} \quad \Delta V = E \cdot \Delta x \Rightarrow V_0 - V = E(x - x_0) \Rightarrow V = V_0 - Ex$$

$$\text{or } V = 90 - 1800 \cdot x \quad (\text{s.I.})$$

$$\text{G)} \quad V = \frac{q}{e} V \Rightarrow$$

$$V = (-1,6 \cdot 10^{-19} \text{ C}) [90 - 1800 \cdot x] \text{ V}$$



$$\text{g)} \quad V = -144 \cdot 10^{-19} + 2880 \cdot 10^{-19} \cdot x \quad (\text{s.I.})$$

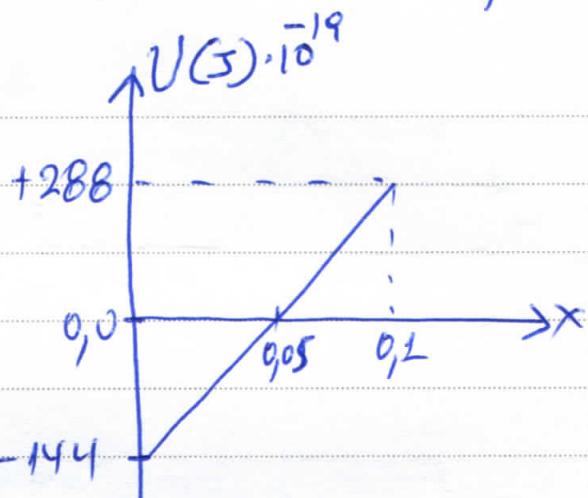
-7-

$$3) \Delta K = W_F$$

$$K - K_0 = -F \Delta x$$

$$K = K_0 - F x$$

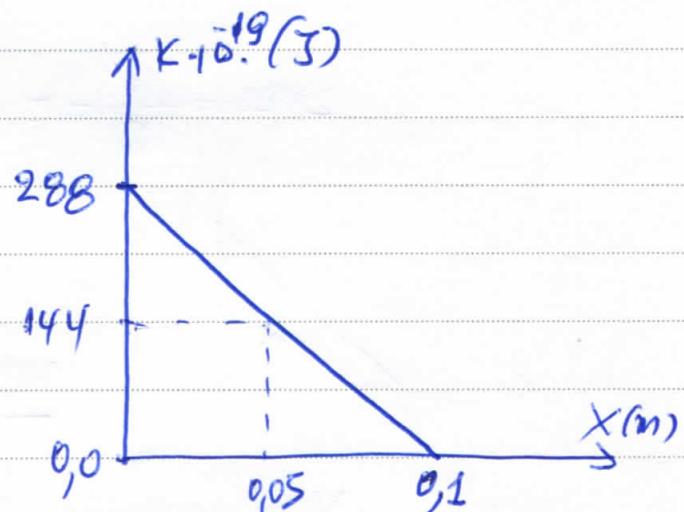
$$x = \frac{1}{2} m v_0^2 - E |v_0| \cdot x$$



$$k_0 = \frac{1}{2} m v_0^2 = \frac{1}{2} 9 \cdot 10^{31} \cdot (8 \cdot 10^6)^2 = 19.64 \cdot 10^{31} \cdot 10^2 \Rightarrow k_0 = 288 \cdot 10^{-19} N$$

$$E |v_0| = 1800 \cdot 1,6 \cdot 10^{-19} = 2880 \cdot 10^{-19} J$$

oder  $\ddot{x} = 288 \cdot 10^{-19} - 2880 \cdot 10^{-19} x \quad (\text{SI})$



8.20

$$\text{a. } \Delta K = W_F \Rightarrow k_A - k_0 = W_F$$

$$\stackrel{0 \rightarrow A}{\Rightarrow} 0 - k_0 = -1/q_e / (V_0 - V_A)$$

$$\Rightarrow \frac{1}{2} m_e v_0^2 = 1/q_e / \Delta V \Rightarrow v_0 = \sqrt{\frac{2/q_e \Delta V}{m_e}}$$

$$\xrightarrow{\text{SI}} v_0 = \sqrt{\frac{2 \cdot 1.6 \cdot 10^{-19} \cdot 180}{3.10^{-31}}} \Rightarrow v_0 = 8 \cdot 10^6 \text{ m/s}$$

$$\text{b. } \Sigma F = m \alpha \Rightarrow -E/q_e = m_e \alpha \Rightarrow -\frac{\Delta V}{d}/q_e = m_e \alpha \Rightarrow \alpha = -\frac{\Delta V / q_e}{d m_e}$$

$$\xrightarrow{\text{SI}} \alpha = -32 \cdot 10^{13} \text{ m/s}^2$$

$$t_{01} = \frac{v_0}{\alpha} \Rightarrow t_{01} = \frac{2 \cdot 8 \cdot 10^6}{32 \cdot 10^{13}} = 0,5 \cdot 10^{-7} \text{ s} \quad t_{02} = 5 \cdot 10^{-8} \text{ s}$$

$$\text{c. } V = V_0 - |\alpha| t = V_0 - |\alpha| \cdot \frac{v_0}{|\alpha|} = -V_0 \text{ m/s} \quad (2.78 + 80 \cdot 10^{-7} \cdot 1140)$$

D. Grav 70% & Tropo 70% max. CMB 70%  $\Rightarrow$  50% n max CMB

$$y = +\frac{v_0}{2} \text{ m/s} \quad v_0 = -\frac{v_0}{2}, \text{ ó többeket}$$

$$V = V_0 - |\alpha| t \Rightarrow +\frac{v_0}{2} = V_0 - |\alpha| t_1 \Rightarrow |\alpha| t_1 = \frac{v_0}{2} \Rightarrow t_1 = \frac{v_0}{2|\alpha|} \Rightarrow t_1 = 1,25 \cdot 10^{-8} \text{ s}$$

$$V = V_0 - |\alpha| t \Rightarrow -\frac{v_0}{2} = V_0 - |\alpha| t_2 \Rightarrow |\alpha| t_2 = \frac{3v_0}{2} \Rightarrow t_2 = \frac{3v_0}{2|\alpha|} \Rightarrow t_2 = 3,75 \cdot 10^{-8} \text{ s}$$

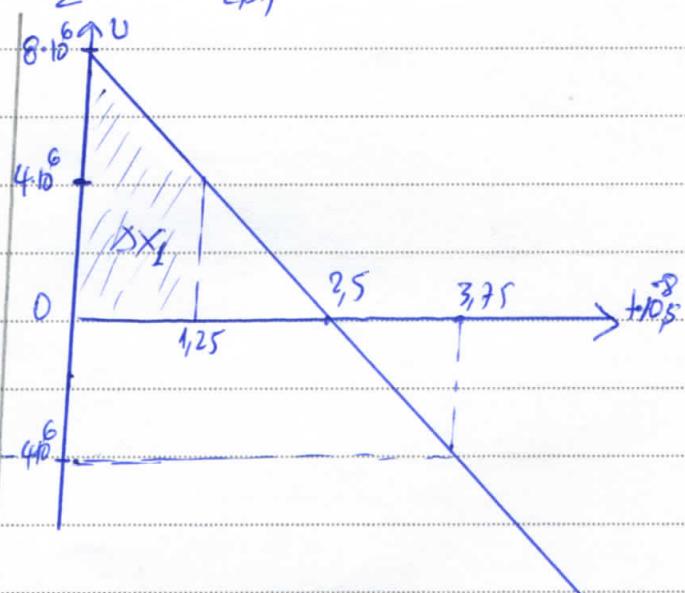
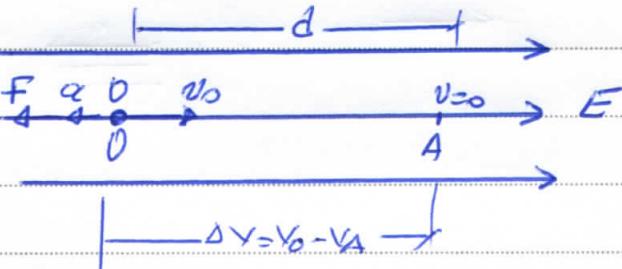
$$\Delta X_1 = \frac{8 \cdot 10^6 + 4 \cdot 10^6}{2} \cdot 1,25 \cdot 10^{-8}$$

$$\Delta X_1 = 7,5 \cdot 10^2 \text{ m} \text{ m/s}$$

$$\Delta X_2 = \frac{1}{2} \cdot 2,5 \cdot 10^{-8} \cdot 8 \cdot 10^6 + \frac{1}{2} (3,75 - 2,5) \cdot 10^{-8} (4 \cdot 10^6)$$

$$\Rightarrow \Delta X_2 = 10 \cdot 10^2 + \frac{1}{2} 1,25 \cdot 10^{-8} (-4) \cdot 10^6$$

$$\Delta X_2 = 7,5 \cdot 10^2 \text{ m} \text{ m/s}$$



$$\Delta X_1 = X_1 - 0 = X_1 = 7,5 \text{ m/s}$$

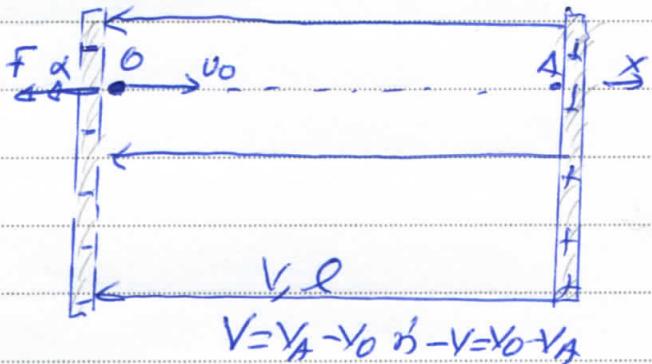
$$\Delta X_2 = X_2 - 0 = X_2 = 7,5 \text{ m/s}$$

z. 90% n max CMB  $\Rightarrow$  80% n max CMB  
 $\Rightarrow$  20% cm degy u x = 7,5 m/s

8.21

$$\alpha \cdot \Sigma F_x = m\alpha \Rightarrow -Eg = ma \\ \Rightarrow \alpha = -\frac{Eg}{m} = -\frac{V}{e} \frac{q}{m} = -5 \cdot 10^8 \text{ m/s}^2$$

$$\Delta K_{O \rightarrow A} = W_f \Rightarrow K_A - K_O = q(V_0 - V_A)$$



$$\Rightarrow K_A - \frac{1}{2}mv_0^2 = q(-V) \Rightarrow K_A = \frac{1}{2}mv_0^2 - qV$$

Da vorausgesetzt ist  $V > 0$  und  $v_0 > 0$ , dann gilt  $K_A < 0 \Rightarrow \frac{1}{2}mv_0^2 - qV < 0$

$$\Rightarrow v_0 < \sqrt{\frac{2qV}{m}} \xrightarrow{SI} v_0 < 1000 \text{ m/s}$$

... und die Abreisetgeschwindigkeit ist ...

$$\Delta x = \frac{v_0^2}{2|q|} = \frac{v_0^2}{2Eg} = \frac{mv_0^2}{2Eg} = \frac{mv_0^2}{2Vg} \quad e < l \Rightarrow v_0 < \sqrt{\frac{2qV}{m}}$$

$$6. \Delta K = W_f \Rightarrow 0 - \frac{1}{2}mv_0^2 = -Eg \Delta x \Rightarrow \frac{1}{2}mv_0^2 = \frac{V}{e} g \Delta x \Rightarrow \Delta x = \frac{mv_0^2 l}{2Vg}$$

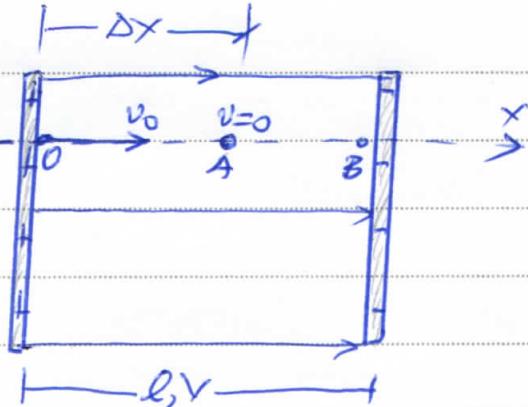
$$\xrightarrow{SI} \Delta x = 64 \cdot 10^3 \text{ m} \quad \text{or} \quad \Delta x = 64 \text{ km}$$

$$\dots \text{ist} \quad \Delta x = \frac{v_0^2}{2|q|} = \frac{800^2}{2 \cdot 5 \cdot 10^6} = 64 \cdot 10^3 \text{ m}$$

$$7. \dots t_{0,1} = \frac{2v_0}{10^3} = \frac{2 \cdot 8 \cdot 10^2}{5 \cdot 10^6} \quad \text{or} \quad t_{0,1} = 3,2 \cdot 10^{-4} \text{ s}$$

8.22

$$a) \frac{\Delta P}{\Delta t} = -F = -E/|q| = -\frac{V}{c}/|q|$$



$$\xrightarrow{SI} \frac{\Delta P}{\Delta t} = -\frac{100}{91} \cdot 10^6 = \frac{\Delta P}{\Delta t} = -10^3 \text{ kg/m/s}$$

$$* E = \frac{V}{c} = \frac{100V}{91m} = 10^3 V/m$$

$$* F = E/|q| = 10^3 \cdot 10^6 = 10^9 N$$

$$b) \Delta K_{0 \rightarrow A} = W_F \Rightarrow 0 - \frac{1}{2}mv_0^2 = q(V_0 - V_A) \Rightarrow -\frac{1}{2}mv_0^2 = -|q| \cdot E \Delta X \Rightarrow V_0 = \sqrt{\frac{2|q|E \Delta X}{m}}$$

$$\xrightarrow{SI} V_0 = \sqrt{\frac{2 \cdot 10^6 \cdot 10^3 \cdot 4,5 \cdot 10^{-2}}{10^{-7}}} \Rightarrow V_0 = 30 \text{ m/s} \quad \text{...нарізано фінітім}$$

$$\text{...} \Delta X = \frac{V_0^2}{2|q|c} \quad \text{як } E/|q| = \frac{E/|q|}{m} = \frac{10^3 \cdot 10^6}{10^{-7}} \Rightarrow |q| = 10^4 \text{ N/m}^2 \quad \text{...}$$

$$d) \Delta U = V_A - V_0 = qV_A - qV_0 = q(V_A - V_0) = -|q| \cdot (-V) = |q|V = |q| \Delta X$$

$$\xrightarrow{SI} \Delta U = 10^6 \cdot 10^3 \cdot 4,5 \cdot 10^{-2} \Rightarrow \Delta U = 4,5 \cdot 10^5 \text{ J} \quad \Delta U = 45 \cdot 10^6 \text{ J}$$

$$\text{...нарізано фінітім} \quad \Delta U = -W_F = -(-F \cdot \Delta X) = +E/|q| \Delta X \quad \text{...}$$

$$e) \text{...} t_{0,2} = \frac{2V_0}{|q|} = \frac{2 \cdot 30 \text{ m/s}}{10^4 \text{ N/m}^2} \Rightarrow t_{0,2} = 6 \cdot 10^{-4} \text{ s} \quad \text{як } t_{0,1} = 6 \cdot 10^3 \text{ s} = 6 \text{ ms}$$

$$V = V_0 - |a|t_{0,2} = 0 - 6 \cdot 10^3 \cdot 6 \cdot 10^{-4} = -30 \text{ m/s}$$

$$f) \Delta K_{0 \rightarrow B} = q(V_0 - V_B) \Rightarrow K_B - K_0 = qV \xrightarrow{t_{B \rightarrow 0}} -K_0 = -|q|V$$

$$\Rightarrow \frac{1}{2}mv_0^2 = |q|V \Rightarrow V = \frac{mv_0^2}{2|q|} = \frac{10^2 \cdot 900}{2 \cdot 10^6} = 45 \text{ V}$$

$$\Rightarrow V = 45 \text{ Volt}$$

8.23

gegeben: Silberbar 2m/s!

$$d) E = \frac{V}{l} = \frac{800V}{0.1} = 8 \cdot 10^3 N/m$$

$$F = E | q | = 8 \cdot 10^3 \cdot 10^{-5} = 8 \cdot 10^{-2} N$$

$$B = m \cdot g = 2 \cdot 10^3 \cdot 10 = 2 \cdot 10^4 N$$

$$|\alpha| = \frac{F + B}{m} = \frac{1010}{2 \cdot 10^3} = 50 m/s^2$$

$$\Delta y = \frac{v_0^2}{2|\alpha|} = \frac{4}{100} = 0,04 m \text{ as } \Delta y = 4 cm \text{ über 0,00120m } \underline{\underline{\phi = 6\pi}}$$

$$\text{und } 0 - \frac{1}{2} m v_0^2 = - F \Delta y - m g \Delta y \text{ as } \Delta y = \frac{\frac{1}{2} m v_0^2}{F + M g} = \frac{\frac{1}{2} \cdot 9 \cdot 10^3 \cdot 4}{10 \cdot 10^2} = 0,04 m$$

$$b) t_{\text{an}} = \frac{2|v_0|}{|g|} = \frac{2 \cdot 2}{50} = 0,08 s$$

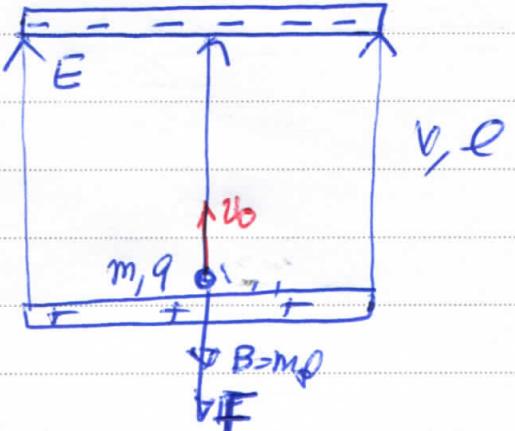
$$d) \Delta y = \frac{v_0^2}{2|\alpha|} = \frac{v_0^2}{2 \frac{E|q| + B}{m}} = \frac{m v_0^2}{2(V|q| + m g)} = \frac{m v_0^2 \cdot l}{2(V|q| + m g \cdot l)} \leq l$$

$$m v_0^2 \leq 2 [V|q| + m g \cdot l] \text{ as } \frac{1}{2} m v_0^2 \leq V|q| + m g \cdot l$$

$$V|q| + m g \cdot l \geq \frac{1}{2} m v_0^2 \Rightarrow V|q| \geq \frac{1}{2} m v_0^2 - m g \cdot l$$

$$V \geq \frac{\frac{1}{2} m v_0^2}{|q|} - \frac{m g \cdot l}{|q|} \text{ as } V \geq \frac{\frac{1}{2} \cdot 2 \cdot 10^3 \cdot 4}{10^{-5}} - \frac{2 \cdot 10^3 \cdot 10 \cdot 0.1}{10^{-5}}$$

$$\text{as } V \geq - \frac{400V}{-200V} = 200V \text{ as } \underline{\underline{V \geq 200 \text{ Volt}}}$$



B.24

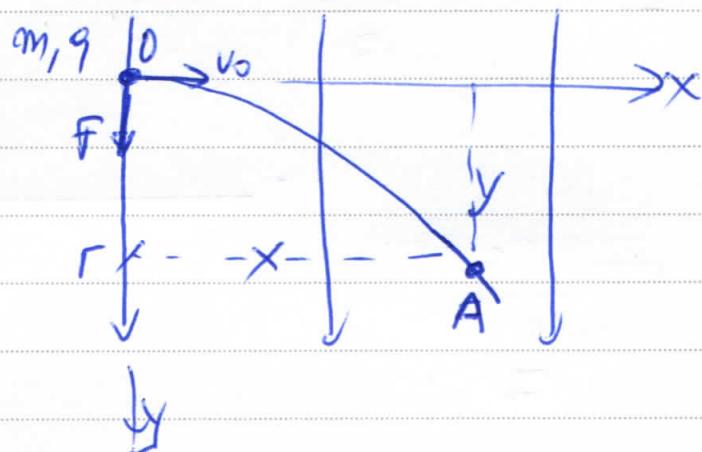
$$t = 0,2 \cdot 10^{-6} = 2 \cdot 10^{-7} \text{ s}$$

$$\alpha = \frac{Eg}{m} = \frac{10^3 \cdot 2 \cdot 10^{-6}}{10^{-16}} = 2 \cdot 10^{13} \text{ m/s}^2$$

$$x = v_0 t = 10^6 \cdot 0,2 \cdot 10^{-6} = 0,2 \text{ m}$$

$$y = \frac{1}{2} \alpha t^2 = \frac{1}{2} \cdot 2 \cdot 10^{13} \cdot 4 \cdot 10^{-14}$$

$$\Rightarrow y = 4 \cdot 10^{-4} \text{ m} \Rightarrow \underline{y = 0,4 \text{ m}}$$



Spd A. ( $x = 0,2 \text{ m}$      $y = 0,4 \text{ m}$ )

$$b) V_0 - V_A = V_0 - V_F = E \cdot y = 10^3 \cdot 0,4 = 400 \text{ V} \quad \underline{V_0 - V_A = 400 \text{ V}}$$

$$c) W = F \cdot y = E g y = 10^3 \cdot 2 \cdot 10^{-6} \cdot 0,4 = 0,8 \cdot 10^{-3} = 8 \cdot 10^{-4} \text{ J}$$

$$W = q (V_0 - V_A) = 2 \cdot 10^{-6} \cdot 400 = 800 \cdot 10^{-6} = 8 \cdot 10^{-4} \text{ J}$$

$$d) \Delta U = -W_F = -8 \cdot 10^{-4} \text{ J}$$

$$\Delta U = q V_A - q V_0 = -q (V_0 - V_A) = -8 \cdot 10^{-4} \text{ Joule}$$

8.25

$$\text{a. } E = \frac{V}{d} = \frac{90V}{9\text{ m}} = 900 \frac{V}{m}$$

$$|\alpha| = \frac{E/9e}{m_e} = \frac{900 \cdot 1,6 \cdot 10^{-19}}{9 \cdot 10^{-31}} = 16 \cdot 10^{13} \frac{1}{s^2}$$

$$\frac{d}{2} = \frac{1}{2} |\alpha| t^2 \Rightarrow d = |\alpha| t^2 \Rightarrow t = \sqrt{\frac{d}{|\alpha|}}$$

$$\Rightarrow t = 25 \cdot 10^9 \text{ s}$$

$$v_y = |\alpha| t = 16 \cdot 10^{13} \frac{1}{s^2} \cdot 25 \cdot 10^9 \text{ s} \Rightarrow v_y = 4 \cdot 10^6 \text{ m/s}, \quad v = \sqrt{v_x^2 + v_y^2} \Rightarrow v = 5 \cdot 10^6 \text{ m/s}$$

Kai Σιαράρετικοί:  $\Delta K = K - K_0 = W_{F_{xy}} \Rightarrow \frac{1}{2} m v^2 - \frac{1}{2} m v_0^2 = F_{xy} \frac{d}{2} \Rightarrow \frac{1}{2} m (v^2 - v_0^2) = E/9e \frac{d}{2}$

$$\Rightarrow m v_y^2 = E/9e \frac{d}{2} \quad \text{and} \quad v_y = \sqrt{\frac{E/9e d}{m}} = 4 \cdot 10^6 \text{ m/s}$$

$$\text{b. } \vec{DP} = \vec{P} - \vec{P}_0 = m \vec{v} - m \vec{v}_0 = m(\vec{v} - \vec{v}_0) = m \vec{v}_y \Rightarrow DP = m v_y = 9 \cdot 10^{31} \text{ kg} \cdot 4 \cdot 10^6 \text{ m/s}$$

$$\Rightarrow DP = 36 \cdot 10^{27} \text{ kg m/s}$$

Σιαράρετικοί  $\Delta P = F_{xy} \cdot t = E/9e / t \stackrel{SI}{=} 900 \cdot 1,6 \cdot 10^{19} \cdot 25 \cdot 10^9 \Rightarrow \Delta P = 36 \cdot 10^{27} \text{ kg m/s}$

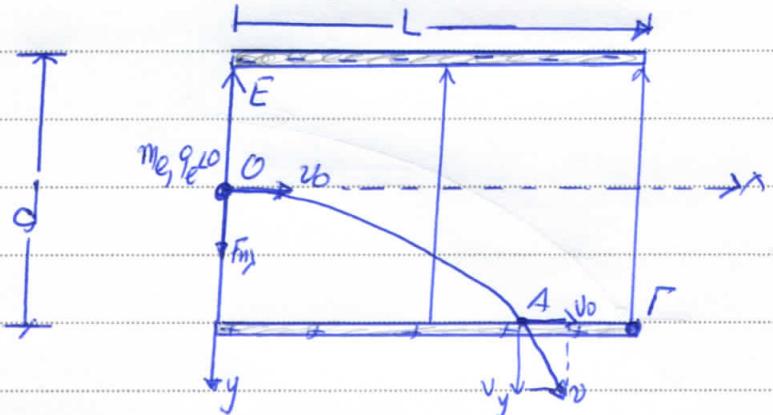
c. \*  $W = \Delta K = 0 = \frac{1}{2} m v_y^2 = \frac{1}{2} 9 \cdot 10^{31} \cdot 16 \cdot 10^{12} \Rightarrow W = 72 \cdot 10^{19} \text{ J}$

\*\*  $W = F \cdot d = E/9e / \frac{d}{2} = 900 \cdot 1,6 \cdot 10^{19} \cdot \frac{9}{2} \Rightarrow W = 72 \cdot 10^{19} \text{ J}$

\*\*\*  $W = q_e \cdot (x_0 - x_A) = -19e \cdot (-\frac{V}{2}) = \frac{1}{2} 19e \cdot V = \frac{1}{2} \cdot 1,6 \cdot 10^{-19} \cdot 90V = 72 \cdot 10^{19} \text{ J}$

d. οος γίγαντος σε δύναμη ουδέν  $y = \frac{d}{2} = 10 \text{ m} \quad \dots t = 25 \cdot 10^9 \text{ s}$

$$x = v_0' t \Rightarrow L = v_0' t = 6 \cdot 10^6 \cdot 25 \cdot 10^9 \text{ (SI)} \Rightarrow L = 0,15 \text{ m}$$



8.26

a) xpóros ζεισην

$$\frac{d}{2} = \frac{1}{2} |\alpha| t^2 \Rightarrow t = \sqrt{\frac{d}{|\alpha|}}$$

$$\Delta \vec{P} = \vec{P} - \vec{P}_0 = m_e \vec{v} - m_e \vec{v}_0 = m_e \vec{v}_y$$

$$\Rightarrow \Delta P = m_e v_y = m_e |\alpha| t = m_e |\alpha| \sqrt{\frac{d}{|\alpha|}}$$

$$\Rightarrow \Delta P = \sqrt{m_e^2 |\alpha| d} = \sqrt{m_e^2 \frac{E/9e}{m_e} d}$$

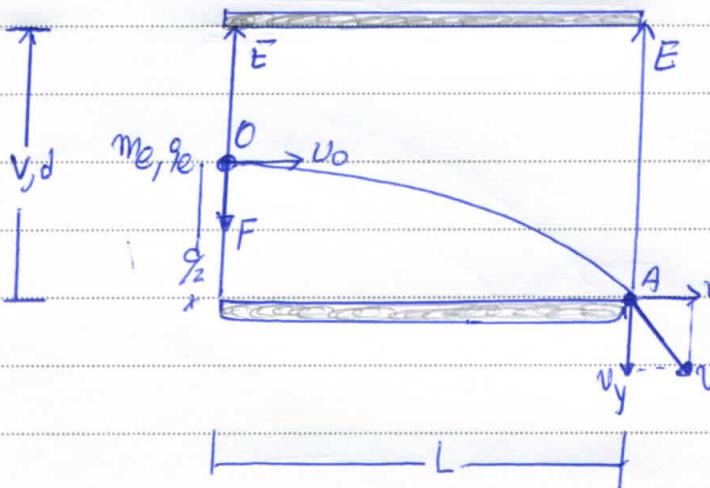
$$\Rightarrow \Delta P = \sqrt{m_e \frac{V}{d} |9e| d} \quad \text{et} \quad \Delta P^2 = m_e V \cdot |9e| \Rightarrow V = \frac{\Delta P^2}{m_e |9e|}$$

~~ΣΣ~~  $V = \frac{(18 \cdot 10^{25} \text{ kg/m/s})^2}{9 \cdot 10^3 \text{ kg} \cdot 1,6 \cdot 10^{-19} \text{ C}} \Rightarrow V = 22,5 V_0 \text{ J}$

b)  $\Delta K = \frac{1}{2} m_e V^2 - \frac{1}{2} m_e V_0^2 = \frac{1}{2} m_e v_y^2$  }  $\Rightarrow \Delta K = \frac{1}{2} m \frac{\Delta P^2}{m_e^2} \Rightarrow \Delta K = \frac{\Delta P^2}{2 m_e}$

...  $\Delta P = m_e V_y$

$\xrightarrow{\Sigma} \Delta K = \frac{(18 \cdot 10^{25} \text{ kg m/s})^2}{2 \cdot 9 \cdot 10^3 \text{ kg}} \Rightarrow \Delta K = 18 \cdot 10^{19} \text{ J}$



8.27

$$\alpha) \frac{1}{2} m v_0^2 = |q| \cdot V \Rightarrow v_0 = \sqrt{\frac{2|q|V}{m}} = \sqrt{\frac{2 \cdot 109 \cdot 125}{5 \cdot 10^{-10}}} = \sqrt{250 \cdot 10} = 50 \text{ m/s}$$

$$\text{b)} E = U_0 \quad t = 1 \quad t = \frac{F}{U_0} = \frac{15 \cdot 10^{-2}}{50}$$

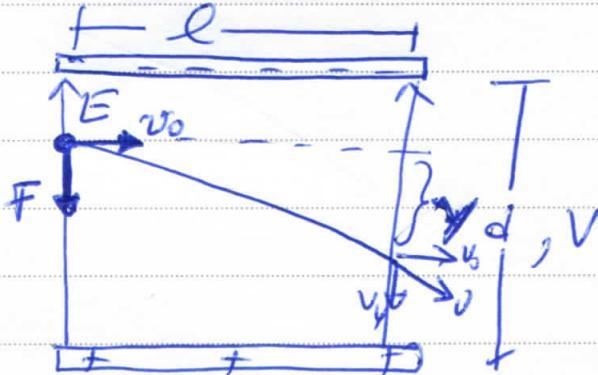
$$\Rightarrow t = 3 \cdot 10^{-3} \text{ s}$$

$$\delta) y = \frac{1}{2} |\alpha| t^2 \Rightarrow |\alpha| = \frac{2y}{t^2}$$

$$|\alpha| = \frac{2 \cdot 4,5 \cdot 10^{-2}}{8 \cdot 10^{-6}} \Rightarrow |\alpha| = 10^4 \text{ m/s}^2$$

$$E|q| = m|\alpha| \Rightarrow E = \frac{m|\alpha|}{q} = \frac{10^1 \cdot 10^4}{10^5} \Rightarrow E = 10^3 \text{ V/m}$$

$$V = F \cdot d = 10^3 \frac{\text{V}}{\text{m}} \cdot 8 \cdot 10^{-2} \text{ m} \Rightarrow V = 80 \text{ V}$$



$$\sigma) \Delta P = m v_y = m |\alpha| t = 10^{10} \cdot 10^4 \cdot 3 \cdot 10^{-3} = 3 \cdot 10^9 \text{ kg m/s}$$

$$\Rightarrow \Delta P = 3 \cdot 10^9 \text{ kg m/s}$$

$$\Delta P = E|q| t = 10^3 \cdot 10^4 \cdot 3 \cdot 10^{-3} = 3 \cdot 10^9 \text{ kg m/s}$$

$$\varsigma) \Delta U = U_{Tg} - U_{\alpha px} = qV_T - qV_\alpha = -19 \text{ J} (+E_y)$$

$$= -19 |E_y| = -10^9 \cdot 10^3 \cdot 4,5 \cdot 10^{-2} = -4,5 \cdot 10^{-8} \text{ J}$$

$$\Delta U = -W_F = -|E| q_y$$

$$= -q(x_{\alpha px} - V_{Tg}) = -(-19) (-|E| q_y)$$

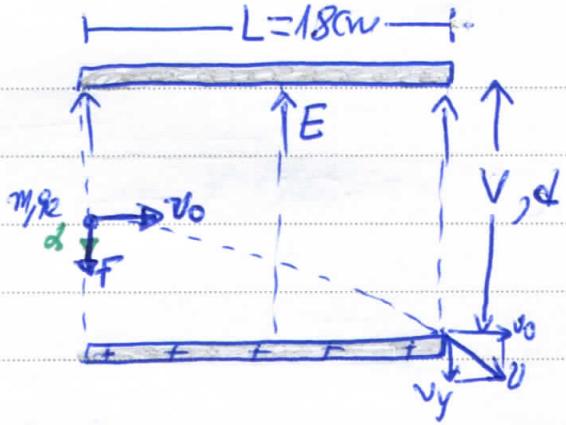
8.28

$$L=18\text{cm} \quad \alpha) \quad E=\frac{V}{d}, \quad F=E/9e= \frac{V}{d}/9e$$

$$d=6\text{cm}$$

$$V=10\text{V} \quad \alpha) \quad |\alpha| = \frac{F}{m_e} = \frac{V/9e}{m_e d}$$

$$\frac{d}{2} = \frac{1}{2}|\alpha|t^2 \Rightarrow t = \sqrt{\frac{d}{|\alpha|}}$$



$$x = v_0 t \geq L \Rightarrow v_0 \sqrt{\frac{d}{|\alpha|}} \geq L \Rightarrow v_0 \geq L \sqrt{\frac{1}{d} \cdot \frac{V/9e}{m_e d}}$$

$$\Rightarrow v_0 \geq \frac{L}{d} \sqrt{\frac{V/9e}{m_e d}} \Rightarrow v_0 \geq \frac{18\text{cm}}{6\text{cm}} \sqrt{\frac{10 \cdot 1.6 \cdot 10^{19}}{9 \cdot 10^3}} \Rightarrow v_0 \geq 3 \sqrt{\frac{16}{9} \cdot 10^6}$$

$$\Rightarrow v_0 \geq 3 \cdot \frac{4}{3} \cdot 10^6 \text{ m/s} \quad \boxed{v_0 \geq 4 \cdot 10^6 \text{ m/s}}$$

$$b) \quad |\alpha| = \frac{V/9e}{m_e d} = \frac{10V \cdot 1.6 \cdot 10^{19}}{9 \cdot 10^3 \text{ kg} \cdot 6 \cdot 10^{-2}} \Rightarrow |\alpha| = \frac{16}{54} \cdot 10^{14} \text{ rad/s} \quad \text{or} \quad |\alpha| = \frac{8}{27} \cdot 10^{14} \text{ rad/s}$$

$$t = \sqrt{\frac{6 \cdot 10^{-2}}{\frac{8}{27} \cdot 10^{14} \text{ rad/s}}} \text{ or } t = \sqrt{\frac{6 \cdot 27}{8} \cdot 10^{16}} \text{ or } \boxed{t = 4.5 \cdot 10^8 \text{ s}}$$

$$f) \quad W = E/9e \cdot \frac{d}{2} = \frac{V}{d} / 9e \cdot \frac{d}{2} = \frac{1}{2} \cdot 10 \cdot 1.6 \cdot 10^{19} = 8 \cdot 10^{19} \text{ J}$$

$$W = \Delta K = \frac{1}{2} m v_y^2$$

$$v_y = \alpha \cdot t = \frac{8}{27} \cdot 10^{14} \cdot 4.5 \cdot 10^8 = \cancel{\frac{360}{27}} \cdot 10^6 = \frac{4}{3} \cdot 10^6 \text{ m/s}$$

$$\hookrightarrow W = \frac{1}{2} \cdot \frac{8 \cdot 10^{19}}{9} \cdot \frac{16}{3} \cdot 10^{12} = 8 \cdot 10^{19} \text{ J}$$

$$\delta) \Delta U = -W_{\text{ext}} = -8 \cdot 10^{19} J$$

$$\text{e)} \text{ Ar n' Taxijen verwend' } |\alpha| = \frac{\chi / 9 eV}{m_e c^2} \text{ idia}$$

αριθμος κυριακη με δεπτο εστω  $t = \sqrt{\frac{e}{\chi}}$ , οποιος

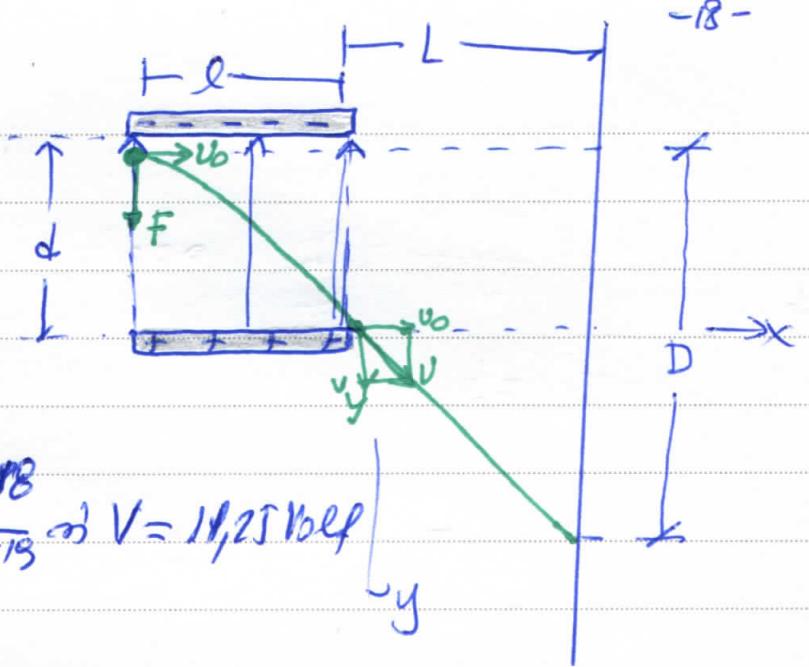
$$\text{Ανδρασι} \cdot \text{ωα δει αντιδια} L_1 = v_0 t < L$$

$$\text{ε.1)} \quad 600676$$

$$\text{ε.2)} \quad L_1 \text{ αντιδια} \approx v_0 t, \text{ ηε αποτελεσματα}$$

8.29

$$l = 9 \text{ m} \quad \Delta F = 1,8 \cdot 10^{18} \text{ N}$$



a)  $\Delta F = M_F = E |v_0| \quad d = \frac{V}{190} / d'$

$$\Delta F = V |v_0| \Rightarrow V = \frac{\Delta F}{|v_0|} = \frac{1,8 \cdot 10^{18}}{1,6 \cdot 10^{13}} \Rightarrow V = 1,125 \text{ kN}$$

$$E = \frac{V}{d} = \frac{1,125}{0,2} = 56,25 \text{ N/mm}$$

b)  $|x| = \frac{E |v_0|}{m} = \frac{56,25 \cdot 1,6 \cdot 10^{13}}{8 \cdot 10^3} \Rightarrow |x| = 10 \cdot 10^12 = 10^{13} \text{ m/s}^2$

c)  $d = \frac{1}{2} |x| t^2 = \frac{1}{2} \frac{|x|}{k} = \sqrt{\frac{2 \cdot 0,2}{10^3}} = \sqrt{\frac{4 \cdot 10^1}{10^3}} = 2 \cdot 10^7 \text{ s}$

$$L = v_0 t \Rightarrow v_0 = \frac{L}{t} = \frac{0,2}{2 \cdot 10^7} \Rightarrow v_0 = 0,1 \cdot 10^{-7} \text{ m/s} \Rightarrow v_0 = 10^6 \text{ m/s}$$

d)  $x = v_0 t' \Rightarrow L = v_0 t' \Rightarrow t' = \frac{L}{v_0} = \frac{0,4}{10^6} \Rightarrow t' = 4 \cdot 10^7 \text{ s}$

$$y = v_y t'$$

$$v_y = dx/t = 10^{13} \text{ m} / 2 \cdot 10^7 \text{ s} = 2 \cdot 10^6 \text{ m/s}$$

$$y = 2 \cdot 10^6 \cdot 4 \cdot 10^7$$

$$y = 8 \cdot 10^{-1} \text{ m}$$

$$y = 0,8 \text{ m}$$

$\Rightarrow D = d + y \Rightarrow D = 1,0 \text{ m}$

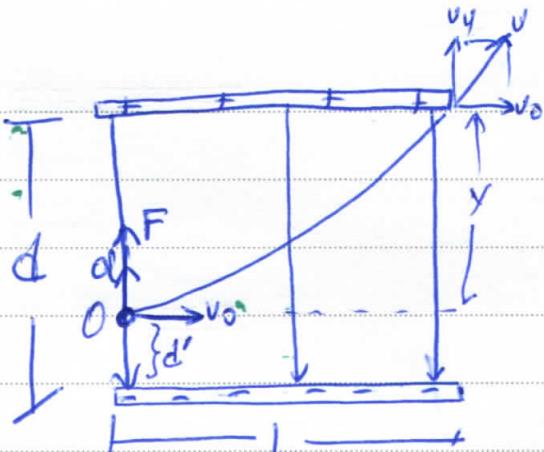
## 8.30

$$d = 64 \text{ cm}$$

$$V = 2035 \text{ V}$$

$$v_0 = 8 \cdot 10^6 \text{ m/s}$$

$$U = 5 v_0 / 4 \Rightarrow U = 11,75 \cdot 10^6 \text{ m/s}$$



$$v_y = \sqrt{v^2 - v_0^2} = \sqrt{\frac{25U}{16} - v_0^2} = \sqrt{\frac{9v_0^2}{16}}$$

$$v_y = \frac{3}{4} v_0 = \frac{3}{4} \cdot 8 \cdot 10^6 \Rightarrow v_y = 6,75 \cdot 10^6 \text{ m/s}$$

a)  $|F|t = \frac{E/9e1}{m_e} = \frac{V}{d} \frac{19e1}{m_e} = \frac{2035 \cdot 1,6 \cdot 10^{-19}}{6,4 \cdot 10^{-2} \cdot 9 \cdot 10^3} \text{ N} \quad \text{of} \quad |F| = 5,625 \cdot 10^{16} \text{ N/m/s}$

b)  $v_y = |\alpha| \cdot t \Rightarrow t = \frac{v_y}{|\alpha|} = \frac{6,75 \cdot 10^6}{5,625 \cdot 10^{16}} \text{ s} \quad \text{at} \quad t = 1,2 \cdot 10^{-8} \text{ s}$

c)  $L = v_0 t = 8 \cdot 10^6 \cdot 1,2 \cdot 10^{-8} \text{ m} \quad \text{at} \quad L = 10,8 \cdot 10^{-2} \text{ m} \quad \underline{L = 10,8 \text{ cm}}$

\* e)  $\Delta P = m v_y = 8 \cdot 10^{-31} \cdot 6,75 \cdot 10^6 \text{ N} \quad \text{at} \quad \Delta P = 60,75 \cdot 10^{-25} \text{ kg m/s}$

$$\Delta P = F \cdot t = E/9e1 \cdot t = \frac{2035 \cdot 1,6 \cdot 10^{-19} \cdot 1,2 \cdot 10^{-8}}{6,4 \cdot 10^{-2}} = 60,75 \cdot 10^{-25} \text{ kg m/s}$$

f)  $N = \frac{1}{2} m v_y^2 = \frac{1}{2} 8 \cdot 10^{-31} \cdot (6,75 \cdot 10^6)^2 = 203,03175 \cdot 10^{-19} \text{ J}$

$$y = \frac{1}{2} |\alpha| t^2 = \frac{1}{2} \cdot 5,625 \cdot 10^{16} \cdot 1,44 \cdot 10^{-16} = 4,05 \cdot 10^{-2}$$

$$V' = -E y = -\frac{V}{4} y = -\frac{2035}{6,4} \cdot 4,05 = 728,144 \text{ V}$$

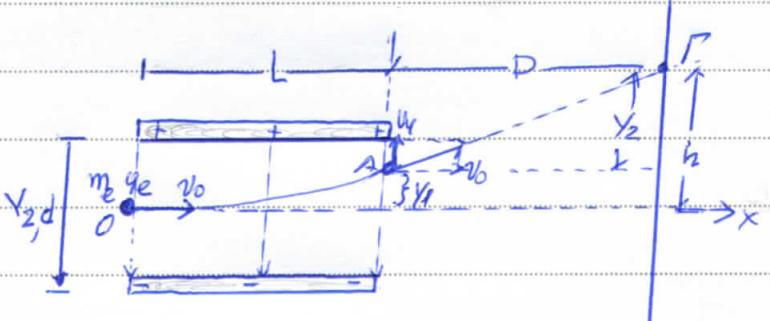
$$W = q_e V' = 203,03000 \cdot 10^{-19} \text{ J}$$

\* g)  $y = \frac{1}{2} |\alpha| t^2 = \frac{1}{2} 5,625 \cdot 10^{16} \cdot (1,2 \cdot 10^{-8})^2 = 4,05 \cdot 10^{-4} = 4,05 \text{ cm}$

To mazatneho 10 sekundu 6 sekundu o delo

$$\alpha = 81 \text{ rad/s}^2 \quad \text{at} \quad T = 2 \pi / \omega = 2 \pi / 81 = 0,785 \text{ s} \quad d' = d - y \Rightarrow d' = 2,35 \text{ cm}$$

8.31



To ηετερούσια συνάντησης

2,00 πν όρχια για την V<sub>1</sub>

μεταβολή ταχύτητας νω

$$|\rho_e| V_1 = \frac{1}{2} m_e v_0^2 \Rightarrow v_0 = \sqrt{\frac{2|\rho_e| V_1}{m_e}} \quad (1)$$

και μεταβολής εργασίας στην αρχή της παραστασής

Η κίνηση της αρχής παραμένει ασταθή

$$x = v_0 t \xrightarrow{A} L = v_0 t_1 \Rightarrow t_1 = \frac{L}{v_0} \quad (2)$$

$$y = \frac{1}{2} \alpha t^2 \xrightarrow{A} y_1 = \frac{1}{2} \alpha t_1^2 = \frac{1}{2} \frac{E I g e}{m_e} \cdot \frac{L^2}{v_0^2} \stackrel{(1)}{=} \frac{1}{2} \frac{V_2}{d} \frac{19e}{m_e} \cdot \frac{L^2}{v_0^2} = \frac{1}{4} \frac{V_2}{d} \frac{L^2}{v_1^2} \Rightarrow$$

$$\Rightarrow y_1 = \frac{1}{4} \frac{50V}{0,1m} \frac{(0,2m)^2}{200V} \Rightarrow y_1 = 0,025m \text{ ή } y_1 = 2,5cm$$

Οι ανισώσεις της Ταχύτητας στην Εξόδο A είναι  $y_2 = y_1 + y_0$ : και  $y_0 = \rho_e t_1$ ,

$$\text{οτι } y_0 = \frac{E I g e t_1}{m_e} \xrightarrow{(2)} y_0 = \frac{V_2}{d} \frac{19e}{m_e} \frac{L}{v_0} \quad (3) \text{ και γε αριθμητικά παρατητικά}$$

αλλαγές της ταχύτητας στην Εξόδο προσδιορίζουν την θέση της Εξόδου στην οδό

οδόν

Η κίνησης γενοί το πρώτο... είναι ευδιπορευόμενη

$$x = v_0 t \xrightarrow{D} D = v_0 t_2 \Rightarrow t_2 = \frac{D}{v_0}$$

$$y = y_1 + \xrightarrow{D} y_2 = y_1 t_2 \Rightarrow y_2 = y_1 \cdot \frac{D}{v_0} \xrightarrow{(3)} y_2 = \frac{V_2}{d} \frac{19e}{m_e} \frac{L}{v_0} \frac{D}{v_0}$$

$$\Rightarrow y_2 = \frac{V_2}{d} \frac{19e}{m_e} \frac{LD}{v_0^2} \xrightarrow{(1)} y_2 = \frac{V_2}{d} \frac{19e}{m_e} \frac{LD}{2|\rho_e| V_1} \Rightarrow y_2 = \frac{V_2}{d} \frac{LD}{2V_1}$$

$$\Rightarrow y_2 = \frac{V_2}{2d} \frac{LD}{V_1} = \frac{V_2}{2V_1} \frac{LD}{d} = \frac{50V}{2 \cdot 200V} \cdot \frac{0,2m \cdot 0,4m}{0,1m} \Rightarrow y_2 = 0,10m$$

$$\text{η } y_2 = 10cm, \text{ Άρα } h = y_1 + y_2 \Rightarrow h = 13,5cm \text{ ή } h = 0,135m$$

B.32

$$\text{d} \cdot E \cdot \varphi = \frac{v_0}{v_y} \Rightarrow v_y = \frac{v_0}{E \cdot \varphi} = \frac{150 \text{ m/s}}{1,5} \Rightarrow v_y = 100 \text{ m/s}$$

$$d = \frac{f}{m} = \frac{Eq}{m} = 50 \frac{\text{V}}{\text{m}} \cdot 200 \frac{\text{C}}{\text{kg}} = 10^4 \text{ m/s}^2$$

$$v_y = a \cdot t \Rightarrow t = \frac{v_y}{a} = \frac{100 \text{ m/s}}{10^4 \text{ m/s}^2} \Rightarrow t = 10^{-2} \text{ s}$$

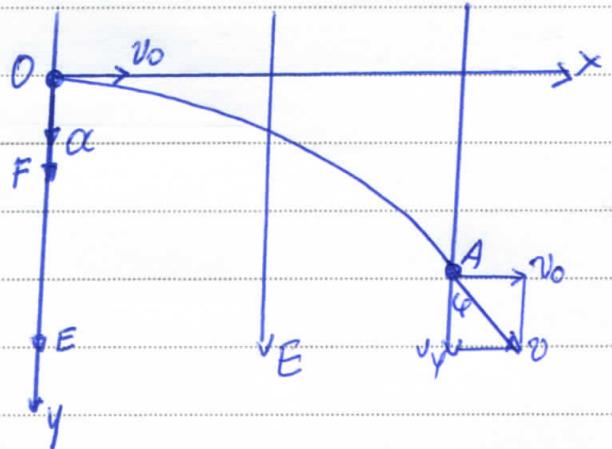
$$\text{B. } y = \frac{1}{2} a t^2 \xrightarrow{\text{SE}} y = \frac{1}{2} \cdot 10^4 \cdot (10^{-2})^2 \Rightarrow y = 0,5 \text{ m}$$

$$V_0 - V_A = E \cdot y = 50 \frac{\text{V}}{\text{m}} \cdot 0,5 \text{ m} \Rightarrow V_0 - V_A = 25 \text{ V}$$

$$\text{J. } \Delta K = \frac{1}{2} m v^2 - \frac{1}{2} m v_0^2 = \frac{1}{2} m (v^2 - v_0^2) = \frac{1}{2} m v_y^2$$

$$\frac{\Delta K}{K_0} = \frac{\frac{1}{2} m v_y^2}{\frac{1}{2} m v_0^2} = \left( \frac{v_y}{v_0} \right)^2 = \left( \frac{100}{150} \right)^2 = \left( \frac{2}{3} \right)^2 = \frac{4}{9}$$

$$\eta \% = \frac{4}{9} \cdot 100 \% = \frac{400}{9} \% \text{ or } \eta \% \approx 44,44 \%$$



Κεφάλαιο 9<sup>ο</sup>. Πυκνωτής Απαραίτης

A. Ερωτήσεις βωμού - απόδοσης

9.1 δ, γ	9.2 δ	9.3 δ, γ	9.4 δ, γ
9.5 δ	9.6 δ, γ	9.7 δ, γ	9.8 δ, γ
9.9 α	9.10 α, δ	9.11 α, γ	9.12 δ
9.13 δ, γ	9.14 δ, γ		

B. Ερωτήσεις παραρρόντων

9.15

Αποτίκαι  $U, V, E$  : ΜΕΡΙΔΗ  $U=4U, V', E'$

$$U'=4U \Rightarrow \frac{1}{2}CV'^2 = 4 \cdot \frac{1}{2}CV^2 \Rightarrow V'^2 = 4V^2 \Rightarrow V' = 2V$$

$$E' = \frac{V'}{e} = \frac{2V}{e} = 2E \quad \text{Αποδείξω τη (B)}$$

9.16

$$1^{\text{η}} \pi \text{εει/π} \text{ποση}: Eg = mg \Rightarrow \frac{V}{e} = \frac{m}{q}g \Rightarrow \frac{q}{m} = \frac{e}{V}g$$

$$2^{\text{η}} \pi \text{εει/α} \text{ποση}: E'g' = mg \Rightarrow \frac{V'}{e} = \frac{m'}{q'}g \Rightarrow \frac{q'}{m'} = \frac{e}{V'}g$$

$$\frac{q'}{m'} = 2\left(\frac{q}{m}\right) \Rightarrow \frac{e}{V'}g = 2\frac{e}{V}g \Rightarrow V = 2V \text{ και } V' = \frac{V}{2}$$

$$\begin{aligned} U' &= \frac{1}{2}CV'^2 \\ U &= \frac{1}{2}CV^2 \end{aligned} \quad \left\{ \Rightarrow \frac{U'}{U} = \frac{|V'|^2}{|V|^2} = \frac{1}{4} \Rightarrow U' = \frac{U}{4} \text{ και } U' = 0,25U$$

Αποδείξω τη (B)

$$9.17 \text{ Αποτίκαι}: mg = Eq \quad \text{Μετα: } U' = 144U \Rightarrow \frac{1}{2}CV'^2 = 144 \cdot \frac{1}{2}CV^2$$

$$\Rightarrow V' = 12V \Rightarrow \frac{E'}{e} = 12 \cdot \frac{E}{e} \Rightarrow E' = 12E$$

$$\alpha = \frac{\Sigma F}{m} = \frac{E'g - mg}{m} = \frac{12Eg - mg}{m} \xrightarrow{(1)} \alpha = \frac{1,2mg - mg}{m} \Rightarrow \alpha = 0,2g$$

Αποδείξω τη (B)

9.18 Αρχικά  $Q, V, U$  Μετα'  $Q'=98Q, V=V, U'$

$$\text{a. } C = \frac{Q}{V} \quad C' = \frac{Q'}{V} = \frac{98Q}{V} = 98 \cdot \frac{Q}{V} = 0,8C \quad \left. \begin{array}{l} \text{Μείωση της χειριτικότητας} \\ \text{μετρη 20\%} \end{array} \right\} Q=7480s$$

$$\text{b. } U = \frac{1}{2} CV^2 \quad U' = \frac{1}{2} C' V'^2 = \frac{1}{2} \cdot 0,8C \cdot V^2 = 0,8 \cdot \frac{1}{2} CV^2 \quad \left. \begin{array}{l} U=0,8U \text{ μείωση της} \\ \text{ενέργειας μετρη 20\%} \end{array} \right\}$$

... να είναι διαφορετική

$$U = \frac{1}{2} QV \quad U' = \frac{1}{2} Q'V = \frac{1}{2} 98QV = 0,8 \frac{1}{2} QV \quad \left. \begin{array}{l} U=0,8U \end{array} \right\}$$

9.19. Αρχικά  $Q, V, C = \frac{Q}{V}, U = \frac{1}{2} QV$

Μετα'  $Q'=Q, V'=1,25V$

$$\text{a. } C' = \frac{Q'}{V'} = \frac{Q}{1,25V} = 0,8 \frac{Q}{V} = 0,8C \quad \left. \begin{array}{l} \text{Μείωση χειριτικότητας 20\%} \\ Q=6000s \end{array} \right\}$$

$$\text{b. } U = \frac{1}{2} QV, U' = \frac{1}{2} Q'V' = \frac{1}{2} Q \cdot 1,25V = 1,25 \cdot \frac{1}{2} QV = 1,25U$$

$$\Delta U = U' - U = 0,25U, \eta \% = \frac{\Delta U}{U} 100\% \Rightarrow \eta \% = 25\%$$

Αυξηση διαστάσης συρράγη πουντώ μετρη 25%

$\eta$

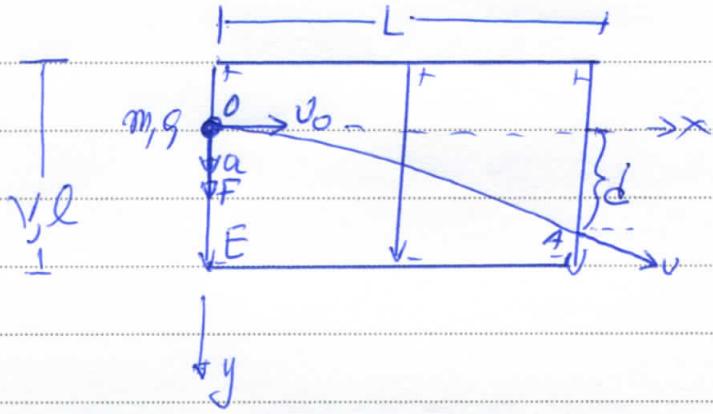
6000s

$$U = \frac{1}{2} CV^2 \quad U' = \frac{1}{2} C' V'^2 = \frac{1}{2} 0,8C \cdot (1,25V)^2 = 0,8 \cdot 1,25^2 \cdot \frac{1}{2} CV^2 = 1,25 \cdot \frac{1}{2} CV^2$$

$$\Rightarrow U' = 1,25U \quad \text{απλ } \Delta U = U' - U \Rightarrow \Delta U = 0,25U$$

g.20

$$a. x = v_0 t \xrightarrow{A} L = v_0 t_{ef} \Rightarrow \\ \Rightarrow t_{ef} = \frac{L}{v_0} \text{ ο ρεστίρηνας} \\ \text{της ταχύτητος } V$$



OP-ΤΟΙΔΟΣ

$$b. y = \frac{1}{2} \alpha t^2 = \frac{1}{2} \frac{Eg}{m} t^2 = \frac{1}{2} \frac{Eg}{m} \frac{L^2}{v_0^2}$$

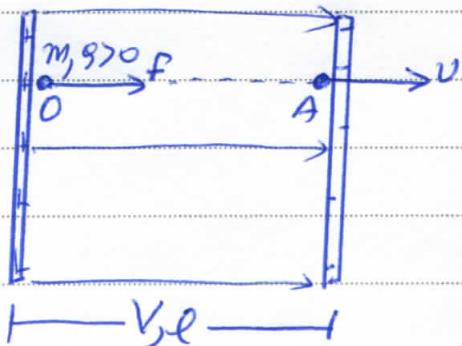
$$\Rightarrow y = \frac{1}{2} \frac{V}{E} \frac{q}{m} \left( \frac{L}{v_0} \right)^2 \Rightarrow y = \frac{q}{2m} \left( \frac{L}{v_0} \right)^2 \cdot V = 6\pi \cdot V \Rightarrow y = 6\pi \cdot V$$

Παραπομπές διτην ευρωδή για παραπομπή σφόδρα ελαττώσεων  
της ταχύτητος ή αριθμού σταθαράδει στην ταχύτητα παραγόμενη  
και συγκροτώντας  $y' = 2y$  ε-ευρωδή

g.21

$$\Delta K_{O \rightarrow A} = W_F = q \cdot (V_0 - V_A) = q \cdot V \Rightarrow$$

$$\Rightarrow \frac{1}{2} m V_0^2 - 0 = q \cdot V \Rightarrow V_0 = \sqrt{\frac{2qV}{m}} \quad (1)$$



$$\text{Άλλη } V' = 2V \Rightarrow 0 = \sqrt{\frac{2q \cdot 2V}{m}} = \sqrt{\frac{2qV}{m}} \cdot \sqrt{2} \quad (2)$$

$$\Rightarrow V = V_0 \sqrt{2}$$

Αριθμού σταθαρή στη (B)

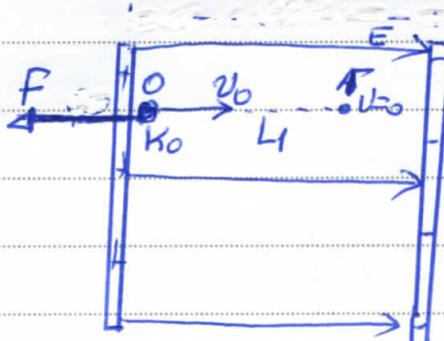
g.22

$$A: K - K_0 = W_F \Rightarrow 0 - K_0 = -F L_1$$

$$\Rightarrow -K_0 = -E/q/L_1 \quad (1)$$

$$B: K - K_0 = W_F' \Rightarrow 0 - K_0 = -F' L_2$$

$$\Rightarrow -K_0 = -E \cdot 2/q/L_2 \Rightarrow K_0 = 2E/q/L_2 \quad (2)$$



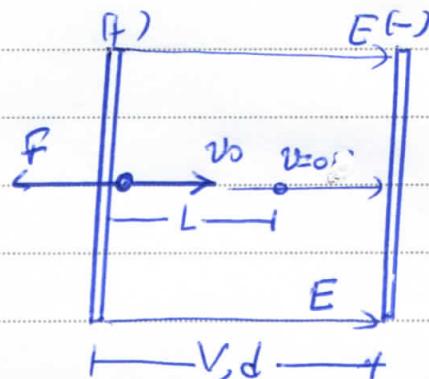
$$1, 2 \Rightarrow E/q/L_1 = 2E/q/L_2 \Rightarrow L_1 = 2L_2 \quad \text{Αριθμού σταθαρή στη (B)}$$

9.23

1<sup>η</sup> ΤΙΕΕ/ΝΤωγά:

$$K - k_0 = W_F \Rightarrow 0 = k_0 = -F \cdot L$$

$$\Rightarrow k_0 = E/q/L \Rightarrow k_0 = \frac{V}{d} q/L \quad (1)$$

2<sup>η</sup> ΤΙΕΕ/ΝΤωγά

$$K - k_0 = W_F' \Rightarrow 0 = k_0 = -F' \cdot d \Rightarrow k_0 = E' q/d \Rightarrow k_0 = \frac{V'}{d} q/d \quad (2)$$

$$(1), (2) \Rightarrow \frac{V}{d} q/L = \frac{V'}{d} q/d \Rightarrow VL = V'd \Rightarrow VL = \frac{V}{2} d \Rightarrow d = 2L$$

? Αριθμοί στη (2)

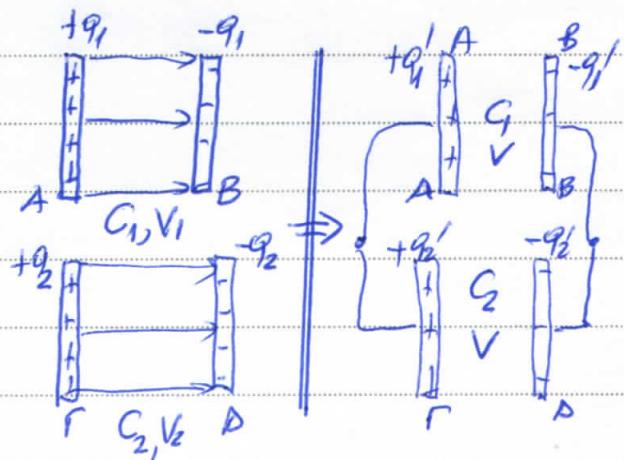
9.24

$$q'_1 + q'_2 = q_1 + q_2 \Rightarrow$$

$$G_1 V + G_2 V = q_1 + q_2 \Rightarrow$$

$$\Rightarrow V = \frac{q_1 + q_2}{G_1 + G_2}$$

? Αριθμοί στη (2)

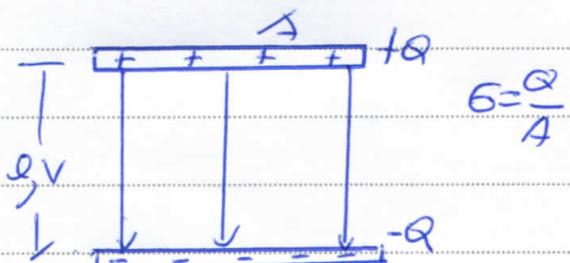


9.25

$$E = \frac{V}{d} = \frac{q/C}{d} = \frac{1}{\epsilon_0} \frac{q}{C}$$

$$\Rightarrow E = \frac{1}{\epsilon_0} \frac{Q}{A} \Rightarrow E = \frac{\sigma}{\epsilon_0}$$

? Αριθμοί στη (2)



# Г! Ағасылардың касаулықтары

9.26

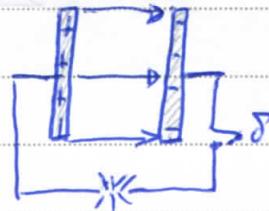
a. Ережегиңін анықтауында  $E_{\text{ок}} = \bar{P} \cdot \Delta t \Rightarrow$

$$E_{\text{ок}} = 540 \cdot 10^3 \text{ Вт} \cdot 10 \cdot 10^3 \text{ с} \Rightarrow E_{\text{ок}} = 54 \cdot 10^3 \text{ дж}$$

$$E_{\text{ок}} = 0,90 \text{ } U_{\text{форвард}} \Rightarrow U = \frac{E_{\text{ок}}}{0,90} \Rightarrow \\ \Rightarrow U = 6 \cdot 10^3 \text{ в}$$

$$\text{б. } U = \frac{1}{2} C V^2 \Rightarrow V = \sqrt{\frac{2U}{C}} \Rightarrow V = \sqrt{\frac{2 \cdot 6 \cdot 10^3}{7,5 \cdot 10^{-4}}} \Rightarrow V = 4 \times 10^4 \text{ в}$$

$$\text{ж. } Q = CV = 7,5 \cdot 10^{-4} \text{ ф} \cdot 4 \text{ в} \Rightarrow Q = 30 \cdot 10^{-4} \text{ К} \Rightarrow Q = 30 \mu \text{К}$$



9.27

a. ПОЕРРЕДІЛІКСІЛІКТЕ  $\sum F_y = 0 \Rightarrow F_{\text{нр}} + mg = 0 \Rightarrow$

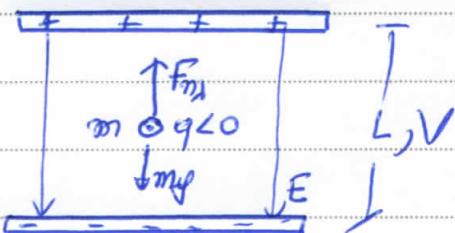
$$F_{\text{нр}} = -mg \Rightarrow Eq = -mg \Rightarrow$$

$$E(-q) = -mg \Rightarrow E = \frac{mg}{|q|}$$

Неге  $E$ ,  $q$  оңгерекшілік, мәнде

бұл бұлдан да

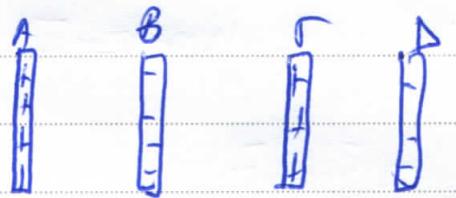
$$\text{б)} \quad \dots E/|q| = mg \Rightarrow E = \frac{mg}{|q|} = \frac{2 \cdot 10^{-4} \text{ кг} \cdot 10 \text{ м/с}^2}{10^6 \text{ К}} \Rightarrow E = 2 \cdot 10^3 \text{ в/м}$$



$$\text{ж)} \quad V = E \cdot L = 2 \cdot 10^3 \frac{\text{в}}{\text{м}} \cdot 9 \cdot 10^2 \text{ м} \Rightarrow V = 40 \text{ коль}$$

$$Q = CV = 30 \text{ ф} \cdot 40 \text{ в} \Rightarrow Q = 1200 \text{ К}$$

9.28



$$d) Q_1 = GV_1 = 1200 \text{ FC} \quad \checkmark$$

$$Q_2 = GV_2 = 1800 \text{ FC} \quad \checkmark$$

$$G = 30 \text{ F}$$

$$V_1 = 40 \text{ V}$$

$$G = 20 \text{ F}$$

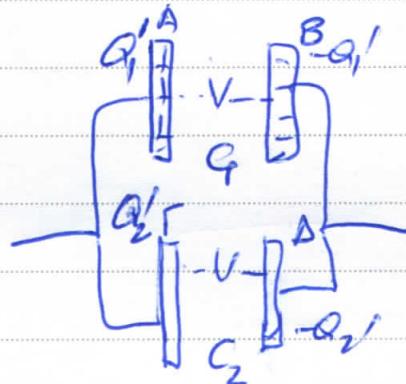
$$V_2 = 90 \text{ V}$$

$$e) Q'_1 + Q'_2 = Q_A + Q_B$$

$$Q'_1 + Q'_2 = Q_1 + Q_2$$

$$\Rightarrow GV + G_2 V = Q_1 + Q_2$$

$$\Rightarrow V = \frac{Q_1 + Q_2}{G + G_2} \Rightarrow V = \frac{3000 \text{ FC}}{50 \text{ F}}$$



$$\Rightarrow V = 60 \text{ Volt} \quad \checkmark$$

$$f) Q'_1 = GV = 30 \text{ F} \cdot 60 \text{ V} = 1800 \text{ FC}$$

$$Q'_2 = G_2 V = 90 \text{ F} \cdot 60 \text{ V} = 1200 \text{ FC}$$

$$\checkmark \Delta Q_A = Q_{A,TG} - Q_{A,DP} = Q'_1 - Q_1 = 1800 \text{ FC} - 1200 \text{ FC} = +600 \text{ FC}$$

$$\checkmark \Delta Q_B = Q_{B,TG} - Q_{B,DP} = Q'_2 - Q_2 = 1200 \text{ FC} - 1800 \text{ FC} = -600 \text{ FC}$$

Sylloge kē p̄ip̄yav 600 FC adō to Q̄d̄l̄yāb̄ P̄  
T̄p̄g j̄v ōl̄t̄āb̄ Ā.

$$g) U_{PAV} = U_1 + U_2 = \frac{1}{2} GV_1^2 + \frac{1}{2} GV_2^2 = \frac{1}{2} \cdot 30 \cdot 10^6 \cdot 40^2 + \frac{1}{2} \cdot 20 \cdot 10^6 \cdot 90^2$$

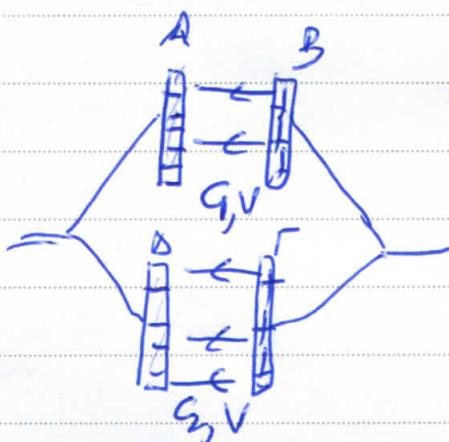
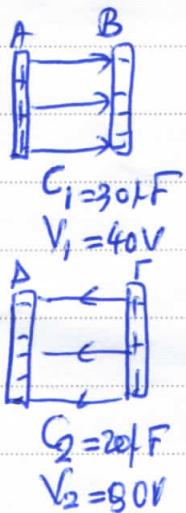
$$\Rightarrow U_{PAV} = 24000 \cdot 10^6 \text{ J} + 81000 \cdot 10^6 \text{ J} \Rightarrow U_{PAV} = 0,105 \text{ J m l o}$$

$$U_{PAZ} = U'_1 + U'_2 = \frac{1}{2} GV_1^2 + \frac{1}{2} GV_2^2 = \frac{1}{2} (G_1 + G_2) V^2 \Rightarrow U_{PAZ} = \frac{1}{2} \cdot 50 \cdot 10^6 \cdot 60^2$$

$$\Rightarrow U_{PAZ} = 0,09 \text{ J}$$

$$\Delta U = U' - U = \underline{\underline{DU = -0,015 \text{ J}}}$$

9.29



$$\alpha) Q_1 = GV_1 = \underline{1200\text{fC}} \quad \left\{ \begin{array}{l} Q_A = +1200\text{fC} \\ Q_B = -1200\text{fC} \end{array} \right.$$

$$Q_2 = G V_2 = \underline{1800\text{fC}} \quad \left\{ \begin{array}{l} Q_T = +1800\text{fC} \\ Q_F = -1800\text{fC} \end{array} \right.$$

$$\beta) Q'_A + Q'_B = Q_A + Q_F = 1200\text{fC} - 1800\text{fC} = -600\text{fC}$$

daß  $Q'_A < 0$  und  $Q'_B > 0$

$$Q'_B + Q'_T = Q_B + Q_F = -1200\text{fC} + 1800\text{fC} = +600\text{fC}$$

daß  $Q'_B > 0$  und  $Q'_T > 0$ .

$$Q'_1 + Q'_2 = Q_1 + Q_F + Q'_B + Q'_T = Q_B + Q_F \Rightarrow GV + G_2V = Q_B + Q_F$$

$$\Rightarrow V = \frac{Q_B + Q_F}{G + G_2} = \frac{+600\text{fC}}{50\text{fF}} \underset{\sim}{=} V = 12\text{ Volt}$$

$$\gamma) Q'_1 = Q'_2 = GV = 30\text{fF} \cdot 12\text{V} = 360\text{fC}$$

$$Q'_2 = Q'_F = G_2V = 20\text{fF} \cdot 12\text{V} = 240\text{fC}$$

$$\left\{ \begin{array}{l} Q'_F = -360\text{fC} \\ Q'_B = +360\text{fC} \end{array} \right.$$

$$\left\{ \begin{array}{l} Q'_T = +720\text{fC} \\ Q'_D = -240\text{fC} \end{array} \right.$$

$$\Delta Q_A = Q_A' - Q_A = -360 \text{ fC} - (+1700 \text{ fC}) = -1560 \text{ fC}$$

$$\Delta Q_D = Q_D' - Q_D = -240 \text{ fC} - (-1800 \text{ fC}) = +1560 \text{ fC}$$

Aan de enige buitenkantige capaciteit moet 1560 fC zijn  
 vanwege  $A \rightarrow D$ .

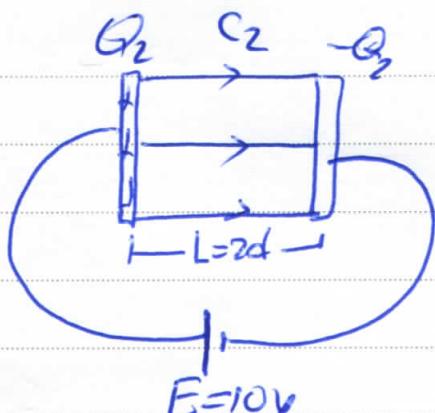
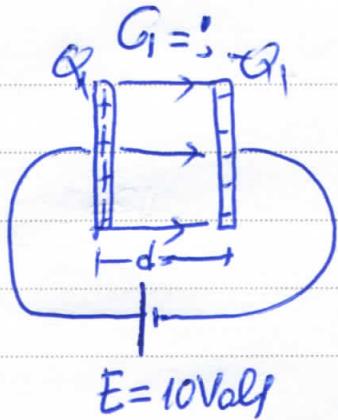
$$\delta) U_{\text{eff},V} = U_1 + U_2 = \frac{1}{2} G V_1^2 + \frac{1}{2} G V_2^2 = 0.00 = 0,105 J$$

$$U_{\text{eff},Z} = U_1' + U_2' = \frac{1}{2} G_1 V^2 + \frac{1}{2} G_2 V^2 = \frac{1}{2} (G_1 + G_2) V^2$$

$$= \frac{1}{2} 50 \cdot 10^{-12} \cdot 12^2 = 0,0036 J$$

$$\Delta U = U_{\text{eff},Z} - U_{\text{eff},V} \Rightarrow \Delta U = -0,1014 J$$

9.30



$$\alpha) \underline{V_1 = E = 10\text{V}}, \underline{V_2 = E = 10\text{V}}$$

$$\beta) G_1 = \frac{Q_1}{V_1} = \frac{20\text{FC}}{10\text{V}} = 2\text{F} \quad G_2 = \epsilon_0 \frac{A}{d} \quad \left. \begin{array}{l} G = \epsilon_0 \frac{A}{d} \\ G = \epsilon_0 \frac{A}{L} \end{array} \right\} \frac{G}{G_2} = \frac{L}{d} \Rightarrow G_2 = G \frac{d}{L}$$

$$\Rightarrow G = 2\text{F} \cdot \frac{2\text{Cm}}{4\text{cm}} = \underline{\underline{G_2 = 1\text{F}}}$$

$$\gamma) \underline{\underline{Q_1 = 90\text{FC}}} \quad Q_2 = G_2 V_2 = 1\text{F} \cdot 10\text{V} = \underline{\underline{Q_2 = 10\text{FC}}}$$

$$\delta) E_1 = \frac{V_1}{d} = \frac{10\text{V}}{2\text{cm}} = 500 \text{V/cm} \Rightarrow \underline{\underline{G_1 = 500\text{V/cm}}}$$

$$E_2 = \frac{V}{L} = \frac{10\text{V}}{4\text{cm}} \Rightarrow \underline{\underline{E_2 = 250 \text{V/cm}}}$$

$$\epsilon) \underline{\underline{U_1 = \frac{1}{2} Q_1 V_1 = \frac{1}{2} 20 \cdot 10^6 \cdot 10\text{V} = 100 \cdot 10^6 \text{J} = 10^4 \text{J}}}$$

$$\underline{\underline{U_2 = \frac{1}{2} Q_2 V_2 = \frac{1}{2} 10 \cdot 10^6 \cdot 10\text{V} = 50 \cdot 10^6 \text{J} = 0,5 \cdot 10^4 \text{J}}}$$

a)  $V_2 = V_1$

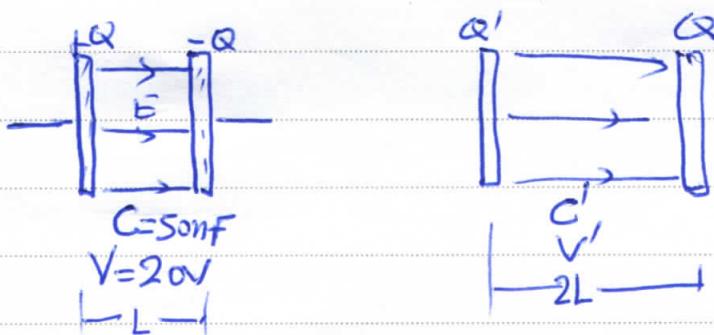
b)  $G_2 = 0,5 G_1$

c)  $Q_2 = 0,5 Q_1$

d)  $E_2 = 0,5 E_1$

e)  $U_2 = 0,5 U_1$

$$9.31 \quad C = 50 \text{ nF} \quad HEB-E = 20V$$



g)  $Q' = Q = C \cdot V = 50 \cdot 10^{-9} \text{ F} \cdot 20 \text{ V} = 10^3 \cdot 10^{-9} \text{ C}$   $\Rightarrow Q' = Q = 10^6 \text{ C} = 1 \text{ F}$

l)  $C' = \epsilon_0 \frac{A}{2L}$     }     $\frac{C'}{C} = \frac{1}{2} \Rightarrow C' = \frac{C}{2} \Rightarrow C' = 25 \text{ nF}$   
 $C = \epsilon_0 \frac{A}{L}$     }

d)  $V' = \frac{Q'}{C'} = \frac{Q}{C/2} = 2 \frac{Q}{C} = 2V$     n'  $V' = 2V$     n'  $V' = 40 \text{ Volt}$

g)  $E' = \frac{V'}{2L} = \frac{2V}{2L} = \frac{V}{L} = E$      $\Rightarrow E' = E$      $\Rightarrow U' = E \cdot \frac{V}{L} = \frac{20V}{10^{-2} \text{ m}} = 2000 \text{ V/m}$

$\Rightarrow E' = E = 2000 \text{ V/m}$

e)  $U = \frac{Q^2}{2C}$     }     $\frac{U'}{U} = \frac{\frac{Q'^2}{2C'}}{\frac{Q^2}{2C}} = \frac{C}{C'} = \frac{C}{C/2} = 2 \Rightarrow U' = 2U$   
 $U' = \frac{Q'^2}{2C'} = \frac{Q^2}{2C}$     }

$$U = \frac{Q^2}{2C} = \frac{1}{2} CV^2 = \frac{1}{2} 50 \cdot 10^{-9} \text{ F} \cdot (20 \text{ V})^2 = \frac{1}{2} 50 \cdot 10^{-9} \cdot 4 \cdot 10^2$$

$$\Rightarrow U = 100 \cdot 10^{-7} \text{ J} \Rightarrow U = 10^{-5} \text{ Joule} \quad 1 \text{ J} = 2 \cdot 10^{-5} \text{ J}$$

$$9.32 \quad q = 8,85 \cdot 10^{-6} C \quad L = 1 \text{ cm} \quad A = 100 \text{ cm}^2 = 100 \cdot 10^{-4} = 10^{-2} \text{ m}^2$$

$$\text{a)} \quad C = \epsilon_0 \frac{A}{L} = 8,85 \cdot 10^{-12} \cdot \frac{10^{-2}}{10^{-2}} \Rightarrow C = 8,85 \text{ pF}$$

$$\text{b)} \quad V = \frac{Q}{C} = \frac{8,85 \cdot 10^{-6}}{8,85 \cdot 10^{-12}} \Rightarrow V = 10^6 \text{ Volt}$$

$$E = \frac{V}{L} \Rightarrow E = \frac{10^6 \text{ V}}{10^{-2} \text{ m}} \Rightarrow E = 10^8 \text{ V/m}$$

$$\text{c)} \quad U = \frac{1}{2} CV^2 = \frac{1}{2} \cdot 8,85 \cdot 10^{-12} \cdot 10^{12} \Rightarrow U = 4,425 \text{ J}$$

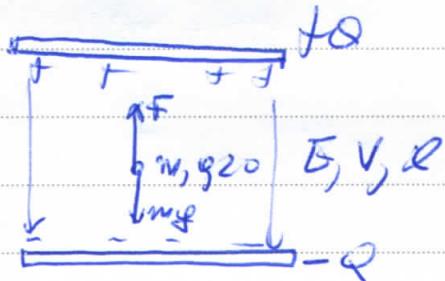
$$\text{d)} \quad F_{\text{ext}} = \frac{Q^2}{2\epsilon_0 A} \Rightarrow F_{\text{ext}} = \frac{(8,85 \cdot 10^{-6})^2}{2 \cdot 8,85 \cdot 10^{-12} \cdot 10^{-2}}$$

$$\Rightarrow F_{\text{ext}} = \frac{8,85 \cdot 10^{-6}}{2 \cdot 10^{-2}} \Rightarrow F_{\text{ext}} = 4,425 \cdot 10^{-4} \text{ N}$$

9.33

$$l = 9 \text{ m} \quad Q = 2 \cdot 10^6 \text{ C}$$

$$m = 10^9 \text{ kg} \quad q = -10^{17} \text{ C}$$



a)  $\sum F_y = 0 \Rightarrow |E|q = mg \Rightarrow E = \frac{mg}{|q|} \Rightarrow$

$$\Rightarrow E = \frac{10^9 \cdot 10}{10^{12}} \text{ N} \quad \text{or} \quad E = \frac{10^8}{10^{-12}} \text{ N} \quad \text{or} \quad E = 10^4 \text{ V/m}$$

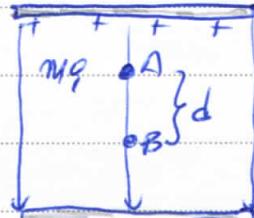
b)  $V = Ed = 10^4 \cdot 0,1 \text{ m} \quad \text{or} \quad V = 10^3 \text{ V}_{\text{eff}}$

$$C = \frac{Q}{V} \Rightarrow C = \frac{2 \cdot 10^6}{10^3} \text{ F} \quad \text{or} \quad C = 2 \cdot 10^3 \text{ F}_{\text{parallel}} \quad \text{or} \quad C = 2 \text{ nF}$$

$$\therefore U = \frac{1}{2} QV = \frac{1}{2} 2 \cdot 10^6 \cdot 10^3 \text{ J} \quad U = 10^3 \text{ J}$$

c)  $V_A - V_B = Ed = 10^4 \cdot 0,05 \text{ V}$

$$\Rightarrow V_A - V_B = 5 \cdot 10^2 \text{ V} \quad V_A - V_B = 500 \text{ V}_{\text{eff}}$$



d)  $W_{AB} = q \cdot (V_A - V_B) \Rightarrow W_{AB} = -10^{12} \text{ C} \cdot 500 \text{ V}$   
 $\Rightarrow W_{AB} = -5 \cdot 10^{10} \text{ J}$

e)  $\Delta U = -W_{AB} \Rightarrow \Delta U_{AB} = +5 \cdot 10^{10} \text{ J}$

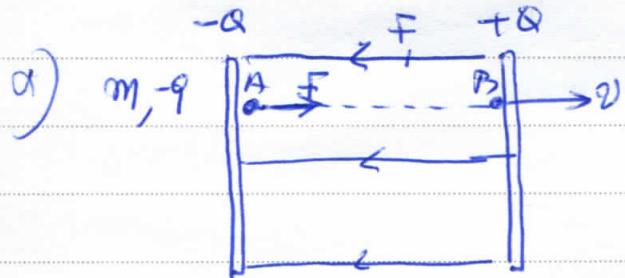
$$\Delta U_{BAC} = -W_B = -(+mg \cdot d) = -10^9 \cdot 10 \cdot 0,05 \text{ J} \Rightarrow \Delta U_{BAC} = -0,5 \cdot 10^8 \text{ J}$$

$$\Delta U_{BAC} = -5 \cdot 10^{10} \text{ J}$$

f)  $W_{Fg} + W_{AB} + W_B = \Delta K \Rightarrow W_{Fg} - \Delta U_{AB} - \Delta U_{BAC} = 0$

$$W_{Fg} = \Delta U_{AB} + \Delta U_{BAC} \Rightarrow W_{Fg} = 0$$

$$9.34 \quad l=9,10 \text{ m} \quad C=5 \text{ F} \quad \left| \begin{array}{l} \text{devantikos osoja} \\ q=-1 \text{ C} \quad K=2 \cdot 10^{-5} \text{ N/C} \\ \text{Geffektus} \end{array} \right.$$



$$\Delta K = W_F \Rightarrow K - 0 = q(V_A - V_B)$$

$$\Rightarrow K = -191(-V)$$

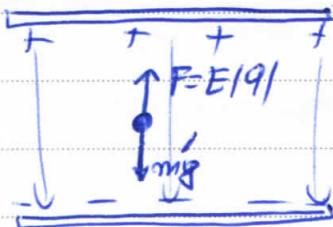
$$\Rightarrow V = \frac{F}{191} \quad \Rightarrow V = \frac{2 \cdot 10^{-5}}{10 \cdot 10^6} \text{ V}$$

$$\Rightarrow V = 20 \text{ Volt}$$

$$Q = C \cdot V = 5 \text{ F} \cdot 20 \text{ V} \quad \Rightarrow \quad Q = 100 \text{ C}$$

$$C = \frac{Q}{V} = \frac{100 \text{ C}}{20 \text{ V}} \quad \Rightarrow \quad C = 5 \text{ F}$$

b)

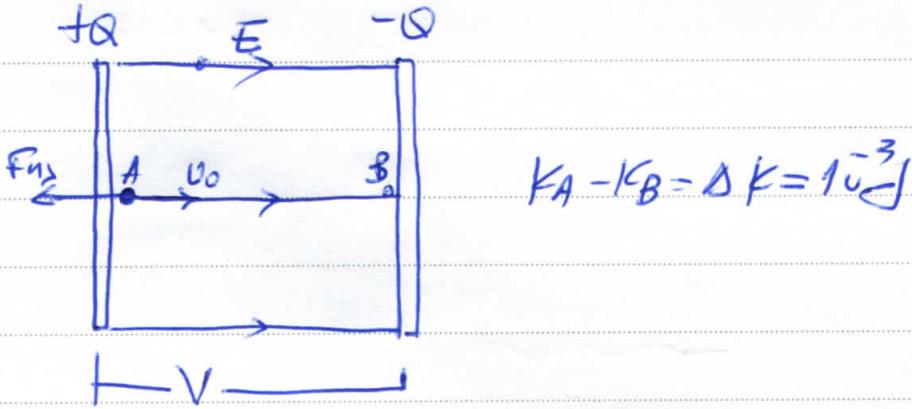


$$F_f = 0 \Rightarrow E/91 = m/g \Rightarrow \frac{V}{d} / 91 = m/g$$

$$\Rightarrow m = -\frac{V/91}{Eg} \quad \Rightarrow \quad m = \frac{20 \cdot 10^6}{910 \cdot 10} \quad \Rightarrow \quad m = 2 \cdot 10^5 \text{ kg}$$

$$9.35 \quad C = 0,1 \text{ nF} \Rightarrow q = 10^{-9} \text{ F} = 10^{-8} \text{ F} \quad | \quad q = -2 \cdot 10^{-6} \text{ C}$$

$$E = 1000 \frac{\text{V}}{\text{m}} \Rightarrow E = 10^3 \frac{\text{V}}{\text{m}}$$



$$k_A - k_B = \Delta k = 10^{-3} \text{ J}$$

$$d) \quad F = E / |q| = 10^3 \frac{\text{V}}{\text{m}} \cdot 2 \cdot 10^{-6} \text{ C} \Rightarrow F = 2 \cdot 10^{-3} \text{ N}$$

$$e) \quad V = E \cdot d = ?$$

$$\Delta k = W_{F_y} \Rightarrow k_B - k_A = q \cdot (V_A - V_B) \Rightarrow k_B - k_A = q \cdot V$$

$$\Rightarrow V = \frac{k_B - k_A}{q} \quad | \quad V = \frac{-10^3}{-2 \cdot 10^{-6}} \text{ Volt} \quad | \quad V = 0,5 \cdot 10^9 \text{ V}$$

$$f) \quad V = E \cdot d \Rightarrow d = \frac{V}{E} = \frac{500 \text{ V}}{1000 \frac{\text{V}}{\text{m}}} \quad | \quad d = 0,5 \text{ m}$$

$$g) \quad Q = C \cdot V \Rightarrow Q = 0,1 \text{ nF} \cdot 500 \text{ V} \Rightarrow Q = 10^{-8} \text{ F} \cdot 5 \cdot 10^2 \text{ V}$$

$$\Rightarrow Q = 5 \cdot 10^{-6} \text{ C} \quad | \quad Q = 5 \text{ fC}$$

$$h) \quad U = \frac{1}{2} Q \cdot V = \frac{1}{2} \cdot 5 \cdot 10^{-6} \cdot 500 \text{ V} \Rightarrow \underline{\underline{U = 12,5 \cdot 10^{-4} \text{ F}}}$$

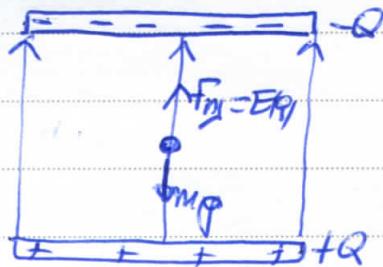
9.36

$$l = 9 \text{ m} \quad C = 1 \text{ nF} = 10^{-9} \text{ F} \quad U = 5 \cdot 10^4 \text{ Joule}$$

$$m = 10^4 \text{ kg}$$

$$\text{d)} \quad U = \frac{1}{2} C V^2 \Rightarrow V = \sqrt{\frac{2U}{C}} = \sqrt{\frac{2 \cdot 5 \cdot 10^4}{10^{-9}}} = 10^3 \text{ Volt}$$

$$\Rightarrow V = 1000 \text{ Volt}$$



$$\text{b)} \quad E = \frac{V}{l} = \frac{10^3}{10^{-1}} = 10^4 \text{ V/m}$$

$$Eq = mg \Rightarrow q = \frac{mg}{E} = \frac{10^4 \cdot 10}{10^4} \Rightarrow q = 10^7 \text{ C} \quad \text{DEPJKO}$$

$$q = n / 9e \Rightarrow n = \frac{q}{9e} = \frac{10^7}{1,6 \cdot 10^{-19} \text{ C}} \Rightarrow n = 0,625 \cdot 10^{12} \Rightarrow n = 625 \cdot 10^9 \text{ e-}$$

$\Rightarrow n = 625 \cdot 10^9$   $\Rightarrow$  625 Millionen Elektronen

$$\text{c)} \quad U' = \frac{1}{2} C V^2 = \frac{1}{100} \cdot 10^4 \cdot V^2 \Rightarrow V' = \frac{25}{100} \text{ V} \Rightarrow V' = 0,25 \text{ V}$$

$$V' = 250 \text{ Volt} \quad E' = \frac{V'}{l} = \frac{250}{10^{-1}} = 2500 \text{ V/m}$$

$$F_{B1} = E q = 2500 \frac{\text{V}}{\text{m}} \cdot 10^7 \Rightarrow F_{B1} = 25 \cdot 10^{-4} \text{ N} \quad \left. \begin{array}{l} \\ \end{array} \right\} B > F_g$$

Während der Bewegung werden die Kräfte aufrechterhalten

$$a = \frac{B \cdot F_B}{m} = \frac{10 \cdot 10^4 \cdot 25 \cdot 10^{-4}}{10^{-4}} \Rightarrow a = 250 \text{ m/s}^2$$

$$\text{d)} \quad V = \sqrt{2 \alpha \frac{l}{2}} = \sqrt{\alpha \cdot l} = \sqrt{7,5 \cdot 10^4} = \sqrt{475} = \sqrt{3 \cdot 0,81} = 0,5 \sqrt{3} \text{ m}$$

$$\Rightarrow V = 0,5 \sqrt{3} \text{ m}$$

~~$$\frac{1}{2} m V^2 = q \cdot E \cdot l = q \cdot \frac{V^2}{2} \Rightarrow V = \sqrt{\frac{2m}{q} \cdot E l}$$~~

$$\frac{1}{2} m V^2 = m g \frac{l}{2} - q \frac{V}{2} \Rightarrow 10^4 \cdot V^2 = 10^4 \cdot 10 \cdot 10^4 - 10^7 \cdot 2 \cdot 10^4$$

$$V^2 = 1 - 0,25 = 0,75$$

9.37

$$Q = 4 \cdot 10^6 C$$

$$l = 0.1 m$$

$$m = 10^3 kg$$

$$q = 10^3 C$$

$$L = 0.9 m$$

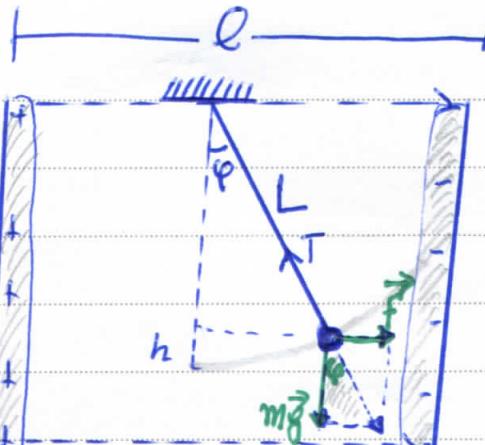
$$\varphi = 11.3^\circ$$

$$\text{a) } \varepsilon_{\text{el}} \varphi = \frac{F}{mg} = \frac{EI\varphi}{mg}$$

$$\Rightarrow E = mg \cdot \frac{\varepsilon_{\text{el}} \varphi}{EI}$$

$$\Rightarrow E = 10^3 \cdot 10 \cdot \frac{0.9^2}{10^8}$$

$$\Rightarrow E = \frac{2 \cdot 10^3}{10^8} \text{ or } E = 2 \cdot 10^5 \frac{V}{m}$$



$$\text{b) } V = El = 2 \cdot 10^5 \frac{V}{m} \cdot 0.1 m \Rightarrow V = 2 \cdot 10^4 \text{ Volt}$$

$$\text{c) } C = \frac{Q}{V} = \frac{4 \cdot 10^6 C}{2 \cdot 10^4} \Rightarrow C = 2 \cdot 10^{10} F$$

$$\text{d) } Q_{\text{ext}} = U = \frac{1}{2} Q \cdot V$$

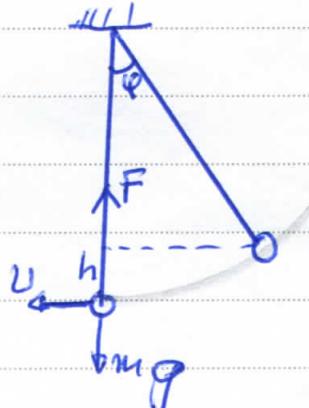
$$\Rightarrow Q_{\text{ext}} = \frac{1}{2} \cdot 4 \cdot 10^6 \cdot 2 \cdot 10^4 \Rightarrow Q_{\text{ext}} = 4 \text{ Farad}$$

$$\text{e) } h = L - L \sin \varphi \Rightarrow h = L(1 - \cos \varphi) \Rightarrow h = 0.90 \cdot (1 - 0.98)$$

$$\Rightarrow h = 0.018 m$$

$$v = \sqrt{2gh} = \sqrt{2 \cdot 10 \cdot 0.018}$$

$$\Rightarrow v = 0.6 m/s$$



$$\sum F_x = m \alpha_K \Rightarrow F - mg = m \alpha_K$$

$$\Rightarrow F = mg + m \frac{u^2}{L} \text{ or } F = 10^3 \cdot 10 + 10^3 \cdot \frac{0.36}{0.9} \Rightarrow F = 104 \cdot 10^3 N$$

9.38

$$C_1 = 3\text{fF}$$

$$\text{d) } Q_1 = CV = GE \quad \text{d}$$

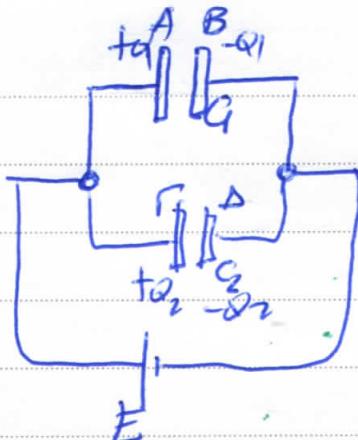
$$C_2 = 2\text{fF}$$

$$E = 100\text{V}$$

$$Q_1 = 3\text{pF} \cdot 100\text{V} \quad \text{d}$$

$$Q_1 = 300\text{fC}$$

$$Q_2 = GV = C_2 E \Rightarrow Q_2 = 200\text{fC}$$



$$\text{e) } U = \frac{1}{2} C_1 V^2 + \frac{1}{2} C_2 V^2 = \frac{1}{2} [C_1 + C_2] V^2 = \frac{1}{2} \cdot 5 \cdot 10^{-6} \cdot 100^2$$

$$\Rightarrow U = \frac{1}{2} \cdot 5 \cdot 10^{-6} \cdot 10^4 \Rightarrow U = 25 \cdot 10^{-2} \text{ Joule}$$

$$\text{f) } U = \frac{1}{2} C \cdot V^2 \Rightarrow C = \frac{2U}{V^2} \quad \text{d) } C = \frac{2 \cdot 25 \cdot 10^{-2}}{100^2}$$

$$\Rightarrow C = 5 \cdot 10^{-6} \text{ F} \Rightarrow C = 5 \text{fF}$$

$$\text{1006878. } C = G + C_2$$

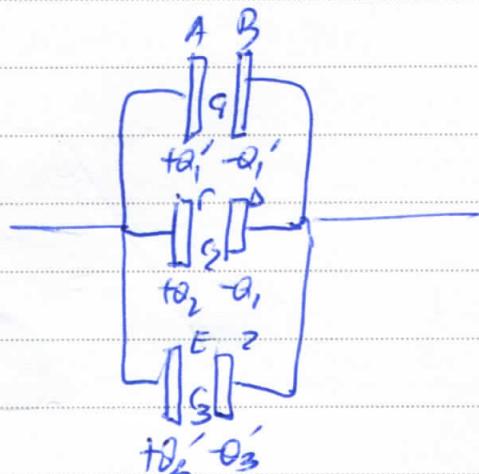
$$\text{g) } 00-15\text{V} \text{ a } 700\text{V}.$$

$$Q_A + Q_B = Q'_A + Q'_B + Q'_E$$

$$Q_1 + Q_2 = Q'_1 + Q'_2 + Q'_3$$

$$Q_1 + Q_2 = GV + GV + G_3 V$$

$$\Rightarrow V = \frac{Q_1 + Q_2}{G + G + G_3} \Rightarrow$$



$$V = \frac{500\text{fC}}{3\text{fF} + 2\text{fF} + 5\text{fF}} \Rightarrow V = 50\text{V}$$

$$\text{h) } Q'_1 = GV = 3\text{fF} \cdot 50\text{V} = 150\text{fC}, Q'_2 = GV = 2\text{fF} \cdot 50\text{V} = 100\text{fC}$$

$$Q'_3 = GV = 5\text{fF} \cdot 50\text{V} = 250\text{fC}$$

$$6T) \quad U' = \frac{1}{2} G V^2 + \frac{1}{2} C_2 V^2 + \frac{1}{2} G Y^2 \Rightarrow U' = \frac{1}{2} (G + C_2 + G) V^2$$

$$\Rightarrow U' = \frac{1}{2} \cdot 10 \cdot 10^6 \text{ J} \cdot 10^2 \Rightarrow U' = 12500 \cdot 10^6 \text{ J}$$

$$U' = 1,25 \cdot 10^9 \text{ J}$$

$$\Delta U = U' - U = 1,25 \cdot 10^9 \text{ J} - 1,50 \cdot 10^7 \text{ J} \Rightarrow \Delta U = -1,25 \cdot 10^7 \text{ J}$$

$$\Rightarrow Q = |\Delta U| = 1,25 \cdot 10^7 \text{ Joule.}$$

ausp

9.39

2)

$$G = 4 \text{ fF}, U = 0,045 \text{ J}, U = \frac{1}{2} G V^2 \Rightarrow V_1 = \sqrt{\frac{2U}{G}}$$

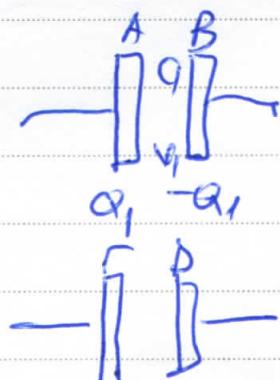
$$\Rightarrow V_1 = \sqrt{\frac{2 \cdot 0,045}{4 \cdot 10^{-6}}} \text{ as } V_1 = 0,15 \cdot 10^3 \text{ as } V_1 = 150 \text{ Volt}$$

$$Q_1 = G V_1 = 4 \text{ fF} \cdot 150 \text{ V} = 600 \text{ fC}$$

$$Q = Q_1 + Q_2' \Rightarrow Q_1 = G V + G_2 U$$

$$\Rightarrow V = \frac{Q_1}{G + G_2} = \frac{600 \text{ fC}}{6 \text{ fF}}$$

$$\Rightarrow V = 100 \text{ Volt}$$



$$2) Q_1' = C_1 V = 400 \text{ fC}$$

$$Q_2' = C_2 U = 200 \text{ fC}$$

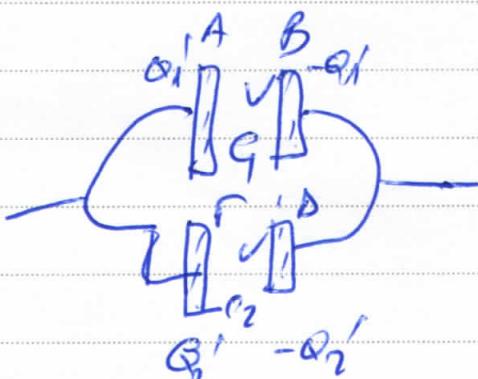
$$2) U = \frac{1}{2} G V^2 + \frac{1}{2} G_2 U^2$$

$$U' = \frac{1}{2} (G + G_2) V^2 \Rightarrow U' = \frac{1}{2} \cdot 6 \text{ fF} \cdot (100 \text{ V})^2$$

$$\Rightarrow U' = 3 \text{ fF} \cdot 10^4 = 3 \cdot 10^6 \cdot 10^4 = 3 \cdot 10^{-2} \text{ J} \Rightarrow U' = 0,030 \text{ J}$$

$$\Delta U = U - U' = 0,030 \text{ J} - 0,045 \text{ J} = -0,015 \text{ J}$$

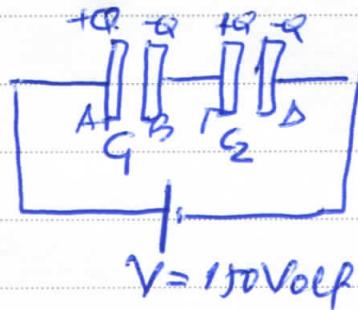
$$Q_{\text{loss}} = |\Delta U| = 0,015 \text{ J}$$



$$9.40 \quad G = G_1 + F \quad G = 3 + F \quad V = 150 \text{ Volt}$$

a)  $7510 \text{ Volt}$

$$V = V_1 + V_2 = V = \frac{Q}{G} + \frac{Q}{G_2}$$



$$V = Q \cdot \left[ \frac{1}{G} + \frac{1}{G_2} \right]$$

$$V = 150 \text{ Volt}$$

$$\Rightarrow V = Q \cdot \frac{G_2 + G}{G \cdot G_2} + Q = V \cdot \frac{G \cdot Q}{G + G_2} \Rightarrow Q = 150 \text{ Volt} \cdot \frac{G + G_2}{G}$$

$$\Rightarrow Q = 150 \text{ Volt} \cdot 2 + F \Rightarrow Q = 300 \text{ FC}$$

$$2) \quad V_1 = \frac{Q}{G} = \frac{300 \text{ FC}}{G + F} = 90 \text{ V} \quad , \quad V_2 = \frac{Q}{G_2} = \frac{300 \text{ FC}}{3 + F} \quad \text{and} \quad V_2 = 100 \text{ V}$$

$$3) \quad U = \frac{1}{2} \frac{Q^2}{G} + \frac{1}{2} \frac{Q^2}{G_2} = \frac{Q^2}{2} \cdot \frac{G + G_2}{G \cdot G_2} = \frac{(300 \cdot 10^6)^2}{2}$$

$$\Rightarrow U = \frac{9 \cdot 10^8}{2} \cdot \frac{1}{2 \cdot 100} \Rightarrow U = 225 \cdot 10^2 \text{ Joule}$$

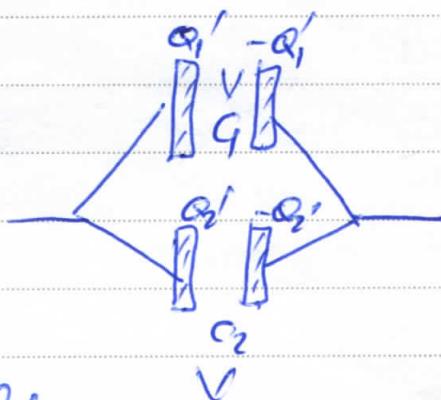
$$4) \quad U = \frac{1}{2} C V^2 \Rightarrow C = \frac{2U}{V^2} = \frac{2 \cdot 225 \cdot 10^2}{150^2} \Rightarrow C = \frac{2 \cdot 225 \cdot 10^2}{225 \cdot 10^4}$$

$$\Rightarrow C = 2 \cdot 10^{-6} \text{ F} \quad \text{and} \quad C = 2 \cdot F$$

$$5) \quad Q + Q = Q_1' + Q_2'$$

$$2Q = GV + GV'$$

$$\Rightarrow V = \frac{2G}{G + G_2} \quad \text{and} \quad V = \frac{2 \cdot 300 \text{ FC}}{8 \mu F}$$



$$\Rightarrow V = \frac{2 \cdot 300}{3 \cdot 3} \text{ Volt} \Rightarrow V = \frac{200}{3} \text{ Volt}$$

$$6) \quad Q_1' = GV = G + F \cdot \frac{200}{3} \text{ V} = 400 \text{ FC}$$

$$Q_2' = GV = 3F \cdot \frac{200}{3} \text{ V} = 200 \text{ FC}$$

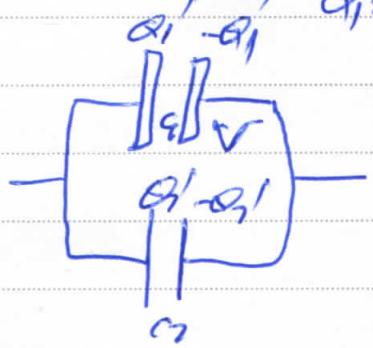
$$9.41 \quad C_1 = 0,1 \text{ nF} = 0,1 \cdot 10^{-9} \text{ F} = 10^{-10} \text{ F} \quad HES-E_1 = 100 \text{ V}$$

$$a) \quad Q_1 = C_1 V = C_1 E_1 = 10^{-10} \text{ F} \cdot 10^2 \text{ V} = 10^{-8} \text{ C} \quad \text{d} \quad Q_1 = 10^{-8} \text{ C} = 10 \cdot 10^{-9} \text{ C}$$

$$b) \quad Q_1' = Q_1 + Q_2'$$

$$Q_1 = C_1 V + C_2 V = V = \frac{Q_1}{C_1 + C_2}$$

$$V = \frac{10^{-8} \text{ C}}{0,5 \cdot 10^{-9} \text{ F}} \Rightarrow V = 20 \text{ V} \text{ off}$$

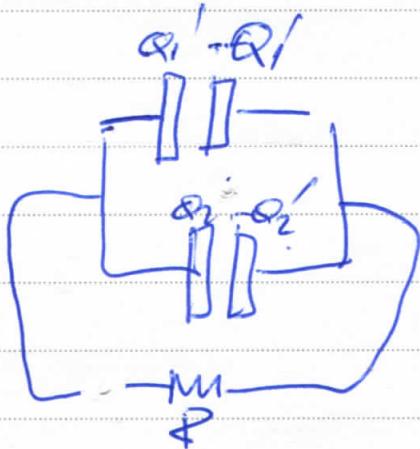


$$Q_1' = C_1 V = 0,1 \text{ nF} \cdot 20 \text{ V} = 2 \text{ nC} = 2 \cdot 10^{-9} \text{ C}$$

$$Q_2' = C_2 V = 0,4 \text{ nF} \cdot 20 \text{ V} = 8 \text{ nC} = 8 \cdot 10^{-9} \text{ C}$$

$$c) \quad Q_{\text{Diss}} = Q_1' + Q_2' =$$

$$= \frac{1}{2} C_1 V^2 + \frac{1}{2} C_2 V^2 \\ = \frac{1}{2} (C_1 + C_2) V^2$$



$$\Rightarrow Q_{\text{Diss}} = \frac{1}{2} \cdot 0,5 \text{ nF} \cdot (20 \text{ V})^2$$

$$Q_{\text{Diss}} = \frac{1}{2} 0,5 \cdot 10^{-9} \cdot 400 = Q_{\text{Diss}} = 100 \cdot 10^{-9} \text{ J}$$

$$\text{d} \quad Q_{\text{Diss}} = 10^{-7} \text{ Joule}$$

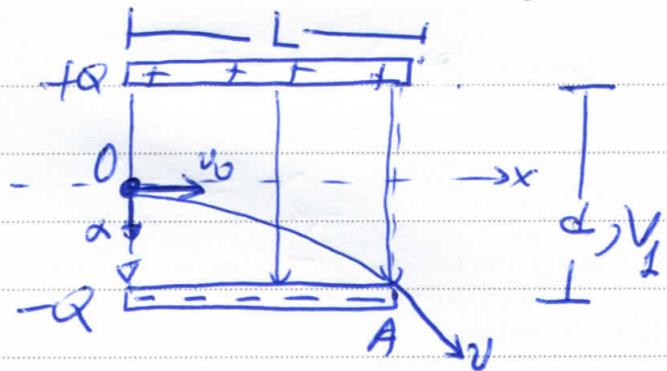
$$e) \quad \bar{P} = \frac{Q_{\text{Diss}}}{t} = \frac{10^{-7} \text{ J}}{20 \cdot 10^3 \text{ s}} \quad \text{d} \quad \bar{P} = \frac{10 \cdot 10^{-8} \text{ J}}{20 \cdot 10^3 \text{ s}} \quad \text{d} \quad \bar{P} = 0,5 \cdot 10^{-5} \text{ W}$$

$$\Rightarrow \bar{P} = 5 \cdot 10^{-6} \text{ W} \quad \text{d} \quad \bar{P} = 5 \mu \text{W}$$

9.42.

$$Q = 4\pi D = 4 \cdot 10^{-9} C$$

$$q = 2 \cdot 10^6 C \quad k_0 = 9 \cdot 10^{-9} \quad k = 1,5 \cdot 10^{-9}$$



d)  $\Delta k = W_{kj} \Rightarrow k - k_0 = q \cdot (x_0 - V_A)$

$$\Rightarrow k - k_0 = q \cdot \frac{V_1}{2} \Rightarrow V_1 = \frac{2 \cdot \Delta k}{q} \text{ und } V_1 = \frac{2 \cdot 1 \cdot 10^{-4}}{2 \cdot 10^6} \text{ und } \underline{\underline{V_1 = 200 V}}$$

e)  $C_1 = \frac{Q}{V_1} = \frac{4 \cdot 10^{-9}}{200 V} \text{ und } G = \frac{4 \cdot 10^{-9}}{2 \cdot 10^6} \text{ und } \underline{\underline{G = 2 \cdot 10^{-12} F}}$   
 $\Rightarrow G = 20 \cdot 10^{12} F \text{ und } \underline{\underline{G = 20 pF}}$

f)  $Q_2 = G V_2 \Rightarrow Q_2 = 10 pF \cdot 100 V \Rightarrow Q_2 = 1000 pC$

$$Q_2 = 10 \cdot 10^{12} C \text{ und } Q_2 = 10^9 C$$

$$Q_1 + Q_2 = Q_1' + Q_2' \Rightarrow Q_1 + Q_2 = GV + G_2 V$$

$$+ V = \frac{Q_1 + Q_2}{G + G_2} = \frac{5 \cdot 10^{-9} C}{30 pF} \Rightarrow V = \frac{5 \cdot 10^{-9} C}{30 \cdot 10^{12} F}$$

$$\Rightarrow V = \frac{5 \cdot 10^3}{30} \text{ und } V = \frac{500}{3} \text{ Volt}$$

g)  $Q_1' = GV = 2 \cdot 10^{-12} \cdot \frac{500}{3} V \Rightarrow Q_1' = \frac{1000}{3} \cdot 10^{-12} C$

$$Q_1' = \frac{10}{3} \cdot 10^9 C$$

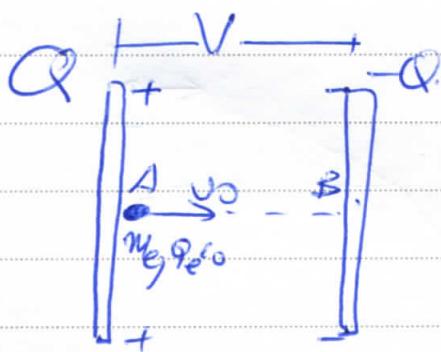
$$Q_2' = GV = 10 \cdot 10^{-12} \cdot \frac{500}{3} = \frac{5000}{3} \cdot 10^{-12} = \frac{5}{3} \cdot 10^{-9} C$$

$$\Rightarrow Q_2' = \frac{5}{3} \cdot 10^9 C$$

9.43

$$Q = 0.40 \text{ C}$$

$$k_0 = 9.4 \cdot 10^{12} \text{ N} \cdot \text{C}^{-2}$$



d)  $K_B - K_A = q_0(V_A - V_B)$

$$0 - k_0 = -q_0 |V| \Rightarrow V = \frac{k_0}{q_0}$$

e)  $V = \frac{9.4 \cdot 10^{12}}{1.6 \cdot 10^{-19} \text{ C}} \Rightarrow V = 400 \text{ Volt}$

$$C = \frac{Q}{V} \quad \text{and} \quad C = \frac{0.40 \cdot 10^{-6} \text{ C}}{400 \text{ V}} \quad \text{and} \quad C = \frac{4 \cdot 10^{-7}}{4 \cdot 10^2} \text{ F} \quad \text{and} \quad C = 10^{-9} \text{ F}$$

f)  $C' = 1 \text{ nF}$

g)  $U = \frac{1}{2} QV \quad \text{and} \quad V = \frac{1}{2} 0.40 \cdot 10^{-6} \cdot 400 \text{ Volt}$

$$U = \frac{1}{2} 4 \cdot 10^{-7} \cdot 4 \cdot 10^2 \Rightarrow U = 8 \cdot 10^{-5} \text{ Joule}$$

9.44

$$Q = 10 \text{ C} \quad C = 10 \cdot 10^6 \text{ C} = 10^7 \text{ C}$$

$$U = 10^2 \text{ F}$$

$$\text{d) } U = \frac{1}{2} Q V \Rightarrow V = \frac{2U}{Q}$$

$$\Rightarrow V = \frac{2 \cdot 10^2 \text{ F}}{10^5 \text{ C}} \text{ m} \quad V = 2000 \text{ Volt}$$

$$C = \frac{Q}{V} = \frac{10^5}{2 \cdot 10^3} \text{ m} \quad C = 0,5 \cdot 10^{-8} \text{ F} \quad C = 5 \cdot 10^{-9} \text{ F}$$

$$\text{b) } y = \frac{1}{2} a t^2 = \frac{1}{2} \frac{F}{m} t^2 = \frac{1}{2} \frac{Eg}{m} t^2 = \frac{1}{2} \frac{V}{\Phi} \frac{q}{m} \left( \frac{L}{v_0} \right)^2$$

$$x = v_0 t \Rightarrow L = v_0 t \Rightarrow t = \frac{L}{v_0}$$

$$+ y = \frac{1}{2} \frac{V}{\Phi} \frac{q}{m} \frac{L^2}{v_0^2}$$

$$k = \frac{1}{2} m v_0^2 + \mu v_0 s = 2 k_0$$

$$\left. \begin{array}{l} \\ \end{array} \right\} y = \frac{1}{2} \frac{V}{\Phi} \frac{q L^2}{2 k_0}$$

$$\Rightarrow y = \frac{1}{4} \frac{V}{\Phi} \frac{q L^2}{k_0} \Rightarrow y = \frac{1}{4} \frac{2 \cdot 10^3}{5 \cdot 10^2} \cdot \frac{1,6 \cdot 10^{-19} \cdot 2 \cdot 10^{-12}}{4 \cdot 10^{15}}$$

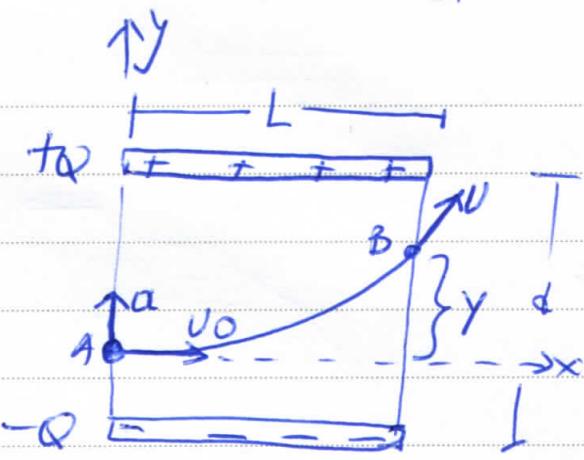
$$\Rightarrow y = \frac{1}{4} \frac{2}{5} \frac{16}{4} \cdot \frac{1,6 \cdot 10^{-19} \cdot 10^{-12}}{10^{-15}} = y = 0,16 \cdot \frac{10^{-18}}{10^{-17}} \Rightarrow y = 0,16 \cdot 10^{-1} \text{ m}$$

$$+ y = 0,16 \cdot 10^{-1} \cdot 10^2 \text{ cm} \Rightarrow y = 1,6 \text{ cm} \quad \underline{\underline{y = 1,6 \cdot 10^{-1} \text{ m}}}$$

$$\text{f) } \Delta V_{BA} = E y = \frac{V}{\Phi} y = \frac{2000 \text{ V}}{5 \text{ m}} \cdot 1,6 \text{ cm} \Rightarrow \Delta V_{BA} = 640 \text{ Volt}$$

$$\Rightarrow V_B - V_A = 640 \text{ V} \quad \text{m} \quad V_A - V_B = -640 \text{ V}$$

$$V_A - V_B = -640 \text{ Volt}$$



$$\delta) \quad \Delta U = V_B - V_A = q(V_B - V_A) = q(V_B - V_A) = (-1,6 \cdot 10^{19}) \cdot (7,64 \cdot 10^6 V)$$

$$\Rightarrow \Delta U = -1,024 \cdot 10^{19} J \quad \text{and} \quad \Delta U = 1,024 \cdot 10^{16} J$$

$$?) \quad W_{\text{m}} = -\Delta U = +1,024 \cdot 10^{16} J$$

$$W_{\text{m}} = q(V_A - V_B) = 0 \text{ J}$$

$$W_{\text{m}} = E_q \cdot y = \frac{V}{2} q y = \frac{2000 \text{ Volt} \cdot 1,6 \cdot 10^{-19} C}{5 \text{ cm}} \cdot 1,6 \cdot 10^{19} = 0 \text{ J} = +1,024 \cdot 10^{16} J$$

$$\text{or} \quad W_{\text{m}} = 10,24 \cdot 10^{17} J$$

$$\text{GT) } K_{\text{TEJ}} - K_{\text{ex}} = W_{\text{m}} \Rightarrow K_{\text{TEJ}} = k_0 + W_{\text{m}}$$

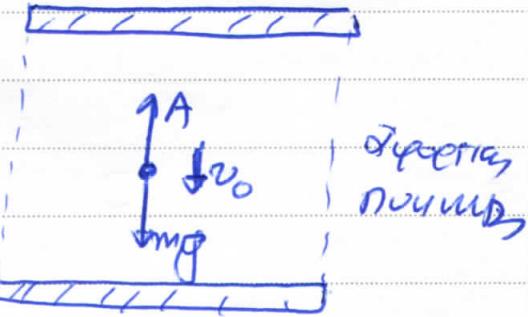
$$\Rightarrow K_{\text{TEJ}} = 4 \cdot 10^{17} J + 10,24 \cdot 10^{17} J$$

$$\Rightarrow \underline{K_{\text{TEJ}} = 14,24 \cdot 10^{17} \text{ Joule}}$$

9.45

a)  $\sum F_y = ma \Rightarrow mg - A = ma$   
 $\Rightarrow mg - kV_0 = m \alpha \xrightarrow[V=V_0]{\alpha=0}$

$$mg - kV_0 = 0 \Rightarrow mg = kV_0 \text{ ; } V_0 = \frac{mg}{k} \quad (I)$$



$$A_{max} = kV_0 = mg \Rightarrow A_{max} = 10^{12} \text{ Np. 10m/2} \Rightarrow \underline{A_{max} = 10^{11} \text{ N}}$$

b)  $\sum F_y = ma \Rightarrow mg - \frac{kV_0}{2} - Eq = 0$

$$mg - kV_0 - Eq = ma \xrightarrow[V=V_0/2]{a=0}$$

$$mg - kV_0 - Eq = 0$$



$$\xrightarrow{(I)} mg - \frac{mg}{2} = Eq \Rightarrow \frac{1}{2}mg = Eq \Rightarrow \frac{1}{2}mg = \frac{V}{4}q$$

$$\Rightarrow mgd = 2Vq \Rightarrow q = \frac{mgd}{2V} \Rightarrow q = \frac{10^3 \cdot 10 \cdot 5 \cdot 10^2}{20500}$$

$$\Rightarrow q = \frac{5 \cdot 10^{13}}{103} \Rightarrow q = 5 \cdot 10^{16} \text{ N/m}$$

c)  $F_{M1} = Eq = \frac{V}{4}q = \frac{500}{5 \cdot 10^2} \cdot 5 \cdot 10^{16} \Rightarrow F_{M1} = 5 \cdot 10^{12} \text{ N}$

$$B = mg = 10^{12} \cdot 10 = 10 \cdot 10^{12} \text{ N}$$

$$A = k \frac{V_0}{4} = \frac{mg}{4} = 2,5 \cdot 10^{12} \text{ N}$$

$$\alpha = \frac{B - F_{M1} - A}{m} = \frac{10 \cdot 10^{12} - 5 \cdot 10^{12} - 2,5 \cdot 10^{12}}{10^{12}} \Rightarrow \boxed{\alpha = 2,5 \text{ rad/s}^2}$$

9.45

$$C_1 = 2 \mu F \quad E_1 = 10V$$

$$C_2 = 3 \mu F \quad E_2 = 30V$$

a)  $Q_1 = C_1 V_1 = C_1 E_1 = 2 \mu F \cdot 10V \Rightarrow Q_1 = 20 \mu C$ .

β) Τι αναλογώς με διαφάνειας

το νόμος γρεγμάτων μεταξύ

δύο συναντήσεων γενικά

αποτελεί την επίπεδη την

διαφάνεια την προστασία

να αποδειχθεί πραγματικός

αναλογικός

$$Q = Q_1 + Q_2 \quad (1)$$

$$\text{μεταξύ } C_2 - V_2' - V_1' = 0$$

$$\Rightarrow E_2 = V_2' + V_1' \quad (2)$$

$$(1) \Rightarrow C_1 V_1 = C_1 V_1' - C_2 V_2'$$

$$\Rightarrow C_1 E_1 = C_1 V_1' - C_2 [E_2 - V_1']$$

$$\Rightarrow C_1 E_1 + C_2 E_2 = (C_1 + C_2) V_1'$$

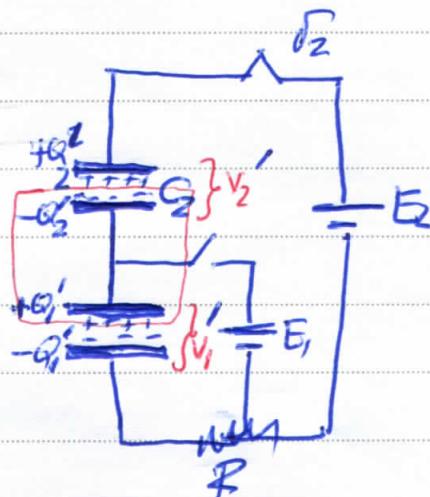
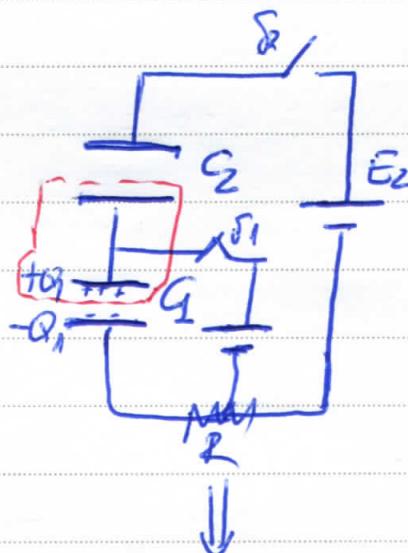
$$\Rightarrow V_1' = \frac{C_1 E_1 + C_2 E_2}{C_1 + C_2} \Rightarrow V_1' = \frac{2 \mu F \cdot 10V + 3 \mu F \cdot 30V}{5 \mu F}$$

$$\Rightarrow V_1' = \frac{110 \mu F \cdot V}{5 \mu F} \Rightarrow \underline{\underline{V_1' = 22 \text{ Volt}}}$$

$$(2) \Rightarrow 30V = V_2' + 22V \Rightarrow \underline{\underline{V_2' = 8 \text{ Volt}}}$$

$$Q_1' = C_1 V_1 = 2 \mu F \cdot 22V = 44 \mu C$$

$$Q_2' = C_2 V_2 = 3 \mu F \cdot 8V = 24 \mu C$$



## 10. Βαρυτικό πεδίο - Αποχημένες

10.1  $\alpha-\Sigma, \beta-\Sigma, \gamma-\Sigma, \delta-\Lambda$

$\alpha, \beta, \gamma$

10.2  $\delta-\Sigma$

$\delta$

10.3  $\alpha-\Sigma, \beta-\Lambda, \gamma-\Sigma, \delta-\Sigma$

$\alpha, \beta, \gamma$

10.4  $\delta-\Sigma$

$\delta$

10.5  $\alpha-\Lambda, \beta-\Lambda, \gamma-\Sigma, \delta-\Sigma$

$\delta, \Gamma$

10.6  $\alpha-\Lambda, \beta-\Sigma, \gamma-\Sigma, \delta-\Lambda$

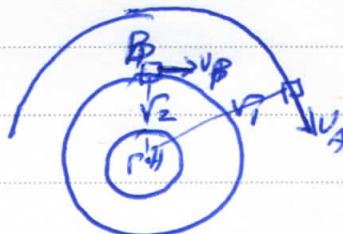
$$U = \sqrt{GM}, \quad \epsilon_F = mg, \quad \alpha \neq g, \quad T = \frac{2\pi r}{v}$$

$\hookrightarrow \alpha, \delta$

10.7

a)  $U_A = \sqrt{\frac{GM}{r_1}}, \quad U_B = \sqrt{\frac{GM}{r_2}}$

$r_1 > r_2 \Rightarrow U_A < U_B \quad \alpha-\Lambda$



b)  $K_A = \frac{1}{2}mv_A^2 = \frac{1}{2}G \frac{Mm}{r_1} \quad K_B = \frac{1}{2}G \frac{Mm}{r_2}$

$r_1 > r_2 \Rightarrow K_A < K_B \quad \beta-\Sigma$

c)  $U_A = -G \frac{Mm}{r_1}, \quad U_B = -G \frac{Mm}{r_2} \quad r_1 > r_2 \Rightarrow \frac{1}{r_1} < \frac{1}{r_2} \Rightarrow -\frac{1}{r_1} > -\frac{1}{r_2}$

$\Rightarrow U_A > U_B \quad \delta-\Sigma$



d)  $E_A = -\frac{1}{2}G \frac{Nm}{r_1}, \quad E_B = -\frac{1}{2}G \frac{Nm}{r_2}$

$E_A > E_B \quad \delta-\Sigma$

άροε  $\alpha-\Lambda, \beta-\Sigma, \gamma-\Sigma, \delta-\Sigma \quad \beta, \gamma, \delta$

10.8  $v_{\delta} = \sqrt{2G \frac{M_F}{R+h}}$   $\alpha-1, \beta-\Sigma, \delta-\Sigma, \delta-1$   $b, \gamma$

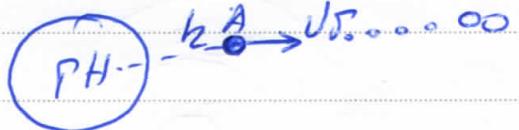
10.9.  $\text{Ταχύτητα διαφυγής}$   $v_{\delta} = \sqrt{2G \frac{M_F}{R}}$   
 $\text{Ταχύτητα προμηδίας}$   $v = \sqrt{G \frac{M_F}{r}}$   $\left\{ \frac{v_{\delta}}{v} = \sqrt{2} \Rightarrow v_{\delta} = v\sqrt{2} \right.$

Άρα σωστή η εξέταση (B).

10.10

$$E_{\text{pot}}(A) = E_{\text{pot}}(00)$$

$$\underset{A}{U} + \underset{A}{K} = U_{00} + K_{00} \Rightarrow$$



$$U_A + \frac{1}{2}mv_A^2 = 0 + 0 \Rightarrow v_A = -\frac{1}{2}mv_S^2$$

Άρα σωστή η εξέταση (α)

10.11  $g = 0,25g_0 \Rightarrow g = \frac{g_0}{4}$  και  $\frac{g}{g_0} \cdot \left(\frac{R}{r}\right)^2 = \frac{1}{4} g_0 \Rightarrow \frac{R}{r} = \frac{1}{2} \Rightarrow r = 2R$

$\Rightarrow R+h = 2R \Rightarrow h=R$  Άρα σωστή η εξέταση (B)

10.12  $V = -G \frac{M_F}{R+h} \xrightarrow{h=R} V = -\frac{GM_F}{2R} = -\frac{g_0 R^2}{2R} = -\frac{1}{2} g_0 R$

Άρα σωστή η εξέταση (δ)

10.13  $\text{Ταχύτητα διαφυγής από την επιφάνεια της Ρώμης}$

$$v_{\delta,F} = \sqrt{2G \frac{M_F}{R}} \quad (1)$$

$$\text{Ταχύτητα διαφυγής στην θέση } \Sigma. \quad v_{\delta,\Sigma} = \sqrt{2G \frac{m}{r}} \quad (2)$$

$$\frac{(2)}{(1)} \Rightarrow \frac{v_{\delta,\Sigma}}{v_{\delta,F}} = \frac{\sqrt{2G \frac{m}{r}}}{\sqrt{2G \frac{M_F}{R}}} \Rightarrow \sqrt{\frac{R}{r} \cdot \frac{m}{M_F}} = \sqrt{\frac{4R}{r} \cdot \frac{m}{100m}} = \frac{2}{10} = 0,2 \Rightarrow v_{\delta,\Sigma} = 0,2 v_{\delta,F}$$

Άρα σωστή η εξέταση (α)

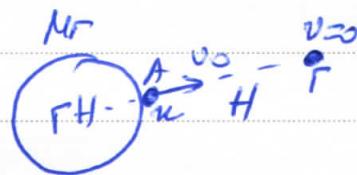
10.14

$$\text{12. Newton's Law of Gravity: } \nabla v g = \text{constant} \quad h = \frac{v_0^2}{2g} \xrightarrow{g=g_0} h = \frac{v_0^2}{2g_0} \quad (1)$$

2<sup>nd</sup> Newton's Law:  $g$  force depends on the mass and the distance.

$$U_A + K_A = U_{\text{eff}} + E \Rightarrow$$

$$-G \frac{M_A M_B}{R} + \frac{1}{2} m_B v_0^2 = -G \frac{M_A m_B}{R+H} + 0$$



$$\Rightarrow -\frac{g_0 R^2 M}{R} + \frac{1}{2} m_B v_0^2 = -\frac{g_0 R^2 M}{R+H} \Rightarrow \frac{v_0^2}{2} = \frac{g_0 R^2}{R} - \frac{g_0 R^2}{R+H} \Rightarrow \frac{v_0^2}{2g_0} = R - \frac{R^2}{R+H}$$

$$\Rightarrow \frac{v_0^2}{2g_0} = \frac{R(R+H)-R^2}{R+H} = \frac{RH}{R+H} \xrightarrow{(1)} h = \frac{RH}{R+H} \Rightarrow hR + hH = RH$$

$$\Rightarrow hR = (R-h)H \Rightarrow H = \frac{Rh}{R-h}$$

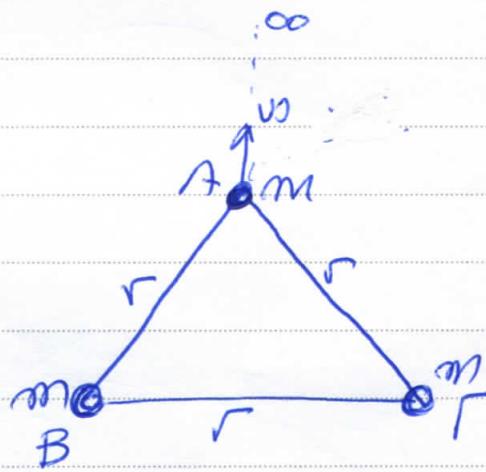
Apparatus in exercise (A) (2)

10.15

$$U_A + K_A = 0 + 0$$

$$-2G \frac{m_A m_B}{r} + \frac{1}{2} m_B v^2 = 0 + 0$$

$$\Rightarrow v = \sqrt{4G \frac{m}{r}} \quad \text{and} \quad v = 2\sqrt{G \frac{m}{r}}$$

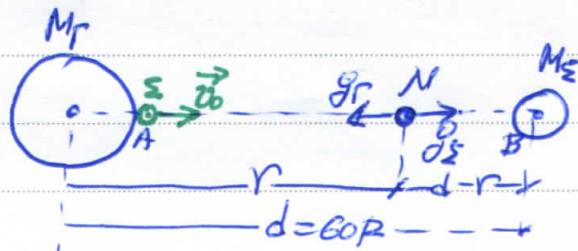


Apparatus in exercise (B) (2)

10.16

$$\sum_{\text{to left}} N - \vec{g}_r = \vec{g}_r + \vec{g}_{\Sigma} = 0$$

$$\Rightarrow \vec{g}_r = -\vec{g}_{\Sigma} \Rightarrow g_r = g_{\Sigma}$$



$$\Rightarrow G \frac{M_r}{d^2} = G \frac{M_s}{(d-R)^2} \Rightarrow G \frac{81M_s}{d^2} = G \frac{M_s}{(d-R)^2} \Rightarrow \left(\frac{d}{d-R}\right)^2 = 81 \Rightarrow \frac{d}{d-R} = 9$$

$$\frac{d}{d-R} = 9 \Rightarrow d = 9(d-R) \Rightarrow 10R = 8d \Rightarrow g_r = 8GMR \Rightarrow R = 0.9d \xrightarrow{d=60R}$$

$$\Rightarrow R = 54R \quad \text{and} \quad d-R = 6R$$

Ειδικό  $R < r \leq 54R \Rightarrow g_r > g_{\Sigma} \Rightarrow \vec{g}_r$  προς το νέκταρο  
της γής

Πιο σύχετα  $r \leq 60R - R_{\text{ΣΕΑ}} \Rightarrow g_{\Sigma} > g_r \Rightarrow \vec{g}_{\Sigma}$  προς το νέκταρο  
της ΣΕΑ ΗΝΩΗ

Η μήνη του Γερματίου

Σ αύριο το A  $\rightarrow$  N

Εποιησε πλιάρια σχέσην

Αν προσεξεις θα δεις το N

εποιησε πλιάρια σχέσην

a) Πιστραφθείτο Σ. επι ΣΕΑ κάτιμ (συρρικνώντας B) προς την

να γίνεται των πλανητών στο N. (οριστηκό να το περισσότερο)

••• πλατιά γενικά το N δεν έχει  $\vec{g}_r$  προς τη Σελήνη

επιτελεί συλλογής την οποία δεν έχει ως αποτέλεσμα

b)  $10^8 \text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2}$  τη στρωτή πλανήτης, η οποία έχει το N  
••• η μήνη της στρωτής πλανήτης έχει έναρξη στρωτής

$$\text{να } \dot{x}_E = v_B = 0$$

c) Συνομιλία

a, c

10.17

a) Надрачдеси си сејми

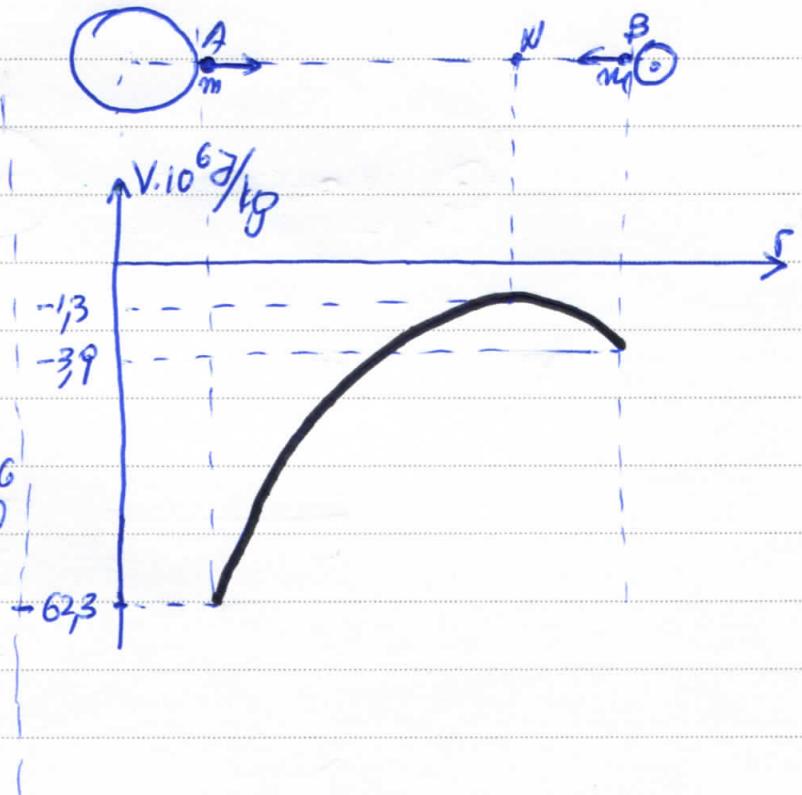
$$U_A + K_A = U_N + K_N$$

$$mV_A + K_A = mV_N + 0$$

$$\Rightarrow K_A = m(V_N - V_A)$$

$$\Rightarrow K_A = 10 \text{ kg} (-13 - (-6,3)) \cdot 10^6 \frac{\text{J}}{\text{kg} \cdot 10}$$

$$\Rightarrow K_A = 6 \cdot 10^7 \text{ Joule}$$

друга  $\sigma - \Sigma M$ б.) искажи  $\sigma$  при  $\sigma$  и  $K_A$ 

$$U_B + K_B = U_N + K_N \Rightarrow mV_B + K_B = mV_N + 0$$

$$\Rightarrow K_B = m(V_N - V_B) \Rightarrow K_B = 10 \text{ kg} [-13 - (-3,9)] \cdot 10^6 \frac{\text{J}}{\text{kg}}$$

$$\Rightarrow K_B = 26 \cdot 10^7 \text{ J}$$

г)  $\sigma = \pi r^2 \rho x \omega$ .  $\delta - 10 \text{ Joules}$   $(\alpha, \beta)$ 

10.18

$$\alpha \cdot v_1 = v_2 = \sqrt{G \frac{M}{r}} \quad \text{10. d}$$

$\alpha - 10 \text{ Joules}$

$$B. \quad \Sigma F_{(1)} = mg, \quad S F_{(2)} = 2mg \Rightarrow S F_{(2)} = 2 S F_{(1)}$$

B.  $\frac{\Sigma F_{(1)}}{\Sigma F_{(2)}}$

$$\alpha_{E,1} = g \quad \alpha_{E,2} = g$$



$$\alpha_{E,1} = \alpha_{E,2}$$

$\delta - \Sigma \omega \rho r^2$

$$\delta) \quad T_1 = \frac{2\pi r}{v_1}, \quad T_2 = \frac{2\pi r}{v_2} \quad \underline{v_1 = v_2} \quad T_1 = T_2$$

$\delta - 10 \text{ Joules}$

(B, D)

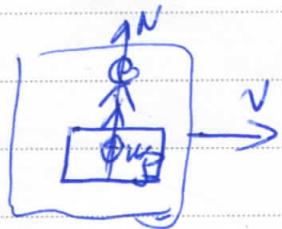
10.19 γ) Α-Αρδεσ συμβιβασης προς τη δραστηριότητα

β) Στήθη της γης είναι μεγάλη

Ο αριθμητικός είναι δορυφόρος

$$SF_k = m \cdot \frac{v^2}{r} \Rightarrow m \cdot g - N = m \frac{v^2}{r} \Rightarrow$$

$$\Rightarrow m \cdot \frac{GM}{r^2} - N = m \frac{\sqrt{GM/r}}{r^2} \Rightarrow GM \frac{m}{r^2} - N = GM \frac{m}{r^2}$$



$\Rightarrow N > 0 \dots$  όποιος αριθμητικός στη διεύρυνση δύναται

σταθερά τη γη στην αύξηση της στρέμματος είναι

όπως αναφέρεται στην κίνηση  $N = 0$

γ) Αριθμητικής είναι η κατάσταση  $B$  που παραχθεί

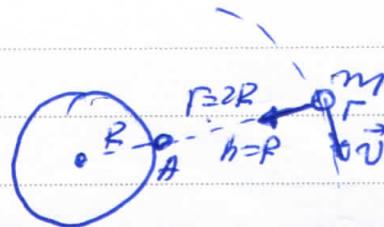
δ) Συγκριτικά.

α-Αρδεσ, β-Αρδεσ, γ-Αρδεσ, δ-Συγκριτικός

10.20

$$E_F = E_A + E_{\text{προσ}G} \Rightarrow$$

$$-G \frac{Mm}{2R} + \frac{1}{2} m v^2 = -G \frac{Mm}{R} + E_{\text{πρ}} \Rightarrow$$



$$\Rightarrow -G \frac{Mm}{2R} + \frac{1}{2} m v^2 = -G \frac{Mm}{R} + E_{\text{πρ}}$$

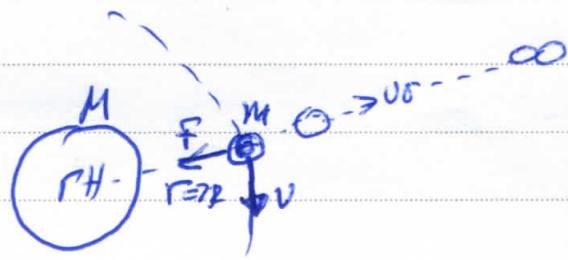
$$\Rightarrow -\frac{1}{2} G \frac{Mm}{2R} = -G \frac{Mm}{R} + E_{\text{πρ}} \Rightarrow E_{\text{προσ}G} = \frac{3}{4} G \frac{Mm}{R} \rightarrow$$

$$\Rightarrow E_{\text{προσ}G} = \frac{3}{4} \frac{G R^2 m}{R} \rightarrow E_{\text{προσ}G} = \frac{3}{4} mg_0 R$$

Άριθμητη σύγκριση (γ)

(γ)

10.21



$$\text{Σερπόντα δύναμη} E_{\text{tot}} = \frac{1}{2}mv^2 - G \frac{Mm}{2R} = \frac{1}{2}m\left(\frac{v^2}{r^2} + \frac{Mm}{2R}\right) - G \frac{Mm}{2R}$$

$$\Rightarrow E_{\text{tot}} = \frac{1}{2}G \frac{Mm}{2R} - G \frac{Mm}{2R} = -\frac{1}{2}G \frac{Mm}{2R} = -\frac{1}{4}G \frac{Mm}{R} \Rightarrow E_{\text{tot}} = -\frac{1}{4}mgfR$$

$$E_{\text{δορυφ}} + E_{\text{προσ}} = E_{\text{tot}} \Rightarrow -\frac{1}{4}mgfR + E_{\text{προσ}} = 0 + 0$$

$$\Rightarrow E_{\text{προσ}} = \frac{1}{4}mgfR$$

Άρει σωμάτων στη σκέψη (b)

$$10.22 \text{ ο} \text{ Σερπόντα δύναμη} E = -\frac{1}{2}G \frac{Mm}{r}$$

$$(E = V + K = -G \frac{Mm}{r} + \frac{1}{2}m\sqrt{G \frac{M}{r}}^2 = \uparrow)$$

Είναι ο δορυφόρος χαρακτηριστικός  $E_2 < E_1$

$$\Rightarrow -\frac{1}{2}G \frac{Mm}{r_2} < -\frac{1}{2}G \frac{Mm}{r_1} \Rightarrow -\frac{1}{r_2} < -\frac{1}{r_1} \Rightarrow \frac{1}{r_2} > \frac{1}{r_1} \Rightarrow r_2 < r_1$$

χαρακτηριστικός αυτής

για κατέτες αλιτέρες

$$\alpha) V = \sqrt{G \frac{M}{r}} \xrightarrow{\text{τη συνέq}} \text{να φαίνεται} \quad v_2 > 0, \quad \alpha-\text{εύθυ}$$

$$\beta) v_2 > v_1 \Rightarrow k_2 > k_1 \quad \text{κανείνα}$$

$$\gamma) r_2 < r_1 \Rightarrow \frac{1}{r_2} > \frac{1}{r_1} \Rightarrow -G \frac{Mm}{r_2} < -G \frac{Mm}{r_1} \quad \text{να γίνεται} \quad \delta-\text{εύθυ}$$

$$\delta) T = \frac{2\pi r}{V} = \frac{2\pi r}{\sqrt{GM/r}} = \frac{2\pi}{\sqrt{GM}} \cdot r^{3/2} \quad \text{τη συνέq} \rightarrow \delta-\text{εύθυ} \\ \text{για εισιτεία} \uparrow \quad (\alpha, \beta, \gamma)$$

10.23

$$\begin{aligned} \sin(\varphi) &= \frac{R}{R+h} = \frac{1}{2} \\ \varphi &= \pi/3 \end{aligned} \quad \left. \begin{aligned} 2R &= R+h \\ \Rightarrow h &= R \end{aligned} \right.$$

Draagarmenig Poi Dri

To groter verd n. r

ind h > R,  $v_r \geq 0$

$$v_A + k_A = v_r + kr$$

$$-G \frac{Mm}{R} + \frac{1}{2}mv^2 = -G \frac{Mm}{2R} + \frac{1}{2}mv^2$$

$$\Rightarrow -\frac{1}{2}G \frac{Mm}{R} + \frac{1}{2}mv^2 = \frac{1}{2}mv_r^2 \Rightarrow v_r^2 = v_0^2 - G \frac{M}{R} \text{ en } v_r^2 = v_0^2 - \frac{80P^2}{R}$$

$$\Rightarrow v_r^2 = v_0^2 - g_{\text{eff}}R \geq 0 \Rightarrow v_0 \geq \sqrt{g_{\text{eff}}R} \Rightarrow \underline{v_0 \geq 8 \text{ km/s}}$$

10.24

$$a) v = \sqrt{G \frac{M}{R+h}} = \sqrt{\frac{80P^2}{2R}} = \sqrt{\frac{80R}{2}} = \sqrt{\frac{10 \cdot 64 \cdot 10^5}{2}} = \frac{8 \cdot 10^3}{\sqrt{2}} = 412 \cdot 10^3 \text{ m/s}$$

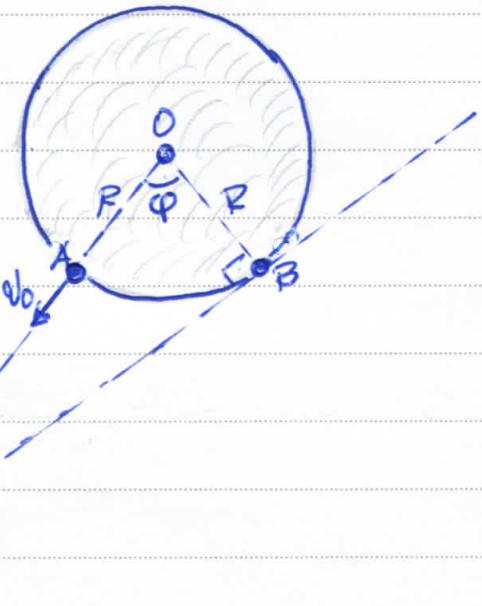
$$\Rightarrow v = 412 \text{ km/s}$$

$$b) g = g_0 \left( \frac{R}{R+h} \right)^2 = g_0 \left( \frac{R}{2R} \right)^2 = \frac{g_0}{4} = 3,5 \text{ m/s}^2$$

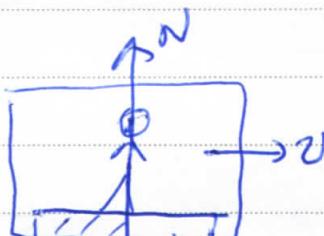
$$f_A = B_A = m_A g = 70 \text{ kg} \cdot 2,5 \text{ m/s}^2 = 175 \text{ N}$$

$$f_S = B_S = m_S g = 2 \text{ kg} \cdot 2,5 \text{ m/s}^2 = 5 \text{ N}$$

$$c) F_{xy} = 0 \quad F_{xN} = 0$$



26.10.2012 17:15  
A: ... ειντερναλ πολιτική και οικονομικού πολυεδών  
TU) Δικαίωμα



$$SF_k = M_A C_k \Rightarrow B_A - N = M_A \frac{v^2}{r} \Rightarrow G \frac{M_A M_A}{r^2} - N = M_A \frac{\sqrt{G M_A v^2}}{r} \Rightarrow N = 0$$

-9-

000 N. Cal Mfg., Inc. All rights reserved. Copyright ©

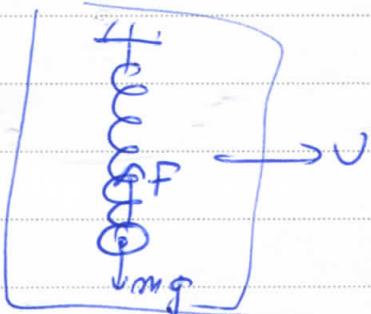
21 figura 01 N=20

Quoia no GreforE 610 Mroq'f srevo

είχας δυνάμεις από

$$\Sigma F_F = m a_F \Rightarrow m g - F = m \frac{v^2}{r}$$

$$G \frac{M_m}{r^2} - f = m \frac{\sqrt{G M_g}}{r} = 1 \quad f = 0$$



$$\delta) F_{\text{ext}} = k \Delta e = 0 \Rightarrow \Delta e = 0$$

$$10.25 \quad m=500 \text{ kg} \quad v_i=4 \text{ km/s} \quad h_1 \\ h_2=R \quad t_1 \quad t_2 \quad \} T=92N$$

$$a) \text{ Given } U_1 = \sqrt{G \frac{M_r}{r}} \Rightarrow U_1 = \sqrt{\frac{8 \pi R^3 P^2}{r}} \Rightarrow U_1^2 = \frac{8 \pi P^2}{r} \Rightarrow r = \frac{8 \pi P^2}{U_1^2}$$

$$\Rightarrow r = 10 \frac{m}{s^2} \cdot \frac{(64 \cdot 10^5)^2}{(4 \cdot 10^3)^2} = 10 \frac{m}{s^2} \cdot \frac{64 \cdot 64 \cdot 10^{10}}{16 \cdot 10^6} = 4 \cdot 64 \cdot 10^5 = 4 R$$

$$\Rightarrow P + h_1 = 4P \Rightarrow h_1 = 3P \quad \text{and} \quad h_1 = 192 \cdot 10^5 \text{ m}$$

$$b) k_1 = \frac{1}{2} m v_1^2 = \frac{1}{2} m \cdot G \frac{M_r}{r} = \frac{1}{2} G \frac{M_r m}{4R}$$

$$K_2 = \frac{1}{2} m v_i^2 = \frac{1}{2} m G \frac{M_r}{r'} \xrightarrow{r' = 2R} K_2 = \frac{1}{2} G \frac{M_r m}{2R}$$

$$\Delta k = k_2 - k_1 = \frac{1}{2} G \frac{NrM}{2R} - \frac{1}{2} G \frac{NrM}{4R} = \frac{1}{2} G NrM \left( \frac{1}{2} - \frac{1}{4} \right)$$

$$\Rightarrow DF = \frac{1}{2} GM rm \frac{1}{4R} = \frac{GM rm}{8R} = \frac{8P^2 m}{BR} = \frac{1}{8} mg_0 R$$

$$\Delta K = \frac{1}{8} \cdot 500 \cdot 10 \cdot 64 \cdot 10^5 \text{ or } \Delta K = 40 \cdot 10^8 \text{ J or } \Delta K = 4 \cdot 10^9 \text{ J}$$

$$rW_B = -\Delta U = -[U_{T\delta} - U_{\text{ex}}] = U_{\text{ex}} - U_{T\delta} = -G \frac{M_{\text{Pl}} w}{4R} + G \frac{M_{\text{Pl}} w}{2R}$$

$$\Rightarrow W_B = G \frac{M_{\text{Pl}} w}{4R} = \frac{g_0 P^2 M}{4R} = \frac{1}{q} m g_0 R$$

$$\Rightarrow W_B = \frac{1}{4} \cdot 500 \cdot 10 \cdot 64 \cdot 10^5 = 80 \cdot 10^8 \text{ J} = 8 \cdot 10^9 \text{ J}$$

$$E = -G \frac{M_{\text{Pl}} w}{r} + \frac{1}{2} m v^2 = -G \frac{M_{\text{Pl}} w}{r} + \frac{1}{2} m \sqrt{G \frac{M_{\text{Pl}} w}{r}}^2 = -\frac{1}{2} G \frac{M_{\text{Pl}} w}{r}$$

$$E_{\text{ex}} = -\frac{1}{2} G \frac{M_{\text{Pl}} w}{4R}$$

$$E_{T\delta} = -\frac{1}{2} G \frac{M_{\text{Pl}} w}{2R}$$

$$\Delta E = E_{T\delta} - E_{\text{ex}} = -\frac{1}{2} G \frac{N_{\text{Pl}} w}{2R} + \frac{1}{2} G \frac{N_{\text{Pl}} w}{4R}$$

$$\Rightarrow \Delta E_{\text{ex}} = -\frac{1}{2} G \frac{M_{\text{Pl}} w}{2R} \left( \frac{1}{2R} - \frac{1}{4R} \right) = -\frac{1}{2} G \frac{M_{\text{Pl}} w}{4R}$$

$$\Rightarrow \Delta E_{\text{ex}} = -\frac{g_0 P^2 M}{8R} = -\frac{1}{8} m g_0 R = -\frac{1}{8} (500 \cdot 10 \cdot 64 \cdot 10^5)$$

$$\Rightarrow \Delta E_{\text{ex}} = 40 \cdot 10^8 \text{ J} = -4 \cdot 10^9 \text{ J} \Rightarrow \underline{\Delta E_{\text{ex}} = -4 \cdot 10^9 \text{ J}} \quad \leftarrow$$

$$\delta) \Delta K = W_B + W_T \Rightarrow 4 \cdot 10^9 = 8 \cdot 10^9 \text{ J} + W_T \Rightarrow W_T = -4 \cdot 10^9 \text{ J}$$

$$W_T = -T \cdot \frac{\$}{\%} \Rightarrow -4 \cdot 10^9 = -0,20 \cdot \frac{\$}{\%} \Rightarrow S_0 = \frac{4 \cdot 10^9}{2 \cdot 10^1} \Rightarrow \underline{S_0 = 2 \cdot 10^{10} \text{ \$/\%}}$$

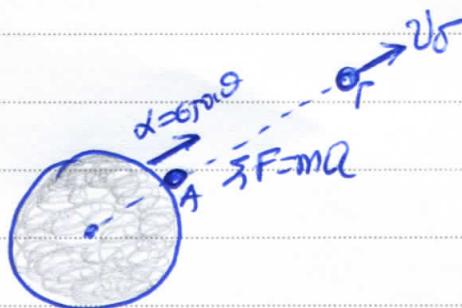
10.26

$$\alpha = \text{m/s}^2$$

d)

$$F_A = mg \Rightarrow \frac{1}{2}mv_F^2 = ma \cdot h$$

$$\Rightarrow \frac{1}{2}\sqrt{2G\frac{M}{R+h}} = \alpha h$$



$$\Rightarrow \frac{80P^2}{R+h} = \alpha h + \frac{80R^2}{R+h} = \alpha h(R+h) \Rightarrow 80R^2 = \alpha Rh + \alpha h^2$$

$$\Rightarrow \alpha h^2 + \alpha Rh - 80R^2 \xrightarrow{\text{SE}} 5h^2 + 5 \cdot 64 \cdot 10^5 \cdot h - 10 \cdot 64 \cdot 10^{10} = 0$$

$$\Delta = 25 \cdot 64^2 \cdot 10^{10} + 4 \cdot 5 \cdot 10 \cdot 64^2 \cdot 10^{10} = 925 \cdot 64^2 \cdot 10^{10}$$

$$\sqrt{\Delta} = 25 \cdot 64 \cdot 10^5 \Rightarrow$$

$$h = \frac{-5 \cdot 64 \cdot 10^5 \pm \sqrt{925 \cdot 64^2 \cdot 10^{10}}}{10} \Rightarrow h = \frac{10 \cdot 64 \cdot 10^5}{10} \Rightarrow h = 64 \cdot 10^5$$

$$\Rightarrow h = 64 \cdot 10^5 \text{ m}$$

$$b) h = \frac{1}{2}\alpha t^2 \Rightarrow t = \sqrt{\frac{2h}{\alpha}} = \sqrt{\frac{2 \cdot 64 \cdot 10^5}{5}} = \sqrt{256 \cdot 10^5} = \sqrt{8,88 \cdot 10^6} \Rightarrow t = 2,96 \cdot 10^3$$

$$\Rightarrow v = \sqrt{2 \frac{GM_r}{2R}} = \sqrt{\frac{2 \cdot 80R^2}{2R}} = \sqrt{\frac{2 \cdot 10 \cdot 64 \cdot 10^5}{2}} = \frac{8 \sqrt{3} \cdot 10^3}{2} = 6,53 \cdot 10^3 \text{ m/s}$$

$$v = \alpha t \Rightarrow t = 1,5 \cdot 10^3 \text{ s}$$

$$d) g = \frac{GM_r}{(2R)^2} = \frac{80P^2}{4R^2} = \frac{80}{4} \quad \eta' \quad g = 2,5 \text{ m/s}^2$$

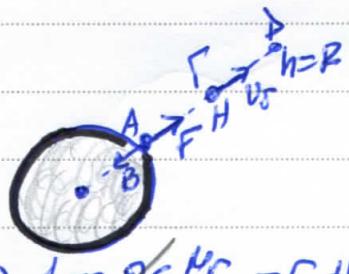
$$V = -\frac{GM_r}{2R} = -\frac{80P^2}{2R} = -\frac{1}{2}80R = -\frac{1}{2}10 \cdot 64 \cdot 10^5 = -32 \cdot 10^6 \frac{\text{N}}{\text{kg}}$$

10.27.

$$m=500 \text{ kg} \quad F=10^4 \text{ N}$$

a)

$$\Delta K = W_F + W_B \Rightarrow$$



$$\Rightarrow \frac{1}{2} m v_f^2 = F \cdot h - [U_f - U_A] \quad \Rightarrow \frac{1}{2} m \cdot 26 \frac{M_f}{P+H} = F \cdot h - \left[ -G \frac{M_f M}{P+H} + G \frac{M_f M}{P} \right]$$

$$\Rightarrow G \frac{M_f M}{P+H} = F \cdot H + G \frac{M_f M}{P+H} - G \frac{M_f M}{P} \Rightarrow F \cdot H = \frac{80 P^2 m}{R} \Rightarrow H = \frac{m g P}{F}$$

$$\Rightarrow H = \frac{500 \cdot 10 \cdot R}{10000} \Rightarrow H = \frac{R}{2} \quad \text{and} \quad H = 32 \cdot 10^5 \text{ m.}$$

$$\Delta E_{\text{kin}} = W_F \Rightarrow E_{\text{kin}}, P = E_{\text{kin}}, A = W_F \Rightarrow 0 - \left[ -G \frac{M_f M}{R} \right] = F \cdot H$$

$$b) \quad \Delta K = W_F + W_B = K - 0 = F \cdot R \neq [U_D - U_A] \Rightarrow$$

$$\Rightarrow K = F \cdot R + U_A - U_D \quad \text{or} \quad K = F \cdot R \neq G \frac{M_f M}{R} + G \frac{M_f M}{2R}$$

$$\Rightarrow K = F \cdot R - \frac{80 P^2 m}{R} + \frac{80 P^2 m}{2R} \Rightarrow K = F \cdot R - \frac{1}{2} m g R$$

$$\Rightarrow K = 10^4 \cdot 64 \cdot 10^5 - \frac{1}{2} \cdot 500 \cdot 10 \cdot 64 \cdot 10^5 = 64 \cdot 10^9 - 16 \cdot 10^9 \Rightarrow K = 48 \cdot 10^9 \text{ J}$$

$$c) \quad U_D + K_D = 0 + k_0 \quad \Rightarrow -G \frac{M_f M}{2R} + K_D = k_0$$

$$- \frac{80 P^2 m}{2R} + K_D = k_0 \Rightarrow k_0 = k_0 - \frac{1}{2} m g R$$

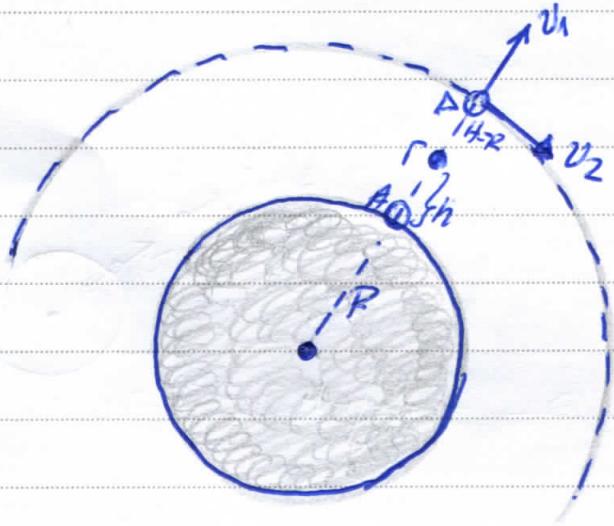
$$\Rightarrow k_0 = 48 \cdot 10^9 - \frac{1}{2} \cdot 500 \cdot 10 \cdot 64 \cdot 10^5 \quad \text{et} \quad \underbrace{k_0 = 32 \cdot 10^9 \text{ Joule}}$$

$$k_0 = F \cdot R - [U_0 - U_A] = F \cdot R - G \frac{M_f M}{R} - F \cdot H - \frac{80 P^2 m}{R}$$

$$k_0 = F \cdot R - m g f R = 10000 \cdot R - 500 \cdot 10 \cdot R = 5000 \cdot 64 \cdot 10^5 = 32 \cdot 10^9 \text{ J}$$

10.28

$$m = 500 \text{ kg} \quad F = 2,5 B_0 = 2,5 m g$$



a)

$$v_2 = \sqrt{G \frac{M}{r}} = \sqrt{\frac{g_0 R^2}{2R}} = \frac{\sqrt{g_0 R}}{\sqrt{2}}$$

$$\Rightarrow v_2 = \frac{\sqrt{10 \cdot 64 \cdot 10^3}}{\sqrt{2}} = \frac{8 \cdot 10^3}{\sqrt{2}} = 4\sqrt{2} \cdot 10^3 \text{ m/s}$$

$$\Rightarrow v_1 = v_2 = 4\sqrt{2} \cdot 10^3 \text{ m/s}$$

$$\therefore b) \Delta K_{AD} = W_F + W_B \Rightarrow K_D - K_A = F \cdot h - \Delta U_{AD} \Rightarrow K_D = F \cdot h - [U_D - U_A]$$

$$\Rightarrow K_D = F \cdot h - U_D + U_A \Rightarrow \frac{1}{2} m G \frac{M r}{2R} = F \cdot h + G \frac{M \cdot m}{2R} - G \frac{M \cdot m}{R}$$

$$\frac{1}{4} G \frac{M \cdot m}{R} = F \cdot h - \frac{1}{2} G \frac{M \cdot m}{R} \Rightarrow \frac{3}{4} G \frac{M \cdot m}{R} = 2,5 m g_0 \cdot h$$

$$\Rightarrow \frac{3}{4} \frac{8 \cdot R \cdot m}{R} = 2,5 m g_0 \cdot h \Rightarrow \frac{3}{4} R = 2,5 h \Rightarrow h = 0,3 R$$

$$\Rightarrow h = 19,2 \cdot 10^5 \text{ m}$$

d)

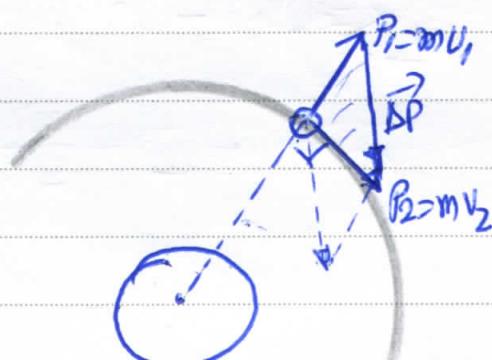
$$\Delta P = \sqrt{P_2^2 - P_1^2} \Rightarrow \Delta P = \sqrt{P_1^2 + B^2}$$

$$\Rightarrow \Delta P = m \sqrt{v_1^2 + v_2^2}$$

$$\Delta P = m v_2 \sqrt{2} = 500 \cdot 4\sqrt{2} \cdot 10^3 \cdot \sqrt{2}$$

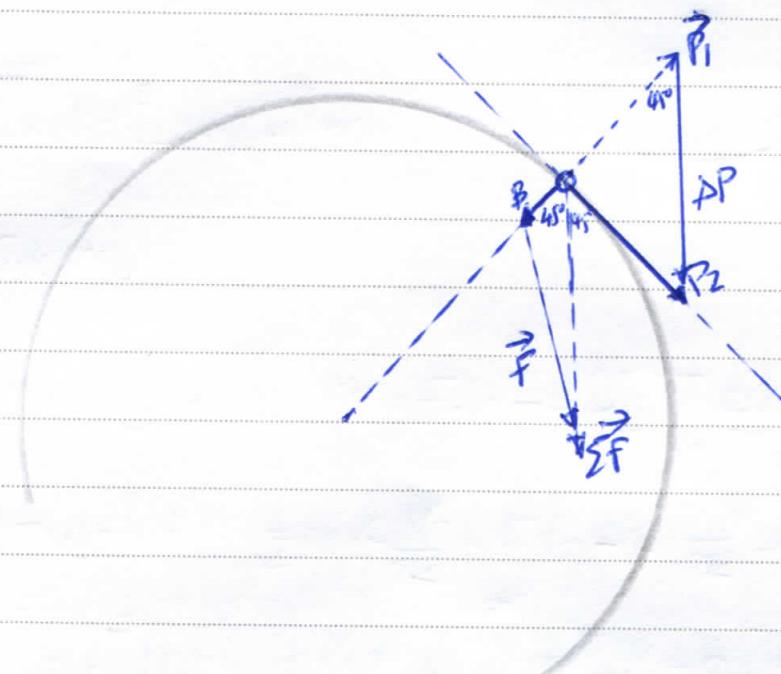
$$\Rightarrow \Delta P = 40 \cdot 10^5 \Rightarrow \Delta P = 4 \cdot 10^6 \text{ kp m/s}$$

$$\Sigma F = \frac{\Delta P}{\Delta t} \Rightarrow \Sigma F = \frac{4 \cdot 10^6 \text{ kp m/s}}{0,1 \text{ s}} \Rightarrow \Sigma F = 4 \cdot 10^7 \text{ N}$$



Συστήματα Στρεστού Σώματος στην θέση της απόστασης  $\vec{S}\vec{F}$   
 Διατί η ισχύ  $\vec{F}$  που αποδίδεται στην θέση  $\vec{B}$  με βάση την δύναμη  
 $B = m\vec{g} = m g_0 \left(\frac{P}{P+H}\right)^2 = m \frac{g_0}{4} = 500 \cdot 10 \cdot \frac{1}{4} \Rightarrow B = 1250 N << \vec{S}\vec{F}$

Άρα η δύναμη  $\vec{F}$  στη θέση  $\vec{B}$  είναι παράλληλη με  $\vec{S}\vec{F}$



$$\begin{aligned} F^2 &= S_F^2 + B^2 - 2S_F B \cos 45^\circ = 4 \cdot 10^7 / 7 + 200^2 \Rightarrow 2 \cdot 500 \cdot 4 \cdot 10^7 / 7 = 2.857 \cdot 10^{10} \\ \Rightarrow F^2 &= 16 \cdot 10^{14} + 4 \cdot 10^4 - 0.707 \cdot 10^{10} \Rightarrow F^2 = \underline{\underline{F = 4 \cdot 10^7 N}} \end{aligned}$$

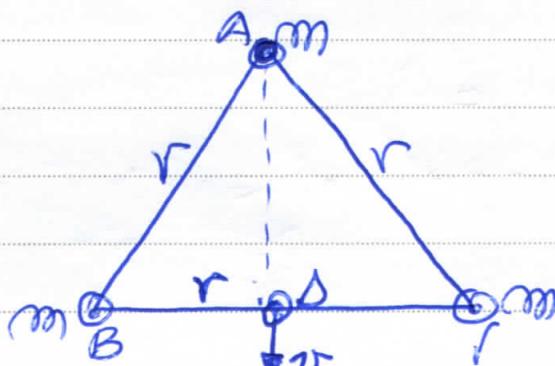
10.29

$$a) E = -G \frac{mm}{r} - G \frac{mM}{r} - G \frac{mM}{r}$$

$$\Rightarrow E = -3G \frac{m^2}{r} \Rightarrow$$

$$\Rightarrow E = -3 \cdot 6,67 \cdot 10^{11} \cdot \frac{(410)^2}{26,68 \cdot 10^2} \Rightarrow$$

$$\Rightarrow E = -3 \cdot 6,67 \cdot 16 \cdot \frac{10^{13}}{4 \cdot 6,67 \cdot 10^2} \Rightarrow E = -12 \cdot 10^{11} \text{ Joule}$$



$$E_{\text{outer}} + E_{\text{inner}} = E_{\text{tot}} = 0 \Rightarrow E_{\text{inner}} = -E_{\text{outer}} \Rightarrow E_{\text{inner}} = 12 \cdot 10^{11} \text{ Joule}$$

$$b) U_A + k_A = U_B + k_B \Rightarrow mV_A + 0 = mV_B + \frac{1}{2}mv^2 \Rightarrow$$

$$m \left[ -G \frac{m}{r} - G \frac{m}{r} \right] = m \left[ -G \frac{m}{r_1} - G \frac{m}{r_2} \right] + \frac{1}{2}mv^2 \Rightarrow$$

$$\Rightarrow -2G \frac{m^2}{r} = -4G \frac{m^2}{r} + \frac{1}{2}mv^2 \Rightarrow \frac{1}{2}mv^2 = 2G \frac{m^2}{r} \Rightarrow v^2 = 4G \frac{m}{r}$$

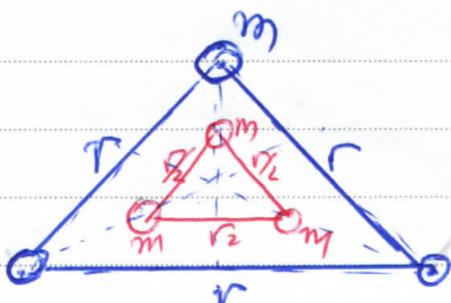
$$\Rightarrow v = \sqrt{4G \frac{m}{r}} \Rightarrow v = 2 \sqrt{6,67 \cdot 10^{11} \frac{410}{26,68 \cdot 10^2}} \approx v = 2 \cdot 10^{10} \text{ m/s} \quad v = 2 \cdot 10^{5} \text{ m/s}$$

$$c) U_{\text{outer}} + k_{\text{outer}} = U_{\text{in}} + k_{\text{in}}$$

$$\Rightarrow -3G \frac{m^2}{r} + 0 = -3G \frac{m^2}{r_1} + \frac{1}{2}mv^2$$

$$\Rightarrow -G \frac{m^2}{r} = -2G \frac{m^2}{r_1} + \frac{1}{2}mv^2 \Rightarrow G \frac{m^2}{r_1} = \frac{1}{2}mv^2 \Rightarrow v^2 = 2G \frac{m}{r}$$

$$\Rightarrow v = \sqrt{2G \frac{m}{r}} \Rightarrow v = \sqrt{2 \cdot 6,67 \cdot 10^{11} \frac{410}{26,68 \cdot 10^2}} \Rightarrow v = 10^5 \sqrt{2} \frac{\text{m}}{\text{s}}$$



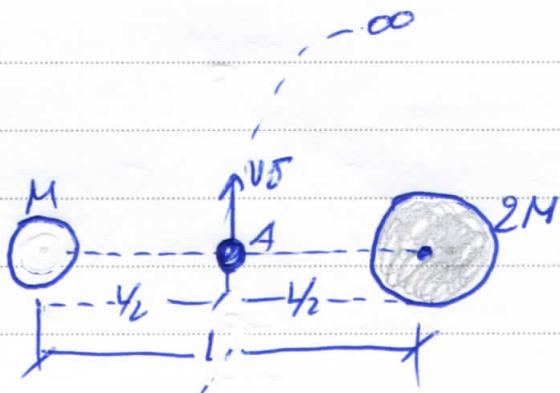
10.30

$$U_A + K_A = U_{\infty} + K_{\infty} \Rightarrow$$

$$-G \frac{Mm}{r_1} - G \frac{2Mm}{r_2} + \frac{1}{2} m v_f^2 + 0$$

$$-6G \frac{Mm}{L} + \frac{1}{2} m v_f^2 \Rightarrow v_f = \sqrt{\frac{12GM}{L}} = \sqrt{\frac{4 \cdot 3 \cdot 6.67 \cdot 10^{11} \cdot 10^{24}}{2901 \cdot 10^9}}$$

$$\Rightarrow v_f = 900 \frac{m}{s}$$



10.31

$$\Delta G(r) R_D = 3,2 \text{ km}$$

a)  $c_s = c_{\text{H2S}}$    
  $\tau_{\text{axial}}(r) \sim \rho r^2$  :  $v_f = \sqrt{2G \frac{M_F}{R_F}}, v_f = \sqrt{G \frac{M_D}{R_D}}$

$$\frac{M_F}{M_D} = \frac{V_F e}{V_D e} - \frac{4 \pi r_F^3}{3 \rho D R_D^3} = \frac{r_F^3}{R_D^3}$$

$$\frac{v_f}{v_f} = \frac{\sqrt{2G \frac{M_F}{R_F}}}{\sqrt{2G \frac{M_D}{R_D}}} = \sqrt{\frac{M_F}{M_D} \frac{R_D}{R_F}} = \sqrt{\frac{r_F^3}{R_D^3} \cdot \frac{R_D}{R_F}} = \frac{r_F}{R_D} \Rightarrow v_f = \frac{R_D}{r_F} v_f$$

$$\Rightarrow v_f = \frac{32 \text{ km}}{6400 \text{ km}} v_f$$

$$v_f = \frac{R_D}{r_F} \sqrt{2G \frac{M_F}{R_F}} = \frac{R_D}{R_F} \sqrt{2 \cdot 10 \cdot 64 \cdot 10^5} = \frac{R_D}{R_F} \sqrt{2 \cdot 64 \cdot 10^8}$$

$$\Rightarrow v_f = \frac{3,2 \text{ km}}{6400 \text{ km}} \cdot \sqrt{2 \cdot 10 \cdot 64 \cdot 10^5} \Rightarrow v_f = \frac{3,2 \cdot 8 \cdot 10^8}{6400} \sqrt{2}$$

$$v_f = 4 \sqrt{2} \text{ m/s} \quad \text{or} \quad v_f \approx 9,66 \text{ m/s}$$

S

$$B) \text{ } h = \frac{v_0^2}{2g} \Rightarrow v_0 = \sqrt{2gh} \Rightarrow v_0 = \sqrt{2 \cdot 10 \cdot 98} \Rightarrow v_0 = 414 \text{ m/s}$$

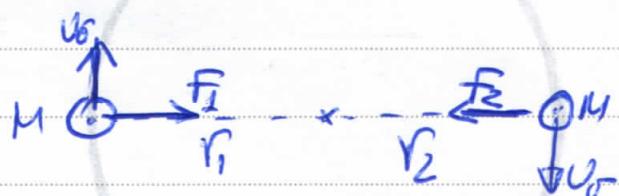
Bei  $v = 2 \text{ m/s} < v_{0,5} = 5,6 \text{ m/s}$

Zwei Sphären vereinfachen die Wirkung

## 10.32

$$M = 2 \cdot 10^{26} \text{ kg}$$

$$L = 13,34 \cdot 10^{11} \text{ m}$$



$$\alpha) F_1 = F_2 = G \frac{MM}{L^2}$$

$$F_1 = \cancel{G \frac{Mv^2}{r_1^2}}, \quad F_2 = \cancel{G \frac{Mv^2}{r_2^2}}$$

$$F_1 = F_2 \Rightarrow$$

$$F_1 = M\omega^2 r_1, \quad F_2 = M\omega^2 r_2$$

$$\left. \begin{array}{l} F_1 = F_2 \Rightarrow r_1 = r_2 \\ r_1 + r_2 = L \Rightarrow 2r_1 = L \end{array} \right\}$$

$$\Rightarrow r_1 = r_2 = \frac{L}{2} \Rightarrow r_1 = r_2 = 6,67 \cdot 10^{11} \text{ m}$$

$$\beta) F_1 = M \frac{v^2}{r_1} \Rightarrow G \frac{M^2}{L^2} = M \frac{v^2}{r_1} \Rightarrow G \frac{M}{L^2} = \frac{v^2}{r_1} \Rightarrow G \frac{M}{L^2} r_1 = v^2$$

$$\Rightarrow v_0 = \sqrt{\frac{GM}{L^2}} \Rightarrow v_0 = \sqrt{\frac{GM}{L^2} \frac{L}{2}} = v_0 = \sqrt{\frac{GM}{2L}} = \sqrt{\frac{6,67 \cdot 10^{11} \cdot 6,67 \cdot 10^{26}}{2 \cdot 13,34 \cdot 10^{11}}} \text{ m/s}$$

$$\Rightarrow v_0 = 100 \text{ m/s}$$

$$\delta) T = \frac{2\pi r}{v_0} = \frac{2\pi}{v_0} \cdot \frac{L}{2} \Rightarrow T = \frac{2\pi}{100} \frac{13,34 \cdot 10^{11}}{2} \Rightarrow T = 13,34 \pi \cdot 10^9 \text{ s} \Rightarrow \underline{\underline{T \approx 41,8 \cdot 10^9 \text{ s}}}$$

$$\sigma) E_{kinX} = -G \frac{Mm}{L} + \frac{1}{2} M v_0^2 = -G \frac{M^2}{L} + M \sqrt{\frac{GM}{2L}}^2 = -G \frac{M^2}{L} + \frac{1}{2} G \frac{M^2}{L}$$

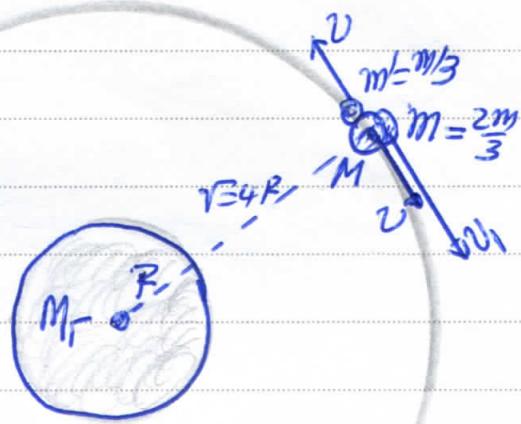
$$\Rightarrow E_{kinX} = -\frac{1}{2} G \frac{M^2}{L} = -\frac{1}{2} 6,67 \cdot 10^{11} \frac{16 \cdot 10^{52}}{13,34 \cdot 10^{11}} \text{ J} \Rightarrow \underline{\underline{E_{kinX} = -4 \cdot 10^{30} \text{ J}}}$$

10.35

$$a) \text{ Δορυφόρος } v = \sqrt{G \frac{M_F}{r}}$$

$$\Rightarrow v = \sqrt{G \frac{M_F}{4R}} \Rightarrow v = \sqrt{\frac{80P^2}{4R}}$$

$$\Rightarrow v = \frac{\sqrt{80P^2}}{2} \Rightarrow v = 4 \cdot 10^3 \text{ m/s} \Rightarrow v = 4 \text{ km/s}$$



$$Mv = mv_1 - m'v \Rightarrow Mv = \frac{2m}{3}v_1 - \frac{m}{3}v \Rightarrow 3v = 2v_1 - v \Rightarrow 4v = 2v_1$$

$$\Rightarrow v_1 = 2v \Rightarrow v_1 = 8 \text{ km/s}$$

b) Η τοξινότητα φυγής στον κύριο πλανήτη είναι  $b = 3R_{\text{πλανήτη}} = 4R$  επί ταύτη

$$v_0 = \sqrt{2G \frac{M_F}{r}} = \sqrt{2G \frac{M_F}{4R}} \Rightarrow v_0 = \sqrt{2} \sqrt{\frac{80P^2}{4R}} \Rightarrow v_0 = 4\sqrt{2} \text{ km/s}$$

Επομένως  $v_1 > v_0$  για να μπει στη φυγή  $(m = \frac{2M}{3})$  φεύγει ο πλανήτης από την πλανήτη.

$$d) \text{ } \sum F_{\text{ext}} + F_{\text{int}} = m a_0 + m v_0 \Rightarrow -G \frac{M_F m}{r^2} + \frac{1}{2} m v_1^2 = \frac{1}{2} m v_0^2$$

$$\Rightarrow -G \frac{M_F m}{r^2} + \frac{v_1^2}{2} = \frac{v_0^2}{2} \Rightarrow v_0^2 = v_1^2 - \frac{80P^2}{2} \Rightarrow v_0^2 = (8 \cdot 10^3)^2 - \frac{10 \cdot 64 \cdot 10^5}{2}$$

$$\Rightarrow v_0^2 = 64 \cdot 10^6 - 32 \cdot 10^6 \Rightarrow v_0^2 = 32 \cdot 10^6 \Rightarrow v_0 = 4\sqrt{2} \cdot 10^3 \text{ m/s} \Rightarrow v_0 = 4\sqrt{2} \text{ km/s}$$

10.34

Ergebnis der Lösung

$$T = 1,5h$$

$$q) E = -G \frac{Mm}{r} + \frac{1}{2}mv^2 = -G \frac{Mm}{r} + \frac{1}{2}m \sqrt{\frac{GM}{r}} \Rightarrow$$

$$T = T_0 - \alpha \cdot t$$

$$\Rightarrow E = -G \frac{Mm}{r} + \frac{1}{2}G \frac{Nm}{r} \Rightarrow E = -\frac{1}{2}G \frac{Nm}{r}$$

$$E_2 < E_1 \Rightarrow -\frac{1}{2}G \frac{Nm}{r_2} < -\frac{1}{2}G \frac{Nm}{r_1} \Rightarrow \frac{1}{r_2} > \frac{1}{r_1} \Rightarrow r_2 < r_1 \text{ und } v_2 > v_1$$

$$k_2 = \frac{1}{2}G \frac{Nm}{v_2}$$

$$k_1 = \frac{1}{2}G \frac{Nm}{v_1}$$

$$r_2 < r_1 \Rightarrow k_2 > k_1 \Rightarrow v_2 > v_1$$

$$b) T = T_0 - \alpha \cdot t \Rightarrow T = 1,5h - \alpha \cdot t \Rightarrow 1,488 = 1,5 - \alpha \cdot 24$$

$$\Rightarrow 24\alpha = 0,012 \Rightarrow \alpha = 5 \cdot 10^{-4}$$

$$\left| \begin{array}{l} T = 1,5h - 0,72m/h = 1,5h - \frac{9}{60}h \\ T = 1,488h \end{array} \right.$$

$$T = \frac{2\pi r}{v} \Rightarrow T = \frac{2\pi r}{\sqrt{GM/r^3}} \Rightarrow T = \frac{2\pi}{\sqrt{GM}} r^{3/2}$$

$$C_0 \text{ für } r = R \quad \text{Ergebnis } T = \frac{2\pi}{\sqrt{GM}} R^{3/2} \quad \left| \begin{array}{l} R^{3/2} = R \cdot R''^2 \end{array} \right.$$

$$\Rightarrow T = \frac{2\pi}{\sqrt{GM}} R''^2 \Rightarrow T = 20 \sqrt{\frac{R''}{g}} \Rightarrow T = 20 \cdot \sqrt{\frac{64 \cdot 10^5}{10}}$$

$$\Rightarrow T = 20 \cdot 8 \cdot 10^2 \Rightarrow T = 1600 \text{ s} \Rightarrow T = 9024 \text{ s} \Rightarrow T = \frac{5024}{3600} h$$

daraus

$$T = T_0 - \alpha \cdot t \Rightarrow T = 1,5 - 5 \cdot 10^{-4} t \quad \left| \begin{array}{l} t \rightarrow h \end{array} \right.$$

$$\Rightarrow \frac{5024}{3600} = 1,5 - 5 \cdot 10^{-4} t \Rightarrow 5 \cdot 10^{-4} t = 1,5 - \frac{5024}{3600} \Rightarrow 5 \cdot 10^{-4} t = \frac{376}{3600}$$

$$\Rightarrow t = 208,89 \text{ h}$$

10.35

$$m = 1200 \text{ kg}$$

$$V_1 = 4 \text{ km/s}$$

$$\Delta E = 64 \cdot 10^8$$

$$h_1$$

$$h_2$$

$$V_1 = \sqrt{G \frac{M}{r_1}} \quad \text{and} \quad V_1' = \sqrt{\frac{80R^2}{r_1}} \quad \text{and} \quad V_1' V_1 = f_0 R^2 \Rightarrow r_1 = \frac{80R^2}{V_1'^2} = \frac{10 \cdot (64 \cdot 10^8)^2}{(4 \cdot 10^3)^2}$$

$$\Rightarrow r_1 = \frac{10 \cdot 64 \cdot 64 \cdot 10^{10}}{16 \cdot 10^6} \Rightarrow r_1 = 4 \cdot 64 \cdot 10^5 \quad \text{and} \quad r_1 = 4R \quad \text{and} \quad h_1 = r_1 - R \quad \text{and} \quad h_1 = 3R$$

$$\Rightarrow h_1 = 192 \cdot 10^5 \text{ m}$$

$$E_1 = U_1 + K_1 = -G \frac{Mm}{r_1} + \frac{1}{2} m V_1^2 \Rightarrow F_1 = -\frac{1}{2} G \frac{Mm}{r_1^2} = -\frac{1}{2} \frac{80R \cdot m}{4R}$$

$$\Rightarrow E_1 = -\frac{1}{8} m f_0 R = -\frac{1}{8} \cdot 1200 \cdot 10 \cdot 64 \cdot 10^5 \quad \text{and} \quad E_1 = -96 \cdot 10^8 \text{ J}$$

$$E_2 = E_1 - \Delta E = -96 \cdot 10^8 - 64 \cdot 10^8 \quad \text{and} \quad E_2 = -160 \cdot 10^8 \text{ J}$$

$$E_2 = -\frac{1}{2} G \frac{Mm}{r_2} = -\frac{1}{2} \frac{80R^2 m}{r_2} \Rightarrow r_2 = -\frac{1}{2} \frac{80R^2 m}{E_2}$$

$$\Rightarrow r_2 = -\frac{1}{2} \frac{10 \cdot 64 \cdot 64 \cdot 10^{10} \cdot 1200}{-160 \cdot 10^8} \quad \text{and} \quad r_2 = \frac{64 \cdot 64 \cdot 12}{2 \cdot 16} \cdot \frac{10^3}{10^9}$$

$$\Rightarrow r_2 = 153,6 \cdot 10^5 \Rightarrow 64 \cdot 10^5 + h_2 = 153,6 \cdot 10^5$$

$$\Rightarrow h_2 = 89,6 \cdot 10^5 \text{ m} \quad \text{and} \quad h_2 = 1,4R$$

10.36

$$m = 100 \text{ kg}$$

$$h_1 = 1,56R \Rightarrow r = 3,56R$$

$$U_1 = \sqrt{\frac{GM}{r}} = \sqrt{\frac{80R}{3,56R}}$$

$$\Rightarrow U_1 = \sqrt{\frac{10 \cdot 64 \cdot 10^5}{3,56}} = \frac{8 \cdot 10^3}{1,6} = 5 \cdot 10^3 \text{ J}$$

$$\Rightarrow U = 5 \text{ km/s}$$

Der Geschwindigkeitsunterschied ist 5 km/s.  $v_0 = \sqrt{2G\frac{M}{r}} = 5r_2 \text{ km/s}$

$$\Delta \vec{P} = \vec{P}_2 - \vec{P}_1 \neq \vec{P}_2 = \vec{P}_1 + \Delta \vec{P} \quad \text{if } P_2 = \sqrt{P_1^2 + \Delta P^2}$$

$$P_1 = m v_0 \quad P_2 = m v_0$$

$$\Delta \vec{P} = \vec{P}_2 - \vec{P}_1 \Rightarrow \Delta P = \sqrt{P_2^2 - P_1^2} = \sqrt{(mv_0)^2 - (mv)^2} = m \sqrt{v_0^2 - v^2}$$

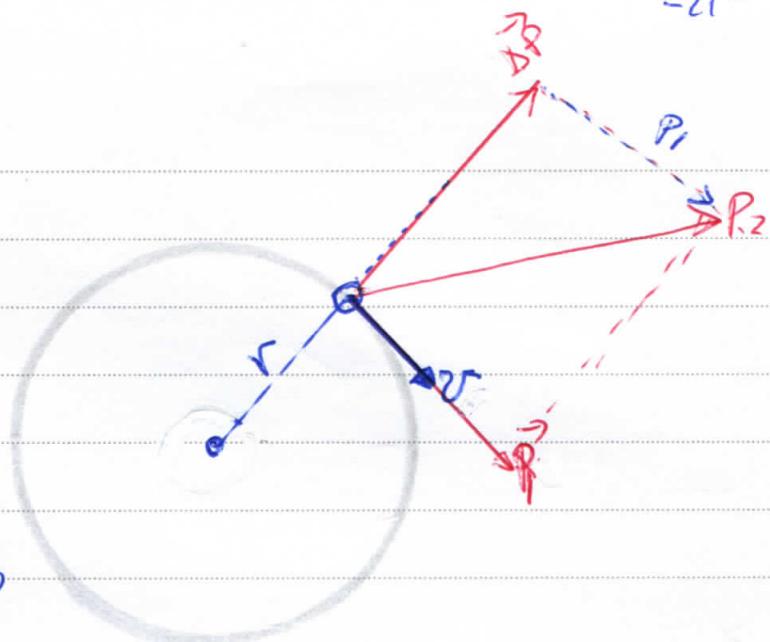
$$\Rightarrow \Delta P = 100 \sqrt{(5r_2 \cdot 10^3)^2 - (5 \cdot 10^3)^2} = 100 \sqrt{25 \cdot 10^6}$$

$$\Rightarrow \Delta P = 5 \cdot 10^5 \text{ kg m/s} = \Sigma F \Delta t \quad \Rightarrow \Sigma F = \frac{\Delta P}{\Delta t} = \frac{5 \cdot 10^5}{0,01}$$

$$\Rightarrow \Sigma F = 5 \cdot 10^7 \text{ N} \rightarrow F - mg = 5 \cdot 10^7 \Rightarrow F \approx 5 \cdot 10^7 \text{ N}$$

$$\int f = f_0 \left(\frac{R}{r}\right)^2 = 10 \left(\frac{R}{3,56R}\right)^2 = \frac{10}{3,56^2} = 1,52 \text{ N/m}$$

$$mg = 100 \text{ kg} \cdot 1,52 \Rightarrow mg \approx 152 \text{ N}$$



10.37

$$m = 500 \text{ kg}$$

$$g) v = \sqrt{G \frac{M}{2R}} = \sqrt{\frac{8\pi^2 P^2}{7R}} = \sqrt{\frac{8\pi^2 R}{2}}$$

$$\Rightarrow v = \sqrt{\frac{10 \cdot 6 \cdot 10^5}{2}} = \sqrt{32 \cdot 10^6}$$

$$\Rightarrow v = 4\sqrt{2} \cdot 10^3 \text{ m/s} \quad \text{and} \quad v = 4\sqrt{2} \text{ km/s}$$

$$e) v_A + k_A = v_r + k_r \Rightarrow -G \frac{Mm}{2R} + \frac{1}{2}mv_1^2 = -G \frac{Mm}{R} + \frac{1}{2}mv_2^2$$

$$\frac{1}{2}mv_1^2 = +G \frac{Mm}{2R} - G \frac{Mm}{R} + \frac{1}{2}mv_2^2 \Rightarrow v_1^2 = \frac{v_2^2}{2} - G \frac{M}{2R}$$

$$\Rightarrow v_1^2 = v_0^2 - \frac{8\pi^2 P^2}{R} \Rightarrow v_1^2 = v_2^2 - 8\pi^2 R \Rightarrow v_1^2 = 16 \cdot 6 \cdot 10^6 - 64 \cdot 10^6$$

$$\Rightarrow v_1^2 = 32 \cdot 10^6 \quad \text{and} \quad v_1 = 4\sqrt{2} \text{ km/s}$$

f)

$$\vec{DP} = \vec{P}_1 - \vec{P}$$

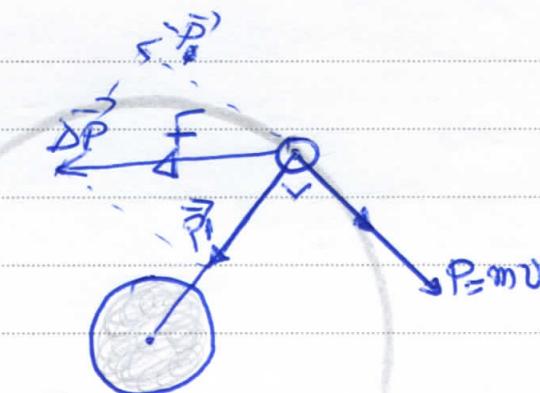
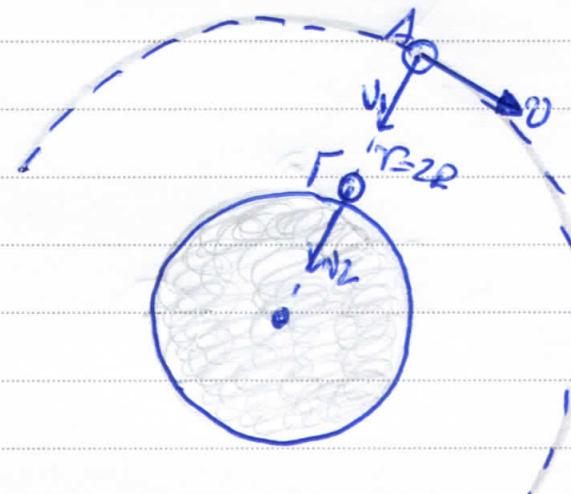
$$DP = \sqrt{P_1^2 + P^2}$$

$$\Rightarrow DP = m\sqrt{v^2 + v_1^2}$$

$$DP = 500 \cdot \sqrt{(4\sqrt{2})^2 + (4\sqrt{2})^2 \cdot 10^6} \Rightarrow DP = 500 \cdot 8 \cdot 10^6 \Rightarrow DP = 4 \cdot 10^9 \text{ Nm/s}$$

$$\Delta P = \Delta F \Delta t \Rightarrow SF = \frac{\Delta P}{\Delta t} \Rightarrow SF = \frac{4 \cdot 10^9}{0,01} \Rightarrow SF = 4 \cdot 10^{11} \text{ N}$$

$$\vec{SF} = \vec{F} + \vec{B} \quad \text{and} \quad SF \approx F \Rightarrow F = 4 \cdot 10^{11} \text{ N}$$

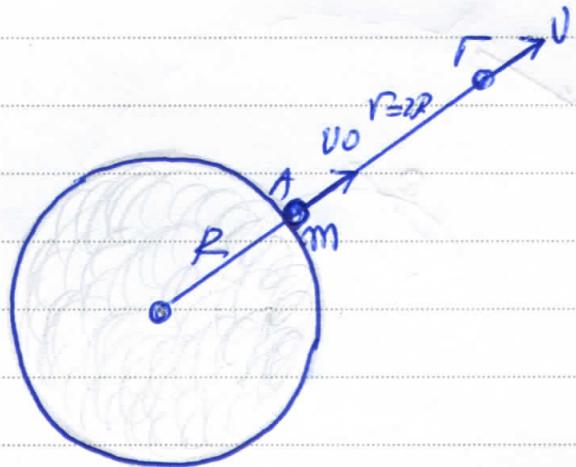


10.38

$$m = 1000 \text{ kg}$$

$$\Delta t = 0,1 \text{ s}$$

$$v_0 = 6\sqrt{2} \text{ km/s}$$



B)

$$\frac{1}{2}mv_0^2 - G \frac{Mm}{r} = \frac{1}{2}mv^2 - G \frac{Mm}{2R}$$

$$\frac{1}{2}mv_0^2 - 2G \frac{Mm}{2R} + G \frac{Mm}{2R} = \frac{1}{2}mv^2 \Rightarrow \frac{v_0^2}{2} - G \frac{Mm}{2R} = \frac{v^2}{2} \Rightarrow \frac{v_0^2}{2} - \frac{GMm}{2R} = \frac{v^2}{2}$$

$$\Rightarrow v^2 = v_0^2 - \frac{GM}{R} \Rightarrow v = 36 \cdot 2 \cdot 10^6 - 64 \cdot 10^6 = 8 \cdot 10^6 \Rightarrow v = 2 \cdot 4 \cdot 10^6$$

$$\Rightarrow v = 2\sqrt{2} \cdot 10^3 \text{ m/s}$$

a) 1

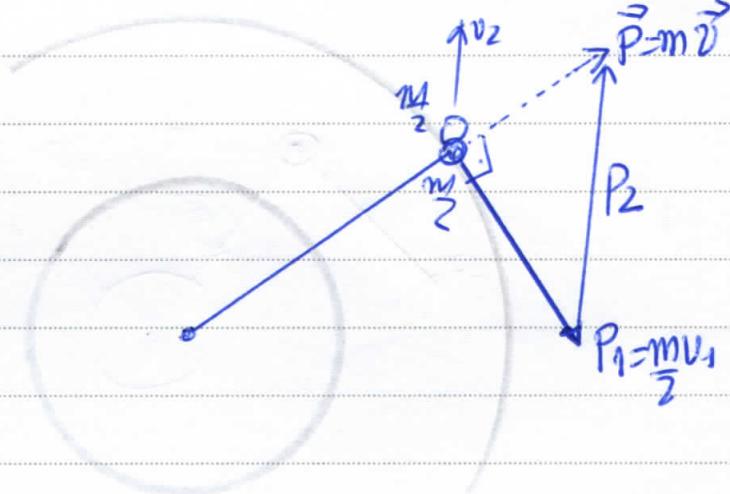
$$\delta F \cdot \Delta t = mv_0 \Rightarrow \delta F = \frac{mv_0}{\Delta t} = \frac{10^3 \cdot 6\sqrt{2} \cdot 10^3}{0,1} \Rightarrow \underline{\delta F = 6\sqrt{2} \cdot 10^7 \text{ N}}$$

$$\delta f = f - B \Rightarrow f = \delta f + B \Rightarrow f = 6\sqrt{2} \cdot 10^7 + 10^4 \approx 6\sqrt{2} \cdot 10^7 \text{ N}$$

$$\text{f)} \quad v_1 = \sqrt{G \frac{M}{r^2}} = 4\sqrt{2} \text{ km/s}$$

$$\vec{P} = \vec{P}_1 + \vec{P}_2$$

$$\Rightarrow P_2 = \sqrt{P_1^2 + P_2^2}$$



$$\frac{m}{2}v_2 = \sqrt{\left(\frac{m}{2}v_1\right)^2 + (mv)^2}$$

$$\frac{v_2}{2} = \sqrt{\frac{v_1^2}{4} + v^2} \Rightarrow \frac{v_2}{2} = \sqrt{\frac{16 \cdot 2 \cdot 10^6}{4} + 4 \cdot 2 \cdot 10^6}$$

$$\Rightarrow \frac{v_2}{2} = \sqrt{8 \cdot 10^6 + 8 \cdot 10^6} = 4 \cdot 10^3 \Rightarrow v_2 = 8 \cdot 10^3 \text{ m/s} \Rightarrow v_2 = 8 \text{ km/s}$$

$$V_0 = \sqrt{2G\frac{M}{r^2}} = \sqrt{\frac{g_0 P^2}{4\pi^2}} = 8 \text{ km/s}$$

Άρα  $V_0 = V_0$  ομοιούχης φεγγίδας θα ήταν  
8 km/s

10.39

$$h = 0,6 R_\Sigma$$

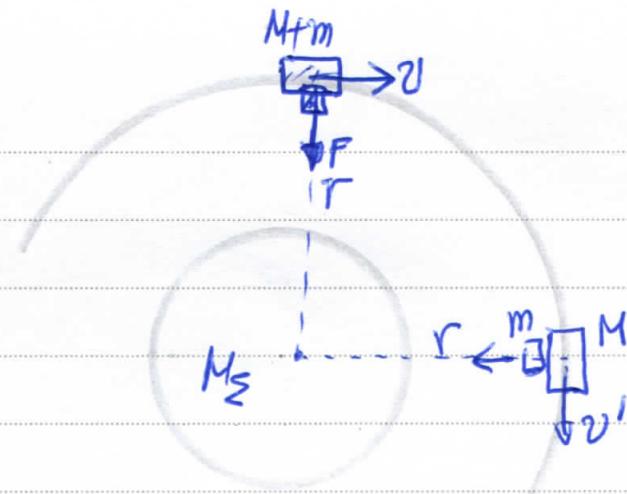
$$r = 1,6 R_\Sigma$$

$$M = 10.000 \text{ kg}$$

$$m = 2000 \text{ kg}$$

$$g_{\Sigma} = 1,6 \cdot g / \text{gr}$$

$$P_\Sigma = 1690 \text{ kN}$$



$$\text{d) } \sum F_k = (M+m) a_k \Rightarrow F = (M+m) \frac{v^2}{r} \Rightarrow G \frac{M_\Sigma (M+m)}{r^2} = (M+m) \frac{v^2}{r}$$

$$\Rightarrow v = \sqrt{G \frac{M_\Sigma}{r}}$$

$$g_\Sigma = G \frac{M_\Sigma}{R_\Sigma^2} \Rightarrow GM_\Sigma = g_\Sigma R_\Sigma^2$$

$$\left. \begin{aligned} v &= \sqrt{\frac{g_\Sigma R_\Sigma^2}{1,6 R_\Sigma}} \\ &= \sqrt{169 \cdot 10^4} \quad \Rightarrow \quad v = 13 \cdot 10^2 \end{aligned} \right\}$$

$$\Rightarrow v = 1300 \text{ m/s} = 1,3 \text{ km/s}$$

$$\text{e) } (M+m)v = M v' \Rightarrow v' = \frac{(M+m)v}{M} = \frac{12000 \text{ kg} \cdot 1,3 \text{ km/s}}{10000 \text{ kg}} \Rightarrow v' = 1,56 \text{ km/s}$$

$$\text{f) } \sum F = N_B + W_F$$

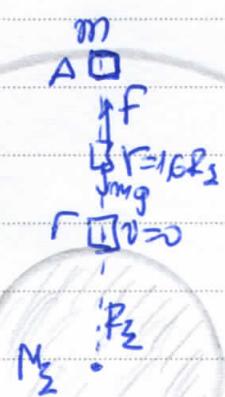
$$0 = -\Delta U + W_F \Rightarrow 0 = -(U_f - U_A) + W_F$$

$$\Rightarrow 0 = U_A - U_f + W_F$$

$$\Rightarrow W_F = U_f - U_A = -G \frac{M_\Sigma m}{R_\Sigma} + G \frac{N_\Sigma m}{r}$$

$$\Rightarrow W_F = -\frac{g_\Sigma R_\Sigma^2 M}{R_\Sigma^2} + \frac{g_\Sigma R_\Sigma^2 m}{1,6 R_\Sigma} \Rightarrow W_F = -m g_\Sigma R_\Sigma + \frac{m g_\Sigma R_\Sigma}{1,6}$$

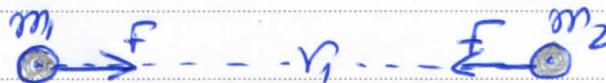
$$W_F = -243 \cdot 1,6 \cdot 1690 \cdot 10^3 + \frac{2 \cdot 10^3 \cdot 16 \cdot 1690 \cdot 10^3}{1,6} \Rightarrow W_F = -2028 \cdot 10^6 \text{ J}$$



$$-5408 \cdot 10^6$$

$$-3380 \cdot 10^6$$

10.40



$$m_1 = 4,67 \cdot 10^3 \text{ kg}$$

$$m_2 = 2 \cdot 10^3 \text{ kg}$$

$$r_1 = 9 \text{ m}$$

$$r_2 = 1 \text{ m}$$

$$E_{kin} = 0 \Rightarrow U_1 + K_1 = U_2 + K_2 \neq$$

$$\Rightarrow -G \frac{m_1 m_2}{r_1} + 0 = -G \frac{m_1 m_2}{r_2} + \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 \Rightarrow$$

$$\Rightarrow m_1 v_1^2 + m_2 v_2^2 = 2 G m_1 m_2 \left( \frac{1}{r_2} - \frac{1}{r_1} \right) \Rightarrow m_1 v_1^2 + m_2 v_2^2 = 2 G m_1 m_2 \frac{r_1 - r_2}{r_1 r_2} \quad (1)$$

$$F. \text{ Energiefreiheit} \Rightarrow 0 = m_1 v_1 - m_2 v_2 \Rightarrow m_1 v_1 = m_2 v_2 \Rightarrow v_2 = \frac{m_1}{m_2} v_1 \quad (2) \xrightarrow{\text{K}}$$

$$\Rightarrow m_1 v_1^2 + m_2 \frac{m_1^2}{m_2} v_1^2 = 2 G m_1 m_2 \frac{r_1 - r_2}{r_1 r_2} \Rightarrow \frac{m_1 m_2 + m_1^2}{m_2} v_1^2 = 2 G m_1 m_2 \frac{r_1 - r_2}{r_1 r_2}$$

$$\Rightarrow \frac{m_1}{m_2} (m_1 + m_2) v_1^2 = 2 G m_1 m_2 \frac{r_1 - r_2}{r_1 r_2}$$

$$v_1^2 = \frac{2 G m_2^2}{m_1 + m_2} \frac{r_1 - r_2}{r_1 r_2} \Rightarrow v_1 = m_2 \sqrt{\frac{2 G}{m_1 + m_2} \frac{r_1 - r_2}{r_1 r_2}}$$

$$\text{Nach } v_2 = \frac{m_1}{m_2} v_1 \Rightarrow v_2 = m_1 \sqrt{\frac{2 G}{m_1 + m_2} \frac{r_1 - r_2}{r_1 r_2}}$$

$$v_1 = 2 \cdot 10^3 \sqrt{\frac{2 \cdot 6,67 \cdot 10^{11}}{6,67 \cdot 10^3} \frac{2-1}{2 \cdot 1}} = 2 \cdot 10^3 \sqrt{10^8} \Rightarrow v_1 = 2 \cdot 10^{-7} \text{ m/s}$$

$$v_2 = 4,67 \cdot 10^3 \sqrt{\frac{2 \cdot 6,67 \cdot 10^{11}}{6,67 \cdot 10^3} \frac{2-1}{2 \cdot 1}} \Rightarrow v_2 = 4,67 \cdot 10^{-7} \text{ m/s}$$

12ο κείμενο θεωρήσεων  
Δυαγύρη εξέργασης

1

Θεώρηση A

A-1)  $V = k \frac{q_1 q_2}{r} < 0 \Rightarrow q_1, q_2 < 0$ , η θεώρηση είναι σωστή.

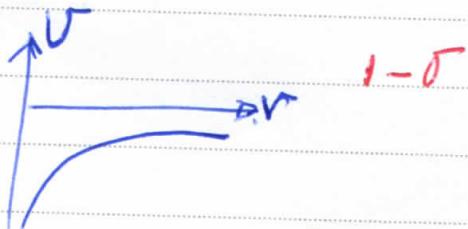


Α - 19'00ς ούτε η δύναμη είναι σωστή

Β - 10'90ς  $WF_{\infty} < 0$

Γ - 3'08'00ς,  $V = k \frac{q}{r}$

Δ - 6'08'00ς



A-2)  $V = k \frac{q_1 q_2}{r} = 0,08 > 0, q_1, q_2 > 0$ , η θεώρηση είναι σωστή.

Α - 10'00ς ούτε η θεώρηση είναι σωστή

Β - 10'90ς  $W_{ext} = V = 0,08 J$ ,  $W_{int} = -0,08 J$

Γ - 3'08'00ς

Δ - 10'00'00ς

2-8

A-3  $V = k \frac{q_1 q_2}{r} < 0 \Rightarrow q_1 < 0, q_2 > 0$

Α - 19'00ς

Β - 10'00ς

Γ - 3'08'00ς  $V_A = \frac{V}{q_1} = \frac{-12000 J}{-2 \cdot 10 C} = 6 \cdot 10 \cdot 10^6 = 6000 V$



Δ - 10'00ς  $V_B = \frac{V}{q_2} < 0$

3-8

$$A \cdot 4 \quad U = k_e \frac{q_1 q}{r} + k_e \frac{q_2 q}{r} + k_e \frac{q_3 q}{r} = 3 k_e \frac{q^2}{r}$$

4-a

Gesamt 70 (a)

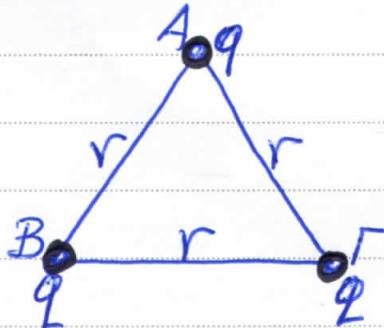
$$A \cdot 5 \quad \alpha-1, \theta-1, \gamma-\bar{\epsilon}, \delta-\Sigma, \varepsilon-\Sigma$$

DEl &amp; B

B-1)

$$U = 3 k_e \frac{q^2}{r} = 9 \cdot 10^3 J$$

$$V_A = k_e \frac{q}{r} + k_e \frac{q}{r} = 2 k_e \frac{q}{r}$$



$$\frac{V_A}{U} = \frac{2 k_e q / r}{3 k_e q^2 / r} = \frac{2}{3} \frac{1}{q} + V_A = \frac{2}{3} \frac{U}{q}$$

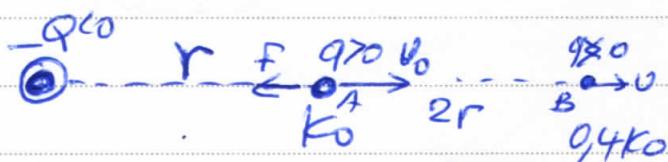
$$\Rightarrow V_A = \frac{2}{3} \frac{9 \cdot 10^3}{10^6} = 6 \cdot 10^3 V \quad \text{denn sonst oxesn (a)}$$

$$U = 3 k_e \frac{q^2}{r} = 9 \cdot 10^3 \Rightarrow k_e \frac{q}{r} = \frac{U}{3q} = \frac{9 \cdot 10^3}{3 \cdot 10^6} = 3 \cdot 10^{-3}$$

$$V_A = 2 k_e \frac{q}{r} = 2 \cdot 3 \cdot 10^{-3} = 6 \cdot 10^3 V$$

(x)

B-2)



$$U_{\text{dipole}} = U + k_0 = -k_e \frac{|Qq|}{r} + k_0 = -k_e \frac{|Qq|}{2r} + 0,4 k_0$$

$$\Rightarrow 0,6 k_0 = k_e \frac{|Qq|}{r} - k_e \frac{|Qq|}{2r} \Rightarrow 0,6 k_0 = \frac{1}{2} k_e \frac{|Qq|}{r} \Rightarrow k_e \frac{|Qq|}{r} = 1,2 k_0$$

→ spona δvroyki 6mv siox 14y; na m'6/126y

$$U_{\text{dipole}} = -k_e \frac{|Qq|}{r} = -1,2 k_0$$

	πολιτική	απόδοση $r$	πρόβλημα $x$	αύξεση $\rightarrow \infty$
$U$ (Πονογία)	-1,2k0	-0,6k0	-0,1k0	0
$K$ (Επιτέλη)	k0	0,4k0	0	-0,2k0
$E$ (Μηχνίκη)	-0,2k0	-0,2k0	-0,2k0	-0,2k0

a) Τοποθετήστε στην εξίσωση την  $E_{yx}(0) = E_{yx}(\text{πονογία})$ ,  
 $\Rightarrow E_{yx}(\infty) = -0,2k0$  και  $U_0 + k_0 = -0,1k0 \Rightarrow \frac{2k0}{2} = 0$

$k_0 = -0,1k0 / 2 = -0,05k0$ , που δεν φέρει  
 $\hookrightarrow$  συμβολικό

b) Τοποθετήστε στην εξίσωση  $X$  την  $E'_{yx} = E_{yx}(\text{πονογία}) = -0,2k0 \Rightarrow U' + K' = -0,2k0$

$$\xrightarrow{k=0} U' = -0,2k0 \Rightarrow -k_c \frac{|Qg|}{X} = -0,2k0 \quad \left. \right\}$$

$$\text{Στη γεγ. } U' = -k_c \frac{|Qg|}{r} = -1,2k0 \quad \left. \right\}$$

$$\frac{-k_c \frac{|Qg|}{X}}{-k_c \frac{|Qg|}{r}} = \frac{-0,2k0}{-1,2k0} \Rightarrow \frac{r}{X} = \frac{1}{6} \Rightarrow X = 6r$$

$$\Rightarrow X = 6 \cdot 0,2m \Rightarrow \underline{\underline{X = 1,2m}}$$

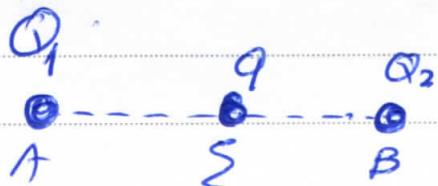
Υπόθεση

Thetaförf

$$A: Q_1 = 4 \text{ C}$$

$$B: Q_2 = 1 \text{ C} \quad m = 2 \cdot 10^3 \text{ g}$$

$$r = 1 \text{ m}$$



$$F1) U = k_c \frac{Q_1 q}{r} + k_c \frac{Q_1 q}{r_1} + k_c \frac{Q_2 q}{r_2} = 0 \Rightarrow k_c \frac{Q_1 q}{r} + 2k_c \frac{Q_1 q}{r_1} + 2k_c \frac{Q_2 q}{r_2} = 0$$

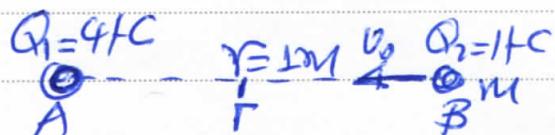
$$\Rightarrow Q_1 Q_2 + 2 Q_1 q + 2 Q_2 q = 0 \Rightarrow 2q(Q_1 + Q_2) = -Q_1 Q_2 \Rightarrow q = -\frac{Q_1 Q_2}{2(Q_1 + Q_2)}$$

$$\Rightarrow q = -\frac{4 \cdot 10^6 \cdot 1 \cdot 10^6}{2 \cdot 5 \cdot 10^6} \text{ m} \quad q = -0.4 \cdot 10^6 \text{ C} \quad \underline{\underline{q = -0.4 \text{ C}}}$$

$$F2) U = k_c \frac{Q_1 q}{r_1} + k_c \frac{Q_2 q}{r_2} = \frac{2k_c q}{r} (Q_1 + Q_2)$$

$$\Rightarrow U = 2 \cdot 9 \cdot 10^9 \cdot \frac{-0.4 \cdot 10^6}{1 \text{ m}} \text{ Si} \text{C} \quad \underline{\underline{U = -26 \cdot 10^3 \text{ Joule}}}$$

F3)



$$U_{\text{ext}} + K_{\text{ext}} = U_{\text{fg}} \Rightarrow k_c \frac{Q_1 q}{r} + \frac{1}{2} m v_0^2 = k_c \frac{Q_1 q}{r_1}$$

$$\frac{1}{2} m v_0^2 = k_c \frac{Q_1 q}{r} - k_c \frac{Q_1 q}{r_1} \Rightarrow \frac{1}{2} m v_0^2 = k_c \frac{Q_1 q}{r} \Rightarrow v_0 = \sqrt{\frac{2 k_c Q_1 q}{m r}}$$

$$\Rightarrow v_0 = \sqrt{\frac{2 \cdot 9 \cdot 10^9 \cdot 4 \cdot 10^6 \cdot 10^3}{2 \cdot 5 \cdot 10^6 \cdot 1 \text{ m}}} \Rightarrow \boxed{v_0 = 6 \text{ m/s}}$$

F4)   
  $\rightarrow$  max \$\theta\$  $\rightarrow r \rightarrow 0$   $\Rightarrow U = 0$

$$U_{\text{ext}} + K_{\text{ext}} = U_{\text{fg}} + K_{\text{fg}} \Rightarrow \frac{1}{2} m v_0^2 + k_c \frac{Q_1 q}{r} = 0 + \frac{1}{2} m v_{\infty}^2$$

$$v_{\max} = \sqrt{v_0^2 + \frac{2k_e Q_1 Q_2}{mv}} = \sqrt{6^2 + \frac{2 \cdot 9 \cdot 10^9 \cdot 4 \cdot 10^6 \cdot 1 \cdot 10^6}{2 \cdot 10^3 \cdot 1}} \Rightarrow v_{\max} = 672 \text{ m/s}$$

$\frac{\partial \delta / \alpha \Delta}{L=2m} \quad \varphi = 37^\circ$ $Q = +61C$ $\sum Q = 11C \quad m = 8 \cdot 10^3 \text{ kg}$	D. 1. $V = k_e \frac{Qq}{L} = 9 \cdot 10^9 \cdot \frac{6 \cdot 10^6 \cdot 1 \cdot 10^6}{2m} \Rightarrow$ $\Rightarrow V = 27 \cdot 10^3 \text{ J} \quad \checkmark$
---	--

$\Delta 2) \quad F_C = k_e \frac{Qq}{L^2} = 9 \cdot 10^9 \cdot \frac{6 \cdot 10^6 \cdot 1 \cdot 10^6}{4} \Rightarrow F_C = 135 \cdot 10^3 \text{ N}$ $B_x = mg \sin \varphi = 8 \cdot 10^3 \cdot 10 \cdot 0,6 = 54 \cdot 10^3 \text{ N}$	$\left. \begin{array}{l} B_x > F_C \\ \text{Zur Sicherstellung} \end{array} \right\}$
---	---

$\cancel{\Delta 2} \quad k_e \frac{Qq}{L} + mg \sin \varphi = k_e \frac{Qq}{d} + mg \sin \varphi \Rightarrow$ $\Rightarrow 8 \cdot 10^9 \frac{6 \cdot 10^6 \cdot 10^6}{2} + 8 \cdot 10^3 \cdot 10 \cdot 2 \cdot 0,6 = 8 \cdot 10^9 \frac{6 \cdot 10^6 \cdot 10^6}{d} + 8 \cdot 10^3 \cdot 10 \cdot d \cdot 0,6$ $\Rightarrow 27 \cdot 10^3 + 108 \cdot 10^3 = \frac{54 \cdot 10^3}{d} + 54d \cdot 10^3$ $135 = \frac{54}{d} + 54d \Rightarrow 135d = 54 + 54d^2$	
---	--

$\cancel{\Delta 2} \quad 54d^2 - 135d + 54 = 0$ $d = \frac{135 \pm 81}{2 \cdot 54}$ $\Rightarrow d = \frac{-7,5 \pm 1,5}{2} - 9 \text{ m}$ $0,75 \text{ m}$	$\Delta = 135^2 - 4 \cdot 54 \cdot 54$ $\sqrt{\Delta} = 81$ $\Delta = 375^2 - 4$ $\Delta = 675 - 4 = 725$ $\sqrt{\Delta} = 27,5$
--	--

$89 \text{ um m} \quad d = 0,5 \text{ m} \quad \checkmark$

$$\Delta-3 \quad \text{dmax} \text{ dTAN } 9\Gamma x = 0 \Rightarrow F_c = Bx \Rightarrow k_c \frac{Qq}{y^2} = m_f y_{\text{MKEP}}$$

$$\Rightarrow \sqrt{8 \cdot 10^8 \frac{6 \cdot 10^6 \cdot 10^6}{y^2}} = 8 \cdot 10^3 \cdot 10 = 0,6 \cdot$$

$$\Rightarrow \frac{6}{y^2} = 6 \Rightarrow \boxed{y = 1 \text{ m}}. \quad \checkmark$$

$$\Delta-4 \quad k_c \frac{Qq}{L} + m_f L m_f v = k_c \frac{Qq}{y} + m_f y_{\text{MKEP}} + k_{\text{max}}$$

$$8 \cdot 10^8 \frac{6 \cdot 10^6 \cdot 10^6}{2} + 8 \cdot 10^3 \cdot 10 \cdot 2 \cdot 0,6 = 8 \cdot 10^8 \frac{6 \cdot 10^6}{4} + 8 \cdot 10^3 \cdot 10 \cdot 1 \cdot 0,6 \text{ Fmax}$$

$$\Rightarrow 27 \cdot 10^3 + 108 \cdot 10^3 = 84 \cdot 10^3 + 84 \cdot 10^3 + k_{\text{max}}$$

$$k_{\text{max}} = 27 \cdot 10^3 \text{ N/m}. \quad \checkmark$$

$$k_{\text{max}} = \frac{1}{2} m v_{\text{max}}^2 + v_{\text{max}} \sqrt{\frac{2 E_{\text{max}}}{m}}$$

$$= v_{\text{max}} = \sqrt{\frac{2 \cdot 27 \cdot 10^3}{9 \cdot 10^3}} \Rightarrow \underline{v_{\text{max}} = \sqrt{6} \text{ m/s}} \quad \checkmark$$

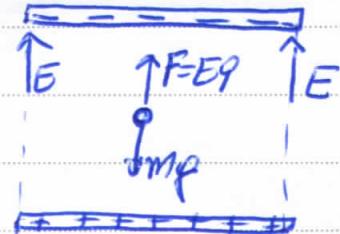
Οργάνωσης της Επιφανείας πεδίου - Πυκνωτής

Θέμα A!

A-1:  $\delta$ , A-2:  $\delta$ A-3: Απόκτα  $\sum F = 0 \Rightarrow E\delta = mg \Rightarrow E = \frac{mg}{\delta}$ 

$$\text{Μετά } \sum F = 4mg - E\delta q = 4mg - \frac{mg}{\delta} \cdot 7q = 2mg$$

$$\alpha = \frac{\delta F}{4m} = \frac{2mg}{4m} = 0.5g$$



Από δύοντα στο (a)

A-4

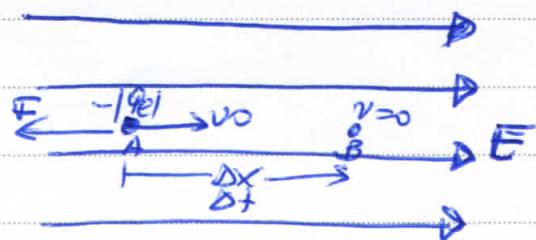
Q-1

B:  $\vec{F}\Delta t = \vec{P} \Rightarrow$ 

$$\Rightarrow -F\Delta t = 0 - mv_0$$

$$-E/q_{el}\Delta t = -mv_0 \Rightarrow \Delta t = \frac{mv_0}{E/q_{el}}$$

Ζετόμενος



Γ. Τα δύο φυσικά φενόνευτα αντέτην για την γενική του

Προστατευτικά μεταβολή  $v_A > v_B \Rightarrow -E/q_{el}/v_A > -E/q_{el}/v_B$ 

$$\Rightarrow -v_A > -v_B \Rightarrow v_A < v_B \Rightarrow v_B > v_A$$

ζετόμενος

$$\delta. \Delta t = v_0 \Delta x \Rightarrow 0 - v_0 = -E/q_{el} \cdot \Delta x \Rightarrow \Delta x = \frac{v_0}{E/q_{el}}$$

Από δύοντα στο δ

A-5 Q-1, B-Σ  $\rightarrow$  Γ-1, Δ-Σ, Ε-ΣΔ. Χρόνος σύστασης  $t = \frac{L}{v_0}$  θετείται στην γενική

$$\epsilon: \epsilon = \frac{F}{m} = \frac{E\delta}{m}$$

Theta B

B-1

$$x = v_0 + \frac{tef}{L} \frac{L}{v_0}$$

$$y = \frac{1}{2} \alpha t^2 = \frac{1}{2} \frac{F}{m} t^2 = \frac{1}{2} \frac{Eg}{m} t^2$$

$$\Rightarrow y = \frac{1}{2} \frac{Vg}{m} t^2 \Rightarrow H = \frac{1}{2} \frac{V}{m} \frac{g}{m} \cdot \frac{L^2}{v_0^2}$$

$$\Delta K = WF = q \Delta V = q \cdot EY = q \cdot \frac{V}{d} Y = \frac{q}{d} \frac{V}{d} \cdot L \cdot \frac{q}{m} \frac{L^2}{m v_0^2} = \frac{1}{2} \frac{V^2}{d^2} \frac{q^2}{m} \frac{L^2}{v_0^2}$$

$$\Delta K = \frac{1}{2} m \omega^2 - \frac{1}{2} m \omega^2 = \frac{1}{2} m (v_0^2 + v_y^2) - \frac{1}{2} m \omega^2 \Rightarrow \Delta K = \frac{1}{2} m v_y^2$$

$$\Rightarrow \Delta K = \frac{1}{2} m (\alpha t)^2 = \frac{1}{2} m \alpha^2 t^2 = \frac{1}{2} m \frac{E^2 g^2}{m^2} \cdot \frac{L^2}{v_0^2}$$

$$\Rightarrow \Delta K = \frac{1}{2} m \frac{V^2}{d^2} \frac{q^2}{m} \frac{L^2}{v_0^2}$$

a)  $\Delta K = \pi \alpha \delta / d \quad \text{and} \quad v_y = \alpha t = \frac{Eg}{m} t = \frac{V}{d} \frac{q}{m} t = \frac{V}{d} \frac{q}{m} \frac{L}{v_0}$

Sind die beiden gleichsetzen

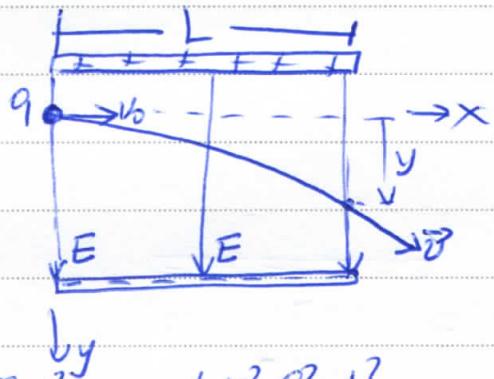
$$\text{für } v_y \Rightarrow \Delta K = \frac{1}{2} m v_y^2$$

$$\text{und da man kennt } \Delta K = \frac{1}{2} \frac{V^2}{d^2} \frac{q^2}{m} \frac{L^2}{v_0^2}$$

$$\Delta K = \alpha \times \alpha \cdot \left( \frac{L}{v_0} \right)^2 \quad \Rightarrow \quad \Delta K = \alpha \cdot \frac{L^2}{v_0^2}$$

b)  $y = \frac{1}{2} \frac{V}{d} \frac{q}{m} \frac{L^2}{v_0^2}$

$$y = \frac{1}{2} \frac{2V}{d} \frac{q}{m} \frac{L^2}{4v_0^2} = \frac{1}{2} y = 0,5 y$$



aus der Befehls

B-2

$$\frac{1}{2}mv^2 - 0 = WF = -|q| (V_A - V_B)$$

$$\frac{1}{2}mV = -|q|(-V)$$

$$V = \sqrt{\frac{2|q|V}{m}}$$

$$V' = \sqrt{\frac{2|q|V'}{m}}$$

$$V' = 2V \Rightarrow V'^2 = 4V^2 \Rightarrow \frac{2|q|V'}{m} = 4 \frac{2|q|V}{m}$$

$$4V' = 4V \Rightarrow V'^2 = 16V^2$$

$$\Rightarrow \frac{1}{2}Cv'^2 = \frac{1}{2}C \cdot 16V^2$$

$$\Rightarrow \underline{V' = 16V}$$

? ApaGwG 70 (5).

OE! / aF!

$$l = 0,20 \text{ m}$$

$$L = 0,18 \text{ m}$$

$$m = 0,016 \text{ g}$$

$$q = 1 \text{ N/C}$$

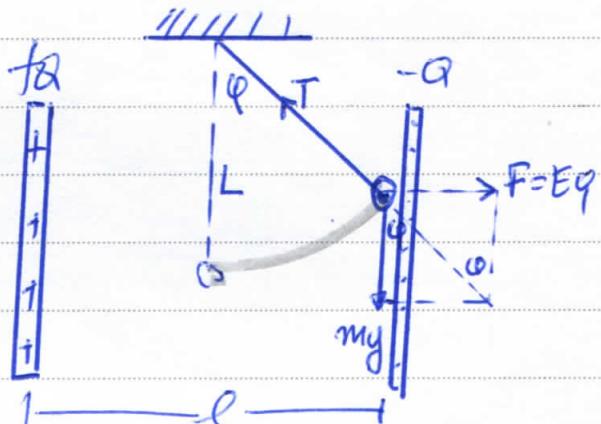
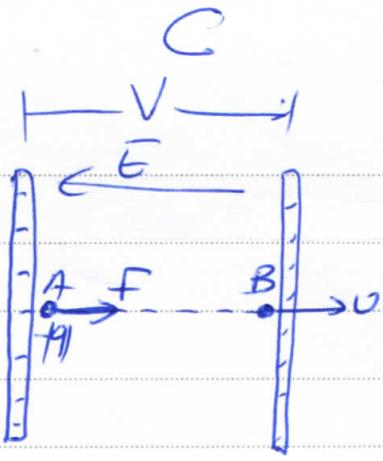
$$\Gamma-1) \quad E + q\varphi = \frac{E|q|}{mg} = 1 \Rightarrow E|q| = mg$$

$$\Rightarrow E = \frac{mg}{|q|} = \frac{10 \cdot 10}{10^6} \Rightarrow E = 10^5 \frac{V}{m}$$

$$\Gamma-2) \quad V = E \varrho = 10^5 \frac{V}{m} \cdot 0,2 \text{ m} = 2 \cdot 10^4 \text{ V}, \quad C = \frac{Q}{V} = \frac{80 \cdot 10^{-6}}{2 \cdot 10^4} \Rightarrow C = 40 \cdot 10^{-10}$$

$$\Rightarrow C = 4 \cdot 10^{-9} \text{ F} \quad \text{et} \quad C = 4 \text{ nF}$$

$$\Gamma-3) \quad V' = \frac{3}{4} V \Rightarrow E' \varrho = \frac{1}{4} E l \Rightarrow E' = \frac{3E}{4} = \frac{3 \cdot 10^5}{4} \frac{V}{m}$$



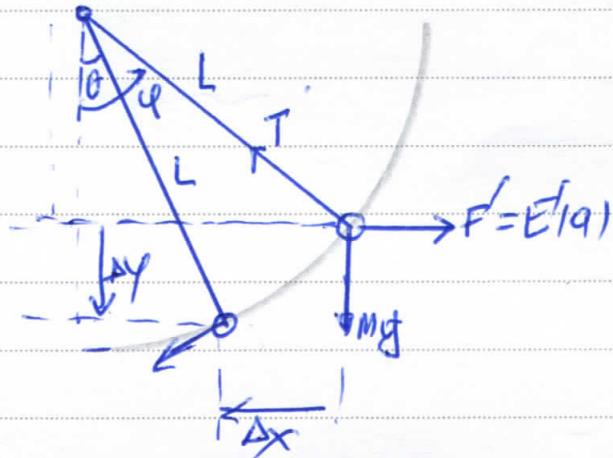
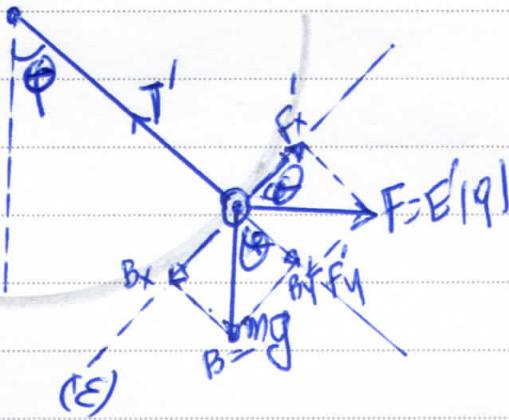
$$\sum F_x = 0 \Rightarrow$$

$$B_x = F_x \Rightarrow$$

$$m g \sin \vartheta = E' / q / 6 \sin \vartheta$$

$$\frac{m g \sin \vartheta}{m g} = \frac{E' / q}{m g} \Rightarrow$$

$$E' \sin \vartheta = \frac{E' / q}{m g} \Rightarrow E' \sin \vartheta = \frac{3 \cdot 10^5 \cdot 10^6}{10^3 \cdot 10} = 0,75 \Rightarrow \underline{\vartheta = 37^\circ}$$



$$\Delta y = L \sin \vartheta - L \sin \varphi = L (0,8 - 0,7) = 0,18 \text{ m} = 0,018 \text{ m}$$

$$\Delta x = L \cos \vartheta - L \cos \varphi = L (0,7 - 0,6) = 0,018$$

$$\Delta K = W_B + W_F \Rightarrow \frac{1}{2} m v_{max}^2 = m g \Delta y - E' / q / \Delta x$$

$$\Rightarrow v_{max}^2 = 2 g \Delta y - 2 \frac{E' / q / \Delta x}{m}$$

$$= 2 \cdot 10 \cdot 18 \cdot 10^{-3} - \frac{2 \cdot 3 \cdot 10^5 \cdot 10^6 \cdot 18 \cdot 10^{-3}}{10^{-2}} = 36 \cdot 10^{-2} - 27 \cdot 10^{-2}$$

$$= 9 \cdot 10^{-2} \Rightarrow \boxed{v_{max} = 0,3 \text{ m/s}}$$

$$\text{F.4} \quad \text{SFK} = m a \Rightarrow T' - P_y - F_y = m \frac{v_{max}^2}{L}$$

$$\Rightarrow T' = mg \sin \theta + E/9/m \cdot \theta + m \frac{v_0^2}{L}$$

$$\Rightarrow T' = 10^7 \cdot 10 \cdot 0,8 + \frac{3}{4} \cdot 10^5 \cdot 10^6 \cdot 0,6 + 10^7 \cdot \frac{0,09}{0,18}$$

$$\Rightarrow T' = 8 \cdot 10^7 + 4,5 \cdot 10^2 + 0,5 \cdot 10^2 \Rightarrow \underline{T' = 11 \cdot 10^7 \text{ N}}$$

DE für D!

$$L = 10 \text{ m}$$

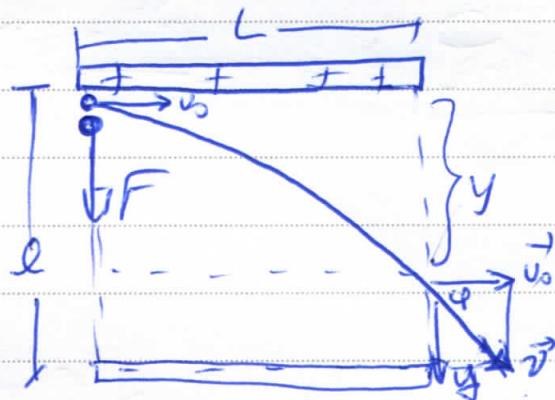
$$l = 0,10 \text{ m}$$

$$m = 10^6 \text{ kg}$$

$$q = 1 \text{ FC}$$

$$v_0 = 400 \text{ m/s}$$

$$G = 4 \text{ G}$$



$$\Delta-1) \quad m_y = m v_0 \sin \theta \Rightarrow v_1 > 0 \Rightarrow \alpha t = 40 \Rightarrow \alpha \frac{L}{v_0} = E$$

$$\Rightarrow \alpha = \frac{v_0^2}{L} \Rightarrow \alpha = \frac{16 \cdot 10^4}{0,10} \Rightarrow \alpha = 10^6 \text{ rad/s}$$

$$\Delta-2) \quad F = m a \Rightarrow E q = m a \Rightarrow E = \frac{m a}{q} = \frac{10^6 \cdot 10^6}{10^6} \Rightarrow E = 10^6 \text{ Nm}$$

$$V = E \cdot l = 10^6 \frac{\text{N}}{\text{m}} \cdot 0,10 \text{ m} \Rightarrow V = 10^7 \text{ Volt}$$

$$Q = C V = 10 \cdot 10^{-12} \cdot 10^7 \Rightarrow Q = 10^6 \text{ C} \Rightarrow \underline{Q = 1 \text{ FC}}$$

$$\Delta-3) \quad \Delta U = -W_F = -E/9 \cdot y \Rightarrow \cancel{E/9 \cdot \frac{1}{2} \alpha t^2}$$

$$y = \frac{1}{2} \alpha t^2 = \frac{1}{2} \alpha \left( \frac{L}{v_0} \right)^2 = \frac{1}{2} \cdot 10^6 \cdot \left( \frac{0,10}{400} \right)^2 = \frac{1}{2} \cdot 10^6 \cdot \left( \frac{10 \cdot 10^{-2}}{4 \cdot 10^2} \right)^2$$

$$= \frac{1}{2} \cdot 10^6 \cdot 16 \cdot 10^{-8} = 8 \cdot 10^2 \text{ m}$$

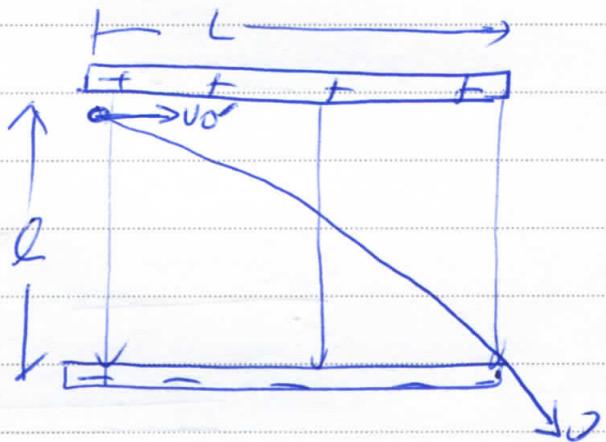
$$\text{für } \Delta U = -E/9 \cdot y = -10^6 \cdot 10^6 \cdot 8 \cdot 10^{-2} \Rightarrow \underline{\Delta U = -0,08 J}$$

D-4

$$y = \frac{1}{2} \alpha t^2 = l$$

$$\Rightarrow \frac{1}{2} \frac{Eq}{m} \left( \frac{l}{v_0} \right)^2 = l$$

$$\frac{1}{2} \cdot \frac{10^6 \cdot 10^6}{10^6} \left( \frac{0,16}{v_0} \right)^2 = 0,1$$



$$10^6 \cdot \frac{10^2 \cdot 10^{-4}}{v_0^2} = 0,2 \Rightarrow v_0^2 = \frac{10^2}{0,2} \cdot 10^{-2}$$

$$\Rightarrow v_0^2 = 128000 \Rightarrow \underline{y = 357,78 \text{ m/s}}$$

14<sup>ο</sup> κείμενο έργων  
Βαρυτικό πεδίο

-13-

Θέμα A!

- |                         |      |
|-------------------------|------|
| 1- [α-1, β-1, γ-1, δ-ε] | 1- δ |
| 2- [α-1, β-1, γ-ε, δ-1] | 2- γ |
| 3- [α-1, β-1, γ-ε, δ-1] | 3- γ |
| 4- [α-ε, β-1, γ-1, δ-1] | 4- α |
| 5. [α-1, β-ε, γ-ε, ε-ε] | 5- ε |

Θέμα B!

B-1.

$$a) \quad U_{0,\delta} = \sqrt{2G \frac{M_r}{R_r}} \quad U_{1,R} = \sqrt{2G \frac{M_r}{R_r + h}}$$

$$U_{1,R} = \frac{U_{0,\delta}}{2} \Rightarrow U_{1,R}^2 = \frac{U_{0,\delta}^2}{4} \Rightarrow 2G \frac{M_r}{R_r + h} = \frac{1}{4} 2G \frac{M_r}{R_r}$$

$$\Rightarrow R_r + h = 4R_r \Rightarrow h = 3R_r \quad \text{από } \alpha-19'005$$

b)

$$U_A + K_A = U_r + K_r \Rightarrow$$

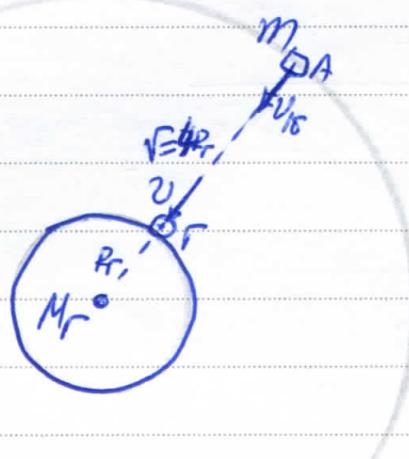
$$-G \frac{M_r m}{4R_r} + \frac{1}{2} m V_r^2 = -G \frac{M_r m}{R_r} + \frac{1}{2} m V_r^2$$

$$\Rightarrow -\frac{3}{4} G \frac{M_r m}{R_r} + \frac{1}{2} m V_r^2 = \frac{1}{2} m V_r^2$$

$$\frac{3}{4} G \frac{M_r m}{R_r} + G \frac{M_r m}{4R_r} = \frac{1}{2} m V_r^2$$

$$\Rightarrow G \frac{M_r m}{R_r} - \frac{1}{2} m V_r^2 = V_r = \sqrt{2G \frac{M_r}{R_r}} = U_{0,\delta}$$

Από  $\alpha-906/η'$



$$B-2 \quad U = \sqrt{G \frac{M_F}{r}}, \quad K = \frac{1}{2} m v^2 \Rightarrow K = \frac{1}{2} G \frac{M_F m}{r}, \quad U = -G \frac{M_F m}{r}$$

$$\frac{U}{K} = \frac{-G M_F m / r}{\frac{1}{2} G M_F m / r} \Rightarrow U = -2K \quad \text{oder} \quad a = 600 \text{ km}$$

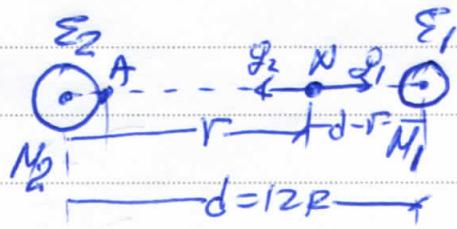
$$E = U + K \Rightarrow E = -2K + K \Rightarrow E = -K, \quad \text{Beweis}$$

Gekör.

$$M_1 = M, N_1 = 4M$$

F.1

$$g_N = 0 \Rightarrow g_1 = g_2 \Rightarrow$$



$$\Rightarrow G \frac{M_1}{(d-r)^2} = G \frac{N_2}{r^2} \Rightarrow \left(\frac{d}{d-r}\right)^2 = \frac{M_2}{M_1} = 4$$

$$\Rightarrow \frac{d}{d-r} = 2$$

$$\frac{d}{d-r} = 2 \Rightarrow r = 2d - 2r \Rightarrow 3r = 2d \Rightarrow r = \frac{2d}{3}$$

$$\Rightarrow r = \frac{2 \cdot 12R}{3} \Rightarrow r = 8R \quad \text{and} \quad d-r = 4R$$

F.2

$$V_N = V_2 + V_1 = -G \frac{M_2}{r} - G \frac{M_1}{d-r} = -G \frac{M_2}{8R} - G \frac{M_1}{4R}$$

$$\Rightarrow V_N = -6,67 \cdot 10^{11} \frac{9,6 \cdot 10^2}{8 \cdot 6,67 \cdot 10^1} - 6,67 \cdot 10^{11} \frac{24 \cdot 10^2}{4 \cdot 6,67 \cdot 10^1}$$

$$\Rightarrow V_N = -12 \cdot 10^8 - 6 \cdot 10^8 \Rightarrow V_N = -18 \cdot 10^8 \text{ J/kg}$$

F.3

$$U_{N+K_N} = U_{00} + K_{00} = 0 \Rightarrow m V_N + \frac{1}{2} m V_D^2 = 0$$

$$\Rightarrow V_D = \sqrt{-2V_N} = \sqrt{-2(-18 \cdot 10^8)} = 6 \cdot 10^4 \text{ m/s}$$

$$\frac{J}{kg} = \frac{Nm}{kg} = \frac{kg \frac{m}{s^2} m}{kg} = \left(\frac{m}{s}\right)^2$$

$$F_4 = -G \frac{M_2}{R} - G \frac{M_1}{11R} = -G \frac{4M}{R} - G \frac{M}{11R} = -G \frac{45M}{11R} = -G 6,67 \cdot 10^{11} \frac{45 \cdot 24 \cdot 10^2}{11 \cdot 6,67 \cdot 10^1}$$

$$\Rightarrow F_A = -\frac{1080}{11} 10^8 \text{ N}$$

$$K_N - K_A = m_B \Rightarrow K_N = K_A + m(V_A - V_N) > 0$$

$$\Rightarrow K_A > -m(V_A - V_N) \Rightarrow \frac{1}{2} m V_D^2 > -m(V_A - V_N)$$

$$V^2 > -2 \left( -\frac{1080}{11} + 18 \cdot 10 \right) \cdot 10^8 \Rightarrow V^2 > \frac{1764}{11} \cdot 10^8$$

$$\Rightarrow V > 12,66 \cdot 10^4 \text{ m/s}$$

$\Theta E$  |  $\Theta \Delta$ !

$$\Delta-1) \Delta K_{AF} = W_F + W_B$$

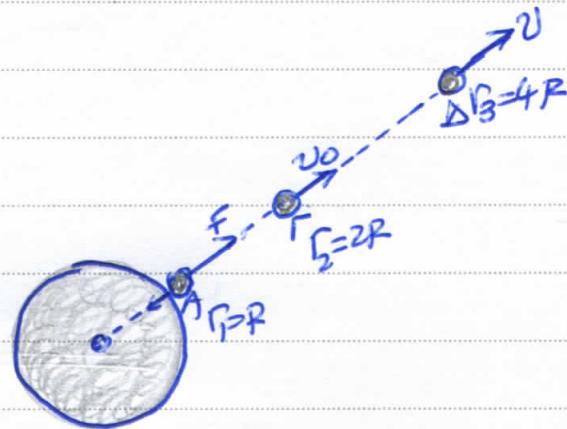
$$\frac{1}{2} m V_0^2 = W_F + m(V_A - V_F)$$

$$\frac{1}{2} m V_0^2 = W_F + m \left[ -G \frac{M_F}{R} + G \frac{M_H}{2R} \right]$$

$$\Rightarrow \frac{1}{2} m V_0^2 = W_F - G \frac{M_H M}{R} + G \frac{M_H m}{2R}$$

$$\Rightarrow \frac{1}{2} m V_0^2 = W_F - \frac{1}{2} G \frac{M_H M}{R} \Rightarrow W_F = \frac{1}{2} m V_0^2 + \frac{1}{2} m \frac{80 P^2}{R} = \frac{1}{2} m V_0^2 + \frac{1}{2} m g R$$

$$\Rightarrow W_F = \frac{1}{2} 2000 \cdot (4 \cdot 13)^2 \cdot 10^6 + \frac{1}{2} 2000 \cdot 10 \cdot 64 \cdot 10^5 \Rightarrow W_F = 48 \cdot 10^9 + 64 \cdot 10^9 \Rightarrow \underline{W_F = 112 \cdot 10^9 \text{ Joule}}$$



$$\Delta-2) K_{\Delta} - K_F = W_B \Rightarrow \frac{1}{2} m V^2 - \frac{1}{2} m V_0^2 = m \left[ -G \frac{M}{2R} + G \frac{M}{4R} \right] = \frac{1}{2} V^2 - \frac{1}{2} V_0^2 = -\frac{GM}{4R}$$

$$\Rightarrow V^2 = V_0^2 - \frac{g_0 R^2}{2R} \Rightarrow V^2 = V_0^2 - \frac{1}{2} g_0 R = V^2 = 48 \cdot 10^6 - \frac{1}{2} 1064 \cdot 10^5 \Rightarrow V^2 = 16 \cdot 10^6$$

$$\Rightarrow V = 4 \cdot 10^3 \text{ m/s} \quad \text{or} \quad V = 4 \text{ km/s}$$

$$\Delta-3) \Sigma_1: \delta \rho v u \phi \delta \rho \phi \quad V_1 = \sqrt{G \frac{M}{4R}} = \sqrt{\frac{g_0 R^2}{4R}} = \frac{\sqrt{g_0 R}}{2} = \frac{\sqrt{10 \cdot 64 \cdot 10^5}}{2} = 4 \text{ km/s}$$

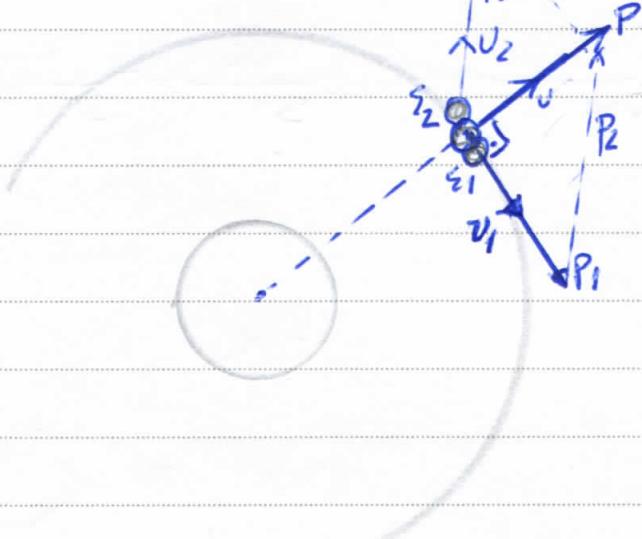
$$\Sigma_2: \text{max}(m) \Rightarrow V_2 = 0$$

$$\vec{P} = \vec{P}_1 + \vec{P}_2 \Rightarrow \vec{P}_2 = \vec{P} - \vec{P}_1$$

$$\Rightarrow P_2 = \sqrt{P^2 + P_1^2} \Rightarrow \frac{mv_1}{2} v_2 = \sqrt{(mv_1)^2 + \left(\frac{mv_1}{2}\right)^2}$$

$$\Rightarrow \frac{v_2}{2} = \sqrt{V^2 + \frac{v_1^2}{4}} \Rightarrow \frac{v_2}{2} = \sqrt{16 + 4}$$

$$\Rightarrow v_2 = 2\sqrt{20} \text{ km/s} \quad \text{or} \quad v_2 = 4\sqrt{5} \text{ km/s}$$



D-4) Parox (m) & Για φυσικό σε νύν  $h=3R$ ,  $R_3=4R$

$$V_{\text{parox}} = \sqrt{2G \frac{M_r}{4R}} = \sqrt{\frac{280R^2}{4R}} = \sqrt{\frac{8R}{2}} = \sqrt{\frac{80 \cdot 64 \cdot 10^3}{2}}$$

$$\Rightarrow V_{\text{parox}} = \frac{8 \cdot 10^3}{\sqrt{2}} = \frac{8\sqrt{2} \cdot 10^3}{2} = 4\sqrt{2} \text{ m/s}$$

Νομοράφτε  $V_2 > V_{\text{parox}}$  σαν ν θέλετε  
εδώ ν είστε λαπούντα.