Часть 1

Олимпиада: **Физика, 11 класс (1 часть)**

Шифр: **21200250**

ID профиля: **165316**

Вариант 8

Чистовик.

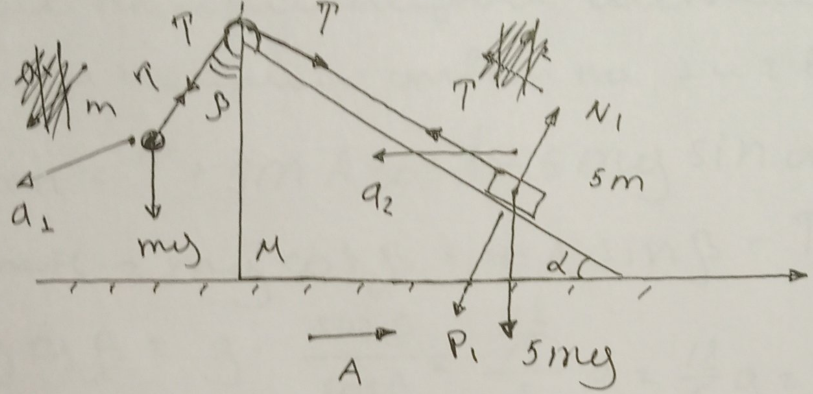
Вариант 11-08.

№1.

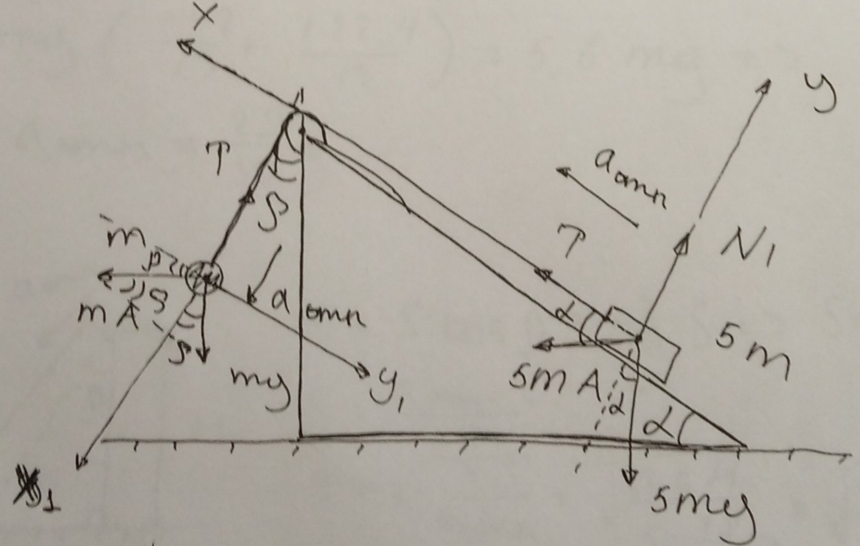
Дано:
$\cos\alpha = \frac{3}{5}$
m
$5m$, H
$\cos\beta = \frac{5}{13}$

A - ?
$a_{отн}$ - ?
τ - ?

Решение:



1) пересядем в Н.С.О., движущуюся вправо ($\rightarrow$) с ускорением A:



2ЗН для бруска:

OX: $5ma_{отн} = T + 5mA\cos\alpha - 5mg\sin\alpha$

~~ОУ~~/

1

Чистовик.

2ЗН для шарика:

$OX_1: \; m a_{отн} = mg\cos\beta + mA\sin\beta - T$

$OY_1: \; mA\cos\beta = mg\sin\beta$

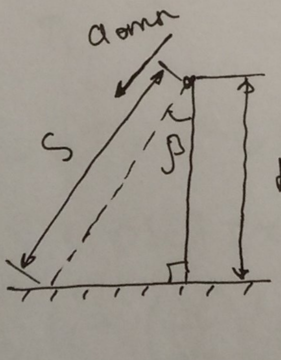
2) Запишем получившуюся систему ур-ний и получим ответ на 1 и 2 вопросы:

$$\begin{cases} 5m a_{отн} = T + 5mA\cos\alpha - 5mg\sin\alpha \\ m a_{отн} = mg\cos\beta + mA\sin\beta - T \\ A = g\,tg\beta = g\cdot\dfrac{\sin\beta}{\cos\beta} = \dfrac{\frac{12}{13}}{\frac{5}{13}}g = \dfrac{12}{5}g = 2{,}4g \end{cases}$$

$$6m a_{отн} = mg(\cos\beta - 5\sin\alpha) + 2{,}4mg(\sin\beta + 5\cos\alpha) = mg\left(\frac{5}{13} - 4\right) + 2{,}4mg\left(\frac{12}{13} + 3\right) = mg\left(\frac{-47}{13} + \frac{122{,}4}{13}\right) = 5{,}8\,mg \Rightarrow$$

$$\Rightarrow a_{отн} = \frac{29}{30}g$$

3)



$H = S\cos\beta = \frac{5}{13}S \Rightarrow S = \frac{13}{5}H$

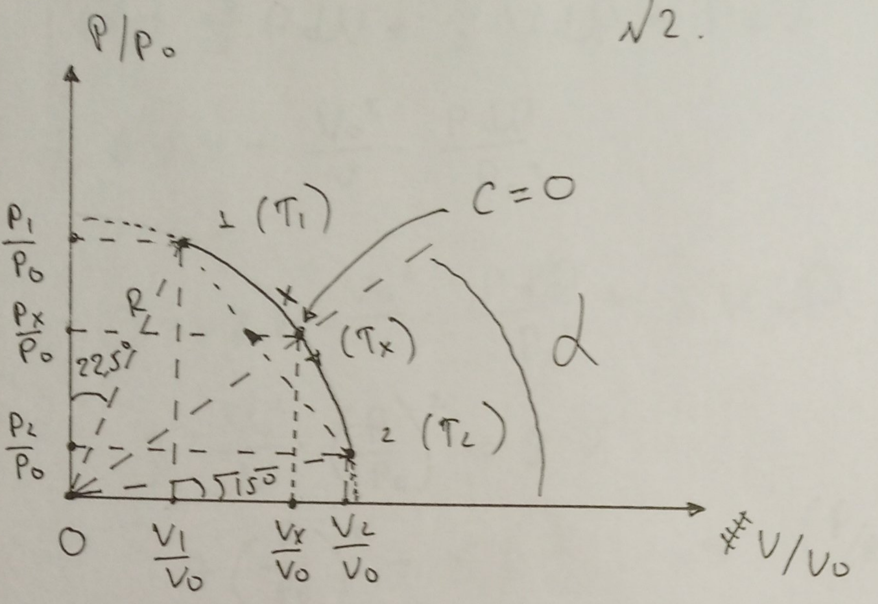
$S = \frac{a_{отн}\tau^2}{2}$

$\tau = \sqrt{\frac{2S}{a_{отн}}} = \sqrt{\frac{26H}{5\cdot\frac{29}{30}g}} = \sqrt{\frac{156H}{29g}}$

Ответ:
1) $A = 2{,}4g$
2) $a_{отн} = \frac{29}{30}g$
3) $\tau = \sqrt{\frac{156H}{29g}}$

Чистовик.

№2.



1) $\begin{cases} \frac{P_1}{P_0} = R\cos 22{,}5^\circ \\ \frac{V_1}{V_0} = R\sin 22{,}5^\circ \\ P_1V_1 = \nu R T_1 \end{cases} \Rightarrow P_0V_0R^2 \sin 22{,}5^\circ \cos 22{,}5^\circ = \nu R T_1 \Rightarrow$

$\Rightarrow T_1 = \frac{P_0V_0R^2}{2\nu R}\sin 45^\circ$

Аналогично получим, что $T_2 = \frac{P_0V_0R^2}{2\nu R}\sin 30^\circ$

$\gamma = \frac{T_1 - T_2}{T_2} = \frac{\sin 45^\circ - \sin 30^\circ}{\sin 30^\circ} = \frac{\frac{\sqrt{2}}{2} - \frac{1}{2}}{\frac{1}{2}} = \sqrt{2} - 1 \approx 0{,}41$

2) $\begin{cases} C\nu\, dT = \frac{5}{2}\nu R\, dT + P\, dV \\ PV = \nu R T \left(\Rightarrow P\,dV + V\,dP = \nu R\, dT\right) \\ \left(\frac{P}{P_0}\right)^2 + \left(\frac{V}{V_0}\right)^2 = R^2 \left(\Rightarrow \frac{P\,dP}{P_0^2} = -\frac{V\,dV}{V_0^2}\right) \\ C = 0 \end{cases}$

Чистовик.

$$\begin{cases} 0 = \frac{5}{2} P dV + \frac{5}{2} V dP + P dV \\ dV = -\frac{V_0^2}{V} \cdot \frac{P dP}{P_0^2} \end{cases}$$

$$0 = -7P \frac{V_0^2}{V} \cdot \frac{P \cancel{dP}}{P_0^2} + 5V \cancel{dP}$$

$$7 \frac{V_0^2}{V} \cdot \left(\frac{P}{P_0}\right)^2 = 5V$$

$$7\left(\frac{P}{P_0}\right)^2 = 5\left(\frac{V}{V_0}\right)^2 \Rightarrow \frac{(P/P_0)}{(V/V_0)} = \sqrt{\frac{5}{7}} = tg\,\alpha \Rightarrow$$

$$\Rightarrow \cancel{tg}\,\alpha = \sqrt{\frac{5}{7}} \Rightarrow \alpha \approx 40^\circ$$

3) • на участке 1-X к газу подводят тепло:

$$Q_н = \frac{5}{2} \nu R (T_x - T_1) + A_1 \quad (Q_н > 0)$$

• на участке X-2 ~~от~~ газа отводят тепло:

$$Q_{от} = \frac{5}{2} \nu R (T_2 - T_x) + A_2 \quad (Q_{от} < 0)$$

• ~~на участке 2-1~~ по условию можно считать, что на участке 2-1 газ адиабатически сжимают.

$$\eta = \frac{Q_н + Q_{от}}{Q_н} = \frac{\frac{5}{2}\nu R (T_2 - T_1) + A}{\frac{5}{2}\nu R (T_x - T_1)}$$

$$A = \int_{V_1}^{V_2} P\,dV = \int_{V_1}^{V_2} P_0 \sqrt{R^2 - \left(\frac{V}{V_0}\right)^2}\,dV = \int_{V_2}^{V_2} - P_0 V_0 \left(R^2 - \left(\frac{V}{V_0}\right)^2\right)^{\frac{1}{2}} \cdot$$

$$\cdot\, d\left(R^2 - \frac{V}{V_0}\right) \approx \frac{P_1 + P_2}{2P_0} \cdot \frac{V_2 - V_1}{V_0} \cdot P_0 V_0 =$$

$$= \frac{P_0 V_0}{2} R^2 (\cos 22{,}5^\circ + \sin 15^\circ)(\cos 15^\circ - \sin 22{,}5^\circ)$$

Чистовик.

$$\eta = \frac{\frac{5}{2}\frac{P_0V_0R^2}{2}(\sin 30^\circ - \sin 45^\circ) + \frac{P_0V_0R^2}{2}(\dots)(\dots)}{\frac{5}{2}\frac{P_0V_0R^2}{2}(\sin 2\alpha - \sin 45^\circ)} =$$

$$= \frac{\frac{5}{2}(\sin 30^\circ - \sin 45^\circ) + (\cos 22{,}5^\circ + \sin 15^\circ)(\cos 15^\circ - \sin 22{,}5^\circ)}{\frac{5}{2}(\sin 60^\circ - \sin 45^\circ)} \approx$$

$$\approx \frac{-1 + 2(0{,}92 + 0{,}26)(0{,}97 - 0{,}38)}{5(0{,}98 - 0{,}7)} \approx 0{,}28$$

Ответ: 1) $\gamma = \frac{T_1 - T_2}{T_2} = \sqrt{2} - 1 \approx 0{,}41$

2) $\operatorname{tg}\alpha = \sqrt{\frac{5}{7}}$

3) $$\eta = \frac{5\left(\frac{1}{2} - \frac{\sqrt{2}}{2}\right) + 2(\cos 22{,}5^\circ + \sin 15^\circ)(\cos 15^\circ - \sin 22{,}5^\circ)}{\frac{5}{\cancel{4}}(\sin 80^\circ - \sin 45^\circ)} \approx$$

$\approx 0{,}28.$

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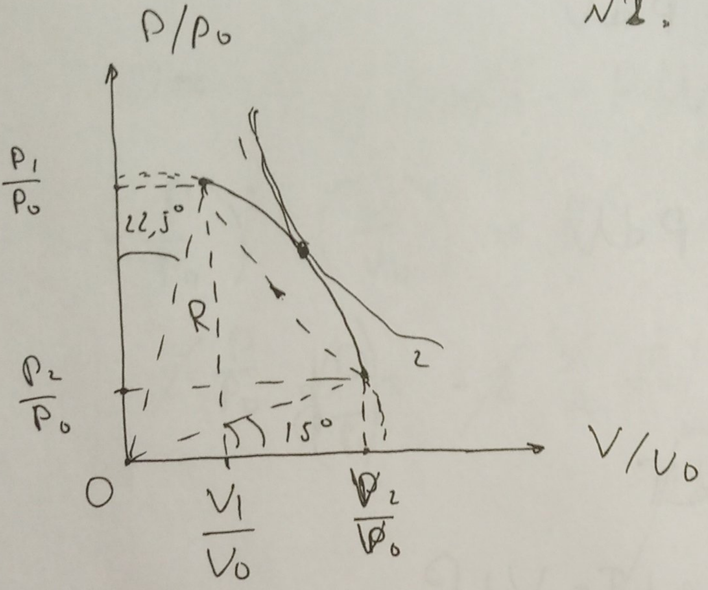
Черновик.

№2.



$$\left(\frac{P}{P_0}\right)^2 + \left(\frac{V}{V_0}\right)^2 = R^2$$

$$\begin{cases} \frac{P_1}{P_0} = R\cos 22{,}5 \\ \frac{V_1}{V_0} = R\sin 22{,}5 \end{cases}$$

$$\begin{cases} \frac{P_2}{P_0} = R\sin 15^\circ \\ \frac{V_2}{V_0} = R\cos 15^\circ \end{cases}$$

$$P_1V_1 = \nu RT_1 = \frac{P_0V_0R^2}{2}\sin 45^\circ$$

$$P_2V_2 = \nu RT_2 = \frac{P_0V_0R^2}{2}\sin 30^\circ$$

$$\frac{T_1 - T_2}{T_2} =$$

Черновик

$$\begin{cases} C\nu\,dT = \frac{5}{2}\nu R\,dT + P\,dV \\ C = 0 \end{cases}$$

$$\begin{cases} 0 = \frac{5}{2}\nu R\,dT + P\,dV \\ PV = \nu R T \end{cases}$$

$$P\,dV + V\,dP = \nu R\,dT$$

$$0 = \frac{5}{2}\nu R\,dT + \nu R\,dT - V\,dP$$

$$\frac{7}{2}\nu R\,dT = V\,dP$$

$$\nu R\,dT = P\,dV + V\,dP$$

$$0 = \frac{5}{2}P\,dV + \frac{5}{2}V\,dP + P\,dV$$

$$\frac{7}{2}P\,dV = -\frac{5}{2}V\,dP \qquad \frac{i+2}{i} = \frac{7}{5}$$

$$\frac{dV}{V} = -\frac{5}{7}\frac{dP}{P}$$

$$VP^{\frac{5}{7}} = const$$

$$PV^{\frac{7}{5}} = const$$

Черновик:

$$0 = \frac{5}{2} \nu R dT + P dV$$

$$\left(\frac{P}{P_0}\right)^2 + \left(\frac{V}{V_0}\right)^2 = R^2$$

$$\cancel{2} \frac{P}{P_0} d\left(\frac{P}{P_0}\right) = -\cancel{2} \frac{V}{V_0} d\left(\frac{V}{V_0}\right) \Rightarrow dV = -\frac{V_0 P\, dP}{V P_0^2}$$

$$0 = \frac{7}{2} P dV + \frac{5}{2} V dP$$

$$dV = -\frac{P}{P_0} \frac{dP}{V}$$

$$0 = -\frac{7}{\cancel{2}} \frac{P^2 \cancel{dP}}{P_0 V} + \frac{5}{\cancel{2}} V \cancel{dP}$$

$$5V = \frac{7P^2}{P_0 V}$$

$$0 = -7P \frac{V_0^2 P \cancel{dP}}{V P_0^2} + 5 V \cancel{dP}$$

$$\cancel{V^2 =} \quad 5\left(\frac{V}{V_0}\right)^2 = 7\left(\frac{P}{P_0}\right)^2$$

Черновик.

$|Q_{+}| = \frac{5}{2}\nu R(T_x - T_1) + A_1$

$|Q_{-}| = \frac{5}{2}\nu R(T_x - T_2) + A_2$

m

$\eta =$

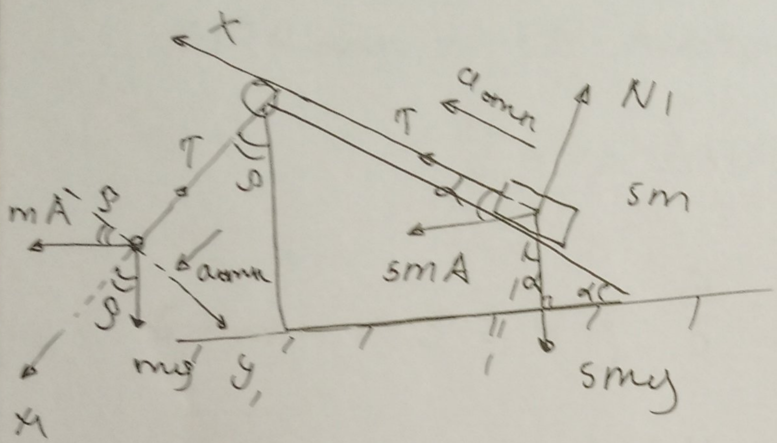
x

$$\left(\frac{P}{P_0}\right)^2 + \left(\frac{V}{V_0}\right)^2 = R^2$$

$$P = \sqrt{R^2 - \left(\frac{V}{V_0}\right)^2}\, P_0$$

Черновик.

5



$$OX: \quad 5m a_{отн} = T + 5m A\cos\alpha - 5mg\sin\alpha$$

$$OX_1: \quad m a_{отн} = mA\sin\beta + mg\cos\beta - T$$

$$OY_1: \quad \cancel{m}A\cos\beta = \cancel{m}g\sin\beta$$

$$A = g\frac{\sin\beta}{\cos\beta} = \frac{\frac{12}{13}}{\frac{5}{13}}g = 2{,}4g$$

$$\cos\beta = \frac{5}{13}; \quad \sin\beta = \sqrt{1-\cos\beta^2} =$$

$$= \frac{\sqrt{13^2-5^2}}{13} = \frac{\sqrt{169-25}}{13} =$$

$$= \frac{\sqrt{144}}{13} = \frac{12}{13}$$

5

Черновик.

$$6ma_{отн} = 5mA\cos\alpha - 5mg\sin\alpha +$$
$$+ mA\sin\beta + mg\cos\beta$$

$$6a_{отн} = 5\cdot 2{,}4g\cdot\frac{3}{5} - 5g\cdot\frac{4}{5} +$$
$$+ 2{,}4\cdot\frac{12}{13}g + g\frac{5}{13} =$$

$$= g\left(7{,}2 - 4 + \frac{28{,}8}{13} + \frac{5}{13}\right) =$$

$$= \left(\frac{33{,}8}{13} + 3{,}2\right)g =$$

$$= \frac{75{,}4}{13}g \Rightarrow$$

$$a = \frac{5{,}8}{6}g = \frac{58}{60}g = \frac{29}{30}g = g$$

Черновик.

$$\left(\frac{P}{P_0}\right)^2 + \left(\frac{V}{V_0}\right)^2 = R^2$$

$$2\frac{P}{P_0}\cdot\frac{dP}{P_0} + 2\frac{V}{V_0}\cdot\frac{dV}{V_0} = 0$$

$$\frac{P\,dP}{P_0^2} = -\frac{V\,dV}{V_0^2} \Rightarrow dV = -\frac{V_0^2}{V}\cdot\frac{P\,dP}{P_0^2}$$

2

21200250 (U165316 M1263769)

Часть 2

Олимпиада: **Физика, 11 класс (2 часть)**

Шифр: **21200250**

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Вариант 8

Чистовик.

Вариант 11-08.

№3.

Дано:

$C_1 = C$

$C_2 = 5C$; R; ε; L

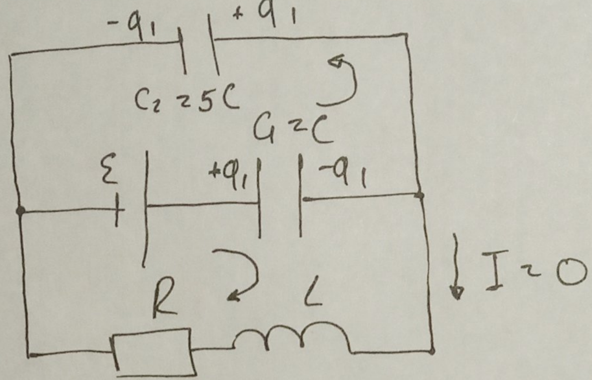
1) $\dfrac{dI_L}{dt}$ - ?

2) Q - ?

3) I_0, U_R - ?

Решение:

1)



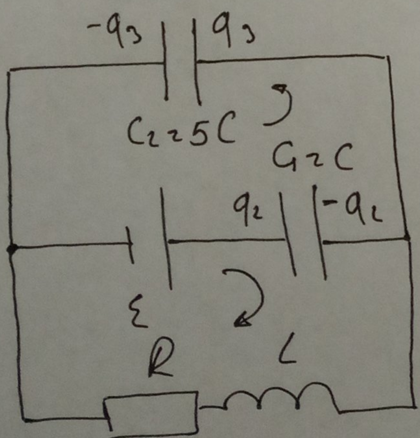
$$\cdot\ \varepsilon = \frac{q_1}{C} + \frac{q_1}{5C} = \frac{6q_1}{5C} \Rightarrow q_1 = \frac{5C\varepsilon}{6} \Rightarrow$$

$$\Rightarrow U_1 = \frac{q_1}{C} = \frac{5\varepsilon}{6}$$

$$\cdot\ \varepsilon = U_1 + L\frac{dI_L}{dt}$$

$$\varepsilon - \frac{5\varepsilon}{6} = L\frac{dI_L}{dt} \Rightarrow \frac{dI_L}{dt} = \frac{\varepsilon}{6L}.$$

2) Установившийся режим после замыкания ключа:



$$\begin{cases} \cdot\ \varepsilon = \dfrac{q_2}{C} + \dfrac{q_3}{5C} \\ \cdot\ \varepsilon = \dfrac{q_2}{C} \end{cases} \Rightarrow$$

$$\Rightarrow q_2 = C\varepsilon \text{ и } q_3 = 0$$

$$\cdot\ A_{ист} = \varepsilon \cdot (q_2 - q_1) = \varepsilon \cdot \left(C\varepsilon - \frac{5C\varepsilon}{6}\right) = \frac{C\varepsilon^2}{6}$$

Чистовик.

• $\Delta W_к = \frac{q_2^2}{2C} - \left(\frac{q_1^2}{2C} + \frac{q_1^2}{2\cdot 5C}\right) = \frac{C^2\mathcal{E}^2}{2C} - \left(\frac{25C^2\mathcal{E}^2}{36\cdot 2\cancel{C}} + \right.$

$\left. + \frac{\overset{5}{\cancel{25}}\, C^2\mathcal{E}^2}{36\cdot 2\cdot \cancel{5}\cancel{C}}\right) = \frac{C\mathcal{E}^2}{2} - \left(\frac{25+5}{36\cdot 2}\cdot C\mathcal{E}^2\right) =$

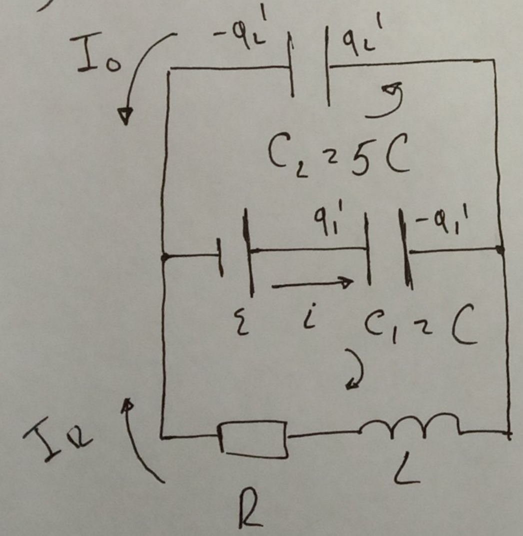
$= \frac{C\mathcal{E}^2}{2} - \frac{\overset{5}{\cancel{30}}}{\underset{6}{\cancel{36}}\cdot 2}\, C\mathcal{E}^2 = \frac{1}{2}C\mathcal{E}^2\left(1 - \frac{5}{6}\right) = \frac{C\mathcal{E}^2}{12}$

• ЗСЭ:

$A_{ист} = Q + \Delta W_к \Rightarrow Q = A_{ист} - \Delta W_к =$

$= \frac{C\mathcal{E}^2}{6} - \frac{C\mathcal{E}^2}{12} = \frac{C\mathcal{E}^2}{12}$

3)



$$\begin{cases} \mathcal{E} = \frac{q_1'}{C} + \frac{q_2'}{5C} \\ I_0 = \frac{dq_2'}{dt} \\ i = \frac{dq_1'}{dt} \\ I_0 + I_R = i \end{cases}$$

$$\begin{cases} 5dq_1' + dq_2' = 0 \\ dq_2' = I_0\,dt \\ dq_1' = (I_0 + I_R)\,dt \end{cases} \Rightarrow$$

$\Rightarrow 5I_0 + 5I_R \mp I_0 = 0 \Rightarrow |I_R| = \frac{6}{5}I_0 \Rightarrow U_R = \frac{6}{5}I_0 R$

Ответ: 1) $\frac{dI_L}{dt} = \frac{\mathcal{E}}{6L}$; 2) $Q = \frac{C\mathcal{E}^2}{12}$; 3) $U_R = \frac{6}{5}I_0 R$.

2

Чистовик.

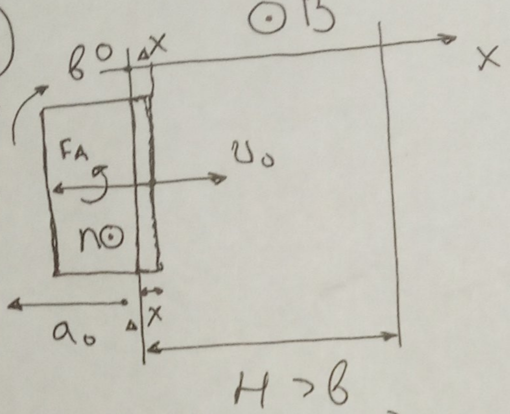
№4.

Дано:
m
$d,\ b = \frac{2d}{3}$
v_0
R
B
$H = 3d$

1) a_0 - ?
2) v_1 - ?
3) v_2 - ?

Решение:

1)



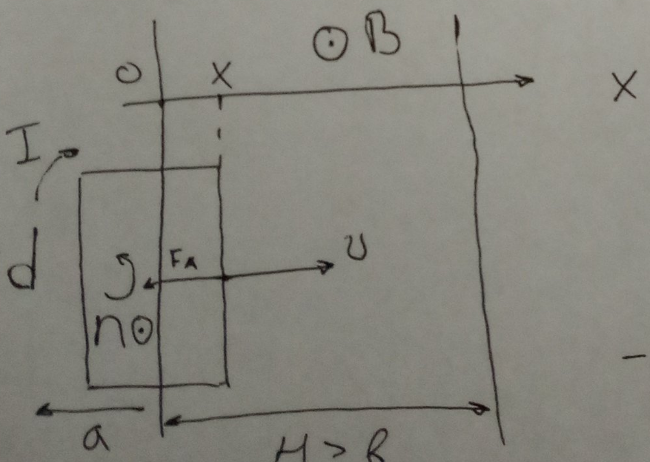
$$\varepsilon = -\frac{d}{dt}(B\cdot d\cdot \Delta x) = -Bdv_0$$

$$-Bdv_0 = -IR \Rightarrow I = \frac{Bdv_0}{R}$$

$$ma_0 = F_A \Rightarrow a_0 = \frac{IBd}{m} = \frac{B^2d^2v_0}{mR}$$

2) · после того как рамка полностью окажется в магнитном поле её скорость перестанет меняться и будет равна v_1.

· рассмотрим произвольный момент заезда рамки в поле:



воспользуемся формулой для ускорения, найденной в пункте 1): $a = \frac{B^2d^2v}{mR}$

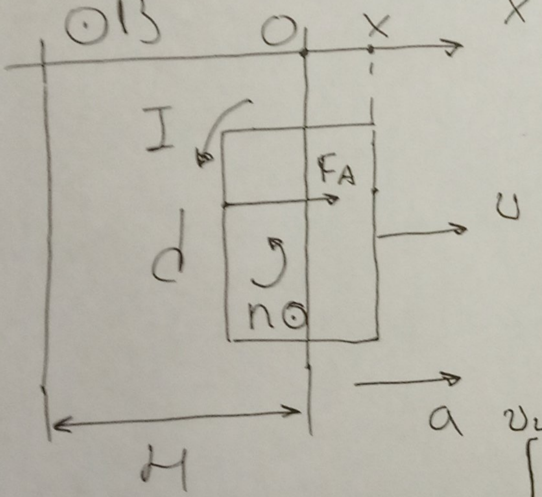
$$-dv = \frac{B^2d^2}{mR}\underbrace{v\,dt}_{dx}$$

Чистовик.

$$-\int_{v_0}^{v_1} dv = \frac{B^2 d^2}{mR}\int_0^{b} dx$$

$$v_0 - v_1 = \frac{2B^2 d^3}{3mR} \Rightarrow v_1 = v_0 - \frac{2B^2 d^3}{3mR}$$

3) рассмотрим произвольный момент выезда рамки из поля:



$$\varepsilon = -\frac{d}{dt}\left(B\cdot d(b-x)\right) = Bdv$$

$$Bdv = IR \Rightarrow I = \frac{Bdv}{R}$$

$$ma = IBd \Rightarrow$$

$$\Rightarrow a = \frac{B^2 d^2 v}{mR}$$

$$\int_{v_1}^{v_2} dv = \frac{B^2 d^2}{mR}\int_0^{b} dx$$

$$v_2 = v_1 + \frac{2B^2 d^3}{3mR} = v_0$$

Ответ: 1) $a_0 = \dfrac{B^2 d^2 v_0}{mR}$

2) $v_1 = v_0 - \dfrac{2B^2 d^3}{3mR}$

3) $v_2 = v_0$

Чистовик.

№5.

Дано:

$l = 25$ см

$\frac{D_1}{D_2} = 5$

1) x - ?

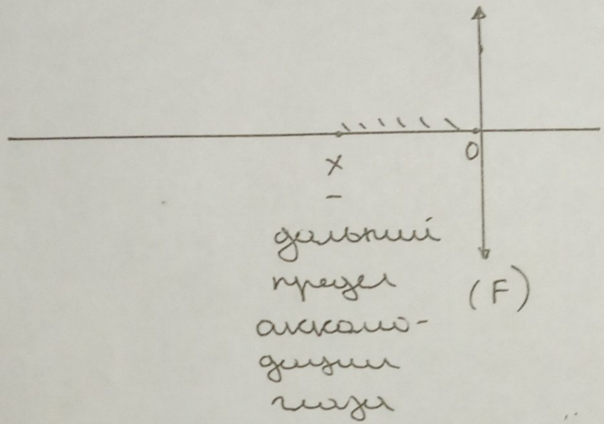
D_1 - ?

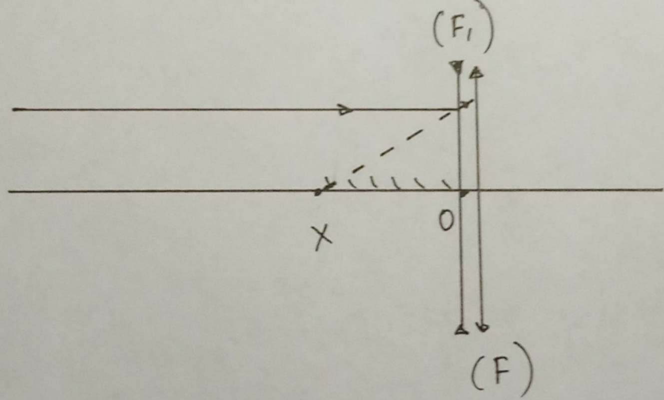
2) $l_1 = 50$ см

D_3 - ?

Решение:

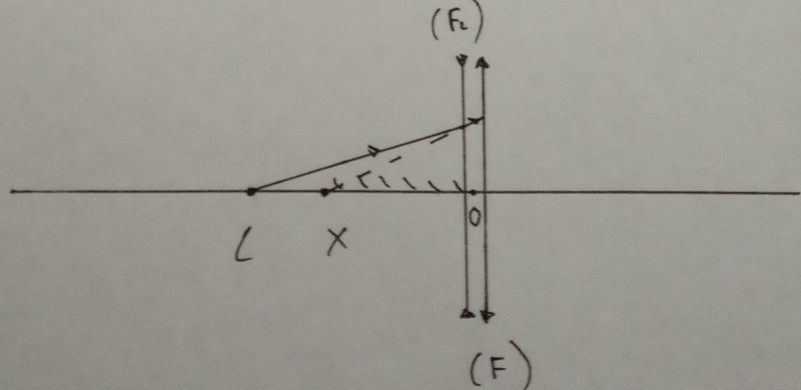
1)





$$0 - \frac{1}{x} = -\frac{1}{F_1} \Rightarrow$$

$$\Rightarrow D_1 = -\frac{1}{x}$$



$$\frac{1}{l} - \frac{1}{x} = -\frac{1}{F_2} \Rightarrow$$

$$\Rightarrow D_2 = \frac{x - l}{xl}$$

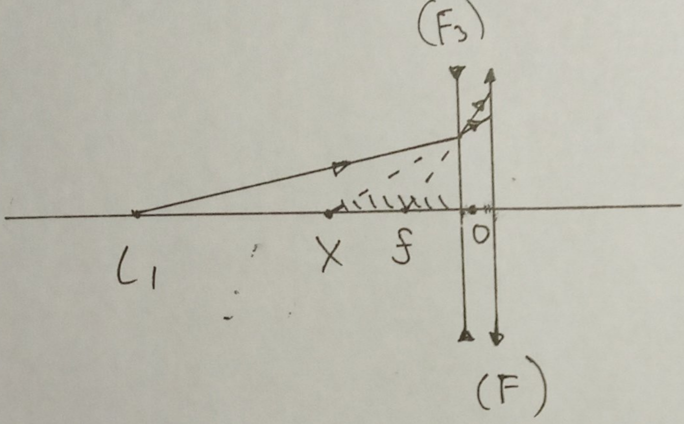
$$\frac{D_1}{D_2} = \frac{xl}{(l-x)x} = 5 \Rightarrow l = 5l - 5x \Rightarrow$$

$$\Rightarrow x = \frac{4l}{5} = 20 \text{ см} \Rightarrow D_1 = -5 \text{ дптр}, \quad 5$$

Чистовик.

также для рассмотрения объектов на бесконечности человеку подойдут очки с оптической силой $D_1 \in (-\infty; -5$ дптр$]$.

2)



$$\frac{1}{l_1} - \frac{1}{f} = -\frac{1}{F_3} = \begin{cases} D_3 = \dfrac{f - l_1}{f l_1} \\ f \in (0; X] \end{cases} \Rightarrow$$

$$\Rightarrow D_3 \in \left(-\infty; \frac{X - l_1}{X l_1}\right] \text{ дптр}$$

$$D_3 \in (-\infty; -3] \text{ дптр.}$$

Ответ: 1) $X = \frac{4l}{5} = 20$ см,

$D_1 \in (-\infty; -5]$ дптр;

2) $D_3 \in (-\infty; -3]$ дптр.

6

Черновик.

$$I_0 = \frac{dq_2'}{dt}$$

$$i = \frac{dq_1'}{dt}$$

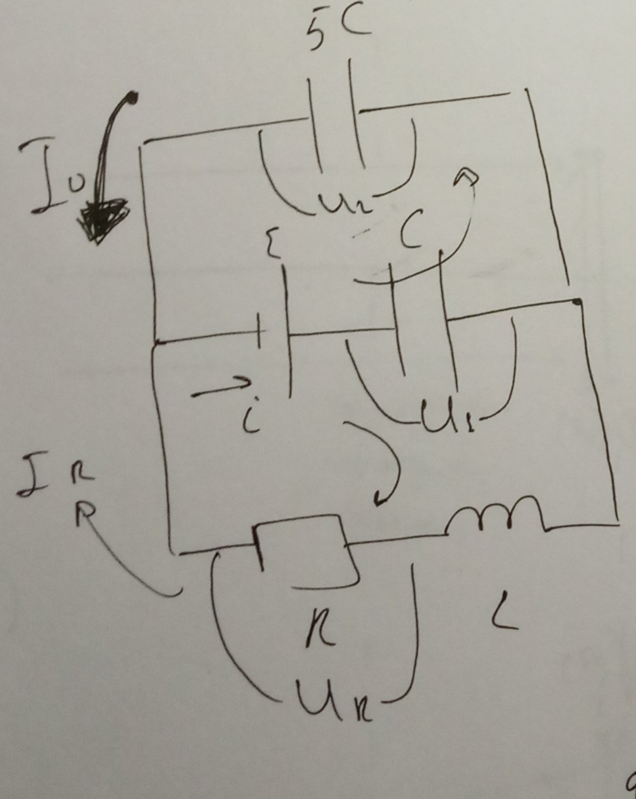
$$\varepsilon = I_R R + \frac{dI_R}{dt} L + \frac{q_1'}{C}$$

$$\frac{q_2'}{5C} = -I_R R - \frac{dI_R}{dt} L$$

$$\frac{25}{72} + \frac{5}{72} = \frac{30}{72} = \frac{5}{12} \approx 0{,}416..$$

$$\frac{1}{2} - \frac{5}{12} = \frac{6}{12} - \frac{5}{12} = 1/12$$

$$I_R + I_0 = i$$



$$\varepsilon = U_1 + U_2$$

$$\varepsilon = U_1 + U_R + L\frac{dI_R}{dt}$$

$$\varepsilon = \frac{q_1'}{C} + \frac{q_2'}{5C}$$

$$\varepsilon = \frac{q_1'}{C} + I_R R + \frac{L\,dI_R}{dt}$$

$$I_0 + I_R = i$$

Черновик.

Д/З

$$\frac{dv}{dt} = \frac{B^2 d^2 v}{mR}$$

$$dv = \frac{B^2 d^2}{mR} \underbrace{v\,dt}_{dx}$$

Черновик.

№5.

$$\frac{\frac{1}{F_1}}{\frac{1}{F_2}} = 5 \Rightarrow$$

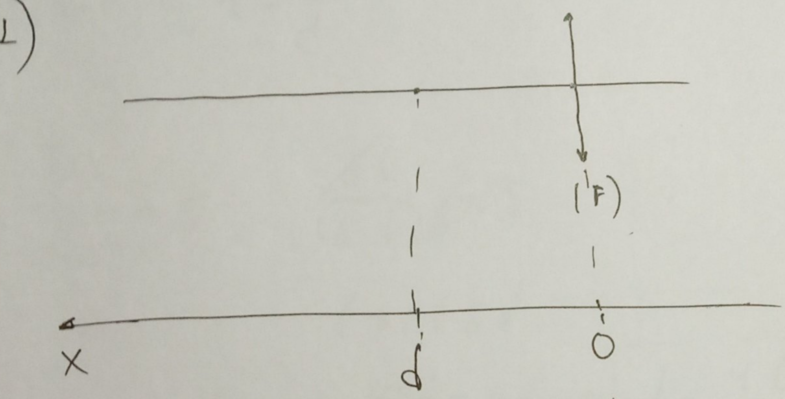
$$\Rightarrow \frac{F_2}{F_1} = 5$$

$$\frac{dl}{(l-d)d} = 5$$

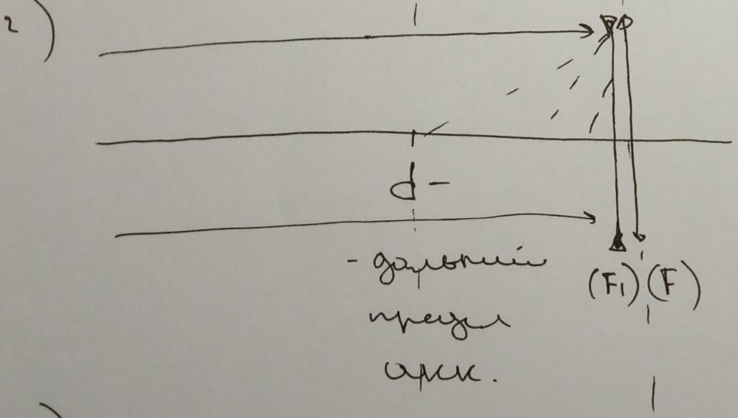
$$l = 5l - d \Rightarrow$$

$$F_1 = d \Rightarrow d = 4l$$

1)

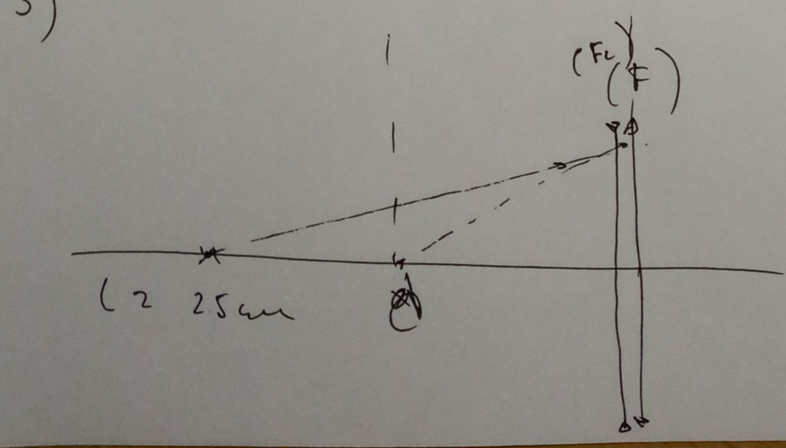


2)



$$\Rightarrow F_1 \in (0; d]$$

3)



$$\frac{1}{l} + \frac{1}{d} = -\frac{1}{F_2}$$

$$F_2 = \left(\frac{1}{d} - \frac{1}{l}\right)^{-1} = \frac{dl}{l-d} =$$

$$= \frac{dl}{d-d}$$

Черновик.

$$D_2 = -\frac{1}{F_2} = -\frac{l-d}{dl}$$

$$D_1 = -\frac{1}{F_1} = -\frac{1}{d}$$

$$\frac{D_1}{D_2} = 5; \quad \frac{\cancel{d}l}{(l-d)\cancel{d}} = 5$$

$$l = 5l - 5d$$

$$5d = 4l \Rightarrow \boxed{d = \frac{4l}{5} = 20\text{ см}}$$

$$D = -\frac{1}{d} = -\frac{1}{0{,}2} = -5\text{ дптр.}$$

4

21200250 (U165316 M1263770)

Черновик.

$dq_2' = I_0\,dt$

$dq_1' = (I_0 + I_R)\,dt$

$0 = 5(I_0 + I_R)\,\cancel{dt} + I_0\,\cancel{dt}$

$I_R = -4 I_0 \Rightarrow |I_R| = 4 I_0 \Rightarrow$

$\Rightarrow U_R =$

5