Часть 1

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

Шифр: **21203175**

ID профиля: **357559**

Вариант 2

Черновик Вариант 11-07

1) $\cos\alpha = \frac{4}{5}$

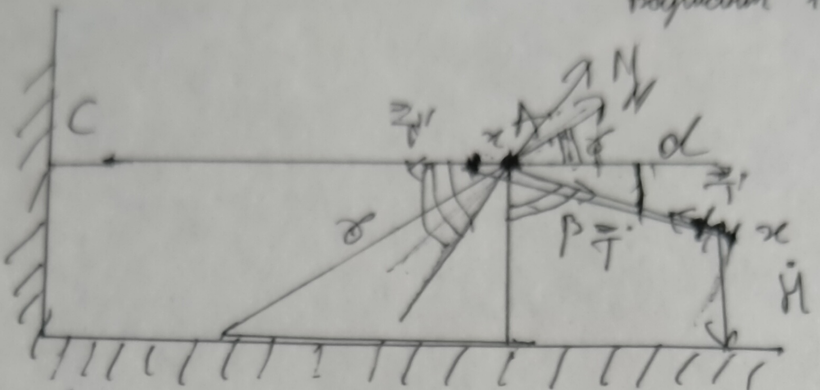
H

$\beta - ?$

$a_{кл} - ?$

$\frac{m}{M} - ?$

$t - ?$



1) $\alpha = const$

Если клин сместится на малое р-е x, то нить сместится на это же р-е x, т.к $\alpha = const$, то ускорение шара будет направлено вдоль нити под углом $\beta = 90° - \alpha$ к вертикали

$\cos\alpha = \sin\beta = \frac{4}{5}$

2) $x_{шара} = x_{клина}$

$\Downarrow$

$a_{кл} = a_{ш}$

$\gamma = \frac{180 - \alpha}{2} = 90 - \frac{\alpha}{2}$

~~$N = 2T\cos\gamma$~~

~~$T\sin\alpha = N\sin\gamma$~~

~~$N = \frac{T\sin\alpha}{\sin\gamma}$~~

~~$T\frac{\sin\alpha}{\sin\gamma} = 2T\cos\gamma$~~

~~$\sin\alpha = \sin 2\gamma$~~

~~$N\sin\gamma = T\sin\alpha$ $N = \frac{T\sin\alpha}{\sin\gamma}$~~

~~$\sin(90 - \frac{\alpha}{2}) = \cos\frac{\alpha}{2}$~~

~~$T - T\cos\alpha - N\cos\gamma = m_{кл}a_{кл}$~~

~~$T - T\cos\alpha - T\sin\alpha\, ctg\gamma = m_{кл}a_{кл}$~~

~~$T = T(\cos\alpha + ctg\gamma\sin\alpha)$~~

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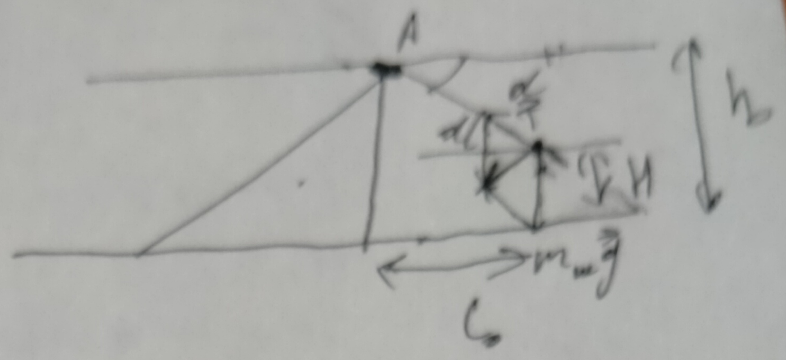
2) составим чертеж



$$tg\,\alpha = \frac{h_0 - H}{l_0}$$

$$tg\,\alpha = \frac{h_0 - H + x_в}{l_0 + x_г}$$

$$\frac{h_0 - H}{l_0} = \frac{h_0 - H + x_в}{l_0 + x_г} \qquad \frac{l_0}{h_0 - H} = ctg\,\alpha$$

$$\frac{l_0 + x_г}{l_0} = \frac{h_0 - H + x_в}{h_0 - H} \qquad x_г = x_в\, ctg\,\alpha$$

ЗСИ:

$$1 + \frac{x_г}{l_0} = 1 + \frac{x_в}{h_0 - H}$$

$$x_г = \frac{l_0}{h_0 - H} x_в$$

$$x_г^2 + x_в^2 = x_{пл}^2$$

$$x_в^2\left(1 + \left(\frac{l_0}{h_0 - H}\right)^2\right) = x_{пл}^2$$

$$x_в^2\left(1 + \frac{\cos^2\alpha}{\sin^2\alpha}\right) = x_{пл}^2$$

$$\frac{x_в}{\sin\alpha} = x_{пл}$$

2) ~~Чистовик~~ черновик

Вариант 11-02

$C(T) = \frac{5}{2} R \frac{T}{T_0}$

ν, T_0

$Q_1 - ?$

$T_{min} - ?$

$A_{min} - ?$

1) $\Delta Q = -C\nu\Delta T$

$\Delta Q = -\frac{5}{2}\nu R \frac{T}{T_0} \Delta T$

$Q_1 = \int_{T_0}^{\frac{T_0}{2}} -\frac{5}{2}\nu R \frac{T}{T_0} dT = -\frac{5}{2} \frac{\nu R}{T_0} \int_{T_0}^{\frac{T_0}{2}} T dT = -\frac{5}{4} \frac{\nu R}{T_0} \left(\frac{T_0^2}{4} - T_0^2\right) =$

$= -\frac{5}{4} \frac{\nu R}{T_0} \cdot \left(-\frac{3}{4}\right) T_0^2 = \frac{15}{2} \nu R T_0$

2) $Q = \Delta U + A$

$\frac{5}{2}\frac{\nu R}{T_0} \int_{T_0}^{T_{min}} T dT = \frac{3}{2}\nu R (T_{min} - T_0) + A$

$A = -\frac{3}{2}\nu R (T_{min} - T_0) + \frac{5}{2}\frac{\nu R}{T_0}\left(\frac{T_{min}^2}{2} - \frac{T_0^2}{2}\right) =$

$= \frac{5}{4}\frac{\nu R}{T_0}(T_{min}^2 - T_0^2) - \frac{3}{2}\nu R (T_{min} - T_0) = \frac{5}{4}\frac{\nu R}{T_0} T_{min}^2 - \frac{5}{4}\frac{\nu R T_0^2}{T_0} -$

$- \frac{3}{2}\nu R T_{min} + \frac{3}{2}\nu R T_0 = \frac{5}{4}\nu R \frac{T_{min}^2}{T_0} - \frac{3}{2}\nu R T_{min} + \left(\frac{3}{2}\nu R T_0 - \frac{5}{4}\frac{\nu R T_0^2}{T_0}\right)$

$A' = \frac{5}{2}\nu R \frac{T_{min}}{T_0} - \frac{3}{2}\nu R = 0$

$\frac{5}{2}\frac{T_{min}}{T_0} = \frac{3}{2}$

$\frac{T_{min}}{T_0} = \frac{6}{10} = \frac{3}{5}$

$T_{min} = \frac{3}{5} T_0$

$A = -\frac{3}{2}\nu R T_0 \left(\frac{3}{5} - 1\right) + \frac{5}{4}\nu R T_0 \left(\left(\frac{3}{5}\right)^2 - 1\right) =$

$= \nu R T_0 \left(+\frac{3}{\cancel{2}} \cdot \frac{\cancel{2}}{5}\right) + \frac{\cancel{5}}{\cancel{4}} \cdot \left(-\frac{\cancel{16}}{\cancel{25}}\right) = \nu R T_0 \left(\frac{3}{5} - \frac{4}{5}\right) =$

$= -\frac{1}{5}\nu R T_0$

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2) черновик В 11-07

1) $dQ = \nu C(T)\,dT$

$Q_1 = \nu \int_{T_0}^{T_0/2} \frac{5}{2} \nu R \frac{T}{T_0}\, dT = \frac{5}{2}\frac{\nu R}{T_0} \int_{T_0}^{T_0/2} T\,dT = -\frac{5}{4}\frac{\nu R}{T_0}\left(\frac{T_0^2}{4} - T_0^2\right) = -\frac{5}{4}\frac{\nu R}{T_0} \cdot \left(-\frac{3}{4}T_0^2\right) =$

$= \frac{15}{16}\nu R T_0$

$Q = A + \Delta U$

$Q = \int_{T_0}^{T_{min}} \frac{5}{2}\nu R \frac{T}{T_0}\, dT = \frac{5}{2}\frac{\nu R}{T_0} \int_{T_0}^{T} T\,dT = \frac{5}{2}\frac{\nu R}{T_0}\left(\frac{T^2}{2} - \frac{T_0^2}{2}\right) = \frac{5}{4}\frac{\nu R}{T_0}\left(T^2 - T_0^2\right)$

$\Delta U = \frac{3}{2}\nu R (T - T_0)$

$A = Q - \Delta U = \frac{5}{4}\frac{\nu R}{T_0}\left(T^2 - T_0^2\right) - \frac{3}{2}\nu R (T - T_0) = \frac{5}{4}\nu R \frac{T^2}{T_0} - \frac{5}{4}\nu R T_0 - \frac{3}{2}\nu R T +$

$+ \frac{3}{2}\nu R T_0 = \frac{5}{4}\nu R \frac{T^2}{T_0} - \frac{3}{2}\nu R T + \frac{1}{4}\nu R T_0$

$\frac{5}{4}\nu R T_0 \left(\left(\frac{3}{5}\right)^2 - 1\right) - \frac{3}{2}\nu R \left(\frac{3}{5} - 1\right)$

$= \frac{5}{4}\nu R T_0 \left(-\frac{16}{25}\right) + \frac{3}{2}\cdot\frac{2}{5}\nu R T_0$

$= -\frac{4}{5}\nu R T_0 + \frac{3}{5}\nu R T_0 = -\frac{1}{5}\nu$

$A' = \frac{5}{2}\nu R \frac{T_{min}}{T_0} - \frac{3}{2}\nu R = 0$

$\frac{5}{2}\frac{T_{min}}{T_0} = \frac{3}{2}$

$T_{min} = \frac{3}{5} T_0$

$A = \frac{5}{4}\nu R \frac{T_0^2}{T_0} \cdot \left(\frac{3}{5}\right)^2 - \frac{3}{2}\nu R \cdot \frac{3}{5} T_0 + \frac{1}{4}\nu R T_0 = \nu R T_0 \left(\frac{5}{4} \cdot \frac{9}{25} - \frac{9}{10} + \frac{1}{4}\right)$

$= \nu R T_0 \left(\frac{9}{20} - \frac{18}{20} + \frac{5}{20}\right) = -\nu R T_0 \cdot \frac{4}{20} = -\frac{1}{5}\nu R T_0$

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2) Чистовик

В 11-02

$C(T)=\frac{5}{2}R\frac{T}{T_0}$

T_0, ν

$Q_1-?$

$T_{min}-?$

$A_{min}-?$

1) $\Delta Q=-\nu C(T)\Delta T=-\frac{5}{2}\frac{\nu R}{T_0}T\Delta T$

$Q_1=-\frac{5}{2}\frac{\nu R}{T_0}\int_{T_0}^{T_0/2}TdT=-\frac{5}{2}\frac{\nu R}{T_0}\left(\frac{T_0^2}{4\cdot 2}-\frac{T_0^2}{2}\right)=$

$=-\frac{5}{4}\nu RT_0\left(-\frac{3}{4}\right)=\boxed{\frac{15}{16}\nu RT_0}$

2) 1 начало т-ки:

$Q=A+\Delta U$

$Q=-\frac{5}{2}\frac{\nu R}{T_0}\int_{T_0}^{T}TdT=\frac{5}{4}\frac{\nu R}{T_0}(T^2-T_0^2)$

$\Delta U=\frac{3}{2}\nu R(T-T_0)$

$A=Q-\Delta U$

$A=\frac{5}{4}\nu R\left(\frac{T^2}{T_0}-T_0\right)-\frac{3}{2}\nu R(T-T_0)=\frac{5}{4}\nu R\frac{T^2}{T_0}-\frac{5}{4}\nu RT_0-$

$-\frac{3}{2}\nu RT+\frac{3}{2}\nu RT_0=\frac{5}{4}\frac{\nu R}{T_0}T^2-\frac{3}{2}\nu RT+\frac{1}{4}\nu RT_0$

$A'=\frac{5}{2}\nu R\frac{T}{T_0}-\frac{3}{2}\nu R$

A_{min} при $A'=0$ $\quad T$ при $A'=0=T_{min}$

$\frac{5}{2}\nu R\frac{T_{min}}{T_0}-\frac{3}{2}\nu R=0$

$\frac{5}{2}\frac{T_{min}}{T_0}=\frac{3}{2}$

$\boxed{T_{min}=\frac{3}{5}T_0}$

3) $A=\frac{5}{4}\frac{\nu R}{T_0}\left(\left(\frac{3}{5}T_0\right)^2-T_0^2\right)-\frac{3}{2}\nu RT_0\left(\frac{3}{5}-1\right)=$

$=\frac{5}{4}\frac{\nu RT_0^2}{T_0}\left(\frac{9-25}{25}\right)+\frac{3}{2}\nu RT_0\cdot\frac{2}{5}=-\frac{5}{4}\nu RT_0\cdot\frac{16}{25}+\frac{3}{5}\nu RT_0=$

$=\nu RT_0\left(\frac{3}{5}-\frac{4}{5}\right)=\boxed{-\frac{1}{5}\nu RT_0}$

Ответ: $Q_1=\frac{15}{16}\nu RT_0$; $T_{min}=\frac{3}{5}T_0$; $A_{min}=-\frac{1}{5}\nu RT_0$

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1) Чистовик

Вариант 11-02

$\cos\alpha = \frac{4}{5}$ $\sin\alpha = \frac{3}{5}$ $\operatorname{tg}\alpha = \frac{3}{4}$

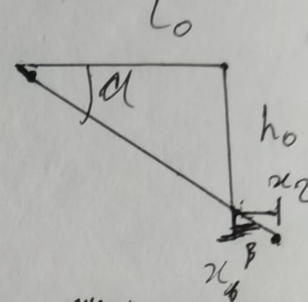
H

β - ?

$a_{кл}$ - ?

$\frac{m_ш}{m_{кл}}$ - ?

t - ?



1) $\alpha = const$

$\operatorname{tg}\alpha = \frac{h_0}{L_0}$

$\operatorname{tg}\alpha = \frac{h_0 + x_в}{x_г + L_0}$

пусть шар сместился на $x_г, x_в$

$x_ш^2 = x_в^2 + x_г^2$

$a_ш \parallel x_ш$

Ответ: $\operatorname{tg}\beta = \frac{4}{3}$; $\frac{m_ш}{m_{кл}} = \frac{4}{5}$

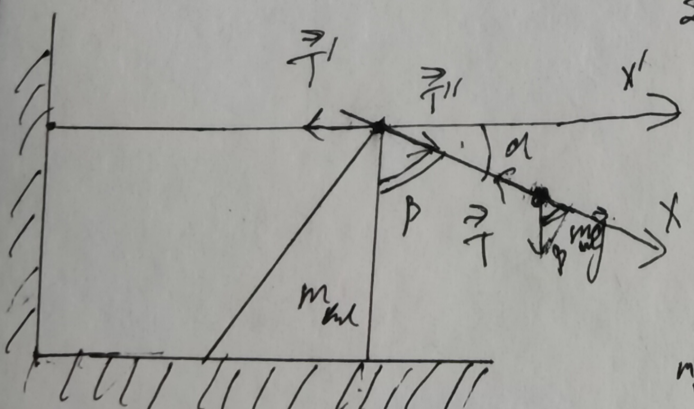
$\frac{h_0 + x_в}{x_г + L_0} = \frac{h_0}{L_0}$

$\frac{x_г + L_0}{L_0} = \frac{h_0 + x_в}{h_0}$

$\frac{x_г}{L_0} + 1 = 1 + \frac{x_в}{h_0}$

$x_г = \frac{L_0}{h_0} x_в = \frac{x_в}{\operatorname{tg}\alpha}$

$\operatorname{tg}\beta = \frac{x_г}{x_в} = \frac{x_в}{x_в \operatorname{tg}\alpha} = \boxed{\operatorname{ctg}\alpha = \frac{4}{3}} \Rightarrow \beta + \alpha = 90°$



2) Нить нерастяжима $\Rightarrow$ значит $x_ш = x_{кл}$

$x_{кл}^2 = x_в^2 + x_г^2 = x_в^2\left(1 + \frac{\cos^2\alpha}{\sin^2\alpha}\right) = x_в^2 \cdot \frac{1}{\sin^2\alpha}$

$x_{кл} = \frac{x_в}{\sin\alpha} = \frac{5}{3} x_в$

$a_{кл} = \frac{5}{3} a_в = \frac{3}{4} \cdot \frac{5}{3} a_г = \frac{5}{4} a_г = a_ш$

2ЗН на ось x:

$m_ш a_ш = m_ш g \cos\beta - T$

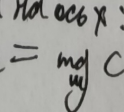
3) на ось x' нет проекций вн. сил., поэтому сумма ускорений клина и шара $= 0$:

$m_{кл} a_{кл} = m_ш a_г$

$\boxed{\frac{m_ш}{m_{кл}} = \frac{a_г}{a_{кл}} = \frac{a_г}{\frac{5}{4} a_г} = \frac{4}{5}}$

2

4) $t^2 = \frac{2L}{a_ш}$ $t = \sqrt{\frac{2L}{a_{кл}}} = \sqrt{\frac{10}{3} \frac{H}{a_{кл}}}$



$L = \frac{H}{\sin\alpha} = \frac{5}{3} H$

Часть 2

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

Шифр: **21203175**

ID профиля: **357559**

Вариант 2

чистовик

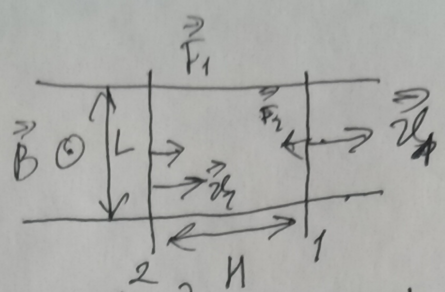
В11-02

4) $B, L, m, R, \frac{m}{2}, 4R, \upsilon_0$

a_{20} - ?

υ_1, υ_2 - ?

ΔH



1) $\mathcal{E} = \frac{d\varphi}{dt} = \frac{d}{dt}(BLH) = \frac{d}{dt}H \cdot BL = BL \cdot (\upsilon_1 - \upsilon_2)$

$I = \frac{\mathcal{E}}{4R+R} = \frac{\mathcal{E}}{5R} = \frac{BL}{5R}(\upsilon_1 - \upsilon_2)$

$F_1 = IBL = \frac{B^2L^2}{5R}(\upsilon_1 - \upsilon_2)$ $\quad F_2 = F_1 = \frac{B^2L^2}{5R}(\upsilon_1 - \upsilon_2)$

$a_2 = \frac{F_1}{\frac{m}{2}} = \frac{2}{5}\frac{B^2L^2}{R}(\upsilon_1 - \upsilon_2)$ $\quad a_1 = \frac{F_2}{m} = \frac{1}{5}\frac{B^2L^2}{R}(\upsilon_1 - \upsilon_2)$

$\upsilon_2(0) = 0 \quad \upsilon_1(0) = \upsilon_0$

$a_{20} = \frac{2}{5}\frac{B^2L^2}{R}\upsilon_0$

2) $a_1 = a_2 = 0 \quad a_2 = 2a_1$

$\upsilon_1 - \upsilon_2 = 0 \quad d\upsilon_2 = 2d\upsilon_1$

$\upsilon_1 = \upsilon_2 \quad \upsilon_2 = 2(\upsilon_0 - \upsilon_1) \Rightarrow \upsilon_1 = 2\upsilon_0 - 2\upsilon_1$

$\upsilon_1 = \frac{2}{3}\upsilon_0 \quad \upsilon_2 = \frac{2}{3}\upsilon_0$

3) $\frac{d\upsilon_2}{dt} = \frac{2}{5}\frac{B^2L^2}{R}(\upsilon_1 - \upsilon_2)$ $\quad \frac{d\upsilon_1}{dt} = \frac{1}{5}\frac{B^2L^2}{R}(\upsilon_1 - \upsilon_2)$

$d\upsilon_2 = \frac{2}{5}\frac{B^2L^2}{R}(\upsilon_1 dt - \upsilon_2 dt)$

$\upsilon_2 = \frac{2}{5}\frac{B^2L^2}{R}(x_1 - x_2) = \frac{2}{5}\frac{B^2L^2}{R}\Delta H$

$\Delta H = \frac{5}{2}\frac{R}{B^2L^2} \cdot \frac{2}{3}\upsilon_0 = \frac{5}{3}\frac{R}{B^2L^2}\upsilon_0$

Ответ: $a_{20} = \frac{2}{5}\frac{B^2L^2}{R}\upsilon_0$; $\upsilon_1 = \upsilon_2 = \frac{2}{3}\upsilon_0$; $\Delta H = \frac{5}{3}\frac{R}{B^2L^2}\upsilon_0$

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4) Черновик В 11-02

$L, m, R, \frac{m}{2}, 4R, v_0$
$a_0 - ?$
$v_1, v_2 - ?$
$\Delta L - ?$

$$\varepsilon_0 = \frac{d\Phi}{dt} = \frac{d}{dt}(BL \cdot dL) = BL\frac{dL}{dt} = BLv_0$$

$$I = \frac{\varepsilon_0}{4R+R} = \frac{\varepsilon_0}{5R} = \frac{BLv_0}{5R}$$

$$F_A = IBL = \frac{v_0}{5R}B^2L^2$$

$$F_a = \frac{m}{2}a_0$$

$$a_0 = \frac{2}{m}F_a = \frac{2}{5}\frac{v_0}{mR}B^2L^2$$

$$F_a = m a_0'$$

$$a_0' = \frac{F_a}{m} = \frac{1}{5}\frac{v_0}{mR}B^2L^2$$

$$a(v) = \frac{2}{5}\frac{B^2L^2}{mR}v \quad a'(v) = \frac{1}{5}\frac{B^2L^2}{mR}v$$

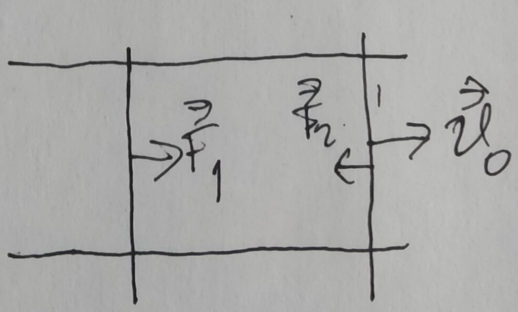
$$\frac{dv}{dt} = \frac{2}{5}\frac{B^2L^2}{mR}\frac{dx}{dt}$$

$$dv = \frac{2}{5}\frac{B^2L^2}{mR}dx \qquad dv' = \frac{1}{5}\frac{B^2L^2}{mR}dx'$$

$$v_2 = \frac{2}{5}B^2L^2x_2 \qquad v_1 - v_0 = \frac{1}{5}\frac{B^2L^2}{mR}x_1$$

$$v_1 = 0$$

$$v_2 = \frac{2}{5}B^2L^2x_2 \qquad v_0 = \frac{1}{5}\frac{B^2L^2}{mR}x_1$$



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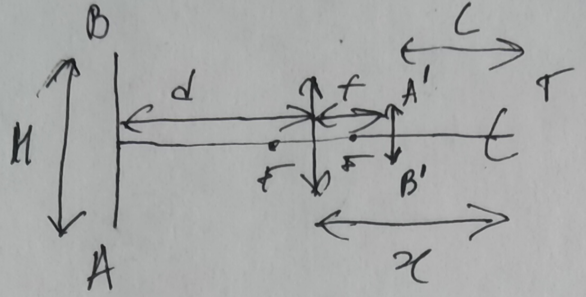
5) Чистовик

В11-07

$H = 9$ см
$d = 48$ см
$L = 24$ см
$F = 12$ см

x - ?
D_m - ?
$L_э$ - ?



1) $\frac{1}{F} = \frac{1}{f} + \frac{1}{d}$ — формула тонкой линзы

$f = \left(\frac{1}{F} - \frac{1}{d}\right)^{-1} = 16$ см $\Gamma = \frac{f}{d} = \frac{1}{3}$ $x = f + L = 40$ см

2) $D > h_{из} = \Gamma H = 3$ см

$D_{min} = \Gamma H = 3$ см

3) $L_э = F = 12$ см нужно расположить экран в фокусе линзы

Ответ: $x = 40$ см; $D_m = 3$ см, $L_э = 12$ см

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В 11-02

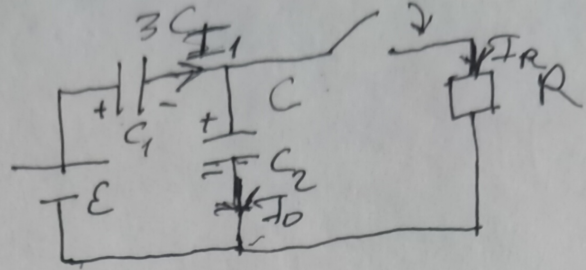
5) Чистовик

$C, 3C, I_0, R, \mathcal{E}$

$I_1 - ?$

$Q - ?$

$U_0 - ?$



$U_{3C} + U_C = \mathcal{E}$

$\frac{q_{3C}}{3C} + \frac{q_C}{C} = \mathcal{E}$

$q_{3C} = q_C$

$\frac{q_C}{C}\left(1 + \frac{1}{3}\right) = \mathcal{E}$ $\quad q_C = \cancel{\frac{3}{4}\frac{\mathcal{E}}{C}}\ \frac{3}{4} C\mathcal{E}$

$U_C = \frac{3}{4}\mathcal{E}$

$U_{3C} = \frac{1}{4}\mathcal{E}$

1) $I_1 R = \mathcal{E} - U_{3C} = \frac{3}{4}\mathcal{E}$

$I_1 = \frac{3\mathcal{E}}{4R}$

2) $A_u = \Delta W_C + \Delta W_{3C} + Q$ $\quad -\ 3C \ni \ U_{3C_K} = \mathcal{E} \quad U_{C_K} = 0$

$\Delta W_C = 0 - \frac{C3^2}{4^2} \cdot \mathcal{E}^2 = -\frac{9}{16} C\mathcal{E}^2$ – изм. эн. конд. C_2

$\Delta W_{3C} = 3\left(\frac{C\mathcal{E}^2}{2} - \frac{1}{16} C\mathcal{E}^2\right) = 3C\mathcal{E}^2 \frac{8-1}{16} = \frac{21}{16} C\mathcal{E}^2$ – изм. эн. конд.

$A_u = \mathcal{E}\left(3C\mathcal{E} - \frac{3}{4} C\mathcal{E} \cdot 2\right) = \frac{3}{2} C\mathcal{E}^2$ – работа источника

$\frac{3}{2} C\mathcal{E}^2 + \frac{9}{16} C\mathcal{E}^2 - \frac{21}{16} C\mathcal{E}^2 = Q$

$C\mathcal{E}^2 \frac{24 - 21 + 9}{16} = Q$ $\quad Q = \frac{3}{4} C\mathcal{E}^2$

3) $\mathcal{E} = U_1 + U_2 = \frac{q_1}{3C} + \frac{q_2}{C}$ $\quad I_1 = I_2 + I_R$

I_1 – ток через C_1

I_2 – ток через C_2

I_R – ток через R

$\mathcal{E}' = \left(\frac{q_1}{3C} + \frac{q_2}{C}\right)'$

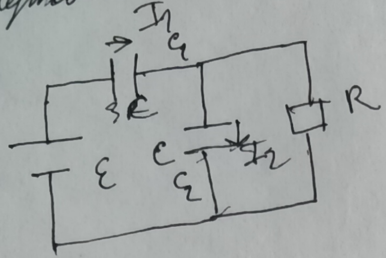
$0 = \frac{I_1}{3C} - \frac{I_2}{C}$ $\quad I_1 = 3I_2 \quad I_2 = I_0$

$I_1 = 3I_0$

$3I_0 = I_0 + I_R$ $\quad I_R = 2I_0 \quad U_0 = I_R R = 2I_0 R$

Ответ: $I_1 = \frac{3\mathcal{E}}{4R}$; $Q = \frac{3}{4} C\mathcal{E}^2$; $U_0 = 2I_0 R$

3) чорновик



$$\mathcal{E} = U_1 + U_R$$

$$U_R = U_2 = \frac{q_2}{C}$$

$$U_1 = \frac{q_1}{3C}$$

$$\mathcal{E} = \frac{q_1}{3C} + \frac{q_2}{C}$$

$$\mathcal{E}' = 0$$

$$\left(\frac{q_1}{3C} + \frac{q_2}{C}\right)' = \frac{I_1}{3C} + \frac{(-I_2)}{C}$$

$$I_2 = I_0$$

$$\frac{I_0}{C} = \frac{I_1}{3C}$$

$$I_1 = 3I_0$$

$$I_1 = I_0 + I_R$$

$$I_R = I_1 - I_0 = 2I_0$$

$$U_0 = I_R R = 2I_0 R$$

5) Чиновик

В 11-07

$H = 9$ см
$F = 12$ см
$d = 48$ см
$L = 24$ см

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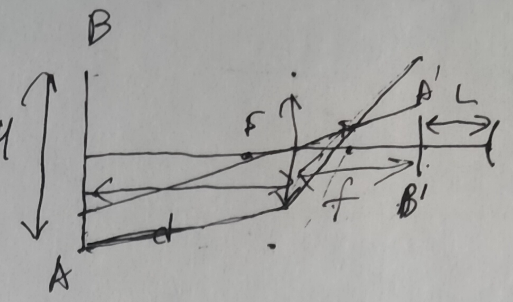
x – ?
D_m – ?
H' – ?



1) $\frac{1}{F} = \frac{1}{d} + \frac{1}{f}$

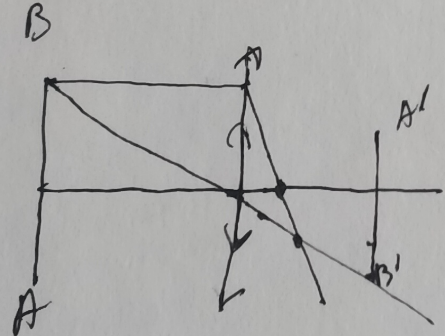
$\frac{1}{f} = \frac{1}{F} - \frac{1}{d}$

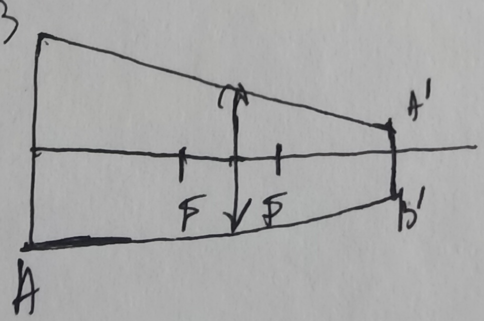
$f = \left(\frac{1}{F} - \frac{1}{d}\right)^{-1} = 16$ см $\Gamma = \frac{f}{d} = \frac{1}{3}$

$x = f + L = 40$ см

2) $D_m = H_{A'B'} = \Gamma H_{AB} = 3$ см

3)





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