# Часть 1

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

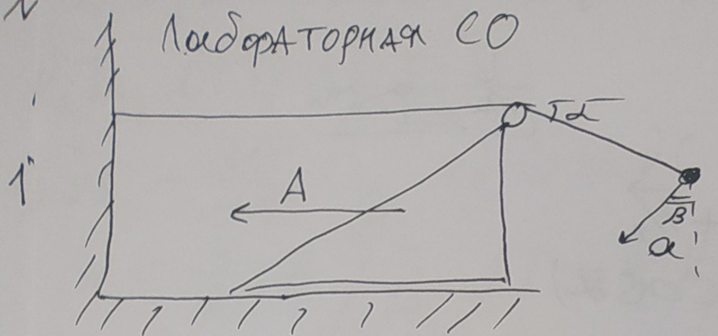
Шифр: **21202051**

ID профиля: **900537**

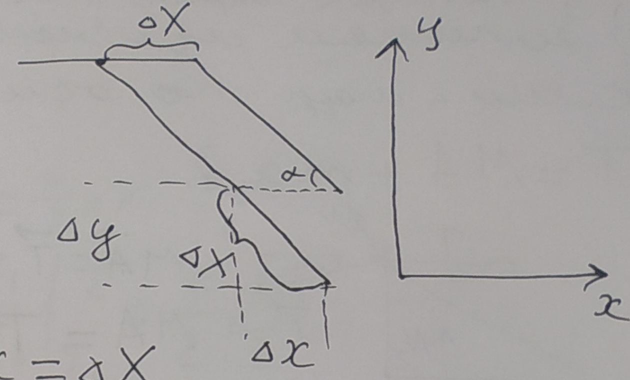
Вариант 2

№1 Чистовик Вариант 11-02

Лабораторная СО



1)

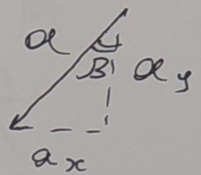


Так как система движется поступательно:

$$\begin{cases} \Delta x = \Delta X - \Delta X \cdot \cos\alpha \\ \Delta y = \Delta X \sin\alpha \end{cases}$$

$$a_x = A(1-\cos\alpha)$$

$$a_y = A\sin\alpha$$



$$tg\,\beta = \frac{a_x}{a_y} = \left(\frac{\sin\alpha}{1-\cos\alpha}\right)^{-1}$$

$$\sin\alpha = \sqrt{1-\cos^2\alpha}$$

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

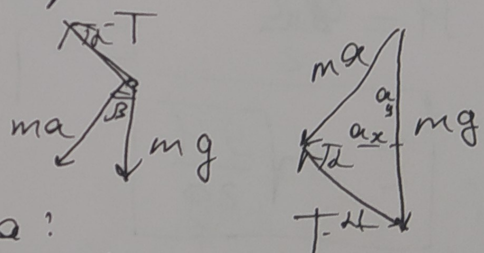
$$tg\,\beta = \frac{1-\cos\alpha}{\sin\alpha} = \frac{5-4}{3} = \frac{1}{3}$$

$$\boxed{tg\,\beta = \frac{1}{3}} \qquad \beta \simeq 0{,}322$$

2) Расставим силы на шар

По з-ну Ньютона:

$$m\vec{a} = \sum \vec{F} = \vec{T} + m\vec{g}$$



Из векторного треугольника:

$$mg = ma_y + ma_x \cdot tg\,\alpha$$

$$tg\,\alpha = T_y \cdot \frac{1}{a_x}$$

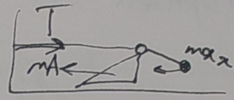
$$g = a_y + a_x\, tg\,\alpha = A\sin\alpha + A(1-\cos\alpha)\, tg\,\alpha$$

$$g = A\cdot(\sin\alpha + tg\,\alpha - \sin\alpha) = A\, tg\,\alpha$$

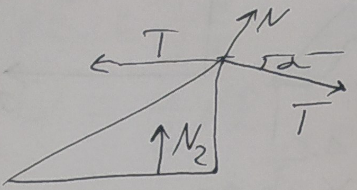
$$\boxed{A = g\, ctg\,\alpha = \frac{4}{3} g}$$

ЧИСТОВИК ВАРИАНТ 11-02

3) Запишем изменение импульса системы клин-шар по оси $x$.




$$T = MA + ma_x$$




$$M\vec{A} = \vec{T}_1 + \vec{T}_2 + \vec{N}_2$$

$$MA = T(1-\cos\alpha)$$

$$\begin{cases} T = MA + ma_x \\ MA = T(1-\cos\alpha) \\ a_x = A(1-\cos\alpha) \end{cases}$$

$$MA = (MA + mA(1-\cos\alpha))(1-\cos\alpha)$$

$$M = M - M\cos\alpha + m(1-\cos\alpha)^2$$

$$\frac{m}{M} = \frac{\cos\alpha}{(1-\cos\alpha)^2}.$$

$$\frac{m}{M} = \frac{\cos\alpha}{(1-\cos\alpha)^2} = \frac{4}{5}\cdot\frac{5^2}{(5-4)^2} = 20$$

$$\boxed{\frac{m}{M} = \frac{\cos\alpha}{(1-\cos\alpha)^2} = 20}$$

4) $a_y = A\sin\alpha = A\cdot\frac{3}{5} = g\cdot\frac{4}{5} = \frac{4}{5}g$

$$H = \frac{a_y\tau^2}{2} \qquad \tau = \sqrt{\frac{2H}{a_y}} = \sqrt{\frac{5H}{2g}}$$

$$\boxed{\tau = \sqrt{\frac{5H}{2g}}}$$

Ответ: 1) $\operatorname{tg}\beta = \frac{1}{3}$

2) $A = \frac{4}{3}g$

3) $\frac{m}{M} = 20$

4) $\tau = \sqrt{\frac{5H}{2g}}$

№2 Чистовик 11-02 вариант

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

1) $\nu C=\frac{dQ}{dT} \qquad dQ=\nu C\,dT=\frac{5}{2}\nu R\frac{T}{T_0}dT$

$Q=\frac{5}{2}\nu R\int_{T_0}^{\frac{T_0}{2}}\frac{T}{T_0}dT=\frac{5}{2}\nu R\frac{T^2}{2T_0}\Big|_{T_0}^{\frac{T_0}{2}}=\frac{5}{2}\frac{\nu R}{2}\left(\frac{1}{4}-1\right)T_0$

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

$Q_1$ – отданное тепло

$\boxed{Q_1=\frac{15}{16}\nu RT_0}$

2) $T_1\to T_2$

$Q=A+\Delta U$ ~~II~~ I начало термодинамики

$\Delta U=\frac{i}{2}\nu R(T_2-T_1)$ Гелий – одноатомный газ. He. $i=3$

$Q=\frac{5}{4}\nu R\frac{T^2}{T_1}\Big|_{T_1}^{T_2}=\frac{5}{4}\nu R\frac{T_2^2}{T_1}-\frac{5}{4}\nu RT_1$

Пусть $\frac{T_2}{T_1}=\alpha$, $A_0=\frac{\cancel{5}}{4}\nu RT_1$

$A=Q-\Delta U=\frac{5}{4}\nu RT_1\left(\frac{T_2^2}{T_1^2}-1\right)-\frac{3}{2}\nu RT_1\cdot\left(\frac{T_2}{T_1}-1\right)$

$A=A_0\left(5(\alpha^2-1)-6(\alpha-1)\right)=\underline{A_0\left(5\alpha^2-6\alpha+1\right)}$

$A$ – min при $A'=0$

$A'=A_0(10\alpha-6)=0 \qquad \alpha=\frac{3}{5} \qquad \boxed{T_2=T_1\cdot\frac{3}{5}}$

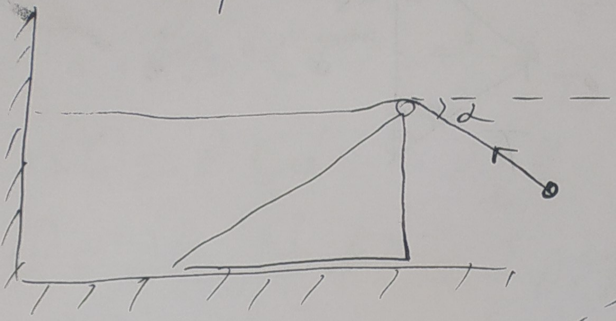
3) $A_{min}=A\left(\alpha=\frac{3}{5}\right)=A_0\cdot\left(\frac{9}{5}-\frac{18}{5}+1\right)=-\frac{4}{5}A_0$

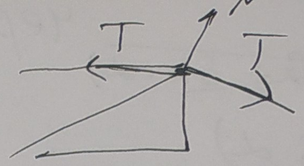
$\boxed{A_{min}=-\frac{1}{5}\nu RT_1}$



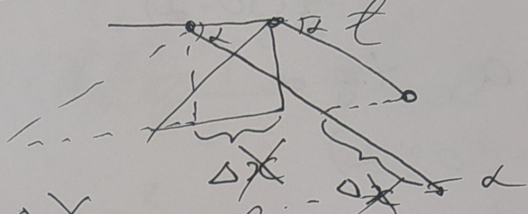
21202051 (U900537 M1265879)

№1 Черновик





1) $a$ - ?



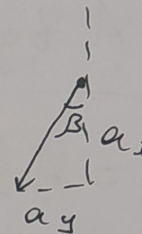
$\Delta X$ - сдвинулся клин

$\Delta x = \Delta X - \Delta X \cos\alpha$

$\Delta y = \Delta X \cdot \sin\alpha$

$a_x = A - A\cos\alpha$

$a_y = A \sin\alpha$

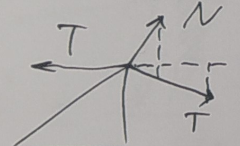


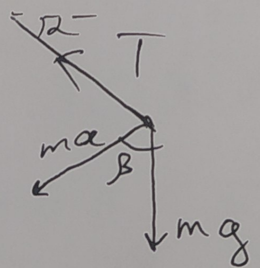
$tg\beta = \frac{a_y}{a_x} = \frac{\sin\alpha}{1-\cos\alpha}$

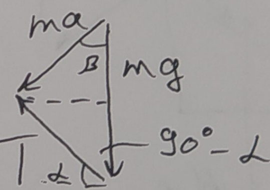
$\sin\alpha = \sqrt{1-\cos^2\alpha} = \frac{3}{5}$

$tg\beta = \frac{3}{5-4} = 3$ $\boxed{tg\beta = 3}$

2)







$MA = T - T\cos\alpha$

$T = MA + ma_x$

$MA = (MA + mA(1-\cos\alpha))(1-\cos\alpha)$

$M = M - M\cos\alpha + m(1-\cos\alpha)^2$

$\frac{M}{m} = \frac{(1-\cos\alpha)^2}{\cos\alpha} = \frac{1}{5^2} \cdot \frac{5}{4} = \frac{1}{20}$

$\frac{T}{\sin\beta} = \frac{mg}{\sin(90° + \alpha - \beta)}$

$\frac{ma}{\sin(90° - \alpha)} = \frac{mg}{\sin(90° + \alpha - \beta)}$

$\boxed{\frac{m}{M} = 20}$

Из векторного треугольника:

$\cancel{mg = a_x \cdot \cos\beta + a_x \cdot \cos(90° - \alpha)}$

$\cancel{a_x = A(1-\cos\alpha)}$

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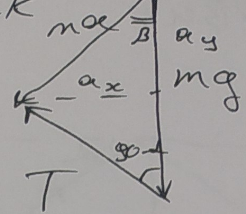
черновик




$\cancel{g = a_x(\cos\beta + \sin\alpha)}$

$a_x = A(1-\cos\alpha)$

$mg = ma_y + ma_x \cdot \dfrac{1}{tg(90-\alpha)}$

$g = a_y + a_x\, tg\,\alpha$

$a_x = A(1-\cos\alpha)$

$a_y = A\sin\alpha$

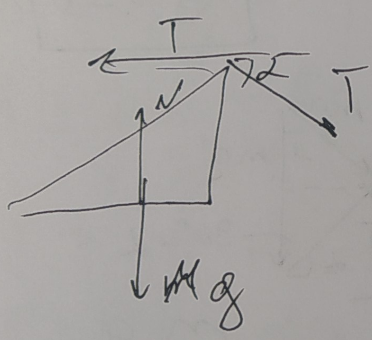
$g = A(\sin\alpha + tg\,\alpha - \sin\alpha) = A\, tg\,\alpha$

$\boxed{g = A\, tg\,\alpha}$ $\quad A = g\cdot\dfrac{4}{3} = \dfrac{4}{3}g = A$

4) $a_y = A\sin\alpha$

$\dfrac{a_y \cdot t^2}{2} = H$ $\quad t = \sqrt{\dfrac{2H}{a_y}} = \sqrt{\dfrac{2H}{\frac{4}{3}g\cdot\frac{3}{5}}} = \sqrt{\dfrac{5H}{2g}}$

$\boxed{t = \sqrt{\dfrac{5H}{2g}}}$



№2 Черновик

$\nu, T_0, \cancel{T_2}$ $C(T) = \frac{5}{2} R \frac{T}{T_0}$

1) $dQ = \nu C dT = \nu \frac{5}{2} R \cdot \frac{T}{T_0} \cdot dT$

$Q = \frac{5}{2} \nu R \cdot \int_{T_0}^{\frac{T_0}{2}} \frac{T}{T_0} dT = \frac{5}{2} \nu R \frac{T^2}{2T_0} \Big|_{T_0}^{\frac{T_0}{2}} = \frac{5}{4} \nu R \left(\frac{1}{4} - 1\right) T_0$

$\boxed{Q = \frac{15}{16} \nu R T_0}$ $Q = \frac{T^2}{2T_0} \frac{5}{2} \nu R$

2) $Q = \Delta U + A$ Гелий He – одноатом. $i = 3$

$A = Q - \Delta U = \frac{5}{4} \frac{\nu R}{T_1} \left(T_2^2 - T_1^2\right) - \frac{3}{2} \nu R (T_2 - T_1)$

$A = \frac{\nu R}{T_1 4} \left(5\left(T_2^2 - T_1^2\right) - 6T_1 (T_2 - T_1)\right)$

Пусть $\frac{T_2}{T_1} = \alpha$

~~$A = \frac{\nu R}{4} \left(5T_1^2 (\alpha^2 - 1) - 6T_1 \cdot (\alpha - 1)\right)$~~

$A = \frac{\nu R}{4} T_1 \left(5(\alpha^2 - 1) - 6(\alpha - 1)\right)$

$y = 5\alpha^2 - 5 - 6\alpha + 6 = 5\alpha^2 - 6\alpha + 1$

$\alpha_1 = 1$ $\alpha_2 = \frac{1}{5}$ $\cancel{\frac{T_2}{T_1}}$

нач. сост.

$\max(y)$ при $y' = 0$ $10\alpha - 6 = 0$ $\alpha = \frac{6}{10}$

$\boxed{T_2 = \frac{6}{10} T_1}$ $\boxed{T_2 = \frac{3}{5} T_1}$

$y = \frac{9}{5} - \frac{18}{5} + 1 = 1 - \frac{9}{5} = -\frac{4}{5}$

$A_{min} = \frac{\nu R T_1}{4} \cdot \left(-\frac{4}{5}\right) = -\frac{\nu R T_1}{5}$

$\boxed{A_{min} = -\frac{\nu R T_1}{5}}$

# Часть 2

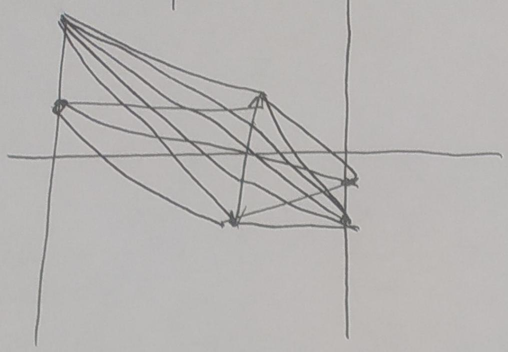
Олимпиада: **Физика, 11 класс (2 часть)**

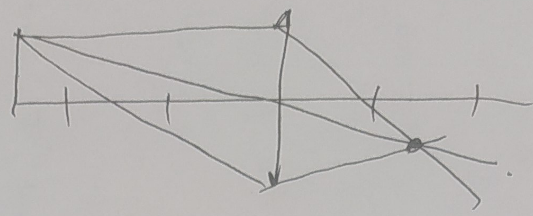
Шифр: **21202051**

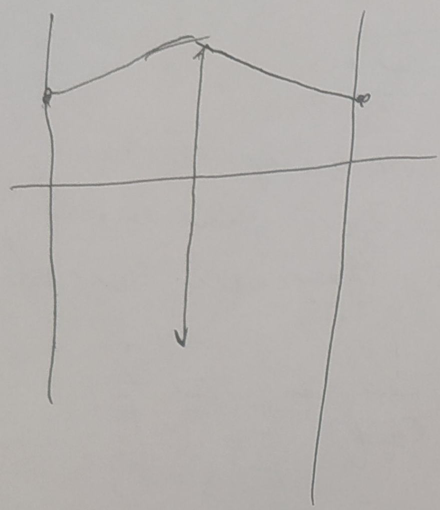
ID профиля: **900537**

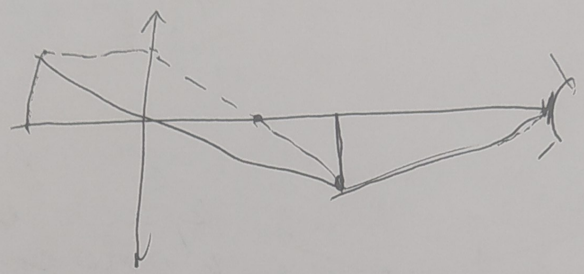
Вариант 2

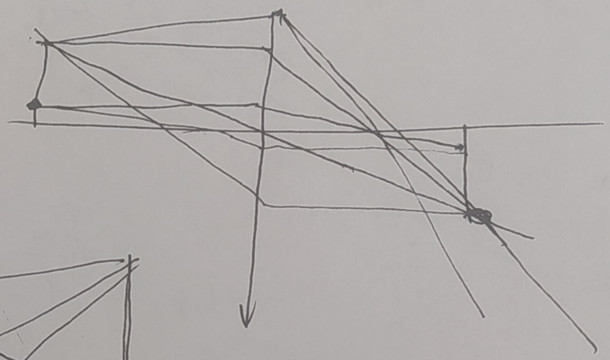
Черновик

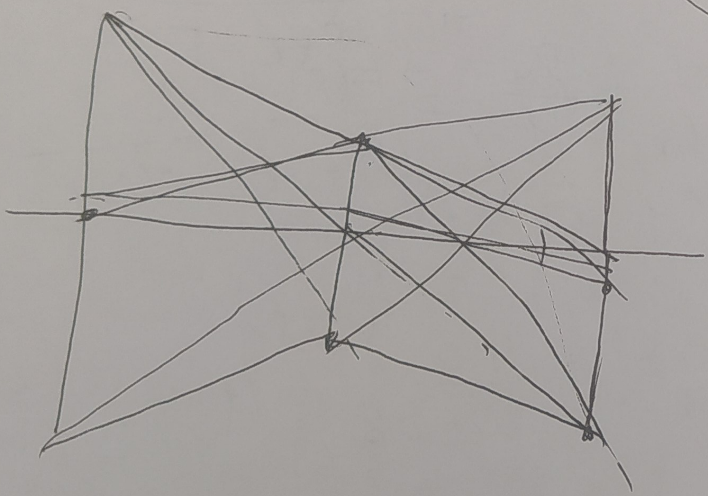






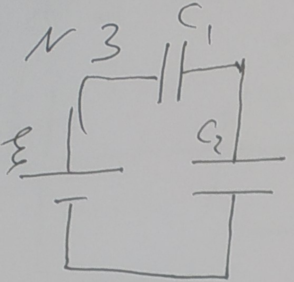






Чистовик Вариант 11-02

№ 3




1)

$\mathcal{E} = U_1 + U_2$

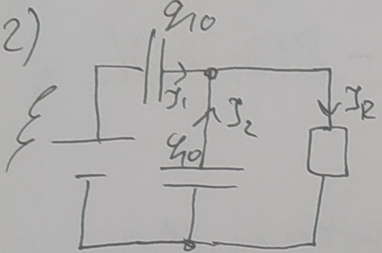
$q_1 = q_2 \quad U_1 \cdot 3C = U_2 \cdot C$

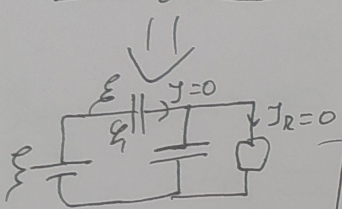
$U_1 = \frac{U_2}{3}$

$U_2 = \frac{3}{4}\mathcal{E}$

$$\boxed{I_R = \frac{U_2}{R} = \frac{3\mathcal{E}}{4R}}$$

2)




$A_{ист} = \mathcal{E} \cdot q_1$

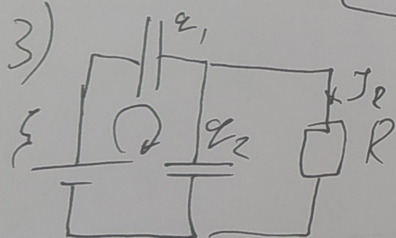
$W_{C_2} = 0$

$W_{C_1} = \frac{3C\mathcal{E}^2}{2} \qquad q_1 = \mathcal{E} \cdot C \cdot 3$

$\mathcal{E} \cdot 3C\mathcal{E} = \frac{3C\mathcal{E}^2}{2} + Q_R$

$$\boxed{Q_R = \frac{3C\mathcal{E}^2}{2}}$$

3)




$\mathcal{E} = U_1 + U_2 = \frac{q_1}{3C} + \frac{q_2}{C}$

$\frac{\dot{q}_1}{3C} + \frac{\dot{q}_2}{C} = 0 \qquad \dot{q}_1 = -3\dot{q}_2$

$\dot{q}_1 = \dot{q}_2 + I_R \qquad \underline{I_R = -4\dot{q}_2}$

$U_R = I_R \cdot R = -4\dot{q}_2 R$

$|\dot{q}_2| = I_0$

$$\boxed{|U_R| = 4 I_0 R}$$



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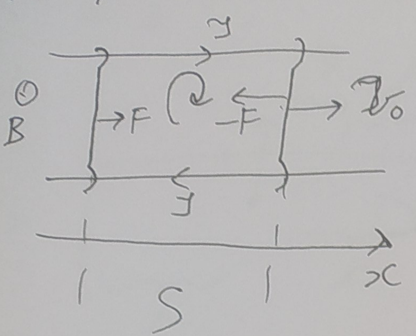
N 4 Чистовик Вариант 11-02




1) $\left(\frac{d\Phi}{dt}\right)_0 = -B v_0 L$

$\mathcal{E}_i = -\frac{d\Phi}{dt} = B v_0 L$

$I = \frac{\mathcal{E}_i}{4R+R} = \frac{B v_0 L}{5R}$

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

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

2) $F_{A_2} = \frac{B(v_1-v_2)L}{5R}\cdot BL$, т.к. $\frac{d\Phi}{dt} = -B(v_1-v_2)L$

$F_{A_1} = -F_{A_2}$

Заметим, что $F_{A_1}+F_{A_2}=0$. Значит, импульс системы сохраняется.

В равновесном устойчивом состоянии

$\frac{d\Phi}{dt}=0 \Leftrightarrow v_1-v_2=0 \Leftrightarrow v_1=v_2=v$

$m v_0 = m v_1 + \frac{m}{2} v_2 = \frac{3}{2} m v$

$$\boxed{v = \frac{2}{3}v_0 = v_1 = v_2}$$

3) $F_{A_2} = \frac{B^2L^2(v_1-v_2)}{5R}$ $\quad a_2 = \frac{2B^2L^2(v_1-v_2)}{5Rm}$

$a_1 = -\frac{F_{A2}}{m} = -\frac{B^2L^2(v_1-v_2)}{5Rm}$

$(a_1-a_2) = -\frac{3}{5}\frac{B^2L^2(v_1-v_2)}{\cancel{5}Rm}$ $\quad a = \frac{dv}{dt}$ $\quad v = \frac{dx}{dt}$

$(dv_1-dv_2) = -\frac{3}{5}\frac{B^2L^2}{Rm}(dx_1-dx_2)$

$\left(\left(\frac{2}{3}v_0-v_0\right)-\left(\frac{2}{3}v_0-0\right)\right) = -\frac{3}{5}\frac{B^2L^2}{Rm}(x_{12}-x_{11}-x_{22}+x_{21})$ $\quad x_{11}-x_{21}=S_0$, $\quad x_{12}-x_{22}=S_0+\Delta S$

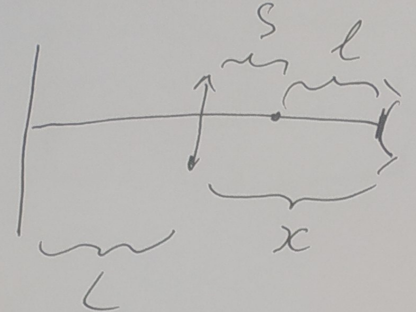
$v_0 = \frac{3}{5}\frac{B^2L^2}{Rm}\Delta S$

$$\boxed{\Delta S = \frac{5}{3}\frac{mR}{B^2L^2}v_0}$$

2

Чистовик Вариант 11-02

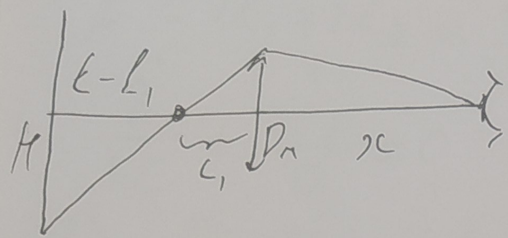
№5



1) $\frac{1}{L}+\frac{1}{S}=\frac{1}{F}$ $S=\frac{L\cdot F}{L-F}=16$ см

$S+l=x$ $\boxed{x=l+\frac{LF}{L-F}=40 \text{ см}}$

2) чтобы человек мог увидеть целиком изображение, крайний луч должен приходить из конца циферблата.

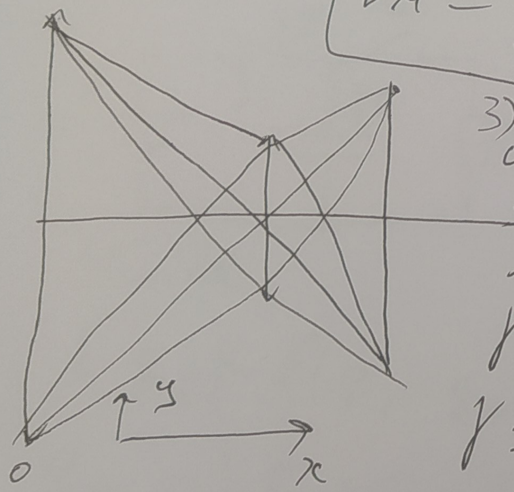


$\frac{1}{x}+\frac{1}{L_1}=\frac{1}{F}$ $L_1=\frac{xF}{x-F}$

$\frac{D_M}{H}=\frac{L_1}{L-L_1}=\frac{xF}{L(x-F)-xF}=\frac{40\cdot 12}{48\cdot 28-40\cdot 12}$

$\frac{D_M}{H}=\cancel{\frac{40}{4\cdot 18}}=\frac{10}{28-10}=\frac{5}{9}$

$\boxed{D_M=\frac{5}{9}H=5 \text{ см}}$



3) чтобы на экране не видеть изображение, надо поставить его в зону, где не проходят лучи от часов через линзу.

$\gamma=\frac{S}{L}$ $\frac{1}{S}+\frac{1}{L}=\frac{1}{F}$ $S=\frac{FL}{L-F}=16$

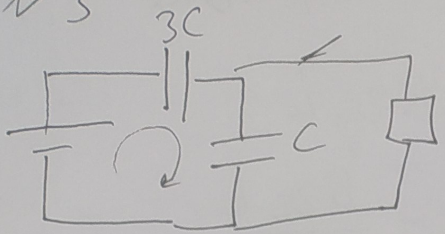
$\gamma=\frac{LF}{L(L-F)}=\frac{F}{L-F}=\frac{12}{48-12}=\frac{1}{3}$

$$\begin{cases}|y|>\frac{9}{2}-\frac{1}{20}x, & x\in[0;40]\\ |y|>\frac{5}{2}(x-40)\cdot\frac{1}{16}, & x\in[40;56]\end{cases}$$

3

черновик

№3




1) $U_1 + U_2 = \mathcal{E}$

$q_{10} = q_{20}$  $U_{10} C_1 = U_{20} C_2$

$3U_{10} = U_{20}$

$U_{20} = \mathcal{E} \cdot \frac{3}{4}$

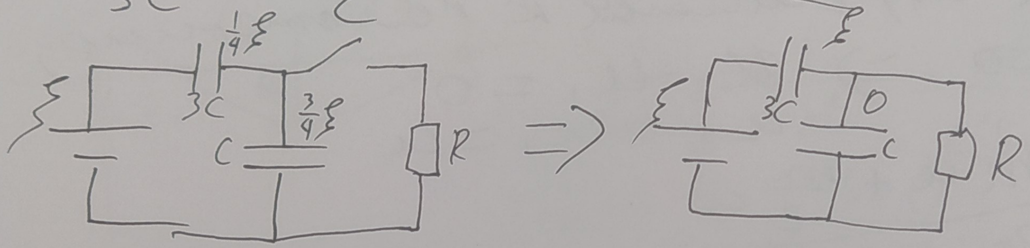
$$\boxed{I_{R0} = \frac{U_{20}}{R} = \frac{3}{4}\frac{\mathcal{E}}{R}}$$

2) $\mathcal{E} = U_1 + U_2 = \frac{q_1}{3C} + \frac{q_2}{C}$

$\frac{\dot{q}_1}{3C} + \frac{\dot{q}_2}{C} = 0$  $\dot{q}_1 = \dot{q}_2 + I_R$

$dQ = I_R \cdot U_R\, dt = dq_R \cdot I_R \cdot R$

$\frac{\dot{q}_2 + I_R}{3C} + \frac{\dot{q}_2}{C} = 0$  $I_R = -4\dot{q}_2$




$3C\ U$:

$\mathcal{E} \cdot q_{10} + \mathcal{E}(q_1 - q_{10}) = Q_R + \frac{3C\mathcal{E}^2}{2}$

$q_{10} = \frac{1}{4}\mathcal{E} \cdot 3C = \frac{3}{4}\mathcal{E}C$

$q_1 = \mathcal{E} \cdot 3C = 3C\mathcal{E}$

$Q_R = 3C\mathcal{E}^2 - \frac{3}{2}C\mathcal{E}^2 = \boxed{\frac{3}{2}C\mathcal{E}^2 = Q_R}$

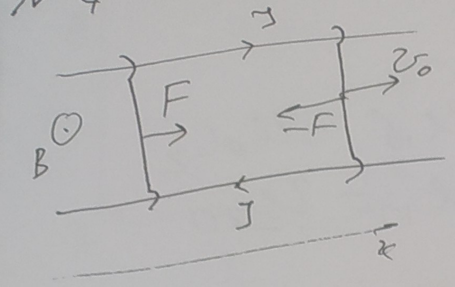
3) $I_R = -4\dot{q}_2$

$$\boxed{|U_R| = 4 I_0 R}$$



21202051 (U900537 M1265880)

№ 4




1) $\frac{d\Phi_0}{dt} = B v_0 \cdot L$ Черновик

$\mathcal{E}_i = -\frac{d\Phi_0}{dt} = -B v_0 L$

$I = \frac{\mathcal{E}_i}{R+4R} = \frac{\mathcal{E}_i}{5R} = -\frac{B v_0 L}{5R}$

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

$\boxed{a_{20} = \frac{2 v_0 B^2 L^2}{5Rm}}$

2) $F_{A_2} = \frac{B(v_2 - v_1)L}{5R} \cdot BL$ $\quad a_2 = \frac{2B^2L^2(v_2 - v_1)}{5Rm}$

$F_{A_1} = -\frac{B(v_2 - v_1)L}{5R} \cdot BL$ $\quad a_1 = -\frac{\cancel{4}B^2L^2(v_2 - v_1)}{5Rm}$

Заметим, что $F_{A_2} = -F_{A_1}$

Значит импульс системы постоянен.

$m v_0 = m u_1 + \frac{m}{2} u_2$

Система стремится к положению, где $\frac{d\Phi}{dt} = 0 \Rightarrow u_2 - u_1 = 0$

$u_2 = u_1 = u$

$m v_0 = m u + \frac{m}{2} u$

$\boxed{u = \frac{2}{3} v_0 = u_1 = u_2}$

3) Пусть $S_0$ начальное расст. ~~она~~ между перемыч.

$\Delta S = \cancel{S_0} \; S - S_0$

$\Delta \dot{S} = (v_2 - v_1)$ $\quad \Delta \ddot{S} = (a_2 - a_1)$

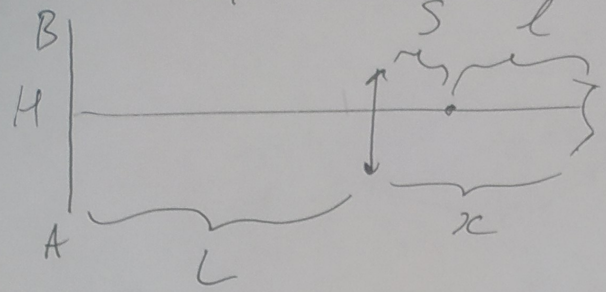
$a_2 - a_1 = \frac{3B^2L^2(v_2 - v_1)}{5Rm}$

$(dv_2 - dv_1) = \frac{3B^2L^2}{5Rm}(dS_2 - dS_1) = \frac{3B^2L^2}{5Rm} \cdot d(\Delta S)$

$\left(\frac{2}{3}v_0 - 0\right) - \left(\frac{2}{3}v_0 - v_0\right) = \frac{3B^2L^2}{5Rm} \cdot \Delta S$

$\boxed{\Delta S = \frac{3B^2L^2}{5Rm v_0}}$

№5 Черновик



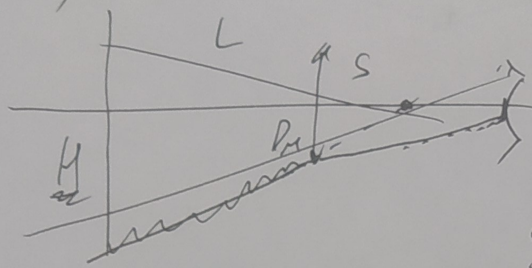

1) $\frac{1}{L} + \frac{1}{S} = \frac{1}{F}$ $\quad S = \frac{LF}{L-F}$

$S + l = x$ $\quad S = 16$

$x = l + \frac{LF}{L-F} = 24 + \frac{48 \cdot 12}{48-12} = 24 + 16 = 40$ см

$\boxed{x = 40 \text{ см}}$

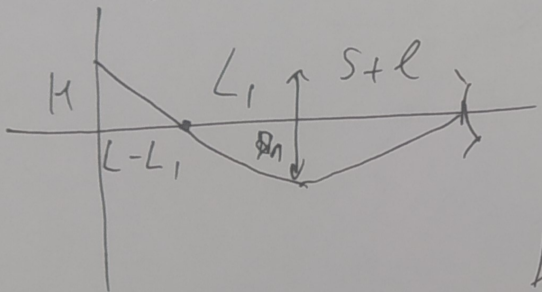
2)




Луч проходящий через край линзы должен попасть в край часов.

$\cancel{\frac{S}{S+L} = \frac{D_M}{H}}$ $\quad \frac{1}{S+l} + \frac{1}{L_1} = \frac{1}{F}$

$L_1 = \frac{F(S+l)}{S+l-F}$



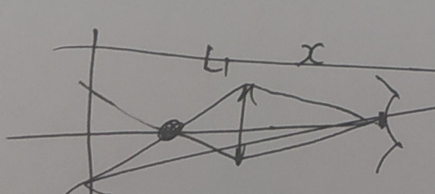

$\frac{L_1}{L-L_1} = \frac{D_M}{H} = \frac{F(S+l)}{L(S+l-F) - F(S+l)}$

$D_M = H \cdot \frac{F(S+l)}{L(S+l-F) - F(S+l)}$

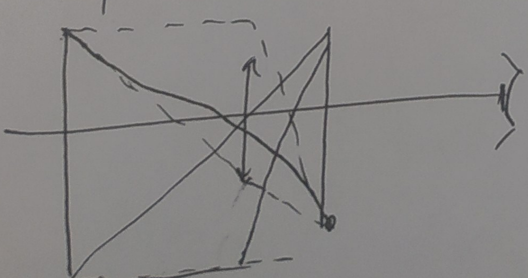
$D_M = H \cdot \frac{\cancel{12} \cdot (16+24)}{\overset{}{\underset{4}{\cancel{48}}} \cdot (40-12) - \cancel{12} \cdot (40)} = H \cdot \frac{40}{120-48} = H \cdot \frac{40}{72} = \frac{20}{36} = \frac{10}{18}$

$\boxed{D_M = \frac{5}{9} H = 5 \text{ см}}$

3)




$\cancel{\frac{1}{L_1} + \frac{1}{x} = \frac{1}{F}}$ $\quad L_1 = \frac{Fx}{x-F} = \frac{12 \cdot 40}{40-12} = \frac{12 \cdot 10}{7}$



$L_1 =$