Часть 1

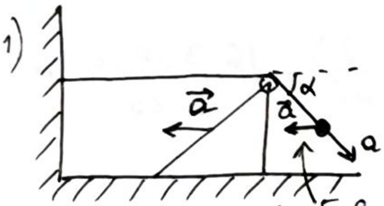
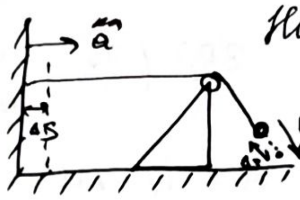
Олимпиада: **Физика, 11 класс (1 часть)**

Шифр: **21203170**

ID профиля: **282949**

Вариант 3

ЧИСТОВИК

1\. 1)  В С.О. Клина: 

Нить смещается на ΔS из-за приближения стены $\Rightarrow$ ускорение груза вдоль нити в этой С.О. по модулю равно a.

добавляется при возврате в исходную С.О.

$\vec{a}_{полн} = \vec{a} + \vec{a}_{отн}$

$a_{полн} = 2a\sin\frac{\alpha}{2}$

По т. синусов

$\frac{a}{\sin\beta} = \frac{2a\sin\frac{\alpha}{2}}{\sin\alpha}$

Из векторного Δ

$\beta = 90° - \frac{\alpha}{2} \Rightarrow \sin\beta = \cos\frac{\alpha}{2}$

$\cos\beta = \sin\frac{\alpha}{2}$

$\boxed{\cos\beta = \frac{2}{\sqrt{13}}}$

$\cos\alpha = \frac{5}{13}$; $\sin\alpha = \frac{12}{13} = 2\sin\frac{\alpha}{2}\cos\frac{\alpha}{2}$

$\frac{6}{13} = \sin\frac{\alpha}{2}\sqrt{1-\sin^2\frac{\alpha}{2}}$ $\quad \sin\frac{\alpha}{2} = t$

$\frac{36}{169} = t^2(1-t^2)$

$t^4 - t^2 + \frac{36}{169} = 0$

$D = 1 - \frac{4\cdot 36}{169} = \frac{25}{169}$

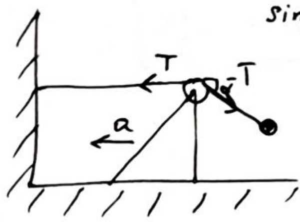
$t^2 = \frac{1 \pm \frac{5}{13}}{2}$

$t_1^2 = \frac{18}{2\cdot 13} = \frac{9}{13}$

$t_2^2 = \frac{8}{2\cdot 13} = \frac{4}{13}$

$\sin\frac{\alpha}{2} = \frac{3}{\sqrt{13}}$ или $\frac{2}{\sqrt{13}}$

т.к. $\frac{\alpha}{2} < 45°$, $\sin\frac{\alpha}{2} < \cos\frac{\alpha}{2}$

2) 

II З.Н. для клина в пр. на Ox:

$Ma = T - T\cos\alpha$

Для груза:

$ma - ma\cos\alpha = T\cos\alpha$

На OY для груза:

$ma\cos\alpha - ma = T - mg\sin\alpha$

$$\begin{cases} ma(\cos\alpha - 1) = T - mg\sin\alpha \\ ma(1-\cos\alpha) = T\cos\alpha \Rightarrow ma(\cos\alpha - 1) = -T\cos\alpha \\ Ma = T(1-\cos\alpha) \end{cases}$$

$T = \frac{ma(1-\cos\alpha)}{\cos\alpha}$

~~$T\cos\alpha = T - mg\sin\alpha$~~

$ma(\cos\alpha - 1) = \frac{ma(1-\cos\alpha)}{\cos\alpha} - mg\sin\alpha$

$ma(1-\cos\alpha)\left(\frac{1}{\cos\alpha} + 1\right) = mg\sin\alpha$

$\boxed{a = \frac{g\sin\alpha}{(1-\cos\alpha)\left(\frac{1}{\cos\alpha}+1\right)}} = \frac{g\cdot\frac{12}{13}}{\frac{8}{13}\cdot\left(\frac{13}{5}+1\right)} = \frac{g\cdot 12}{8\left(\frac{18}{5}\right)} = \frac{3g\cdot 5}{2\cdot 18} = \boxed{\frac{5g}{12}} \approx 4{,}1\,\frac{м}{с^2}$

$a = \frac{g\sin\alpha\cdot\cos\alpha}{1-\cos^2\alpha} = \frac{g}{tg\alpha}$

3) $\frac{m}{M}(1-\cos\alpha) = \frac{\cos\alpha}{1-\cos\alpha}$

$\boxed{\frac{m}{M} = \frac{\cos\alpha}{(1-\cos\alpha)^2}} = \frac{5\cdot 13^2}{13\cdot 8^2} = \frac{5\cdot 13}{64} = \boxed{\frac{65}{64}}$

4) По вертикали шар движется с ускорением

$a\sin\alpha = \frac{12}{13}a = \frac{5}{13}g = a_в$

$a_в = \frac{g\sin^2\alpha\cdot\cos\alpha}{(1-\cos^2\alpha)} = g\cos\alpha$

$H = \frac{a_в t^2}{2} \Rightarrow t = \sqrt{\frac{2H}{a_в}} = \sqrt{\frac{2H}{g\cos\alpha}}$;

Ответ:

1) $\cos\beta = \sin\frac{\alpha}{2} = \frac{2}{\sqrt{13}} \approx 0{,}55$

2) $a = \frac{g}{tg\alpha} = \frac{5g}{12} \approx 4{,}1\,\frac{м}{с^2}$

3) $\frac{m}{M} = \frac{\cos\alpha}{(1-\cos\alpha)^2} = \frac{65}{64} \approx 1{,}02$

4) $t = \sqrt{\frac{2H}{g\cos\alpha}} = \sqrt{\frac{26H}{5g}}$

Чистовик

2.1) $dQ_1 = 3R\frac{T}{T_0}\cdot dT\cdot\nu$

$$Q_1 = \int_{\frac{3}{5}T_0}^{T_0} \frac{3R\nu}{T_0}\cdot T dT = \frac{3R\nu}{T_0}\left(\frac{T_0^2}{2} - \frac{9T_0^2}{2\cdot 25}\right) = \frac{3\nu R T_0}{2}\left(1-\frac{9}{25}\right) = \frac{16\cdot 3\nu R T_0}{2\cdot 25} = \boxed{\frac{24\nu R T_0}{25}}$$

2) $Q = A + \Delta U \Rightarrow A = Q - \Delta U$

$$A = \frac{3R\nu}{T_0}\left(\frac{T_k^2}{2} - \frac{T_0^2}{2}\right) - \frac{3}{2}\nu R(T_k - T_0) =$$

$$= \frac{3}{2}\nu R\left(\frac{T_0+T_k}{T_0} - 1\right)(T_k - T_0) = \frac{3}{2}\nu R(T_k - T_0)\cdot\frac{T_k}{T_0} = \frac{3\nu R}{2T_0}\underbrace{(T_k - T_0)\cdot T_k}_{\text{квадр. функция.}}$$

минимум при $\boxed{T_k = \frac{T_0}{2}}$

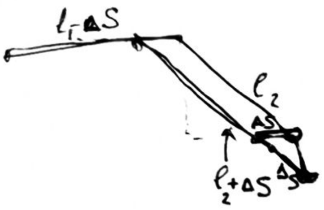
3) $A_{min} = \frac{3\nu R}{2T_0}\left(-\frac{T_0}{2}\right)\cdot\frac{T_0}{2} = -\frac{3\nu R T_0}{8}$

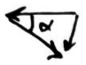
Ответ: 1) $Q_1 = \frac{24\nu R T_0}{25}$

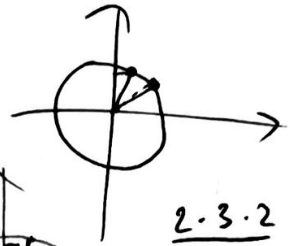
2) $T_k = \frac{T_0}{2}$

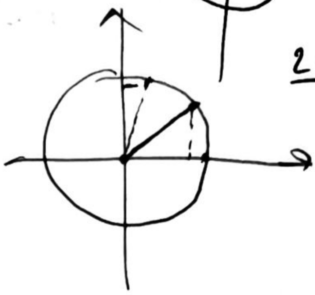
3) $A_{min} = -\frac{3\nu R T_0}{8}$

ЧЕРНОВИК









$$\frac{2 \cdot 3 \cdot 2}{13}$$

$$\cancel{dA = p\,dV}$$

$$\cancel{\frac{dp}{p} + \frac{dV}{V} = \frac{dT}{T}}$$

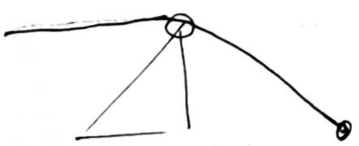
$$\cancel{Q = \frac{3}{2}\frac{\nu R}{T_0}(}$$

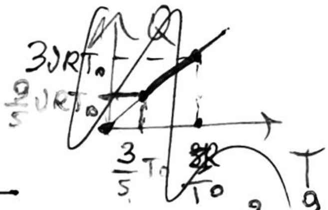
$$Q = \frac{3\nu R}{2T_0}\left(T_K^2 - T_0^2\right) = \frac{3\nu R}{2T_0}\left(\frac{T_0^2}{4} - T_0^2\right) = -\frac{9\nu R T_0}{8}$$

$$\Delta U = \frac{3}{2}\nu R\left(\frac{T_0}{2} - T_0\right) = -\frac{3}{4}\nu R T_0 \quad -\frac{3T_0^2}{4}$$

$$-\frac{9}{8}\nu R T_0 = -\frac{3}{4}\nu R T_0 + A$$

$$\frac{3}{4} - \frac{9}{8} = \frac{6-9}{8} = -\frac{3}{8}\nu R T_0$$



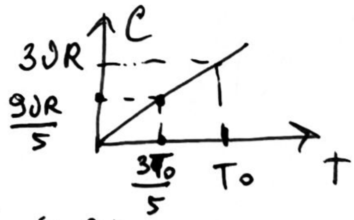


$\cancel{C}$

$$C = \frac{dQ}{dT}$$

$C = 3\nu R$ при $T = T_0$

$$3 - \frac{9}{5} =$$



$$a_{полн} = \sqrt{a^2 + a^2 - 2a^2\cos\alpha}$$

$$a_{полн} = a\sqrt{2 - 2\cos\alpha}$$

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

$$\sin\beta = \frac{\sin\alpha}{\sqrt{2(1-\cos\alpha)}} = \frac{\cancel{12}}{\cancel{13}}$$

$$\Delta U = -\frac{3\nu R}{\cancel{2}} \cdot \frac{\cancel{2}}{5}T_0$$

$$\frac{\left(3 + \frac{9}{5}\right)\nu R}{\cancel{2}} \cdot \frac{\cancel{2}}{5}T_0$$

$$-\frac{24}{25}\nu R T_0 + \frac{3}{5}\nu R T_0$$

$$\frac{(15+9)\nu R T_0}{25} = \frac{24}{25}\nu R T_0$$

$$\left(\frac{3}{5} - \frac{24}{25}\right) = -\frac{9}{25}$$

$$-\frac{24}{25}\nu R T_0 + \frac{3}{\cancel{2}}\nu R \cdot T_0 \cdot \frac{\cancel{2}}{5}$$

$$\sqrt{\frac{1+\cos\alpha}{2}} = \sqrt{\frac{18}{2 \cdot 13}} = \cancel{8}\,\frac{3}{\sqrt{13}}$$

$$\left(\frac{3}{5} - \frac{24}{25}\right) = -\frac{9}{25} = -0{,}36$$

0,125
3
0,375
1,25

Часть 2

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

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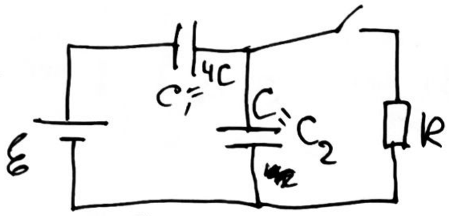
Вариант 3

Чистовик

3.



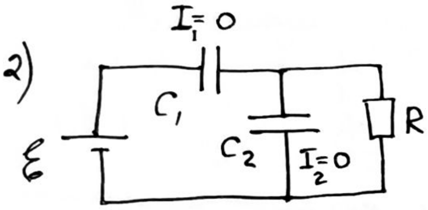
1) $\frac{q}{C_1} + \frac{q}{C_2} = \mathcal{E}$

$q = \frac{\mathcal{E}}{\frac{1}{C_1} + \frac{1}{C_2}} = \frac{C_1 C_2 \mathcal{E}}{C_1 + C_2}$

$U_2 = \frac{q}{C_2} = \frac{C_1 \mathcal{E}}{C_1 + C_2}$

$\boxed{I_R} = \frac{U_2}{R} = \boxed{\frac{C_1 \mathcal{E}}{(C_1 + C_2) R}} = \frac{4C\mathcal{E}}{5CR} = \boxed{\frac{4}{5}\frac{\mathcal{E}}{R}}$

2)



$I_R = I_1 - I_2 = 0$, в уст. режиме тока через конденсатор нет

$U_2 = I_R \cdot R = 0 \Rightarrow U_1 = \mathcal{E} - U_2 = \mathcal{E}$

$q_2 = 0; \quad q_1 = C_1 \mathcal{E}$

ЗСЭ: $W_0 + A_{ист} = W_к + Q$

$A_{ист} = \mathcal{E}(q_к - q_0)$

$\frac{q^2}{2C_1} + \frac{q^2}{2C_2} + \mathcal{E}(q_1 - q) = \frac{C_1 \mathcal{E}^2}{2} + Q$

$\frac{C_1 + C_2}{2C_1 C_2} \cdot \left(\frac{C_1 C_2 \mathcal{E}}{C_1 + C_2}\right)^2 + \mathcal{E}\left(C_1 \mathcal{E} - \frac{C_1 C_2 \mathcal{E}}{C_1 + C_2}\right) = \frac{C_1 \mathcal{E}^2}{2} + Q$

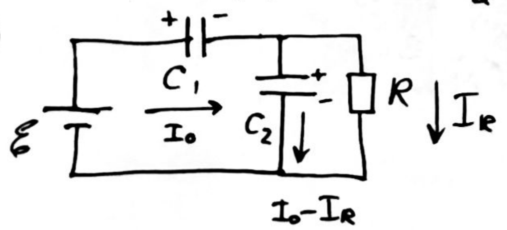
$\frac{C_1 C_2 \mathcal{E}^2}{2(C_1 + C_2)} + \mathcal{E}^2 C_1 \left(1 - \frac{C_2}{C_1 + C_2}\right) = \frac{C_1 \mathcal{E}^2}{2} + Q$

$\frac{C_1 C_2 \mathcal{E}^2}{2(C_1 + C_2)} + \mathcal{E}^2 C_1 \frac{C_1}{C_1 + C_2} = \frac{C_1 \mathcal{E}^2}{2} + Q$

$Q = C_1 \mathcal{E}^2 \left(\frac{C_2}{2(C_1 + C_2)} + \frac{C_1}{C_1 + C_2} - \frac{1}{2}\right) = C_1 \mathcal{E}^2 \left(\frac{\cancel{C_2} + 2C_1 - C_1 - \cancel{C_2}}{2(C_1 + C_2)}\right) =$

$= \frac{(C_1 \mathcal{E})^2}{2(C_1 + C_2)} = \frac{16 C^2 \mathcal{E}^2}{2 \cdot 5C} = \boxed{\frac{8C\mathcal{E}^2}{5}}$

3)



$\mathcal{E} = U_1 + U_R$

$I_0 = \frac{dq_1}{dt}$

$I_0 - I_R = \frac{dq_2}{dt}$

$\mathcal{E} = \frac{q_1}{C_1} + \frac{q_2}{C_2}$

$0 = \frac{1}{C_1} \cdot \frac{dq_1}{dt} + \frac{1}{C_2} \cdot \frac{dq_2}{dt}$

$0 = \frac{1}{C_1} I_0 + \frac{1}{C_2}(I_0 - I_R)$

$\frac{I_R}{C_2} = I_0 \frac{C_1 + C_2}{C_1 C_2}$

$I_R = I_0 \frac{C_1 + C_2}{C_1}$

$U_R = I_R \cdot R = I_0 R \left(1 + \frac{C_2}{C_1}\right) =$

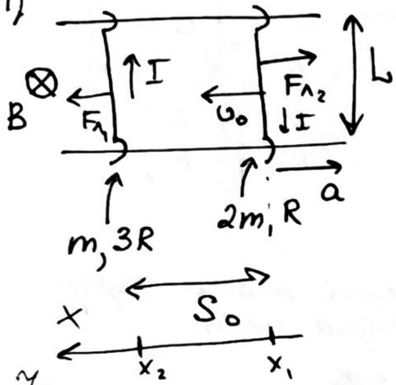
$= I_0 R \left(1 + \frac{C}{4C}\right) = \boxed{\frac{5}{4} I_0 R}$

Ответ: 1) $I_R = \frac{4}{5} \cdot \frac{\mathcal{E}}{R} = \frac{C_1 \mathcal{E}}{(C_1 + C_2) R}$

2) $Q = \frac{(C_1 \mathcal{E})^2}{2(C_1 + C_2)} = \frac{8C\mathcal{E}^2}{5}$

3) $U_R = I_0 R \left(1 + \frac{C_2}{C_1}\right) = \frac{5}{4} I_0 R$

4. 1)



Чистовик

$$\mathcal{E}_0 = -\frac{d\Phi}{dt} = -\frac{B\cdot dS}{dt} = \frac{BL\cdot dx}{dt} = BLv_0$$

$$I_0 = \frac{\mathcal{E}_0}{4R} = \frac{BLv_0}{4R}$$

$$2ma = F_A = IBL = \frac{BLv_0}{4R}\cdot BL$$

$$\boxed{a = \frac{v_0 (BL)^2}{8mR}}$$

2) Через продолжительный промежуток времени скорость перемычек перестанет меняться $\Rightarrow a_1 = a_2 = 0$, то есть $I = 0 \Rightarrow \mathcal{E} = 0$, а поскольку $\mathcal{E} = -\frac{d\Phi}{dt} = -\frac{BdS}{dt} = 0$, площадь контура не меняется, то есть $v_1 = v_2 = v$

II З.Н. для каждой перемычки в проекции на OX:

$$\begin{cases} 2m\ddot{x}_1 = -F_{A_1}, \\ 3m\ddot{x}_2 = F_{A_2} \end{cases}$$

т.к. $F_A = IBL$, а $I_1 = I_2$ (заряд в контуре не накапливается)

$F_{A_1} = F_{A_2}$

$$2\ddot{x}_1 = -3\ddot{x}_2$$

$$2\frac{dv_1}{dt} = -3\frac{dv_2}{dt}$$

$$2(v_1 - v_0) = -3(v_2 - 0)$$

$$2(v - v_0) = -3v \Rightarrow \boxed{v = \frac{2v_0}{5} = v_1 = v_2}$$

3) $F_A = IBL = \frac{dp}{dt} \Rightarrow \Delta p = \int_0^{t_k} IBL\,dt = \Delta q\, BL$

Но $\frac{dq}{dt} = -\frac{d\Phi}{4dt\cdot R} \Rightarrow \Delta q = \frac{\Phi_0 - \Phi_k}{4R}$

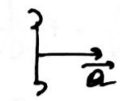
Для каждой перемычки $\Delta p = \frac{6mv_0}{5}$; $\Phi_0 = BLS_0$, $\Phi_k = BLS_k$

$$\frac{6mv_0}{5} = BL\cdot\frac{BL(S_0 - S_k)}{4R}$$

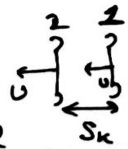
$$S_0 - S_k = \frac{24mv_0R}{5(BL)^2}$$

$$\boxed{S_k = S_0 - \frac{24mv_0R}{5(BL)^2}}$$

Ответ: 1) $a = \frac{v_0(BL)^2}{8mR}$



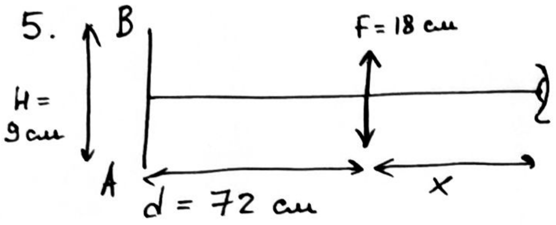
2) $v_1 = v_2 = v = \frac{2v_0}{5}$



3) $S_k = S_0 - \frac{24mv_0R}{5(BL)^2}$

Чистовик

5.



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

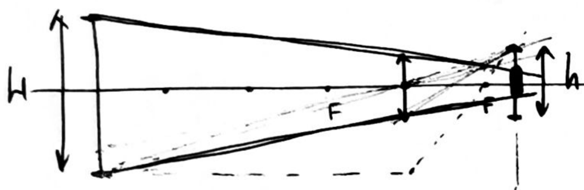
$\frac{1}{f} = \frac{1}{F} - \frac{1}{d} = \frac{d-F}{dF}$

$f = \frac{dF}{d-F} = \frac{72\cdot 18}{72-18} = \frac{72\cdot \cancel{18}}{\cancel{18}(4-1)} = 24$ см

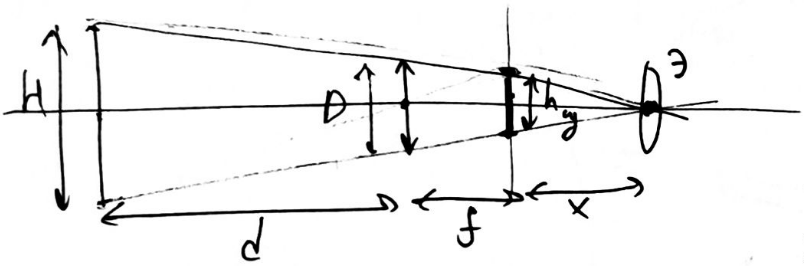
Для глаза предмет должен находиться на расстоянии $L = 24$ см

$\Rightarrow x = f + L = \boxed{48 \text{ см}}$

2) $\Gamma = \frac{f}{d} = \frac{24}{72} = \frac{1}{3} \Rightarrow h_{из} = 3$ см



По рисунку видно, что на часть изображения наложатся лучи, идущие не через линзу, т.е. оно не будет четким.



$\frac{h_{из}}{x} = \frac{H}{f+d+x}$

$h_{из}(f+d) + h_{из}x = Hx$

$x = \frac{h_{из}(f+d)}{H - h_{из}} = \frac{\Gamma(f+d)}{1-\Gamma} =$

$= \cancel{\frac{3}{2}}\cdot(72+24)\cdot\frac{1}{2} = 48$ см

$\frac{D}{f+x} = \frac{H}{f+d+x}$

$D = \frac{H(f+x)}{f+d+x} = \frac{9\cdot(24+48)}{72+24+48} = \frac{9\cdot 3}{3+1+2} = \boxed{4{,}5 \text{ см}}$

3) ~~Экран можно поместить в точке пересеч. лучей, чтобы он попадал все выходящие из линзы~~

~~$L = f + x = 24 + 48 = 72$ см~~

3) Экран нужно ~~поставить вплотную к линзе~~ в фокальной плоскости (через фокус проходят все лучи, ∥ ГОО), то есть все изобр. будет размыто

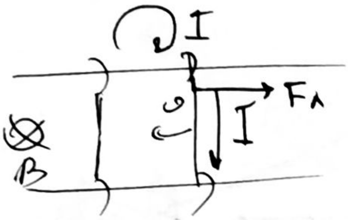
Ответ: 1) 48 см

2) 4,5 см

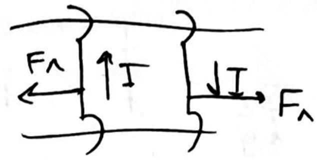
~~3) 72 см справа от линзы~~

3) 18 см справа от линзы

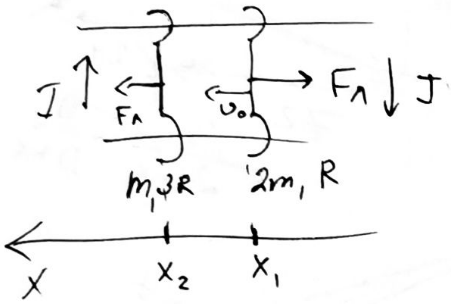
Черновик



$$\begin{cases} 2m\ddot{x}_1 = \cancel{-q} - IBL \\ 3m\ddot{x}_2 = IBL \end{cases}$$



$$I = \frac{\mathcal{E}}{4R} = \frac{(\dot{x}_1 - \dot{x}_2)BL}{4R}$$



$$\mathcal{E} = (\dot{x}_1 - \dot{x}_2)BL \qquad F = IBL = \frac{dp}{dt}$$

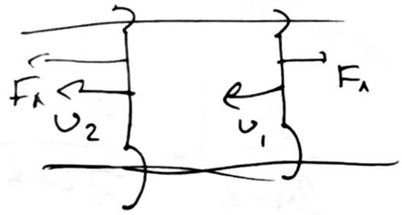
$$2m\ddot{x}_1 = -\frac{(BL)^2}{4R}(\dot{x}_1 - \dot{x}_2) \qquad p = \int IBL\,dt$$

$$3m\ddot{x}_2 = \frac{(BL)^2}{4R}(\dot{x}_1 - \dot{x}_2) \qquad \Delta p = qBL = \frac{\Delta\varphi}{4R}BL$$

$$-2\ddot{x}_1 = 3\cancel{m}\ddot{x}_2 \qquad \frac{dq}{dt} = \frac{d\varphi}{dt\,R}$$

$$\cancel{-2\dot{x}_1} \quad -2(v_1 - v_0) = 3v_2$$

$$-2(\dot{x}_1 - \cancel{v_0}) = 3\dot{x}_2$$



$$P_{пот} = I^2 \cdot 4R$$

$$P_{F_A} = IBL \cdot (v_2 - v_1) = I^2 \cdot 4R$$

$$BL(v_2 - v_1) = 4IR$$

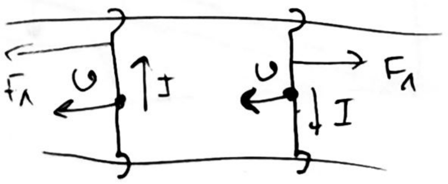
80 мин.

$$\mathcal{E} = (v_1 - v_2)BL$$

$$2m\ddot{x}_1 = -\frac{(BL)^2}{4R}\cdot\left(\dot{x}_1 + \frac{2(\dot{x}_1 - v_0)}{3}\right)$$

$$2m\ddot{x}_1 = -\frac{(BL)^2}{4R}\left(\frac{5}{3}\dot{x}_1 - \frac{2}{3}v_0\right)$$

$$\ddot{x}_1 = -\frac{(BL)^2}{8mR}\left(\frac{5}{3}\dot{x}_1 - \frac{2}{3}v_0\right) = -\frac{(BL)^2}{8mR}\cdot\frac{5}{3}\left(\dot{x}_1 - \frac{2}{5}v_0\right)$$



$$-2(v - v_0) = 3v$$

$$\cancel{-2} - 2v + 2v_0 = 3v$$

$$\cancel{v_0 = 5} \quad v = \frac{2}{5}v_0$$

$$2(v_1 - v_0) = -3v_2$$

$$\cancel{-2(v - v_0) = 3v}$$

$$\cancel{2v - 2v_0 = 3v}$$

$$2mv_0 = 2mv + 3mv$$

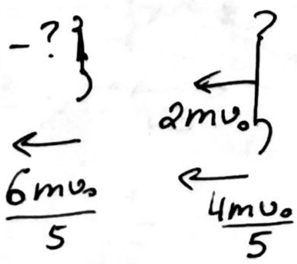
$$v = \frac{2v_0}{5}$$

$$v_1 - v_0 = -\frac{3}{2}v_2$$

$$\frac{dx_1}{dt} - v_0 = -\frac{3}{2}\frac{dx_2}{dt}$$

$$x_2 - x_1 - ?$$

$$dx_1 - v_0\,dt = -\frac{3}{2}dx_2$$



$$\Delta p = \Delta q BL$$

$$\frac{6mv_0}{5} = \Delta q BL$$

$$F_A = IBL =$$

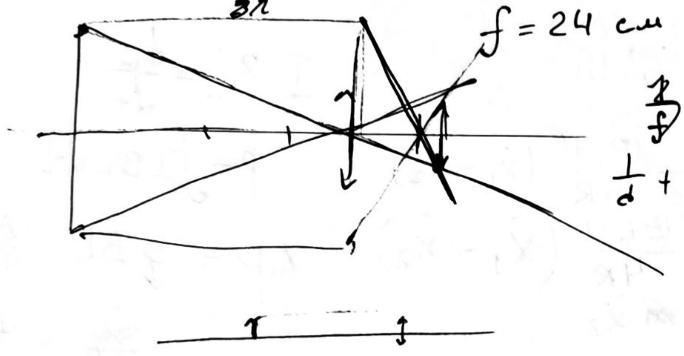
$$I = -\frac{d\varphi}{dt \cdot R}$$

Черновик

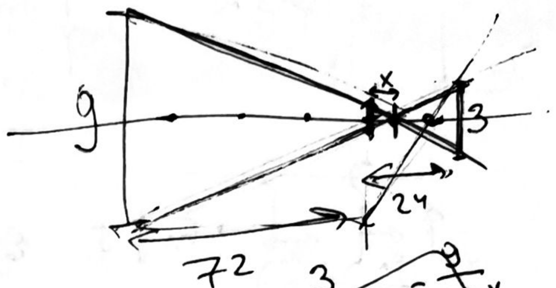
$$\frac{1}{72} + \frac{1}{f} = \frac{1}{18}$$

$8 \cdot 9$

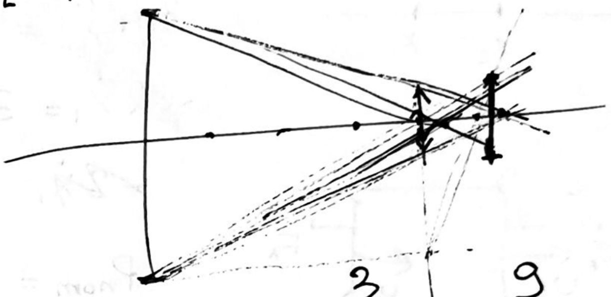
$$\frac{1}{f} = \frac{1}{18}\left(1 - \frac{1}{4}\right) = \frac{3}{4 \cdot 18} = \frac{1}{24}$$



$$\frac{1}{d} + \frac{1}{L} = \frac{1}{F}$$



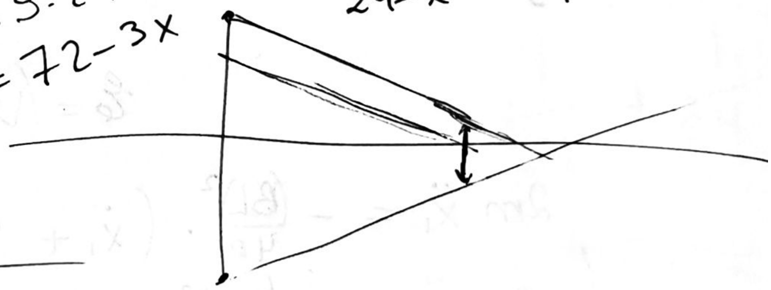
$$\frac{3}{24-x} = \frac{9}{D+x}$$

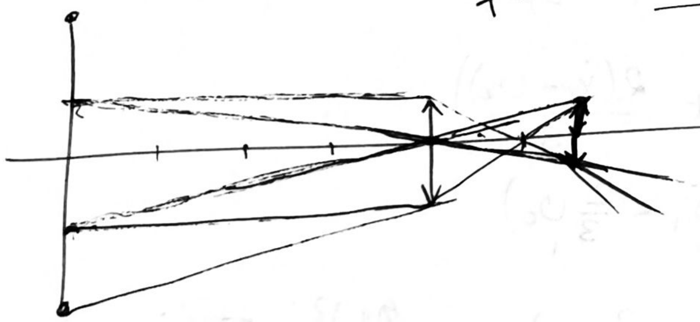


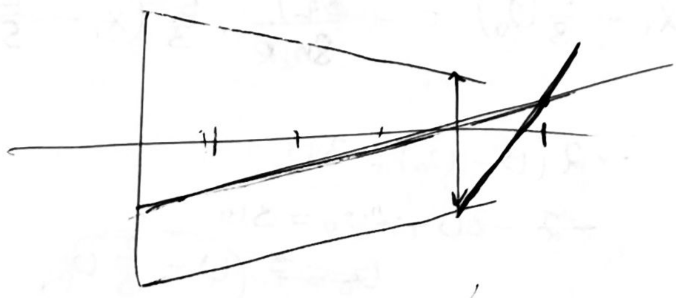
$$\frac{3}{24-x} = \frac{9}{72+x}$$

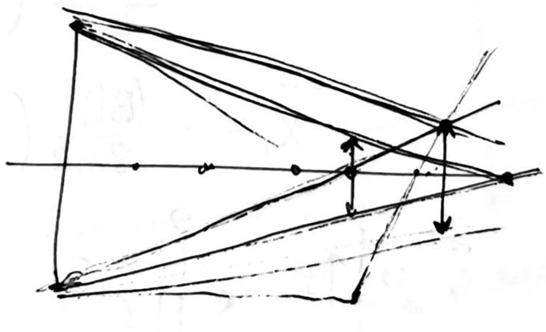
$$3 \cdot 72 + 3x = 9 \cdot 24 - 9x$$

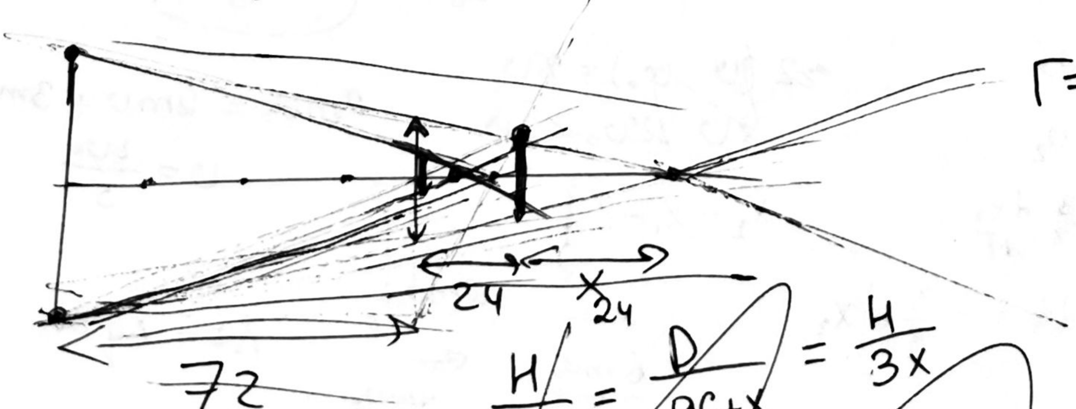
$$72 + x = 72 - 3x$$











$$\Gamma = \frac{f}{d} = \frac{24}{72} = \frac{1}{3}$$

$\cancel{\frac{H}{72}}\ \Gamma$

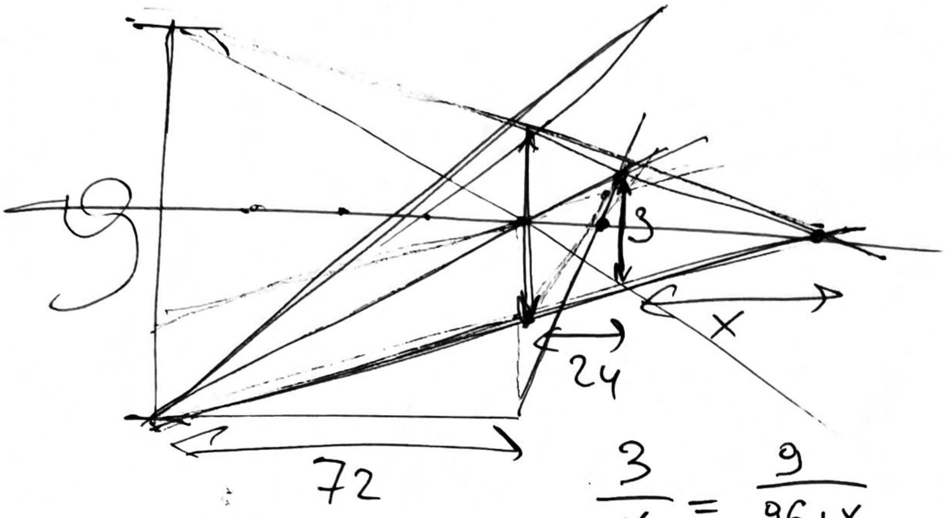
$$\frac{H}{72} = \frac{D}{96+x} = \frac{H}{3x}$$

$$\frac{H}{72} = \frac{D}{120}$$

$x = 24$

$$D = \frac{120}{72}$$

ЧЕРНОВИК



$$\frac{3}{x} = \frac{9}{96+x}$$

$3 \cdot 96 + 3x = 9x$

$96 + x = 3x$

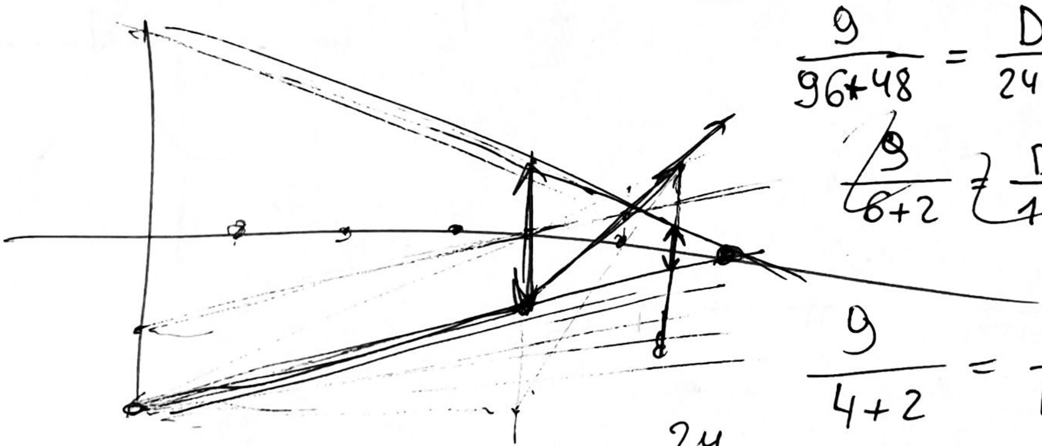
$$\frac{1}{72} + \frac{1}{24} = \frac{1}{18}$$

$2x = 96$

$x = 48$ см

$$\frac{9}{96+48} = \frac{D}{24+48}$$

$$\cancel{\frac{9}{6+2} = \frac{D}{1+2}}$$

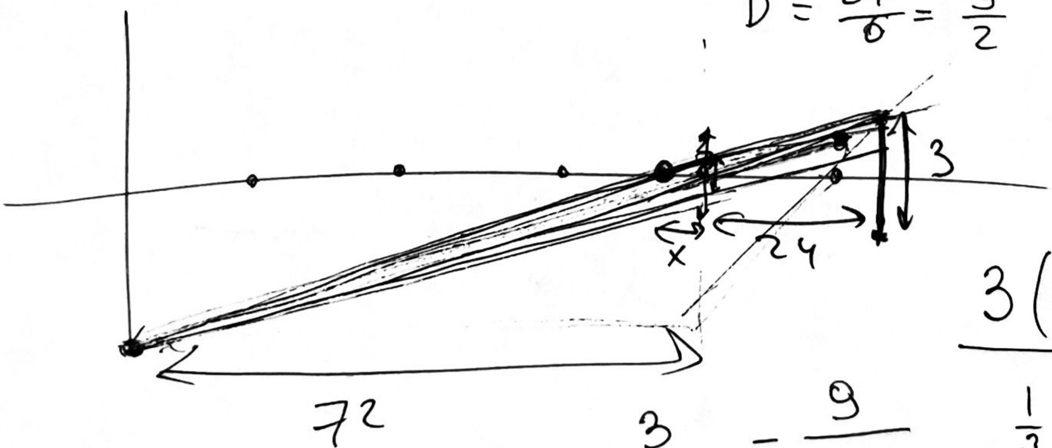


$$\frac{9}{4+2} = \frac{D}{1+2}$$

$$\begin{array}{r} 24 \\ \times\ 4 \\ \hline 96 \end{array}$$

$$\frac{9}{6} = \frac{D}{3}$$

$$D = \frac{27}{6} = \frac{9}{2}$$



$$\frac{3(72+24)}{6}$$

$$\frac{3}{x+24} = \frac{9}{72-x} \qquad \frac{1}{3}$$

$\cancel{3 \cdot 7}$ $72 - x = 3x + 3 \cdot 24$

$$\frac{\frac{1}{3} \cdot 3}{2}$$