Часть 1

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

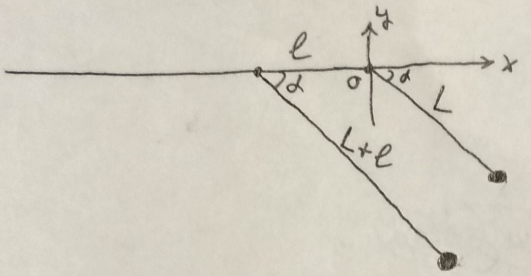
Шифр: **21201942**

ID профиля: **268161**

Вариант 3

Чистовик

№1

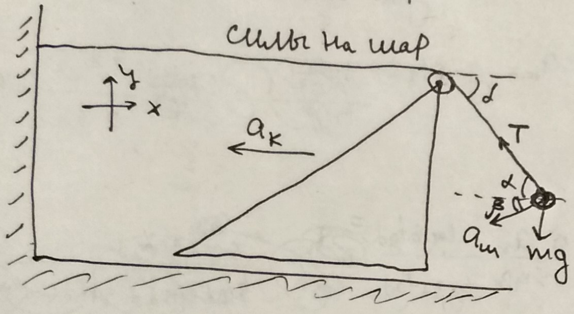


$$\left.\begin{aligned} x_1 &= L\cos\alpha \\ y_1 &= -L\sin\alpha \\ x_2 &= -l+(L+l)\cos\alpha \\ y_2 &= -(L+l)\sin\alpha \end{aligned}\right\} \Rightarrow \left.\begin{aligned} \Delta x &= -l(1-\cos\alpha) \\ \Delta y &= -l\sin\alpha \end{aligned}\right\} \Rightarrow$$

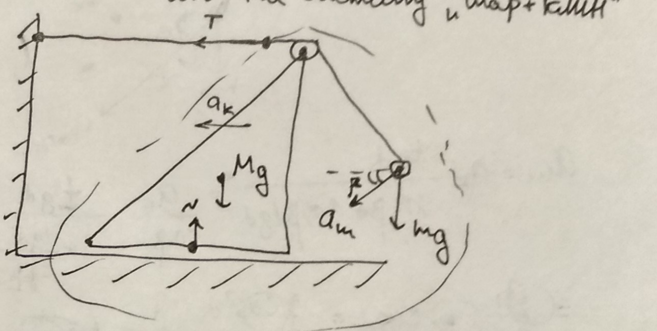
$\Rightarrow \frac{\Delta y}{\Delta x} = \frac{\sin\alpha}{1-\cos\alpha} = const \Rightarrow$ прямолинейное движение $\Rightarrow \vec{a}_ш \uparrow\uparrow \vec{v} \Rightarrow tg(\angle(\vec{v}, Ox)) = tg(\angle(\vec{a}, Ox)) = tg\beta = \frac{\Delta y}{\Delta x} = \frac{\sin\alpha}{1-\cos\alpha} \Rightarrow$

$\Rightarrow \beta = arctg\left(\frac{\sin\alpha}{1-\cos\alpha}\right)$, $\beta = 56{,}3°$ $\quad tg\beta = \frac{\sin\alpha}{1-\cos\alpha} = \frac{2\sin\frac{\alpha}{2}\cos\frac{\alpha}{2}}{2\sin^2\frac{\alpha}{2}} = ctg\frac{\alpha}{2}$

силы на шар



силы на систему „шар+клин"

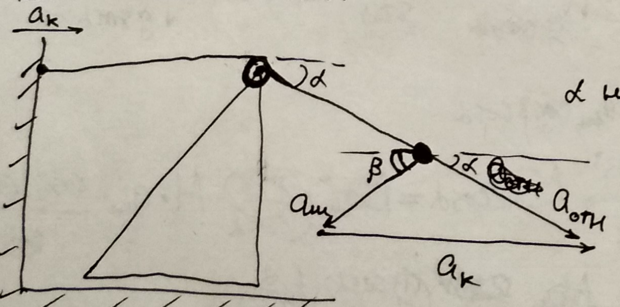


II з. Ньютона: для шара: Ox: $m a_ш \cos\beta = T\cos\alpha$

Oy: $-m a_ш \cdot \sin\beta = -mg + T\sin\alpha$

для сист. „шар+клин": Ox: $-T = -Ma_к - m a_ш\cos\beta$

~~Клина~~ В СО клина:



α не меняется $\Rightarrow$ $\overset{v_{отн}}{a_{отн}}$ вдоль нити

Кинематические связи:

$$\left.\begin{aligned} a_{отн}\sin\alpha &= a_ш\sin\beta \\ a_{отн}\cos\alpha + a_ш\cos\beta &= a_к \end{aligned}\right\} \Rightarrow$$

$\Rightarrow tg\alpha = \frac{a_ш\sin\beta}{a_к - a_ш\cos\beta} \Rightarrow a_ш = a_к\frac{tg\alpha}{\sin\beta + \cos\beta\, tg\alpha}$

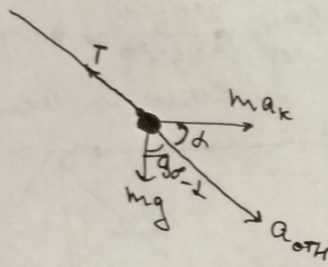
$a_к = a_ш\frac{\sin\beta + \cos\beta\, tg\alpha}{tg\alpha} = a_ш\cdot\cos\beta\cdot\frac{tg\beta + tg\alpha}{tg\alpha}$

$1 + tg^2\beta = \frac{1}{\cos^2\beta} \Rightarrow \cos\beta = \sqrt{\frac{1}{1+\frac{\sin^2\alpha}{(1-\cos\alpha)^2}}} = \frac{1-\cos\alpha}{\sqrt{2-2\cos\alpha}} = \frac{1-\cos\alpha}{2\sin\frac{\alpha}{2}} = \sin\frac{\alpha}{2}$

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

Чистовик

В СО клина:



$ma_к \cdot \sin\alpha = mg \cdot \cos\alpha \Rightarrow$

$\Rightarrow a_к = g \cdot ctg\,\alpha = \frac{9{,}8\,\frac{м}{с^2}}{2{,}4} = 4{,}1\,\frac{м}{с^2}$

$a_ш = a_к \frac{tg\,\alpha}{\sin\beta + \cos\beta\, tg\,\alpha} = \frac{a_к}{\sin\beta}\,\frac{tg\,\alpha}{1 + \frac{tg\,\alpha}{tg\,\beta}} = \frac{a_к}{\sin\beta}\,\frac{tg\,\beta\, tg\,\alpha}{tg\,\beta + tg\,\alpha} =$

$= \frac{a_к}{\cos\frac{\alpha}{2}} \cdot tg\,\alpha \cdot \frac{\sin\alpha\cos\alpha}{\sin\alpha\cos\alpha + \sin\alpha(1-\cos\alpha)} = \frac{a_к \sin\alpha}{\cos\frac{\alpha}{2}} = \frac{g\cos\alpha}{\cos\frac{\alpha}{2}}$

$\frac{H}{\sin\alpha} = a_ш \frac{\tau^2}{2} \Rightarrow \tau = \sqrt{\frac{2H\cos\frac{\alpha}{2}}{g\sin\alpha\cos\alpha}}$

$T\cos\alpha = ma_ш\cos\beta = Ma_к \cdot \cos\alpha + ma_ш\cos\beta\cos\alpha$

$ma_ш\cos\beta(1-\cos\alpha) = ma_ш\frac{(1-\cos\alpha)^2}{2\sin\frac{\alpha}{2}} = Ma_к\cos\alpha = M \cdot a_ш \cdot \frac{\cos\frac{\alpha}{2}\cos\alpha}{\sin\alpha}$

$\frac{m}{M} = \frac{2\cos\frac{\alpha}{2} \cdot \sin\frac{\alpha}{2} \cdot \cos\alpha}{(1-\cos\alpha)^2 \cdot \sin\alpha} = \frac{\cos\alpha}{(1-\cos\alpha)^2} = 1{,}02$

Ответ: $\sin\beta = \cos\frac{\alpha}{2}$; $a_к = g \cdot ctg\,\alpha = 4{,}1\,\frac{м}{с^2}$; $\frac{m}{M} = \frac{\cos\alpha}{(1-\cos\alpha)^2} = 1{,}02$; $\tau = \sqrt{\frac{2H\cos\frac{\alpha}{2}}{g\sin\alpha\cos\alpha}}$

Чистовик

№2

$$C(T) = 3R\frac{T}{T_0} = \frac{dQ_{подв}}{\nu dT} \Rightarrow dQ_{подв} = -dQ_{отд} = \frac{3\nu R}{T_0} T dT \Rightarrow Q_1 = -\int_{T_0}^{0,6T_0} \frac{3\nu R}{T_0} T dT =$$

$$= \frac{3\nu R}{2T_0}\left(T_0^2 - (0,6T_0)^2\right) = 0,96\,\nu R T_0$$

I начало т.д.: $Q = A + \Delta U$

$$Q = \int_{T_0}^{T} \frac{3\nu R}{T_0} T dT = \frac{3\nu R}{2T_0}\left(T^2 - T_0^2\right)$$

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

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

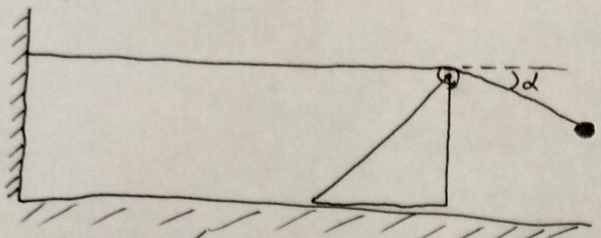
$\Rightarrow A(T)$ – парабола ветвями вверх $\Rightarrow A_{min}$ при $T = \dfrac{-\left(-\frac{3}{2}\nu R\right)}{2\cdot\frac{3\nu R}{2T_0}} = \dfrac{T_0}{2} \Rightarrow$

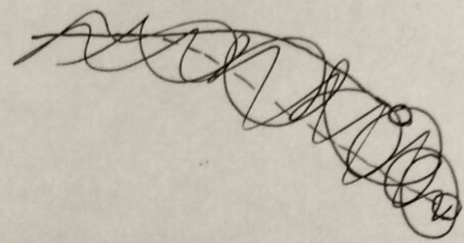
$$\Rightarrow A_{min} = \frac{3}{8}\nu R T_0 - \frac{3}{4}\nu R T_0 = -\frac{3}{8}\nu R T_0$$

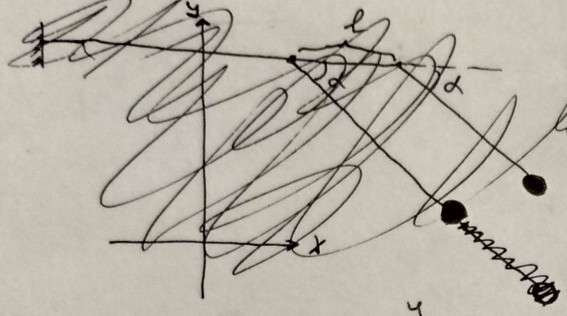
Ответ: $Q_1 = 0,96\nu R T_0$; $T = \frac{T_0}{2}$; $A_{min} = -\frac{3}{8}\nu R T_0$.

~~Чистовик~~ Черновик

№1

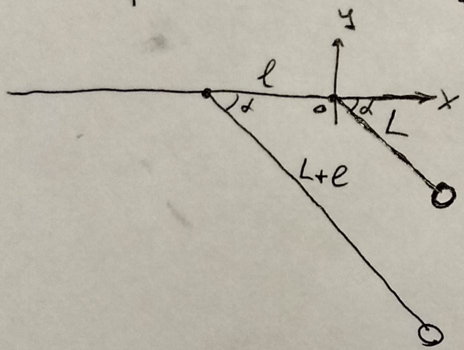






$\Delta y =$

$\Delta x =$



$y_1 = -L \sin\alpha$ $\quad y_2 = -(L+\ell)\sin\alpha$

$x_1 = L\cos\alpha$ $\quad x_2 = -\ell + (L+\ell)\cos\alpha$

$$\left.\begin{array}{l}\Delta y = -\ell \sin\alpha \\ \Delta x = \ell(\cos\alpha - 1)\end{array}\right| \Rightarrow$$

$$\Rightarrow \frac{\Delta y}{\Delta x} = \frac{\sin\alpha}{1-\cos\alpha} = \operatorname{tg}\beta$$

Часть 2

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

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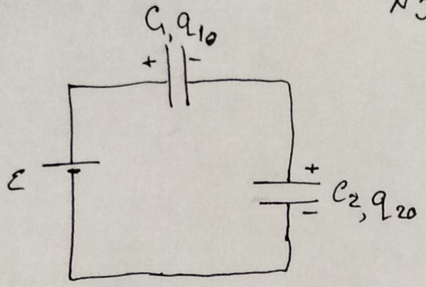
Вариант 3

Чистовик

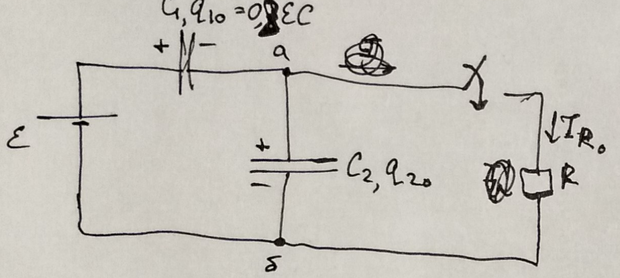
№3



ЗСЗ: $q_{20} - q_{10} = 0$

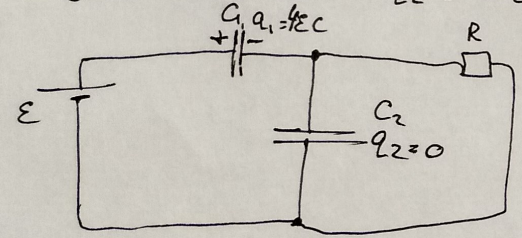
$\mathcal{E} = \frac{q_{10}}{C_1} + \frac{q_{20}}{C_2} = \frac{q_{10}}{4C} + \frac{q_{20}}{C}$ => $\frac{q_{20}}{C} + \frac{q_{20}}{4C} = \frac{5q_{20}}{4C} = \mathcal{E}$ =>

=> $q_{20} = q_{10} = 0{,}8\mathcal{E}C$



$\varphi_а - \varphi_б = I_{R_0} R = \frac{q_{20}}{C_2} = 0{,}8\mathcal{E}$ => $I_{R_0} = 0{,}8\frac{\mathcal{E}}{R}$

В уст. режиме $I_R = 0$ => $q_2 = 0$ => $\mathcal{E} = \frac{q_1}{4C}$ => $q_1 = 4\mathcal{E}C$



ЗСЭ: $\frac{q_{10}^2}{2C_1} + \frac{q_{20}^2}{2C_2} + A_{ист} = \frac{q_1^2}{2C_1} + Q$

$A_{ист} = \mathcal{E} \cdot \Delta q = \mathcal{E} \cdot (4\mathcal{E}C - 0{,}8\mathcal{E}C) = 3{,}2\mathcal{E}^2C$ =>

=> $\frac{(0{,}8\mathcal{E}C)^2}{8C} + \frac{(0{,}8\mathcal{E}C)^2}{2C} + 3{,}2\mathcal{E}^2C = \frac{(4\mathcal{E}C)^2}{8C} + Q$ => $Q = \mathcal{E}^2C(0{,}08 + 0{,}32 + 3{,}20 - 2)$ =>

=> $Q = 1{,}6\mathcal{E}^2C$

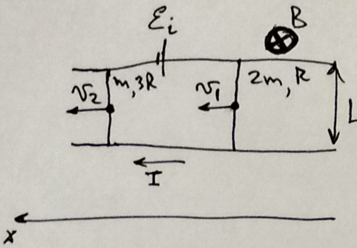
$I_1 = \frac{dq_1}{dt} = I_2 + I_R = \frac{dq_2}{dt} + \frac{U_R}{R}$ => $4C \cdot \frac{dU_1}{dt} = C \cdot \frac{dU_R}{dt} + \frac{U_R}{R}$

$U_1 + U_R = \mathcal{E}$ => $\frac{dU_1}{dt} + \frac{dU_R}{dt} = 0$ => $5C\frac{dU_1}{dt} = \frac{5}{4}I_1 = \frac{U_R}{R}$ => $U_R = 1{,}25 I_0 R$

Ответ: $I_{R_0} = 0{,}8\frac{\mathcal{E}}{R}$; $Q = 1{,}6\mathcal{E}^2C$; $U_R = 1{,}25 I_0 R$.

Чистовик

№4



$$\mathcal{E}_i = -\frac{d\Phi}{dt} = -B\cdot\frac{dS}{dt} = -B\cdot\frac{L(v_2-v_1)dt}{dt} = -B\cdot L\cdot(v_2-v_1) \Rightarrow$$

$$\Rightarrow I = -\frac{BL(v_2-v_1)}{4R} \Rightarrow F_{1x} = -BIL = \frac{B^2L^2(v_2-v_1)}{4R}$$

$$F_{2x} = BIL = \frac{-B^2L^2(v_2-v_1)}{4R}$$

$$v_{20}=0,\ v_{10}=v_0 \Rightarrow a_{10} = |a_{10x}| = \left|\frac{F_{1x}}{2m}\right| = \frac{B^2L^2v_0}{8mR}$$

$$\left.\begin{aligned} a_{1x} &= \frac{dv_1}{dt} = \frac{B^2L^2}{8mR}(v_2-v_1) \\ a_{2x} &= \frac{dv_2}{dt} = \frac{-B^2L^2}{4mR}(v_2-v_1) \end{aligned}\right\} \Rightarrow \frac{d(v_1-v_2)}{dt} = -\frac{3B^2L^2}{8mR}(v_1-v_2) \Rightarrow$$

$$\Rightarrow \ln\frac{v_1(t)-v_2(t)}{v_0} = -\frac{3B^2L^2}{8mR}t \Rightarrow$$

$$\Rightarrow v_1(t)-v_2(t) = v_0\cdot e^{-\frac{3B^2L^2}{8mR}t} \Rightarrow \text{при } t\to\infty \quad v_1 = v_2 = v$$

$F_{1x}+F_{2x}=0 \Leftrightarrow$ ЗСИ для сист.: $Ox: 2m\cdot v_0 = 3m\cdot v \Rightarrow v = \frac{2}{3}v_0$

$$v_1(t)-v_2(t) = \frac{d(x_1-x_2)}{dt} = v_0 e^{-\frac{3B^2L^2}{8mR}t} \Rightarrow$$

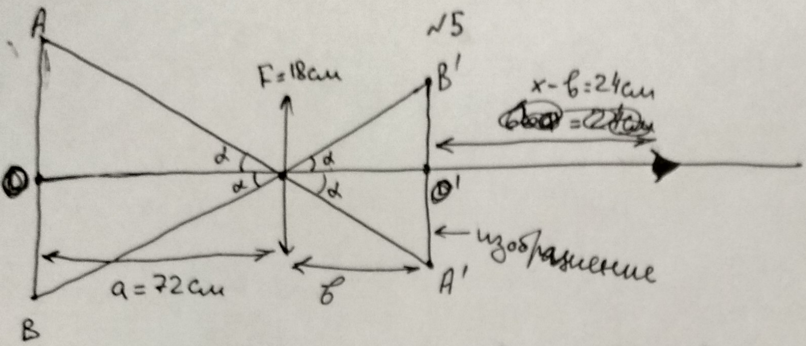
$$\Rightarrow \int_{-S_0}^{-S} d(x_1-x_2) = S_0 - S = \int_0^{\infty} v_0 e^{-\frac{3B^2L^2}{8mR}t}dt = \left(-\frac{8mRv_0}{3B^2L^2}e^{-\frac{3B^2L^2}{8mR}t}\right)\Bigg|_0^{\infty} =$$

$$= \frac{8mRv_0}{3B^2L^2} \Rightarrow S = S_0 - \frac{8mRv_0}{3B^2L^2}$$

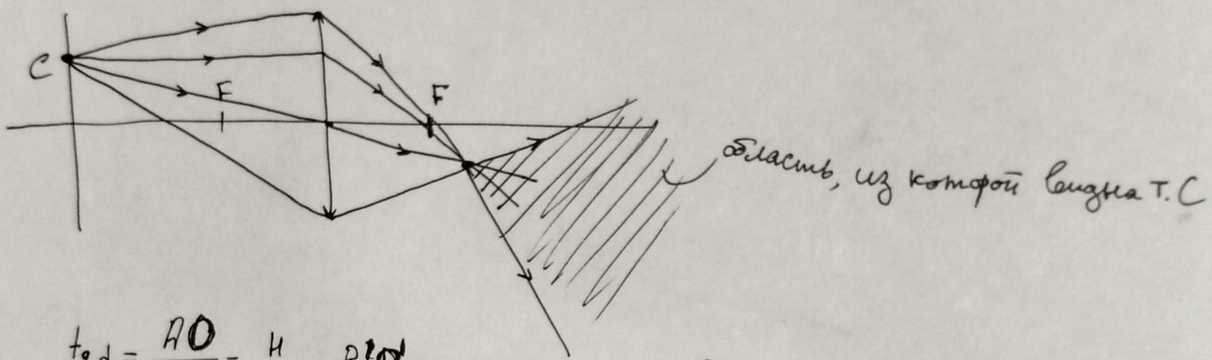
Ответ: $a_{10} = \frac{B^2L^2v_0}{8mR}$; $v_1(t\to\infty) = v_2(t\to\infty) = \frac{2}{3}v_0$; $S(t\to\infty) = S_0 - \frac{8mRv_0}{3B^2L^2}$.

Чистовик

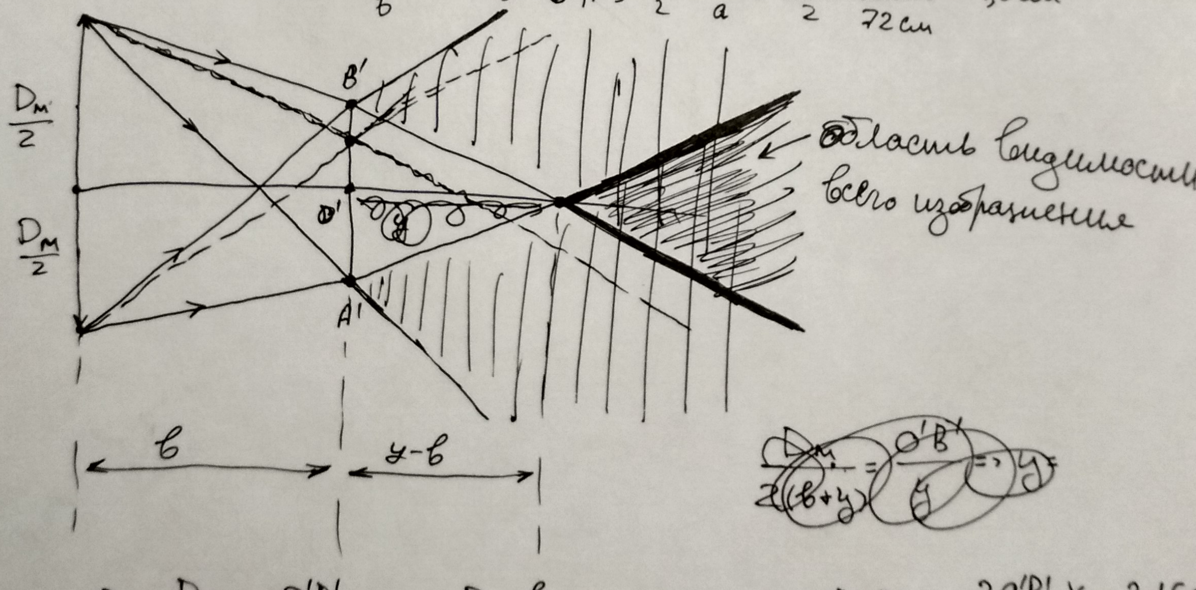
№5



$$\frac{1}{a}+\frac{1}{в}=\frac{1}{F} \Rightarrow в=\frac{aF}{a-F}=\frac{72см\cdot 18см}{54см}=24см \Rightarrow x=в+24см=48см$$



$$tg\,\alpha=\frac{AO}{a}=\frac{H}{2a}=\frac{B'O'}{в} \Rightarrow B'O'=O'A'=\frac{H}{2}\cdot\frac{в}{a}=\frac{9см}{2}\cdot\frac{24см}{72см}=1{,}5см$$



$$\frac{D_м}{2y}=\frac{O'B'}{y-в} \Rightarrow y=\frac{D_м\cdot в}{D_м-2\cdot O'B'}\le x \Rightarrow D_м\ge\frac{2O'B'\cdot x}{x-в}=\frac{2\cdot 1{,}5см\cdot 48см}{24см}=6см$$

Не будем видеть изображение, если экран слева от линзы, а изображение экрана попадает на зрачок $\Rightarrow \frac{1}{a_э}+\frac{1}{x}=\frac{1}{F} \Rightarrow a_э=\frac{xF}{x-F}=\frac{48см\cdot 18см}{30см}=28{,}8см$

Ответ: $x=48см$; $D_м=6см$; $a_э=28{,}8см$ (Экран слева от линзы).

Черновик №5