# Часть 1

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

Шифр: **21203703**

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Вариант 1

№2 вариант-11-01. Чистовик №1.

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

1) $Q_1 - ?$

2) $T - ?\ (A_{min})$

3) $A_{min} - ?$

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

$$\int_0^Q dQ = \nu\int_{T_0}^{\frac{5}{6}T_0}\frac{2RTdT}{T_0}$$

$$Q = \nu\frac{2R}{T_0}\cdot\frac{T^2}{2}\Big|_{T_0}^{\frac{5}{6}T_0} = \frac{\nu R}{T_0}\cdot\left(\frac{25T_0^2}{36} - \frac{36T_0^2}{36}\right) =$$

$$= -R\cdot\frac{11T_0\nu}{36}. \quad Q_1 = |Q| = \frac{11RT_0\nu}{36}. \quad \boxed{Q_1 = \frac{11\nu RT_0}{36}}$$

2) $Q = \Delta U + A$. $A_{min}$ при $pdV = 0$. $U = \frac{i}{2}\nu RT$, $i = 3$ т.к. газ-Не. (одноатомный)

$dQ = dU + dA^{=0}$

$dQ = dU$; $2R\nu\frac{TdT}{T_0} = \frac{3}{2}\nu R dT$; $\frac{2T}{T_0} = \frac{3}{2}$

$2T = \frac{3T_0}{2} \Rightarrow \boxed{T = \frac{3T_0}{4}}$

3) ~~$dQ =$~~ $Q_2 = \frac{2\nu R}{T_0}\int_{T_0}^{\frac{3T_0}{4}} TdT = \frac{2\nu R}{T_0}\cdot\frac{T^2}{2}\Big|_{T_0}^{\frac{3T_0}{4}} =$

$$= \frac{2\nu R}{2T_0}\cdot\left(\frac{9T_0^2}{16} - \frac{16T_0^2}{16}\right) = -\frac{\nu R T_0\cdot 7}{16}$$

$Q_2 = \Delta U_2 + A_0$; $A_0$ - минимальная работа

$$-\frac{\nu RT_0\cdot 7}{16} = \frac{3}{2}\nu R\left(\frac{3T_0}{4} - T_0\right) + A_0 = \frac{3\nu RT_0}{2}\left(\frac{3}{4} - 1\right) + A_0$$

~~$A_0 = -\frac{7\nu RT_0}{16} - \frac{3\nu R}{2\cdot 4}$~~

$$A_0 = -\frac{\nu RT_0\cdot 7}{16} + \frac{3\nu RT_0}{2\cdot 4} = \nu RT_0\left(\frac{3}{8} - \frac{7}{16}\right) =$$

$$= \frac{\frac{3}{2}RT_0(6-7)}{16} = \frac{-\frac{3}{2}RT_0}{16}; \boxed{A_{min} = \frac{-\frac{3}{2}RT_0}{16}}$$

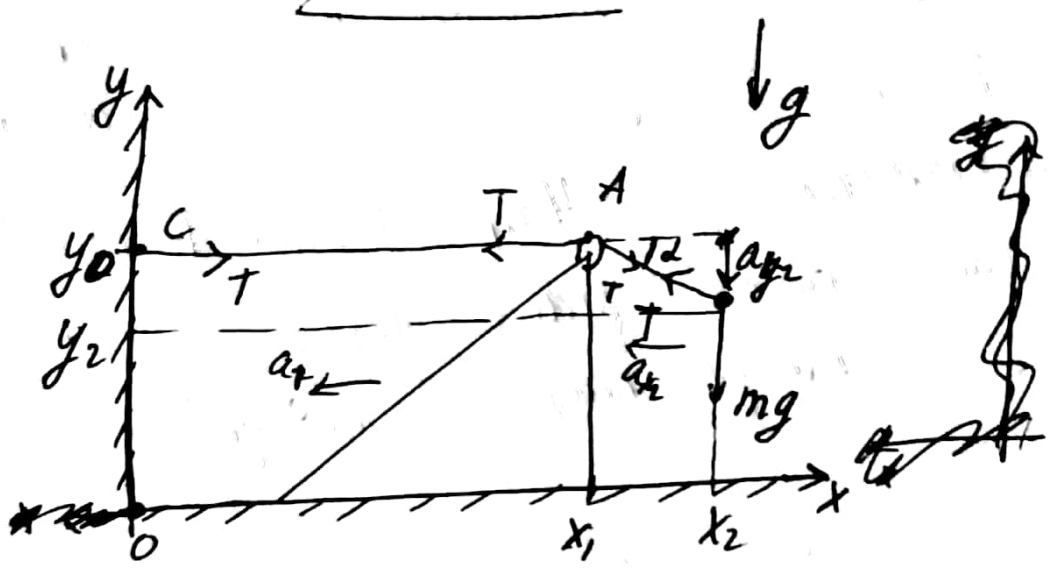
**Ответ:** 1) $Q_1 = \frac{11\frac{3}{2}RT_0}{36}$; 2) $T = \frac{3T_0}{4}$; 3) $A_{min} = \frac{-\frac{3}{2}RT_0}{16}$

Вариант — 11-01. Чистовик №2

№1

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

1) $\beta$ — ?
2) $a_1$ — ?
3) $\frac{m}{M}$ — ?
4) $t_0$ — ?




1) L — длина нити. $\sin\alpha = \sqrt{1-\cos^2\alpha} = \frac{4}{5}$

$L = x_1 + \frac{x_2 - x_1}{\cos\alpha} = const$ ; $L = x_1 + \frac{y_0 - y_2}{\sin\alpha} = const$

дважды дер. по t. $\alpha = const$.

$$a_{x_1} + \frac{a_{x_2} - a_{x_1}}{\cos\alpha} = 0 \; ; \; a_{x_1} + \frac{a_{y_2}}{\sin\alpha} = 0$$

$a_1$ — ускорение клина ; $\beta$ — угол ускорения шара с горизонтом

$a_2$ — ускорение шара

$$a_{x_1}\cos\alpha + a_{x_2} - a_{x_1} = 0$$

$$\begin{cases} a_{x_2} = a_{x_1}(1-\cos\alpha) \\ a_{x_1} = \frac{a_{y_2}}{\sin\alpha} \end{cases} \Rightarrow a_{x_2} = \frac{a_{y_2}}{\sin\alpha}(1-\cos\alpha)$$

$$tg\beta = \frac{a_{y_2}}{a_{x_2}} = \frac{\sin\alpha}{1-\cos\alpha} = \frac{\frac{4}{5}}{1-\frac{3}{5}} = \frac{\frac{4}{5}}{\frac{2}{5}} = 2$$

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

2) Т.к. клин не отрывается от стола $\Rightarrow$ ~~$a = |a_{x_2}|$~~

$a_1 = |a_{x_1}|$

$\sum \vec{F} = m\vec{a}$ – II З.Н.

для клина на ox: $Ma_{x_1} = T\cos\alpha - T$ (2)

для шара на ox: $ma_{x_2} = -T\cos\alpha$

на oy: $ma_{y_2} = T\sin\alpha - mg$ (1)

$$tg\beta = 2 = \frac{a_{y_2}}{a_{x_2}} = \frac{T\sin\alpha - mg}{-T\cos\alpha}$$

$$T\sin\alpha - mg = -2T\cos\alpha$$

$$mg = T(\sin\alpha + 2\cos\alpha). \quad T = \frac{mg}{\sin\alpha + 2\cos\alpha} =$$

$$= \frac{mg}{\frac{4}{5} + \frac{2\cdot 3}{5}} = \frac{mg\cdot 5}{4+6} = \frac{mg}{2}.$$

подставляем $T = \frac{mg}{2}$ в (1)

$$ma_{y_2} = \frac{mg}{2}\sin\alpha - mg \; ; \; a_{y_2} = g\left(\frac{\sin\alpha}{2} - 1\right)$$

~~$a_{y_2} = g\left(\frac{4}{5}\cdot\frac{1}{2} - 1\right) = g\left(\frac{4^2}{2\cdot 5} - 1\right) \quad \frac{3g}{5}$~~

$$a_{x_1} = \frac{g\left(\frac{\sin\alpha}{2} - 1\right)}{\sin\alpha} = g\left(\frac{1}{2} - \frac{1}{\sin\alpha}\right) = g\left(\frac{1}{2} - \frac{5}{4}\right) = -\frac{3g}{4}$$

$$a_1 = |a_{x_1}| = \frac{3g}{4}. \quad \boxed{a_1 = \frac{3g}{4} = 7{,}5\ \frac{м}{с^2}}$$

$$a_{x_1} = \frac{a_{y_2}}{\sin\alpha} \Rightarrow \frac{a_{y_2}}{a_{x_1}} = \sin\alpha$$

3) (1) : (2) Вариант — 11-01 Чистовик №3

$$\frac{ma_{y2}}{Ma_{x1}} = \frac{T\sin\alpha - mg}{T\cos\alpha - T} = \frac{m\sin\alpha}{M}$$

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

$$\frac{m}{M} = \frac{2 - \sin\alpha}{(1-\cos\alpha)\sin\alpha} = \frac{2 - \frac{4}{5}}{\left(1 - \frac{3}{5}\right)\cdot\frac{4}{5}} = \frac{\frac{10}{5} - \frac{4}{5}}{\frac{2}{5}\cdot\frac{4}{5}} = \frac{\frac{6}{5}}{\frac{8}{5\cdot 5}}$$

$$\frac{m}{M} = \frac{\overset{3}{\cancel{6}}\cdot 5}{\underset{4}{8}} = \frac{15}{4} = 3{,}75$$

$$\boxed{\frac{m}{M} = 3{,}75}$$

4) & $\vec{S} = \vec{v}_0 t + \frac{\vec{a}t^2}{2}$

на oy:

$$S_y = v_{oy} t + \frac{a_{y2} t_0^2}{2}$$

$S_y = -H$; $v_{oy} = 0$; $a_{y2} = g\left(\frac{\sin\alpha}{2} - 1\right)$

$$H = \frac{1}{2}\cdot g\left(1 - \frac{\sin\alpha}{2}\right) t_0^2$$

$$t_0 = \sqrt{\frac{2H}{g\left(1 - \frac{\sin\alpha}{2}\right)}} = \sqrt{\frac{2H}{g\left(1 - \frac{\frac{4}{5}}{2}\right)}} = \sqrt{\frac{10H}{3g}}$$

$$\boxed{t_0 = \sqrt{\frac{10H}{3g}}}$$

Ответ: 1) $\operatorname{tg}\beta = \frac{\sin\alpha}{1-\cos\alpha} = 2$; 2) $a_1 = \frac{3g}{4} = 7{,}5\ \frac{м}{с^2}$;

3) $\frac{m}{M} = \frac{2-\sin\alpha}{(1-\cos\alpha)\sin\alpha} = 3{,}75$; 4) $t_0 = \sqrt{\frac{104}{3g}}$

# Часть 2

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

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Вариант 1

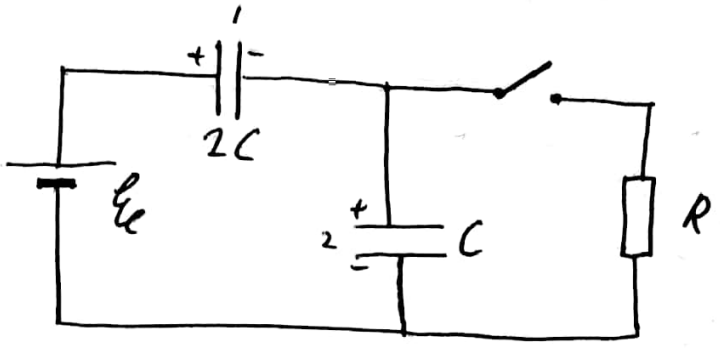
№3 Листовик №1. Вариант — 11-01.

C, ℰ, R

1) $\nu_{R_0}$ - ?

2) Q - ?

3) $\nu_R$ - ?




1) ключ разомкнут.
в установившемся режиме

$\mathcal{E} = U_1 + U_2$; $U_1 = \frac{q}{2C}$; $U_2 = \frac{q}{C}$

$\mathcal{E} = \frac{q}{2C} + \frac{q}{C} = \frac{q+2q}{2C} = \frac{3q}{2C} \Rightarrow q = \frac{2C\mathcal{E}}{3}$

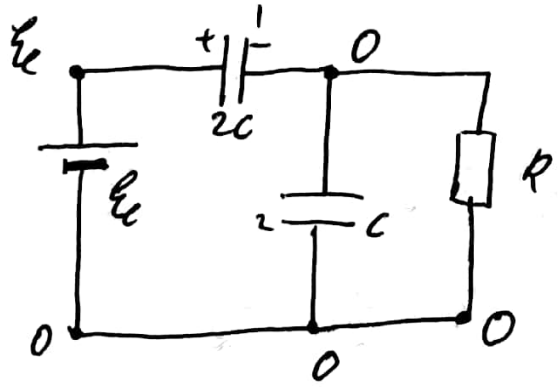
$U_2 = \frac{q}{C} = \frac{2C\mathcal{E}}{3C} = \frac{2\mathcal{E}}{3}$

2) сразу после замыкания ключа

$U_R = U_2 = \nu_{R_0} \cdot R = \frac{2\mathcal{E}}{3} \Rightarrow$ $\boxed{\nu_{R_0} = \frac{2\mathcal{E}}{3R}}$

3) ключ замкнут
в установившемся режиме

$\dot{q}_1 = 0$ и $\dot{q}_2 = 0$. $\nu_R = \nu_1 - \nu_2 \Rightarrow \nu_R = 0 \Rightarrow U_R = 0$




$U_1' = \mathcal{E}$; $U_2' = 0$. $q_1 = U_1' \cdot 2C = 2C\mathcal{E}$

ЗСЭ: $W_0 + A_{ист} = W + Q$

$$W_0 = \frac{q^2}{2C} + \frac{q^2}{2\cdot 2C} = \frac{4C^2\mathcal{E}^2}{9\cdot 2C} + \frac{4C^2\mathcal{E}^2}{9\cdot 2\cdot 2C} = \frac{2C\mathcal{E}^2}{9} + \frac{C\mathcal{E}^2}{9}$$

$$W_0 = \frac{3C\mathcal{E}^2}{9} = \frac{C\mathcal{E}^2}{3}$$

$$W = \frac{q_1^2}{2\cdot 2C} = \frac{4C^2\mathcal{E}^2}{2\cdot 2C} = C\mathcal{E}^2$$

$$A_{ист} = (q_1 - q)\mathcal{E} = \left(2C\mathcal{E} - \frac{2}{3}C\mathcal{E}\right)\mathcal{E} = C\mathcal{E}^2\left(\frac{6}{3} - \frac{2}{3}\right) = \frac{4}{3}C\mathcal{E}^2$$

$$Q = W_0 + A_{ист} - W$$

$$Q = \frac{C\mathcal{E}^2}{3} + \frac{4C\mathcal{E}^2}{3} - C\mathcal{E}^2 = \frac{1+4-3}{3}\cdot C\mathcal{E}^2 = \frac{2}{3}C\mathcal{E}^2$$

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

~~$\mathcal{E} = U_1 + U_2$~~ ~~$0 = \dot{U}_1$~~

~~$\mathcal{E} = U_1 + y_R\cdot R$~~ ~~$\mathcal{E} = U_1 + U_2 \Rightarrow 0 = \dot{U}_1 + \dot{U}_2 \Rightarrow \frac{dU_1}{dt} = -\frac{dU_2}{dt}$~~

$U_2 =$

~~$\int dU_1 = -dU_2$~~

$U_2 + y_R\cdot R = 0 \Rightarrow \dot{U}_2 = -\dot{y}_R R$

$\mathcal{E} = U_1 + y_R\cdot R \Rightarrow \dot{U}_1 = -y_R\cdot R$ $\Rightarrow \dot{U}_1 = \dot{U}_2$ (1)

$$y = \dot{q} = C\dot{U} \Rightarrow \dot{U} = \frac{y}{C}$$

Из (1) $\Rightarrow \frac{y_0}{C_1} = \frac{y_2}{C_2}$; $\frac{y_0}{2C} = \frac{y_2}{C} \Rightarrow y_2 = \frac{y_0}{2}$.

~~$y_R = y_0 +$~~ $y_R = y_1 + y_2 = y_0 + \frac{y_0}{2} = \frac{3y_0}{2}$

$$\boxed{y_R = \frac{3y_0}{2}}$$

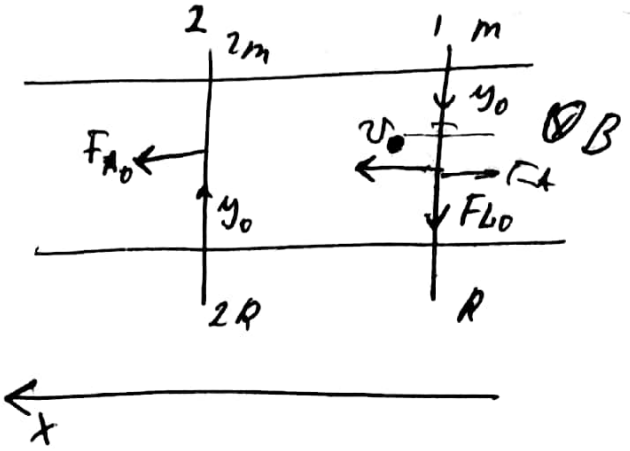
**Ответ:** 1) $y_{R_0} = \frac{2\mathcal{E}}{3R}$; 2) $Q = \frac{2}{3}C\mathcal{E}^2$; 3) $y_R = \frac{3y_0}{2}$.

№4

Чистовик №2. Вариант — 11-01

$B, L, m, R, v_0, S_0$

1) $a_{02}$ — ?
2) $U$ — ?
3) $S$ — ?

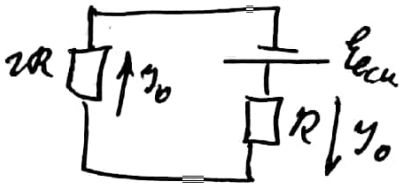



$\sum \vec{F} = m\vec{a}$ — II З. Н.

$\Phi = (\vec{B} \cdot \vec{S})$

на ох: ~~$F_{A_0} = ma_{02}$~~ $F_{A_0} = 2ma_{02}$

$2ma_{02} = y_0 BL$



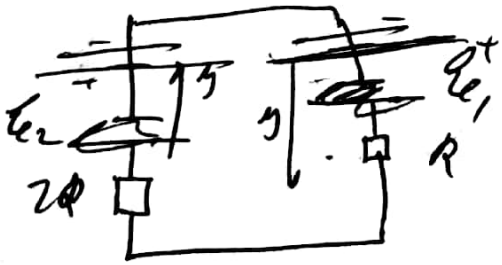

$|\mathcal{E}_{ecu}| = \frac{|d\Phi|}{dt}$ ~~$= \frac{|d(BS)|}{dt}$~~

~~S~~

$|\mathcal{E}_{ecu}| = \frac{BdS}{dt} = \frac{Bv_0 dt \cdot L}{dt} = Bv_0 L$

$y_0 = \frac{|\mathcal{E}_{ecu}|}{3R} = \frac{Bv_0 L}{3R}$

$2ma_{02} = \frac{B^2 L^2 v_0}{3R} \Rightarrow \boxed{a_{02} = \frac{B^2 L^2 v_0}{6mR}}$




$3JR = \mathcal{E}_1 + \mathcal{E}_2$

U — установившаяся скорость.

~~$\Rightarrow$~~ $y = 0$.

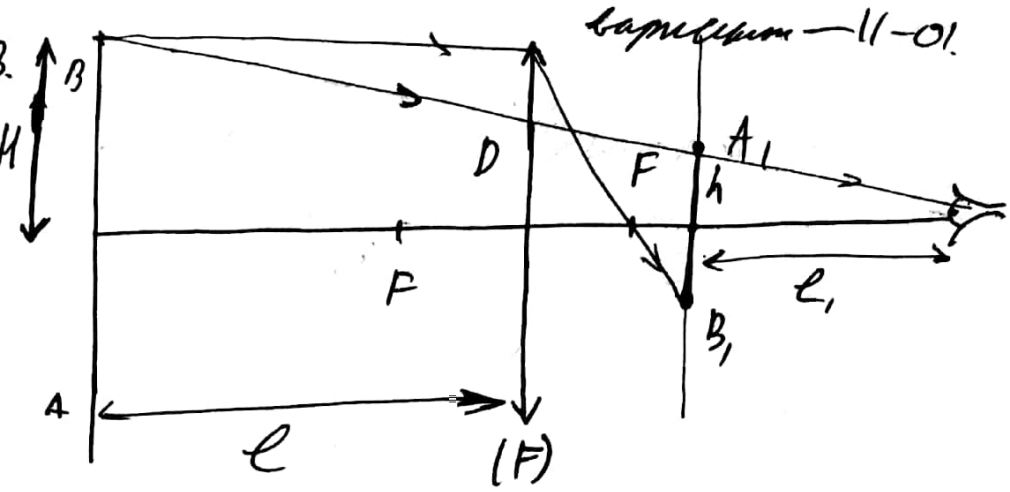
~~$\mathcal{E}_2$~~

Mas:

$$\mathcal{F}_{BL} = ma = m\frac{dv}{dt}$$

$$BL\mathcal{F}dt = m\,dv$$

№5 Чистовик №3. вариант — 11-01.




$F = 9$ см

$H = 9$ см

$l = 36$ см

~~$f = 24$ см~~ $l_1 = 24$ см

1) $x$ — ?

2) $D_л$ — ?

3) $L$ — ?

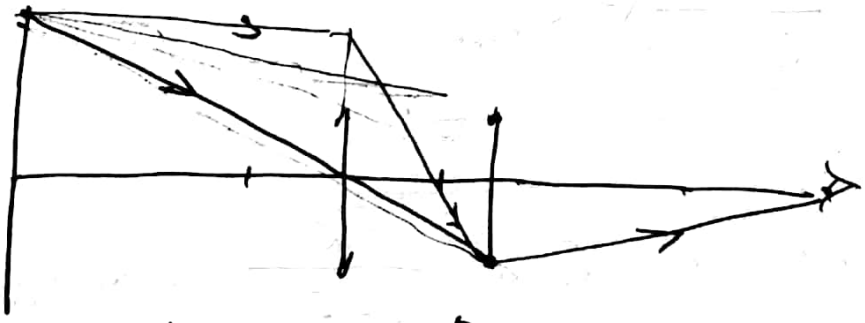
Л — собирающая. $l > F \Rightarrow$ И — действ.

$$\frac{1}{F} = \frac{1}{l} + \frac{1}{f}; \quad \frac{1}{f} = \frac{1}{F} - \frac{1}{l} \Rightarrow f = \frac{Fl}{l-F} = 12 \text{ см}$$

$$x = f + l_1 = 12 \text{ см} + 24 \text{ см} = 36 \text{ см}$$

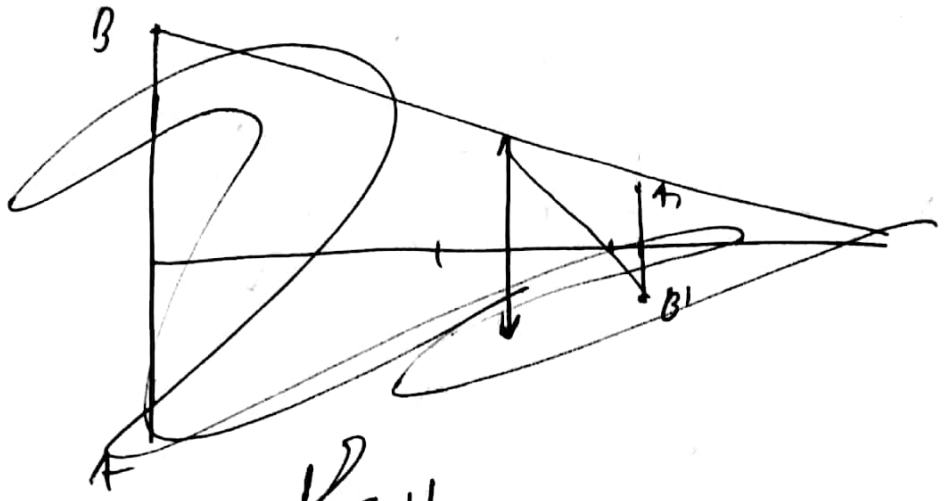
И: действ., перевёрнутое, уменьшенное

$$\boxed{x = \frac{Fl}{l-F} + l_1 = 36 \text{ см}}$$



$$\operatorname{tg}\alpha = \frac{h}{l_1} = \frac{H}{l+f+l_1} = \frac{D_л}{2l_1}$$

$$\boxed{D_л = \frac{2Hl_1}{l+f+l_1} = 6 \text{ см}}$$




$$\frac{1}{F} = \frac{1}{L} + \frac{1}{f_1};\ f_1 = f + l_1 =$$

$$\frac{1}{L} = \frac{1}{F} - \frac{1}{f_1} \Rightarrow L = \frac{F f_1}{F - f_1} < 0.$$

$$\Rightarrow \frac{1}{F} = \frac{1}{L} - \frac{1}{f_1} \Rightarrow \frac{1}{L} = \frac{1}{F} + \frac{1}{f_1} \Rightarrow L = \frac{F f_1}{F + f_1}$$

$$L = \frac{F(f+l)}{F+f+l_1} = 7{,}2\text{ см}$$

Ответ: 1) $x = \frac{Fl}{l-F} + l_1 = 36\text{ см}$

2) $D_л = \frac{2Hl_1}{l+f+l_1} = 6\text{ см}$ 3) $L = \frac{F(f+l_1)}{F+f+l_1} = 7{,}2\text{ см}$