Часть 1

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

Шифр: **21200358**

ID профиля: **300539**

Вариант 2

Чистовик, лист 2

№1

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

$\alpha = const$

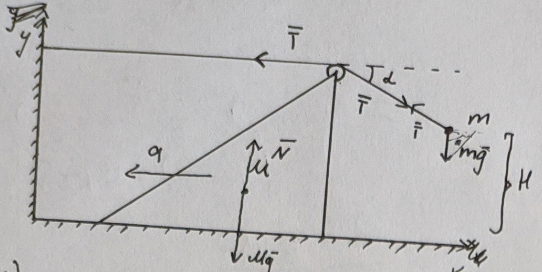
H

β_a - ?

$a_{кл}$ - ?

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

τ - ?



1) 2 З Н для клина:

$$T - T\cos\alpha = Ma$$

2) 2 З Н для шара:

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

$$T\cos\alpha = ma$$

Шарик движется по горизонтали с ускорением клина a, а также вдоль нити с ускорением a

$$\begin{cases} a_x = a - a\cos\alpha \\ a_y = a\sin\alpha \end{cases}$$

$a\sin\beta = a_x$

$a\cos\beta = a_y$

$\frac{a_x}{a_y} = \frac{a - a\cos\alpha}{a\cos\beta} = tg\,\beta$

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

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

$$tg\,\beta = \frac{1}{3}$$

1) 2 З Н для клина:

$Ox: T + T\cos\alpha = Ma$

$Oy: N - Mg - T\sin\alpha = 0$

2 З Н для шарика:

$Ox: -T\cos\alpha = ma_x$

$Oy: -mg + T\sin\alpha = ma_y$

$a_y = a\cos\beta$

$a_x = a\sin\beta$

$\frac{a_x}{a_y} = tg\,\beta$

$\frac{-\frac{T}{m}\cos\alpha}{-g + \frac{T}{m}\sin\alpha} = tg\,\beta$

3) $mg\sin\alpha - T = ma$; $T - T\cos\alpha = Ma$

$mg\sin\alpha - T - ma = 0$

$T = m(g\sin\alpha - a)$

$T - T\cos\alpha = Ma$

$m(g\sin\alpha - a)(1-\cos\alpha) = Ma$

$mg\sin\alpha(1+\cos\alpha) - ma(1-\cos\alpha) = Ma$

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

$T = \frac{ma}{\cos\alpha}$

$\frac{ma}{\cos\alpha} - \frac{ma}{\cos\alpha}\cos\alpha = Ma$

$\frac{m}{\cos\alpha} - 1m = M \,|: m$

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

$T = \frac{mg\sin\alpha}{\cos\alpha + 1}$

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

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

$$\Rightarrow \frac{M}{m} = \frac{1}{\cos\alpha} - 1 = \frac{5}{4} - 1 = \frac{1}{4}$$

21200358 (U300539 M1267204)

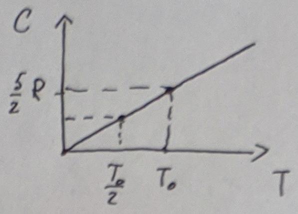
Чистовик, лист 1.

√2

ν; $i=3$

T_0

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



$Q_1^{отд}$ - ?

$c=\frac{\Delta Q}{\nu\Delta T}$ $C(T_0\cdot\frac{1}{2})=\frac{5}{4}R$

1) $\Delta T=\frac{1}{2}T_0-T_0=-\frac{1}{2}T_0$

$Q=-S_{гр}\nu=-\frac{\frac{5}{2}R+\frac{5}{4}R}{2}\cdot(T_0-\frac{T_0}{2})\nu=$

$=-\frac{15}{8}R\cdot\frac{T_0}{2}\nu=-\frac{15}{16}RT_0\nu$

$Q_1^{отд}=\frac{15}{16}\nu RT_0$

I 3-4 термодинамики

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

$A=\Delta Q-\Delta U$

$c=\frac{\Delta Q}{\nu\Delta T}$ $\Delta Q=c\nu\Delta T$

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

~~$A=\frac{3}{2}\nu R(T_0-T)-\frac{5}{2}R\cdot\frac{T}{T_0}\nu(T_0-T)=\frac{5}{2}R\frac{T}{T_0}\cdot\nu(T-T_0)$~~

~~$A=\frac{3}{2}\nu RT_0-\frac{3}{2}\nu RT-\frac{5}{2}R\nu(T-\frac{T^2}{T_0})=$~~

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

~~т.к. $A=A_{min}$, то $A'=0$~~

~~$A'(T)=0-\frac{3}{2}\nu R-\frac{5}{2}\nu R+5\nu R\cdot\frac{T}{T_0}=0$~~

~~$-4\nu R+5\nu R\frac{T}{T_0}=0$~~

~~$\frac{T}{T_0}5\nu R=4\nu R$~~

~~$T=\frac{4}{5}T_0$~~

~~2) $Q=\Delta U+A$~~

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

~~$Q=c\cdot\nu\cdot T=c(T)\cdot T\cdot\nu$~~

~~$A=c(T)\cdot T\cdot\nu$~~

~~т.к. $A=A_{min}$, то $A'=0$~~

~~$A'(T)=\nu(c'(T)\cdot T+T'c(T))$~~

~~$A'(T)=\nu(c\nu T+c\nu T)$~~

~~$A=c(T)\cdot T\nu-\frac{3}{2}\nu R(T-T_0)=$~~

~~$A_{min}=A(T)=\frac{3}{2}\nu RT_0-4\nu R\cdot\frac{4}{5}T_0+5\nu R\cdot\frac{\frac{16}{25}T_0^2}{2T_0}=\nu RT_0(\frac{3}{2}-\frac{16}{5})+\frac{8}{5}\nu RT_0=$~~

~~$=\nu RT_0\cdot\frac{3}{2}=\frac{3}{2}\nu RT_0$ $\nu RT_0(\frac{3}{2}-\frac{16}{5}+\frac{8}{5})=\frac{31-32}{5}\nu RT_0=-\nu RT_0$~~

$A=-\frac{3}{2}\nu R(T-T_0)+\frac{5}{2}R\cdot\frac{T}{T_0}\nu(T-T_0)=-\nu R(\frac{3}{2}T-\frac{3}{2}T_0-\frac{5}{2}\frac{T^2}{T_0}+\frac{5}{2}T)=-\nu R(4T-\frac{3}{2}T_0-\frac{5}{2T_0}T^2)$

$A'=0$, т.к $A=A_{min}$ (точка минимума)

$A'(T)=0=-\nu R(4-5\cdot\frac{T}{T_0})=0$

$4-5\frac{T}{T_0}=0$ $4=5\frac{T}{T_0}$ => $T=\frac{4}{5}T_0$

тогда $A_{min}=A(T)=-\nu R(4\cdot\frac{4}{5}T_0-\frac{3}{2}T_0-\frac{5}{2T_0}\cdot\frac{16}{25}T_0^2)=-\nu RT_0(\frac{16}{5}-\frac{3}{2}-\frac{8}{5})=-\nu RT_0\frac{32-15-16}{10}=-\frac{1}{10}\nu RT_0$

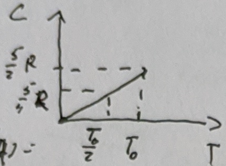
Ответ: $\frac{15}{16}\nu RT_0$; $\frac{4}{5}T_0$; $-\frac{1}{10}\nu RT_0$

Черновик, лист 1

$$\nu c(T-T_0)\left(\frac{3}{2}R\frac{T}{T_0}-R\right)=\nu R c(T-T_0)\left(\frac{3}{2}\frac{T}{T_0}-1\right)=\nu R\left(\frac{3}{2}\frac{T^2}{T_0}-T-\frac{3}{2}T_0+T_0\right)=$$

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

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



$$A'=\frac{3}{2}\frac{T}{T_0}-\frac{5}{2}=0$$

$$3\frac{T}{T_0}=\frac{5}{2}$$

$$\frac{5}{2}R\frac{T}{T_0}=\frac{3}{2}R+\frac{A}{\nu(T-T_0)}$$

$$\frac{5}{2}R\frac{T}{T_0}-\frac{3}{2}R=\frac{A}{\nu(T-T_0)}$$

$$\frac{3}{5}T_0 \quad \frac{1}{5}T_0$$

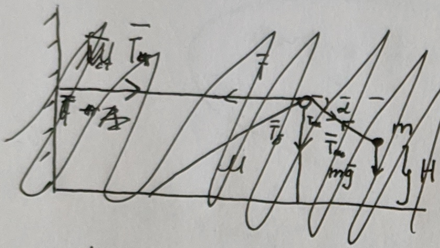
$$-\nu RT_0\left(\frac{12}{5}-\frac{3}{2}-\frac{9}{25}\cdot\frac{5}{2}\right)=$$

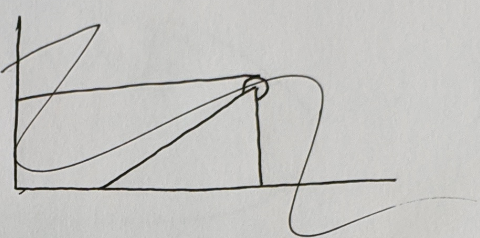
$$A=\frac{5}{2}\frac{T}{T_0}R\nu(T-T_0)-\frac{3}{2}\nu R(T-T_0)$$

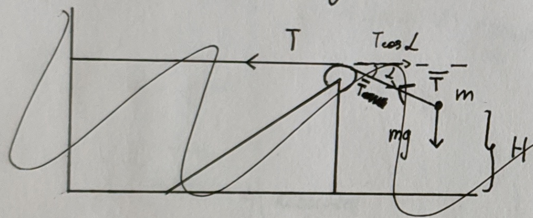
№1

$$=-\nu RT_0\cdot\left(\frac{24}{10}-\frac{15}{10}-\frac{9}{10}\right)=0$$

$$q=\frac{\frac{5}{2}+\frac{5}{4}}{2}R\cdot\frac{T_0}{2}=\frac{15}{8\cdot 2}RT_0=\frac{15}{16}RT_0 \quad Q=\frac{15}{16}\nu RT_0$$







$$E_{полн}=mgH \quad \cos\alpha=\frac{4}{5} \quad \alpha=const$$

$$H=\frac{at^2}{2} \quad \sqrt{\frac{2H}{a\sin\alpha}}=\sqrt{\frac{2H}{\frac{4}{15}g\cdot\frac{3}{5}}}=\sqrt{\frac{H}{g}}\cdot\sqrt{\frac{1}{\frac{6}{15\cdot 5}}}=$$

$$=\sqrt{\frac{H}{g}}\cdot\sqrt{\frac{15\cdot 5}{6}}=\frac{5}{\sqrt{2}}\sqrt{\frac{H}{g}}$$

$$a_y=a\cdot\sin\alpha$$

$$H=\frac{a_y t^2}{2} \quad t=\sqrt{\frac{2H}{a\sin\alpha}}=$$

$$\sqrt{\frac{H}{g}}\cdot\sqrt{\frac{2}{\frac{1}{5}\cdot\frac{8}{5}}}$$

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4) $\begin{cases} T - T\cos\alpha = Ma \\ mg\sin\alpha - T = ma \\ T\cos\alpha = ma \end{cases}$ $\quad mg\sin\alpha - T = T\cos\alpha$

$$T = \frac{mg\sin\alpha}{1+\cos\alpha}$$

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

$$g\sin\alpha\,\frac{1-\cos\alpha}{1+\cos\alpha} = \frac{M}{m}a$$

$$a = 4\cdot g\cdot\frac{3}{5}\cdot\frac{\frac{1}{5}}{\frac{9}{5}} = \frac{12}{5}g\cdot\frac{1}{9} = \frac{4}{15}g$$

5) ВСЭ: $mgH = Mv^2\cdot\frac{1}{2} + mg\cdot 0$ – для системы.

$$2\frac{m}{M}gH = v^2$$

$$v = \sqrt{\frac{m}{M}gH\cdot 2} \text{ – у клина}$$

$$v = v_0 + at \quad (v_0 = 0)$$

$$\sqrt{\frac{m}{M}gH\cdot 2} = at$$

$$t = \frac{2\sqrt{2}\sqrt{gH}}{\frac{4}{15}g} = \sqrt{\frac{H}{g}}\cdot\frac{2\sqrt{2}}{\frac{4}{15}} = \sqrt{\frac{H}{g}}\cdot\frac{30\sqrt{2}}{4} = \sqrt{\frac{H}{g}}\cdot\frac{15\sqrt{2}}{2}$$

5) $H = \frac{a_y t^2}{2}$

$$t = \sqrt{\frac{2H}{a_y}} = \sqrt{\frac{2H}{a\sin\alpha}} =$$

$$= \sqrt{\frac{H}{g}}\sqrt{\frac{2}{\frac{4}{15}\cdot\frac{3}{5}}} =$$

$$= \sqrt{\frac{H}{g}}\cdot\frac{5}{\sqrt{2}} = \frac{5\sqrt{2}}{2}\sqrt{\frac{H}{g}}$$

Ответ: $\frac{1}{3}$; $\frac{4}{15}g$; $\frac{1}{4}$; $\frac{5\sqrt{2}}{2}\sqrt{\frac{H}{g}}$

Часть 2

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

Шифр: **21200358**

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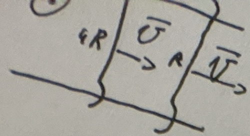
Вариант 2



– напр. вправо.

$I=0 \Rightarrow U=0 \Rightarrow \Phi'=0 \qquad \Phi = B\cdot l\cdot x$

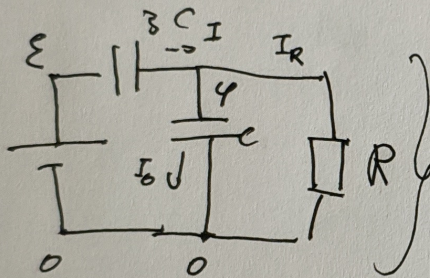
по ЗСИ: $mv_0 = \frac{m}{2}v + mv$

$v = \frac{mv_0}{1{,}5m} = \frac{2v_0}{3}$

4) $F_{A_1} = BIL = BL\cdot\frac{BLv}{5R} = ma_1$

$a_1 = \frac{B^2L^2v}{5Rm}$

Чистовик, лист 4



метод потенциалов

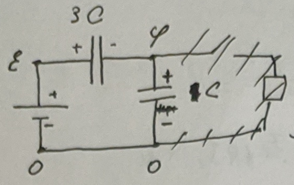
$I_0 = q'$ $\qquad I_0\Delta t = \Delta q$

$I_R = \frac{U}{R}$ $\qquad R = \frac{U}{I}$

Чистовик, лист 1. (часть 2)

№3

до замыкания:
уст. реж.



} метод потенциалов

$C = \frac{q}{U}$ $q = UC$

$q_1 = (\mathcal{E} - \varphi) \cdot C$

$q_2 = \varphi \cdot 3C$, но $q_1 = q_2$ $\Rightarrow$

$\Rightarrow 1 = \frac{(\mathcal{E}-\varphi) C}{\varphi \cdot 3C}$

$3\varphi = \mathcal{E} - \varphi$

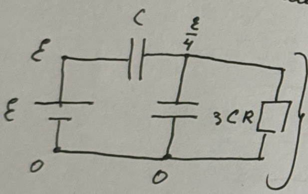
$\varphi = \frac{\mathcal{E}}{4}$ $\quad q_{общ_1} = C \cdot \frac{3\mathcal{E}}{2}$

$q_1 = q_2 = C \cdot \frac{3\mathcal{E}}{4}$

$W_0 = W_{c_0} + W_{3c_0} = \frac{CU_c^2}{2} + \frac{CU_{3c}^2}{2} = \frac{C \cdot \left(\frac{3\mathcal{E}}{4}\right)^2}{2} + \frac{3C \cdot \left(\frac{\mathcal{E}}{4}\right)^2}{2} =$

$= \frac{C \cdot 9\mathcal{E}^2}{32} + \frac{3C\mathcal{E}^2}{32} = \frac{3}{8} C\mathcal{E}^2$

сразу после замыкания; напр. на конд. скачком не меняется.

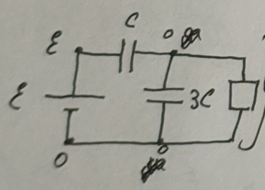


метод потенциалов

$U_R = \frac{\mathcal{E}}{4} - 0 = \frac{\mathcal{E}}{4}$

$I_R = \frac{U_R}{R} = \frac{\frac{\mathcal{E}}{4}}{R} = \frac{\mathcal{E}}{R \cdot 4}$

уст. реж. после замыкания; тока через резистор нет.



метод потенциалов
значит $U_{3c} = 0$

$q_{c_1} = \mathcal{E} \cdot C$

$q_{c_2} = 0 \cdot 3C = 0$ $\quad q_{общ_2} = \mathcal{E} \cdot C$

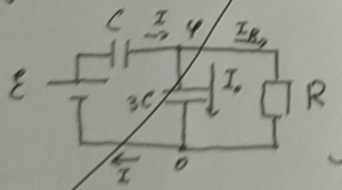
$\Delta q = (C \cdot \frac{3\mathcal{E}}{2} - \mathcal{E}C) = + \frac{C\mathcal{E}}{2}$

ЗСЭ: всей энергии

$A_{ист} = \mathcal{E} \Delta q = +\frac{C\mathcal{E}^2}{2} = W_0 + Q$

$Q = \frac{C\mathcal{E}^2}{2} - W_0 = \frac{C\mathcal{E}^2}{2} - \frac{3}{8} C\mathcal{E}^2 = \frac{1}{8} C\mathcal{E}^2$

когда $I_{c_2} = I_0$:



} метод потенциалов.

$U_R = \varphi$ $\quad R = \frac{U}{I}$ $\quad I = \frac{U}{R}$

$I_R = \frac{\varphi}{R}$

ЗСЗ: $I = I_R + I_0 = \frac{\varphi}{R} + I_0$

$U_{3c} = \varphi$

$q_{3c} = 3C\varphi$ $\quad I_0 = q'_{3c}$

$I_0 = 3C \cdot \varphi'$

Р№4

B

L

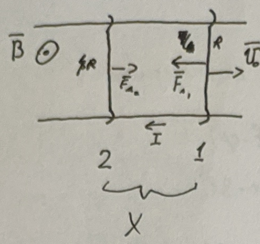
m; R - 1

$\frac{m}{2}$; 4R - 2

a_2 - ?

v - ?

l - ?



1) $\mathcal{E}_i = -\frac{\Delta\Phi}{\Delta t} = -\Phi' = -BS' = -B\cdot L\cdot x' = -BLv_0$

$U = BLv = 4RI_2 + RI_1$

$R = \frac{U}{I}$

$U = RI$

$\frac{BLv_0}{R} = 4I_2 + I_1 \quad I_1 = I_2 = I$

2) $F_A = BIL$ $\quad \frac{BLv}{R} = 5I$

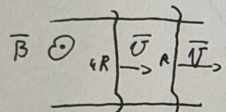
$F_{A_1} = BIL = ma_1$ $\quad I = \frac{BLv}{5R}$

$F_{A_2} = BIL = \frac{m}{2}a_2$

$B\cdot\frac{BLv}{5R}\cdot L = \frac{m}{2}a_2$

$a_2 = \frac{2B^2L^2v_0}{5mR}$ – напр. вправо.

3) $I=0 \Rightarrow U=0 \Rightarrow \Phi'=0$ $\quad \Phi = B\cdot l\cdot x$



по ЗСИ: $mv_0 = \frac{m}{2}v + mv$

$v = \frac{mv_0}{1{,}5m} = \frac{2v_0}{3}$

4) $F_{A_1} = BIL = BL\cdot\frac{BLv}{5R} = ma_1$

$a_1 = \frac{B^2L^2v}{5Rm}$ $\quad v = \frac{2v_0}{3} =$

$a_2 = \frac{2B^2L^2v}{5mR}$

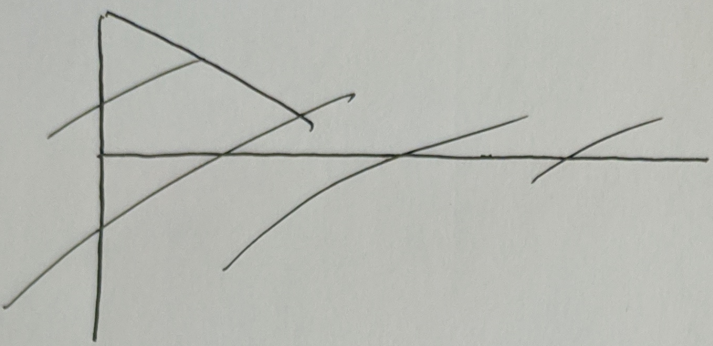
$\frac{2v_0}{3} = v_0 - \Sigma a_i t_i$

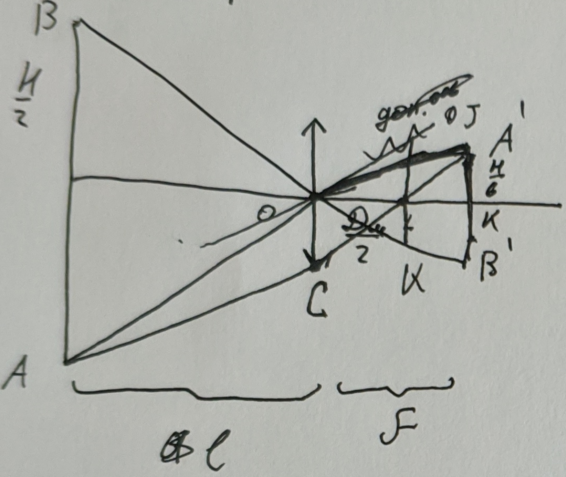
$+\frac{v_0}{3} = \Sigma a_i t_i$

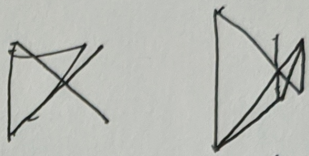
Ответ: $\frac{2B^2L^2v_0}{5mR}$; $\frac{2v_0}{3}$

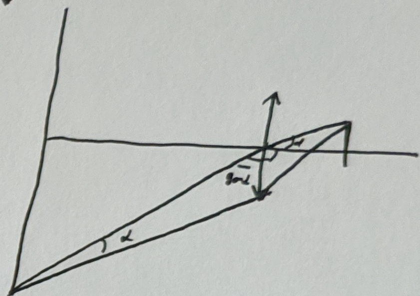
21200358 (U300539 M1267205)

Чистовик, лист 6









луч из A в A' идет чер. опт. центр, если $D = D_м$

AC прямолинейная и уходит в A'

$$\frac{D_м/2}{H_6/6} = \frac{OL}{LK}$$, но L на гл. опт. оси => пересечение доп. опт. оси с фокальной пл-ю

OL = F = 12 см

LK = f − F = 4 см

$$\frac{D_м}{H_6/3} = 3$$

$D_м = H = 9$ см

$$JK = 2 \cdot \frac{\frac{H}{3} \cdot D_м}{\frac{H}{3} + D_м}$$

$\frac{H}{3}$

Чистовик, лист 5

№3

$F = 12$ см

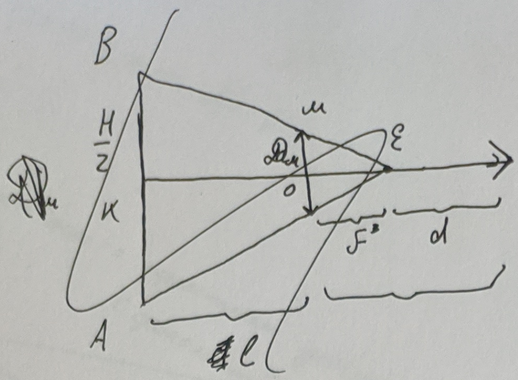
$H = 9$ см

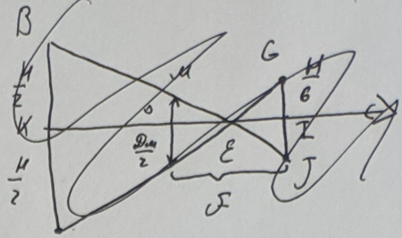
$l = 48$ см

$d = 24$ см

x - ?

$D_м$ - ?





1) Формула тонкой линзы:

$$\frac{1}{F} = \frac{1}{l} + \frac{1}{f}$$

$$f = \frac{Fl}{l-F} = 16 \text{ см} \qquad Г = \frac{f}{l} = \frac{16}{48} = \frac{1}{3}$$

$$x = f + d = 40 \text{ см}$$

2) $\triangle BεK \sim \triangle MεO$:

$$\frac{\frac{H}{2}}{\frac{D_м}{2}} = \frac{f+l}{f} \qquad \frac{H}{D_м} = \frac{16+48}{16} = 4$$

$$D_м = \frac{H}{4} = \frac{9}{4} = 2{,}25 \text{ см}$$

2) Подобие $\triangle$:

$$\frac{\frac{D_м}{2}}{\frac{H}{2}} = \frac{Oε}{εK}$$

$$\frac{\frac{D_м}{2}}{\frac{H}{6}} = \frac{Oε}{εI}$$

$$\frac{Kε}{εI}$$

3) 2) $\triangle BεK \sim \triangle εIJ$:

$$\frac{\frac{H}{2}}{\frac{H}{6}} = \frac{Kε}{εI} \qquad \frac{Kε}{εI} = \frac{3}{1} \qquad Kε = 48$$

$$Kε + εI = f + l = 64 \qquad Kε + εI = 64 \qquad εI = 16$$

$$\frac{\frac{D_м}{2}}{\frac{H}{2}} = \frac{Oε}{l} \qquad Oε = \frac{lD_м}{H}$$

$$\frac{\frac{D_м}{2}}{\frac{H}{6}} = \frac{Oε}{εI} \qquad \frac{\frac{D_м}{2}}{\frac{H}{6}} = \frac{lD_м}{HεI}$$

$$3 = \frac{l}{εI} \qquad εI = \frac{l}{3} = 12$$

2) $$\frac{\frac{H}{2}}{\frac{D_м}{2}} = \frac{f+l}{f} \qquad \frac{H}{D_м} = \frac{16+48}{16} = 4$$

$$D_м = \frac{H}{4} = \frac{9}{4} = 2{,}25 \text{ см}$$

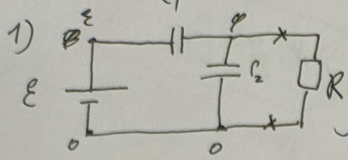
Ответ: 40 см; 2,25 см.

21200358 (U300539 M1267205)

Чистовик, лист 3

№3

1) уст. режим до замык.



метод потенциалов.

$C_1 = 3C$

$C_2 = C$

$q_1 = 3C(\varepsilon - \varphi)$

$q_2 = C\varphi$

$q_1 = q_2 = q$

$3C(\varepsilon - \varphi) = \varphi$

$3\varepsilon - 3\varphi = \varphi$

$\varphi = \frac{3}{4}\varepsilon$

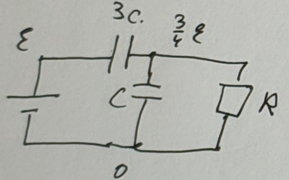
$q = \frac{3}{4}C\varepsilon \cdot 2 = \frac{3}{2}C\varepsilon$

$$W_0 = W_{c_1} + W_{c_2} = \frac{3C\cdot(\varepsilon - \frac{3}{4}\varepsilon)^2}{2} + \frac{C(\frac{1}{4}\varepsilon)^2}{2} =$$

$$= \frac{3C\cdot\frac{9}{16}\varepsilon^2}{2} + \frac{C\cdot\frac{1}{16}\varepsilon^2}{2} =$$

$$= \frac{27}{32}C\varepsilon^2 + \frac{1}{32}C\varepsilon^2 = \frac{7}{8}C\varepsilon^2$$

2) сразу после замыкания ключа, напр. на конд. скачком не меняется

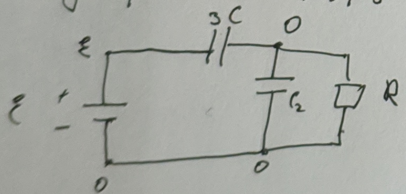


$U_R = \frac{3}{4}\varepsilon$

$R = \frac{U_R}{I}$

$I = \frac{U_R}{R} = \frac{3\varepsilon}{4R}$

3) уст. реж, тока через резистор нет



$U_2 = 0$

$U_1 = \varepsilon$

$q_1 = 3CU_1 = 3C\varepsilon$

$q_{общ} = 3C\varepsilon$

$\Delta q = 3C\varepsilon - \frac{3}{2}C\varepsilon = \frac{3}{2}C\varepsilon$

$W = \frac{3C\varepsilon^2}{2}$

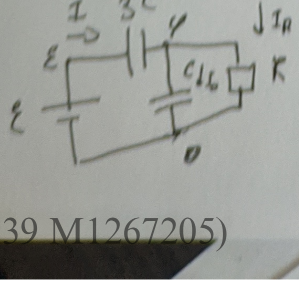
$\Delta W = W - W_0 = \frac{3}{2}C\varepsilon^2 - \frac{7}{8}C\varepsilon^2 = \frac{5}{8}C\varepsilon^2$

ЗСЭ (вся): $A_{ист} = \varepsilon\Delta q = \varepsilon\cdot\frac{3}{2}C\varepsilon^2 = Q + \frac{5}{8}C\varepsilon^2$

$Q = \frac{3}{2}C\varepsilon^2 - \frac{5}{8}C\varepsilon^2 = \frac{7}{8}C\varepsilon^2$

Ответ: $\frac{3}{4}\frac{\varepsilon}{R}$; $\frac{7}{8}C\varepsilon^2$

4)



$I = I_0 + I_R$ (ЗСЗ)

$R = \frac{U}{I}$

$I_0 = q'$

$R I_R = R_c I_c$