Часть 1

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

Шифр: **21202943**

ID профиля: **833989**

Вариант 4

Чистовик

№2 1) Пусть $\Delta T \to 0$, тогда соответствующее $\Delta Q = \frac{9RT}{5T_0}\nu\Delta T \; (Q = C\nu\Delta T)$

$\int\limits_0^{Q_1'} dQ = \int\limits_{T_0}^{\frac{3T_0}{4}} \frac{9RT}{5T_0}\nu\, dT$; $\int\limits_a^b x\,dx = \frac{x^2}{2}\Big|_a^b \Rightarrow Q_1' = \frac{9}{10}\frac{RT^2\nu}{T_0}\Big|_{T_0}^{\frac{3T_0}{4}} = -\frac{63}{160}\nu RT_0 =$

$= -0{,}39375\,\nu RT_0 \Rightarrow Q_1 = |Q_1'| = 0{,}39375\,\nu RT_0$

2) $\Delta T \to 0$; $Q = A + \Delta U \Rightarrow \Delta Q = \Delta A + \Delta U$; $U = \frac{i}{2}\nu RT \Rightarrow \Delta U = \frac{i}{2}\nu R\Delta T = \frac{3}{2}\nu R\Delta T$

$\Rightarrow \Delta A = \Delta Q - \Delta U = \nu R\Delta T\left(\frac{9T}{5T_0} - \frac{3}{2}\right)$; $\int\limits_0^{A_1} dA = \int\limits_{T_0}^{T_1} \nu R\,dT\left(\frac{9T}{5T_0} - \frac{3}{2}\right) \Rightarrow A_1 = \frac{9}{10}\frac{RT^2\nu}{T_0}\Big|_{T_0}^{T_1} -$

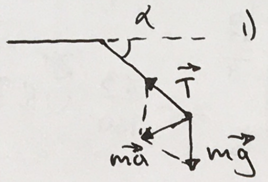
$- \frac{3}{2}\nu RT\Big|_{T_0}^{T_1} = \frac{9}{10}\frac{RT_1^2\nu}{T_0} - \frac{3}{2}\nu RT_1 + \frac{3}{5}\nu RT_0 \Rightarrow A_1$ min при $T_1' = \frac{\frac{3}{2}\nu R}{2\frac{9}{10}\frac{R\nu}{T_0}} = \frac{5}{6}T_0 \Rightarrow$

3) $A_{1min} = \nu RT_0\left(\frac{9}{10}\cdot\frac{25}{36} - \frac{3}{2}\cdot\frac{5}{6} + \frac{3}{5}\right) = -\frac{1}{40}\nu RT_0 = -0{,}025\,\nu RT_0$

Ответ: $Q_1 = 0{,}39375\,\nu RT_0$; $T_1' = \frac{5}{6}T_0$; $A_{1min} = -0{,}025\,\nu RT_0$

Чистовик

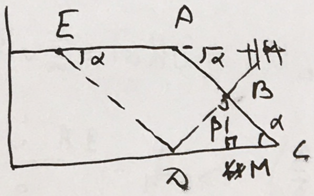
№1



1) по 2 з. Ньютона для шарика: $m\vec a = \vec T + m\vec g$; т.к. $T = const$ и $mg = const$ => $ma = const$ => шарик движется вдоль одной прямой; рассмотрим два положения шарика: начальное и конечное (B и D): β – искомый угол.

т.к. нить нерастяжима, то $AE + AB = ED$;

т.к. $ED \parallel AC$ и $AE \parallel CD$ => ACDE – параллелограмм, причём $ED = AC = AB + BC = AE + AB$ => $BC = EA = CD$; $BC = \frac{17H}{15} = H\frac{1}{\sin\alpha}$; $\sin\alpha = \sqrt{1-\cos^2\alpha} = \frac{15}{17}$; ~~ED и EA~~ $CM = \frac{BC}{\cos\alpha} = \frac{8}{15}H$



=> $DM = \frac{9}{15}H$ => $tg\,\beta = \frac{DM}{BM} = \frac{9}{15}$ (т.к. ускорение клина также постоянно и $BC = EA$)

2) $a_{кл} = g\sin\alpha = \frac{15}{17}g$

Ответ: 1) $tg\,\beta = \frac{9}{15}$ 2) $a_{кл} = \frac{15}{17}g$

Черновик.

$\Delta T \to 0 \quad \Delta Q = \frac{9RT}{5T_0}\nu\Delta T$, интегр. $\int_0^{Q_1'} = Q_1' = \frac{9}{10}\frac{RT^2\nu}{T_0}\Big|_{T_0}^{\frac{3T_0}{4}} =$

$= \frac{9RT_0^2\nu\cdot 9}{10\cdot 16\, T_0} - \frac{9}{10}\nu RT_0 = -\frac{7\cdot 9 T_0 \nu R}{10\cdot 16} = 0{,}39375\,\nu RT_0$

$\int_a^8 x\,dx = \frac{x^2}{2}\Big|_a^8$

$\Delta Q = \Delta A + \Delta U \Rightarrow$

$\Delta A = \Delta Q - \Delta U = \frac{9RT\nu\Delta T}{5T_0} - \frac{3}{2}\nu R\Delta T$

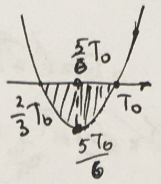
$\frac{6}{10} = \frac{3}{5}$

$= \nu R\Delta T\left(\frac{9T}{5T_0} - \frac{3}{2}\right)$

$A_1 = \frac{9}{10}\frac{RT_1^2\nu}{T_0} - \frac{9}{10}\nu RT_0 - \frac{3}{2}\nu RT_1 + \frac{3}{2}\nu RT_0 = \frac{9}{10} - \frac{3}{2} + \frac{3}{5}$

$T_0' = \frac{8\cdot 10^5}{2\cdot 2\cdot 9\cdot 3} = \frac{5}{8}T_0$

$81+225$



$D = \frac{9}{4} - \frac{3}{5}\cdot 4\cdot\frac{9}{10\cdot 5} =$

$= \frac{9}{4} - \frac{2\cdot 27}{525} = \frac{9}{100} = \frac{3}{10}$

$\frac{3}{2} - \frac{3}{10} = \frac{12}{8\cdot 9\cdot 3} = \frac{2}{3}$

$T_{1,2} = \frac{\frac{3}{2} \pm \frac{3}{10}}{2\cdot 9}10 = \frac{18}{2\cdot 9} = 1T_0$

$1 - \frac{5}{6} = \frac{1}{6} \quad \frac{5}{6} - \frac{1}{6} = \frac{4}{6} = \frac{2}{3}T_0$

$\frac{8\cdot 10^5}{2\cdot 9\cdot 3} =$

$\frac{3}{2} - \frac{9}{10} = \frac{6}{10} = \frac{3}{5}$

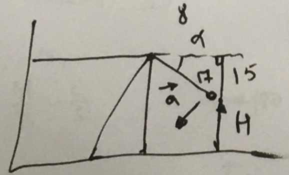
$\frac{9}{10}\cdot\frac{25}{36\cdot 4} - \frac{3}{2}\cdot\frac{5}{2\cdot 8} + \frac{3}{5} = \frac{5}{8} - \frac{5}{4} + \frac{3}{5} = -\frac{5}{8} + \frac{3}{5} = -\frac{1}{40}\nu RT_0 =$

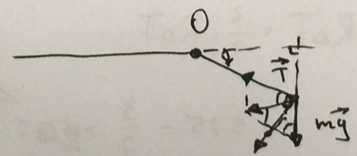
$= 0{,}025$

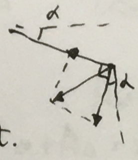
$\frac{9}{10}\cdot\frac{25}{36\cdot 4}$

ЗСИ: $mv_1 = mv_2$

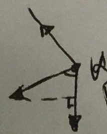
$\boxed{a = const}$

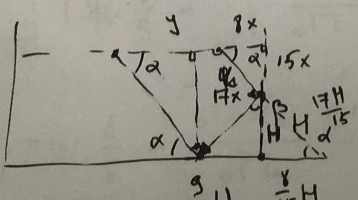


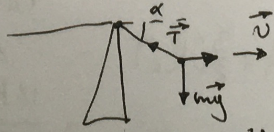


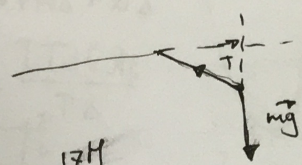


T = const.



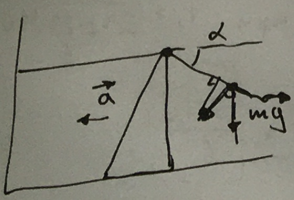






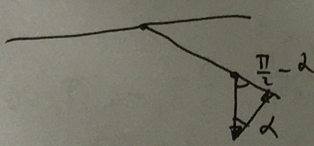
$y + 17x = \frac{17}{}x + \frac{17H}{15} \qquad y = \frac{17H}{15}$

$\frac{17-8}{15} = \frac{9}{15}$



$\tg\alpha = \frac{9}{15}$

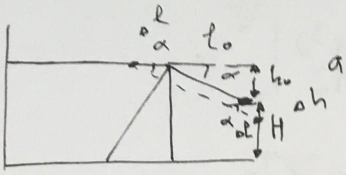
$y = \frac{at^2}{2}$;



21202943 (U833989 M1264453)

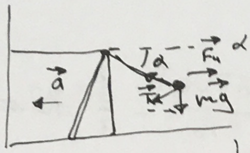
Черновик

№1

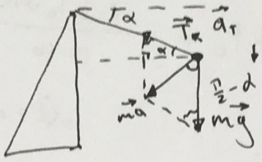


a-?

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



~~T ≠ const~~

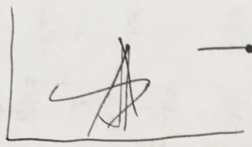


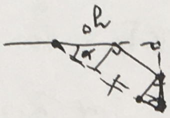
$\downarrow a m g = g$

$$tg\alpha = \frac{h_0}{l_0} = \frac{h_0 + \Delta h}{l_0 + \Delta L} \qquad tg\alpha = \frac{\Delta h}{\Delta l}$$

$$\Delta l(1 + tg\alpha) = \Delta l\left(\sin\alpha + \frac{\sin^2\alpha}{\cos\alpha}\right)$$

$$\frac{\Delta l \sin^2\alpha}{\cos\alpha}$$





№2 ν; T_0 $\qquad c(T) = \frac{9}{5}R\frac{T}{T_0}$ $\qquad \Delta Q = c\nu\Delta T$ $\qquad pV = \nu RT$

$$\int x\,dx = \frac{x^2}{2}\Big|_a^b \qquad \Delta Q = \frac{9RT\nu\Delta T}{5T_0}$$

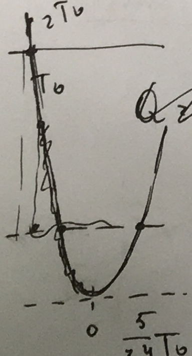
$$Q_1' = \int_{T_0}^{\frac{3T_0}{4}} \frac{9RT\nu dT}{5T_0} = \frac{18R\nu T^2}{5T_0}\Big|_{T_0}^{\frac{3T_0}{4}} =$$

$$\boxed{Q_1 = |Q_1'| = 1{,}575\,\nu RT_0} \qquad = \frac{18R\nu \cdot 9T_0^2}{5\cdot T_0\cdot 16} - \frac{18R\nu T_0}{5} = -\frac{18R\nu T_0\, 7}{5\cdot 16\cdot 8} = -1{,}575\,R\nu T_0$$

$$0 > Q = \frac{18R\nu T^2}{5T_0}\Big|_{T_0}^{T_1} = A + \underset{\frac{3}{2}\nu R(\Delta T)}{\Delta U} < 0 \Rightarrow \int_0^{A_1} dA = \frac{9RT\nu\Delta T}{5T_0} - \nu R\Delta T = \int_{T_0}^{T_1} \nu R\Delta T\left(\frac{9T}{5T_0} - \frac{3}{2}\right)$$

$$\frac{9}{5} - \frac{3}{2} =$$

$$\Delta U = \frac{i}{2}\nu R\Delta T = \frac{3}{2}\nu R\Delta T$$



<0 работа отриц.

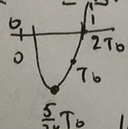
$$\frac{3}{2} - \frac{10}{5} =$$

$$-1{,}575 - \frac{3}{2} = \ldots > 0.$$

$\Delta Q = \Delta A + \Delta U$ для ΔT.

$$A_1 = \frac{18R\nu T^2}{5T_0}\Big|_{T_0}^{T_1} - \frac{3}{2}\nu RT\Big|_{T_0}^{T_1} =$$

$$\frac{9R\nu\Delta T T}{5T_0} = \Delta A + \frac{3}{2}\nu R\Delta T$$



$$= \frac{18R\nu T_1^2}{5T_0} - \frac{18R\nu T_0^2}{5T_0} - \frac{3}{2}\nu RT_1 + \frac{3}{2}\nu RT_0 =$$

$$= \frac{18R\nu T_1^2}{5T_0} - \frac{3}{2}\nu RT_1 - 2{,}1\nu RT_0\ ; A_1 \text{ мин при } T_1 = \frac{3\nu R\cdot 5T_0}{2\cdot 2\cdot 18\cdot R\nu} =$$

$$T_1 = \boxed{\frac{5}{24}T_0} \qquad \frac{9T}{5T_0} = \frac{3}{2} \Rightarrow T = \frac{15T_0}{18} = \boxed{\frac{5T_0}{6}}$$

$$2 - \frac{5}{24} = \frac{43}{24} \qquad \frac{3\cdot 5}{2\cdot 2\cdot 18} = \frac{5}{24}$$

$$\frac{18T_1^2}{5T_0} - \frac{3}{2}T_1 - 2{,}1T_0 = 0 \qquad \frac{9}{4} + 4\cdot 2{,}1\cdot\frac{18}{5} = 5{,}7 \quad (30{,}24)$$

$$T_{1,1,1} = \frac{\frac{3}{2} \pm 5{,}7}{18}5 = 2T_0$$

21202943 (U833989 M1264453)

Часть 2

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

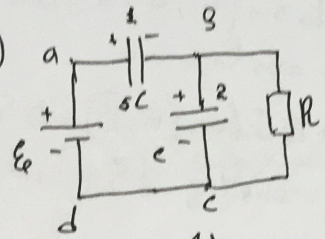
Шифр: **21202943**

ID профиля: **833989**

Вариант 4

Чистовик

№3 1)



по 2-ому прав. Кирхгофа для контура abcda:

$\mathcal{E} = U_1 + U_2$; $q_1 = q_2 = CU_2 = 5CU_1 \Rightarrow U_2 = 5U_1$

(т.к. до замыкания обкладки изолированы) после замыкания U_2 не успевает поменяться, значит $U_2 = IR$; $U_2 = \frac{5}{6}\mathcal{E}$ и

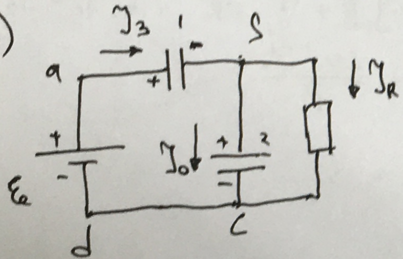
$U_1 = \frac{\mathcal{E}}{6} \Rightarrow I = \frac{U_2}{R} = \frac{5\mathcal{E}}{6R}$

2) В уст. режиме после замыкания ток через R и C_2 не течёт, $U_1' = \mathcal{E}$

$A_{ист} = \mathcal{E}\Delta q = \mathcal{E}(q_1' - q_1)$; $q_1' = 5C\mathcal{E}$; ЗСЭ: $\frac{5CU_1^2}{2} + \frac{CU_2^2}{2} + A_{ист} = \frac{5CU_1'^2}{2} + Q \Rightarrow$

$$\frac{5C\mathcal{E}^2}{36} + \frac{25}{36}C\mathcal{E}^2 + 2\mathcal{E}C\left(5\mathcal{E} - \frac{5\mathcal{E}}{6}\right) = 5C\mathcal{E}^2 + 2Q \Rightarrow Q = \frac{25}{12}C\mathcal{E}^2$$

3)



по 2-ому прав. Кирхгофа для контура abcda:

$\mathcal{E} = U_3 + U_0$; $U_3 = \frac{q_3}{5C}$; $U_0 = \frac{q_0}{C}$; $I_0 = -\frac{dq_0}{dt}$;

$I_3 = \frac{dq_3}{dt} \Rightarrow$ т.к. $\mathcal{E} = const$: $0 = \frac{dq_3}{dt}\cdot\frac{1}{5C} + \frac{dq_0}{dt}\cdot\frac{1}{C} \Rightarrow$

$I_3 = 5I_0$; по 1-ому прав. Кирхгофа: $I_3 = I_R + I_0 \Rightarrow$

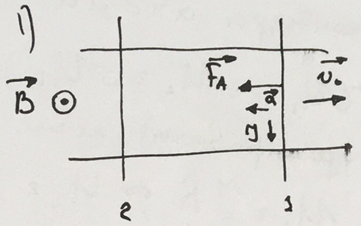
$I_R = I_3 - I_0 = 4I_0$

Ответ: 1) $I = \frac{5\mathcal{E}}{6R}$ 2) $Q = \frac{25}{12}C\mathcal{E}^2$ 3) $I_R = 4I_0$

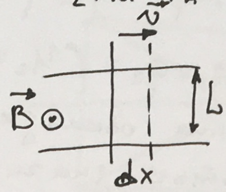
стр 4

Чистовик

№4 1)



$2m\vec a = \vec F_A \Rightarrow F_A = 2ma$; $F_A = JBL\sin(\vec L;\vec B) = JBL$



для движущегося проводника:

$\mathcal{E}_i = -\frac{d\Phi}{dt}$; $\Phi = BS\cos(\vec n;\vec B) = BS$;

$d\Phi = BdS$ т.к. $B = const$; $dS = Ldx = L\,v\,dt$ $\left(v = \frac{dx}{dt}\right) \Rightarrow \mathcal{E}_i = -\frac{BLvdt}{dt} = -BLv$; $|\mathcal{E}_i| = BLv$

В начальный момент ток через 2-ую перемычку не течёт $\Rightarrow |\mathcal{E}_i| = JR = BLv_0$

$\Rightarrow J = \frac{v_0 BL}{R} \Rightarrow a = \frac{JBL}{2m} = v_0\frac{(BL)^2}{2mR}$

2) через прод. пром. времени $F_{A1} = F_{A2} = 0 \Rightarrow J = 0 \Rightarrow |\mathcal{E}_{i1}| = |\mathcal{E}_{i2}| \Rightarrow v_1 = v_2$

ЗСИ: $2mv_0 = 2mv_1 + \frac{m}{2}v_2 \Rightarrow 4v_0 = 4v_1 + v_2 = 5v_1 \Rightarrow v_1 = v_2 = \frac{4v_0}{5}$

3) В произвольный момент времени: $BL(v_1 - v_2) = J_1R + J_1 5R$ т.к. $J_1 = J_2 \Rightarrow$

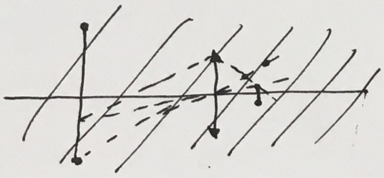
$BL v_{отн} = 6J_1R \Rightarrow v_{отн} = \frac{dl}{dt}$; $\Rightarrow \Delta l = \frac{6J^2R}{BL} = \frac{6v_0^2BL}{R}$

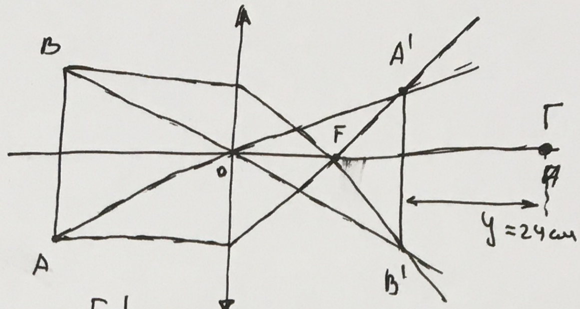
Ответ: 1) $a = v_0\frac{(BL)^2}{2mR}$ 2) $v_1 = v_2 = \frac{4v_0}{5}$ 3) $\Delta l = \frac{6v_0^2BL}{R}$

Чистовик

№5

1)

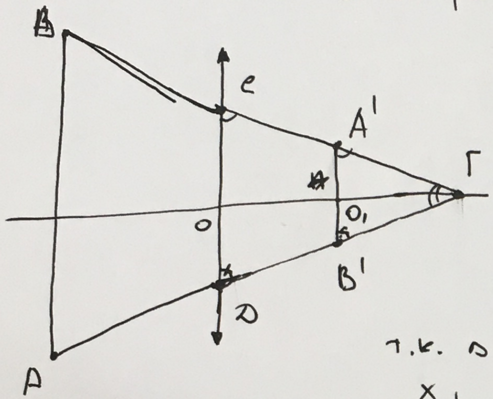




т.к. размер зрачка пренебрежительно мал, то глаз можно считать точкой на главной оптической оси

$$\frac{1}{d}+\frac{1}{f}=\frac{1}{F} \Rightarrow \frac{1}{f}=\frac{1}{F}-\frac{1}{d} \Rightarrow f=\frac{Fd}{d-F}=\frac{24\cdot 96}{96-24}=32\text{см}; \quad x=y+f=24+32=56\text{ см}$$

2)



для того, чтобы видеть циферблат целиком, $D_д \geq CD$; $\triangle FA'B' \sim \triangle ГCD$ (по двум углам)

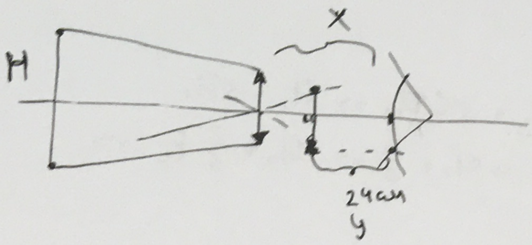
$$\Rightarrow \frac{A'B'}{CD}=\frac{ГO_1}{ГO}; \quad ГO=x; \; ГO_1=y; \; A'B'=h;$$

для собирающей линзы (из рисунка к пункту(1) т.к. $\triangle OAB \sim \triangle OA'B'$, то $\frac{h}{H}=\frac{f}{d}$) $\frac{h}{H}=\frac{f}{d} \Rightarrow h=\frac{f}{d}H$;

$$\Rightarrow CD=\frac{x}{y}h=\frac{x}{y}\cdot\frac{f}{d}\cdot H=\frac{56}{24}\cdot\frac{32}{96}\cdot 9=7\text{см} \Rightarrow D_м=CD=7\text{ см}$$

Ответ: 1) $x = 56$ см 2) $D_м = 7$ см

№8

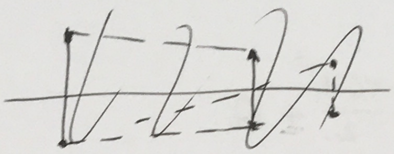


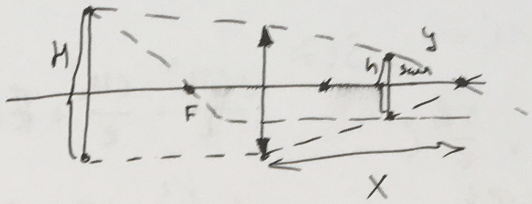
$f = 24$ см
$d = 96$ см
$F = 24$ см
$y = 24$ см

$\frac{1}{d} + \frac{1}{f} = \frac{1}{F} \Rightarrow \frac{1}{f} = \frac{1}{F} - \frac{1}{d} \Rightarrow$

$f = \frac{Fd}{d-F} = \frac{2304}{72} = 32$ см

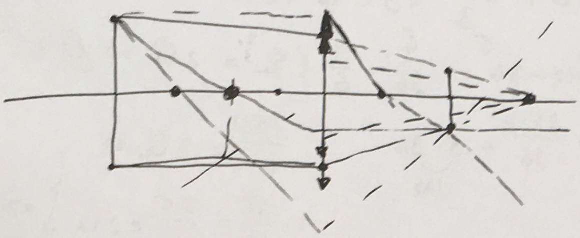
$\Rightarrow x = y + f = 32 + 24 = 56$ см



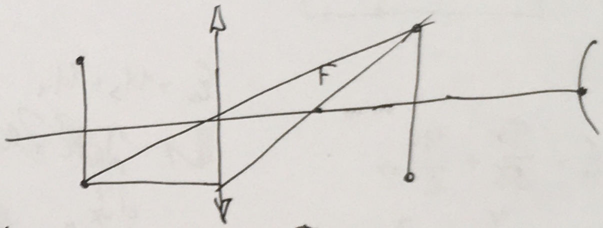


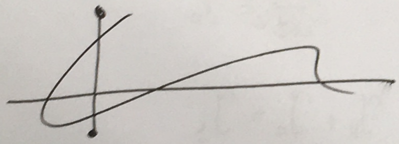
$\frac{H}{h} = \frac{d}{f} \Rightarrow h = \frac{f}{d} H = \frac{32}{96} \cdot 9 = 3$ см

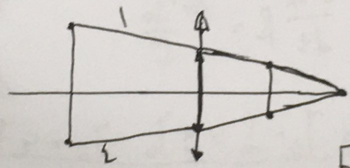
$\frac{\Delta_H}{x} = \frac{h}{y} \Rightarrow \Delta_H = \frac{x}{y} h = \frac{56}{24} \cdot 3 = 7$ см



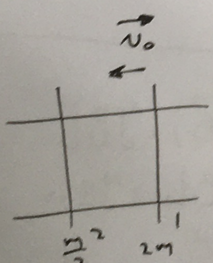
$\Phi = BL(l + \Delta l)$
$\Phi_0 = BLl$







$\frac{\Delta\Phi}{\Delta t} = \frac{B v_0 L}{2}$



~~$F_{A1} = 5 F_{A2}$~~
~~$F_{A1} = 2m\, a_1$~~
~~$F_{A2} = \frac{m}{2} a_2$~~

$\varepsilon_{i1} + \varepsilon_{i2} = I_1 R + I_1 5R = 6 I_1 R$

$BL(v_1 + v_2) = 6 I_1 R$

$4 v_0 = 4 v_1 + v_2 \Rightarrow v_2 = 4 v_0 - 4 v_1$

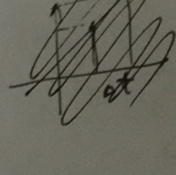
$BL(v_1 + 4v_0 - 4v_1) = 6 I_1 R \Rightarrow BL(4v_0 - 3v_1) = 6 I_1 R \Rightarrow$

$v_1 = 4 v_0 - \frac{6 I_1 R}{BL}$ $\quad v_2 = \frac{6 I_1 R}{BL} - 4 v_0$ $\quad I_1(t)$

~~$\frac{dl}{dt} = \frac{6 I_1 R}{BL} \Rightarrow \int_0^{\Delta l} dl = \int_0^{?} \frac{6 I_1 R}{BL} dt$~~

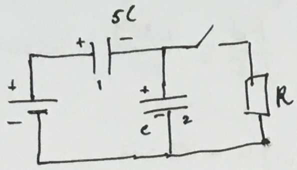
$dl = \frac{6 I_1 R}{BL} dt$

$\Delta l = \frac{6 I_0^2 R}{BL} = \frac{6 v_0^2 B^2 L^2 R}{R^2 BL} = \frac{6 v_0^2 BL}{R}$



Черновик

№3



$U_1 + U_2 = \mathcal{E}$

$q_1 = q_2 = CU_2 = 5CU_1 \Rightarrow U_2 = 5U_1$

$6U_1 = \mathcal{E} \Rightarrow U_1 = \frac{\mathcal{E}}{6} \Rightarrow U_2 = \frac{5}{6}\mathcal{E} \Rightarrow$

1) $I = \frac{5\mathcal{E}}{6R}$

2) $\mathcal{E} = U_1' \Rightarrow$

ЗСЭ:

$\frac{5CU_1^2}{2} + \frac{CU_2^2}{2} + \mathcal{E}\Delta q = \frac{5CU_1'^2}{2} + Q$

$q_0 = CU_2 = \frac{5\mathcal{E}}{6}C$

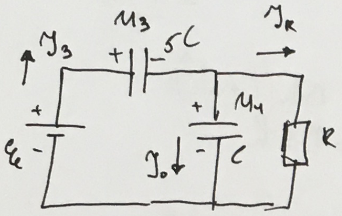
$q_0' = 5CU_1' = 5C\mathcal{E}$

$5\mathcal{E} - \frac{5}{6} = \frac{25}{6}$

$\frac{5C\cdot\mathcal{E}^2}{36\cdot 2} + \frac{25}{36}C\mathcal{E}^2 + 2\mathcal{E}C\left(\mathcal{E} - \frac{5\mathcal{E}}{6}\right) = 5C\mathcal{E}^2 + 2Q$

$\frac{30}{36}C\mathcal{E}^2 + \frac{C\mathcal{E}^2}{3} = 5C\mathcal{E}^2 + 2Q$

$30 + 12 - 36 = \frac{6}{36} = \frac{1}{6}C\mathcal{E}^2 = 2Q \Rightarrow \cancel{Q = \frac{C\mathcal{E}^2}{12}}$



$30 + \frac{25\cdot 6}{36} - 5\cdot 36$

$\frac{150}{36} = 2Q \Rightarrow$

$\frac{50}{12} = \frac{25}{6} = 2Q \Rightarrow Q = \frac{25}{12}C\mathcal{E}^2$

$\mathcal{E} = U_3 + U_4$

$\mathcal{E} = \frac{q_3}{5C} + \frac{q_4}{C} \Rightarrow$

$\cancel{\mathcal{E} = I_R R = U_4 = \frac{q_4}{C}}$ $\cancel{\frac{dq_4}{dt} = I_0}$

$\frac{dI_R}{dt}R = \frac{I_0}{C}$

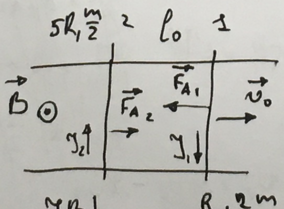
$I_R + I_0 = I_3$

$0 = \frac{I_3}{5C} - \frac{I_0}{C} \Rightarrow$

$I_0 = -\frac{dq_4}{dt}$ $I_3 = +5I_0 \Rightarrow I_R = I_3 - I_0 = 5I_0 - I_0 = 4I_0$

$I_3 = \frac{dq_3}{dt}$

№4



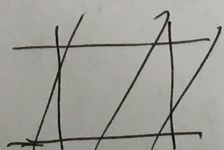
$F_A = IBL\sin(\vec{L};\vec{B}) = IBL$

$|\mathcal{E}_i| = v_0BL = IR \Rightarrow$

$\mathcal{E}_i = -\frac{d\Phi}{dt} = -\frac{Bv\cancel{t}L}{\cancel{t}} = -BvL$

$F_A = 2ma = IBL \Rightarrow a = \frac{IBL}{2m}$

$\mathcal{E}_{i1} + \mathcal{E}_{i2} = I_1 6R$



$I = \frac{v_0BL}{R} \Rightarrow a = \frac{v_0(BL)^2}{2mR}$

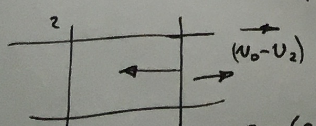
$BL(v_1 \pm v_2) = I_1 6R$

т.к. трение отсутств. $\Rightarrow F_{A1} = F_{A2} = 0 \Rightarrow I = 0 \Rightarrow \mathcal{E}_{i1} = -\mathcal{E}_{i2} = v_1BL$

ЗСИ: $2mv_0 = 2mv_1 \pm \frac{m}{2}v_2$ $4v_0 = 4v_1 \pm v_2$ $v_1 = v_2$ $4a_1 = a_2$

$4v_0 = 5v_1 \Rightarrow v_1 = v_2 = \frac{4v_0}{5}$

$I_1R = 5RI_2 \Rightarrow I_1 = 5I_2$



$F_{A1} = 5F_{A2}$

$2ma_1 = 5\frac{m}{2}a_2$

$4a_1 = 5a_2$

$\frac{2mv_0^2}{2} = mv_1^2 + Q$