Часть 1

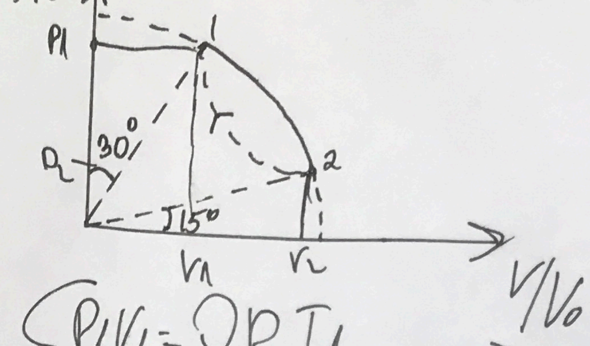
Олимпиада: **Физика, 11 класс (1 часть)**

Шифр: **21203022**

ID профиля: **348455**

Вариант 5

ЧЕРНОВИК



$2 \to 1 \quad Q=0$

$\Delta U = A_2$ (не адиаб)

$1: V_1 = R\sin(30°) \quad P_1 = R\cos(30°)$

$2: P_2 = R\sin(15°) \quad V_2 = R\cos(15°)$

$$\begin{cases} P_1V_1 = \nu R T_1 \\ P_2V_2 = \nu R T_2 \end{cases} \Rightarrow \frac{T_1}{T_2} = \frac{P_1V_1}{P_2V_2} = \frac{R^2\sin(30°)\cdot\cos(30°)}{R^2\sin(15°)\cdot\cos(15°)} =$$

$$= \frac{\sin(60°)}{\sin(30°)} = \sqrt{3}$$

$d\Delta U = dA_2$

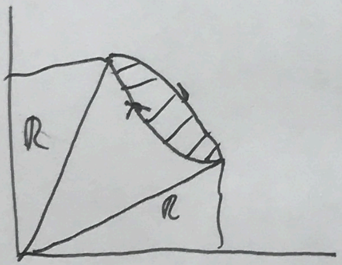
$k = \frac{C - C_p}{C - C_V} = \frac{5}{3}$

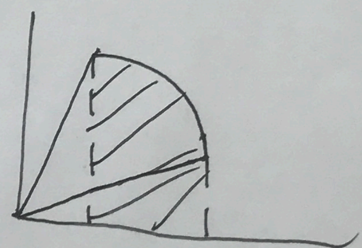
$C = \frac{Q}{\nu \Delta T} \; (Q=0)$

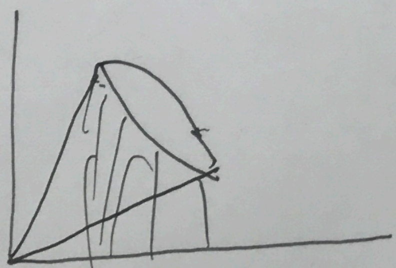
$PV^{\frac{5}{3}} = const$

$\frac{\Delta p}{p} + \frac{\Delta V}{V} = \frac{\Delta T}{T}$

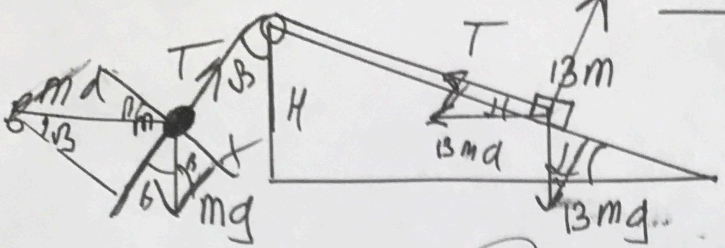
$\frac{3}{2}(\Delta(pV)) = p\Delta V \quad A_1 =$







Черновик



$\alpha = ?$

$a_{отн} = ?$

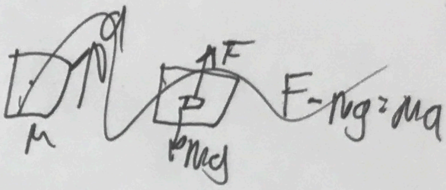
$t = ?$

$$\begin{cases} 13ma\cos\alpha + T - 13mg\sin\alpha = 13m a_0 \\ ma\sin\beta + mg\cos\beta - T = m a_0 \end{cases}$$

$$\begin{cases} T = 13m a_0 + 13mg\sin\alpha - 13ma\cos\alpha \\ T = ma\sin\beta + mg\cos\beta - m a_0 \end{cases}$$

$$\cancel{m}a\cos\beta = \cancel{m}g\sin\beta$$

$$\boxed{a = g\,tg\,\beta}$$



$$13m a_0 + 13mg\sin\alpha - 13ma\cos\alpha = ma\sin\beta + mg\cos\beta - m a_0$$

$$14\cancel{m} a_0 = \cancel{m}a\sin\beta + \cancel{m}g\cos\beta - 13\cancel{m}g\sin\alpha + 13\cancel{m}a\cos\alpha$$

$$14 a_0 = g\,tg\beta\sin\beta + g\cos\beta - 13g\sin\alpha + 13g\,tg\beta\cos\alpha$$

$$14 a_0 = g\frac{\sin^2\beta}{\cos\beta} + g\cos\beta - 13g\sin\alpha + 13g\,tg\beta\cos\alpha =$$

$$= g\cdot(tg\beta\sin\beta + \cos\beta - 13\sin\alpha + 13\,tg\beta\cos\alpha)$$

$$a_0 = \frac{g}{14}\cdot(tg\beta\sin\beta + \cos\beta - 13\sin\alpha + 13\,tg\beta\cos\alpha)$$

$$S = \frac{H}{\cos\beta} = \frac{a_0 t^2}{2}$$

$$t^2 = \frac{2H}{\cos\beta\, a_0} \Rightarrow t = \sqrt{\frac{2H}{\cos\beta\, a_0}}$$

В силу нерастяжимости $a_1' = a_2' = A$

чистовик

$$\begin{cases} m(a - A\cos\beta) = T\sin\beta \\ m(g - A\sin\beta) = T\cos\beta \\ (M(a - A\cos\alpha) + T\cos\alpha)\cos\alpha = (MA\sin\alpha - T\sin\alpha)\sin\alpha \end{cases}$$

$$Ma\cos a - MA\cos^2\alpha + T\cos^2\alpha = MA\sin^2\alpha - T\sin^2\alpha$$

$$Ma\cos\alpha + T = MA \Rightarrow T = MA - Ma\cos a$$

$$mg - mA\sin\beta = MA\cos\beta - Ma\cos\alpha\cos\beta$$

$$A(M\cos\beta + m\sin\beta) - a\cdot M\cos\alpha\cdot\cos\beta = mg$$

$$ma - mA\cos\beta = T\sin\beta = m(g - A\sin\beta)\,tg\,\beta$$

В силу равноускоренного и прямолинейного движения шара в СО клина; нулевой нач. скорости получаем:

$$a = g\frac{m\cos\beta + M\sin\beta}{M\cos\beta - M\cos\alpha\cos 2\beta + m\sin\beta}$$

$$A = g\frac{m + M\cos\alpha\sin\beta}{M(\cos\alpha + \cos\beta - \cos\alpha\, tg^2(\beta)) + m\sin\beta}$$

$$\boxed{a = \frac{215g}{191}}$$

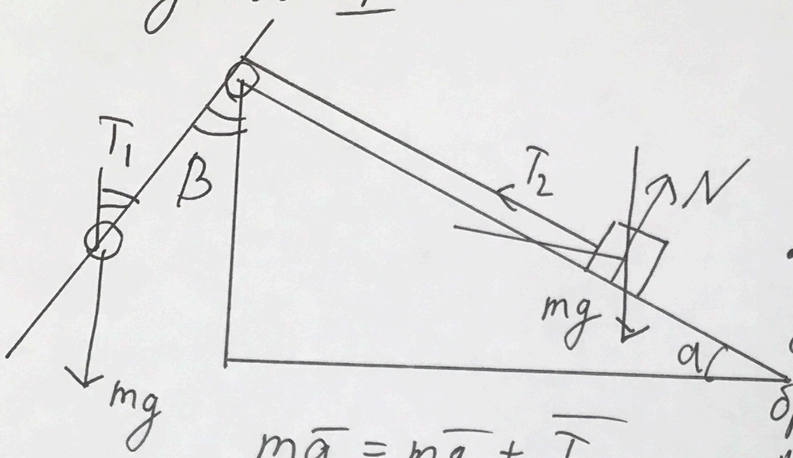
$$A = \frac{205g}{191}$$

Ответ: на I вопрос $= \frac{215}{191}g$

Ответ на II вопрос $= \frac{205}{191}g$ $\boxed{25}$

Задача 1

Чистовик



$M = 13m$

$\cos\beta = 4/5$

$\sin\beta = \sqrt{1-\frac{16}{25}} = 3/5$

• В силу линейности уравнений Ньютона и лин. условия связи, сразу следует постоянство ускорений бруска и шара в СО клина

$m\bar{a}_1 = m\bar{g} + \bar{T}_1$

$M\bar{a}_2 = \bar{N} + \bar{T}_2 + M\bar{g}$

$|\bar{T}_1| = |\bar{T}_2| = T$

Движение шарика складывается из равноускоренного движения вдоль оси под углом β относительно клина и равноускоренного движения вместе с клином. Аналогично для бруска.

$a = ?$
$a_2' = ?$
$a_1' = ?$
$T = ?$
$N = ?$

$$\begin{cases} \bar{a}_1 = \bar{a}_1' + \bar{a} \\ \bar{a}_1' = -(a_1'\cos\beta,\ a_1'\sin\beta) \end{cases}$$

$$\begin{cases} \bar{a}_2 = \bar{a}_2' + \bar{a} \\ \bar{a}_2' = (-a_2'\cos\alpha,\ a_2'\sin\alpha) \end{cases}$$

$$\begin{cases} m(a - a_1'\cos\beta) = T\sin\beta \\ -m a_1'\sin\beta = -mg + T\cos\beta \end{cases}$$

$$\begin{cases} M(a - a_2'\cos\alpha) = -T\cos\alpha + N\sin\alpha \\ M a_2'\sin\alpha = T\sin\alpha + N\cos\alpha \end{cases}$$

$$N = \frac{M(a - a_2'\cos\alpha) + T\cos\alpha}{\sin\alpha} = \frac{Ma_2'\sin\alpha - T\sin\alpha}{\cos\alpha}$$

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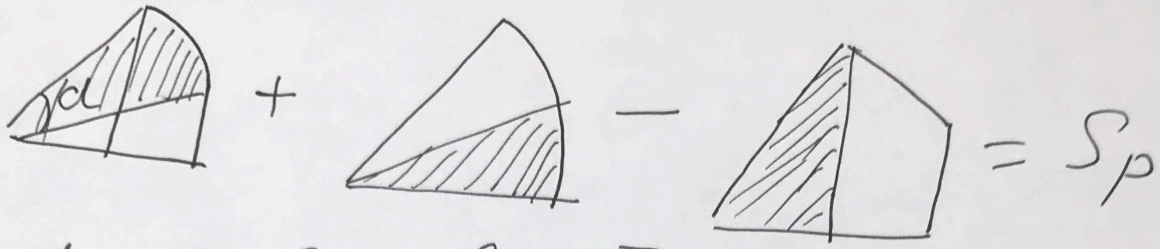
$H1$

$$S_p = \frac{\alpha r^2}{2} + \frac{x_2 y_2}{2} - \frac{x_1 y_1}{2}$$



$$\alpha = 60^\circ - 15^\circ = 45^\circ \sim \frac{\pi}{4} \qquad x_1^2 + y_1^2 = x_2^2 + y_2^2 = r^2$$

$$S_p = \frac{r^2}{2}\left(\frac{\pi}{4} + \frac{2\cos 15^\circ \sin 15^\circ}{4} + \frac{2\cos 60^\circ \sin 60^\circ}{4}\right) =$$

$$= \frac{r^2}{8}\left(\pi + \sin 30 + \sin 120\right) = \frac{r^2}{8}\left(\pi + \frac{1}{2} + \frac{\sqrt{3}}{2}\right)$$

$$\frac{r^2 \sin 15^\circ \cos 15^\circ}{\frac{1}{4}} = \frac{p_2 V_2}{p_0 V_0} = \frac{\nu R T_2}{p_0 V_0} \Rightarrow r^2 = \frac{4 \nu R T_2}{p_0 V_0}$$

$$S_p = \frac{\nu R T_2}{p_0 V_0}\left(\pi + \frac{1}{2} + \frac{\sqrt{3}}{2}\right)\frac{1}{2} \approx 2{,}25 \frac{\nu R T_2}{p_0 V_0}$$

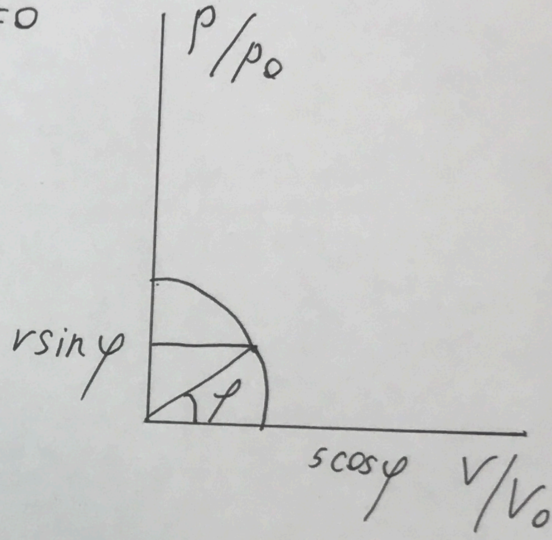
$$\frac{A_{цикл}}{A_{рассм}} = \frac{2{,}25 - 0{,}59}{2{,}25} \approx 0{,}74$$

$$\ln\left(T_1/T_2\right)=\frac{5/3-1}{5/3+1}\left(\ln(\sqrt{3})-\ln(tg15^\circ)\right)=\frac{2}{8}(\dots)=$$

$$=\frac{1}{4}\ln\left(\frac{\sqrt{3}}{tg(15^\circ)}\right)\Rightarrow\boxed{T_1/T_2=\left(\frac{\sqrt{3}}{tg15^\circ}\right)^{1/4}\approx 1{,}59}$$

$$\delta Q=\frac{5}{2}p\,dV+\frac{3}{2}V\,dp=0$$

Пусть точка с 0 теп-ю располагается так:



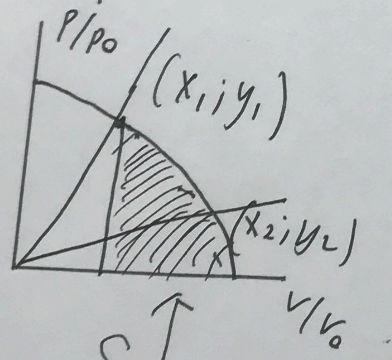
$$5\sin\varphi\, d(\cos\varphi)+3\cos\varphi\, d(\sin\varphi)=0$$

$$0=-5\sin^2\varphi+3\cos^2\varphi$$

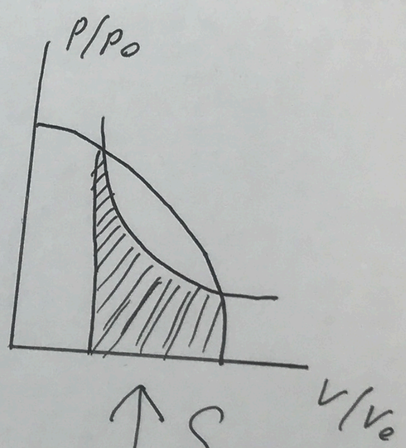
$$5tg^2(\varphi)=3\Rightarrow tg\varphi=\sqrt{\frac{3}{5}}$$

$$\Downarrow$$

$$\varphi\approx 37{,}8^\circ$$



S_p



S_a

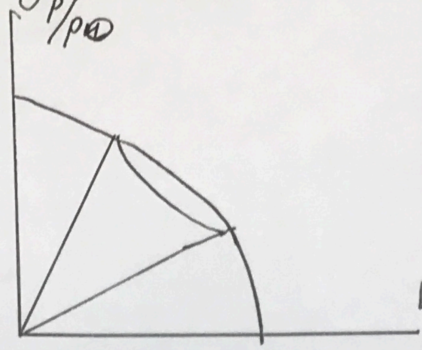
$$\frac{A_{цикл}}{A_{росш}}=\frac{S_p-S_a}{S_a}$$

На $2\Rightarrow 1$ $\delta Q=0\Rightarrow$

$$\Rightarrow\frac{|\Delta V|}{p_0V_0}=S_a=\left|\frac{p_1V_1-p_2V_2}{p_0V_0}\right|=\frac{\nu R}{p_0V_0}|T_1-T_2|\approx$$

$$\approx 0{,}59\frac{\nu R}{p_0V_0}T_2$$

Задача 2



$$\frac{p_1/p_0}{V_1/V_0} = tg(90° - 30°) = tg(60°) = \sqrt{3}$$

$$\frac{p_2/p_0}{V_2/V_0} = tg(15°)$$

$$\delta Q = p\,dV + \frac{3}{2}\underbrace{(p\,dV + V\,dp)}_{\nu R\,dT}$$

$$\frac{T_1}{T_2} = \frac{p_1 V_1}{p_2 V_2} = \frac{p_1/p_0 \cdot V_1/V_0}{p_2/p_0 \cdot V_2/V_0}$$

$p_1 V_1^{\gamma} = const = p_2 V_2^{\gamma}$; $\gamma = \frac{5}{3}$

Пусть $\ln(p_1/p_0) = a_1$ $\quad \ln(V_1/V_0) = b_1$

$\ln(p_2/p_0) = a_2$ $\quad \ln(V_2/V_0) = b_2$

$$\begin{cases} \ln(T_1/T_2) = a_1 + b_1 - a_2 - b_2 \\ a_1 - b_1 = \ln(\sqrt{3}) \\ a_2 - b_2 = \ln(tg(15°)) \\ a_1 + \frac{5}{3} b_1 = a_2 + \frac{5}{3} b_2 \end{cases}$$

$\Rightarrow a_1 - b_1 - a_2 + b_2 = \ln(\sqrt{3}) - \ln(tg 15°)$

$$a_1 - a_2 = \frac{5}{3}(b_2 - b_1) = -(b_2 - b_1) - \ln(\sqrt{3}) - \ln(tg 15°)$$

$$\ln(T_1/T_2) = \frac{5}{3}(b_2 - b_1) + b_1 - b_2 = \left(\frac{5}{3} - 1\right)(b_2 - b_1)$$

$$b_2 - b_1 = \left(\frac{5}{3} + 1\right)^{-1}\left(-\ln(tg 15°) + \ln(\sqrt{3})\right)$$

$$\frac{5}{3} - 1 = \frac{2}{3} \qquad \frac{5}{3} + 1 = \frac{8}{3}$$

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Чистовик

1

Часть 2

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

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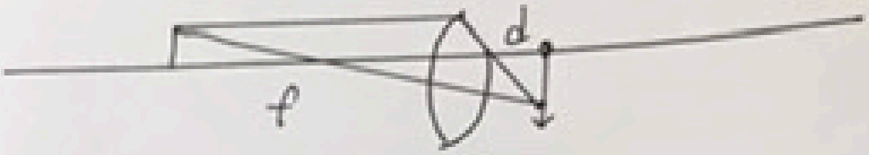
Вариант 5

Задача №5 Чистовик

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



При $f \to \infty \Rightarrow D_\infty + \frac{1}{F} = \frac{1}{d}$

При $f = 25$ см $\Rightarrow D_{25} + \frac{1}{F} = \frac{1}{d} + \frac{1}{f_{25}}$

При $D_\infty = 2D_{25}$

$$2D_{25} + \frac{1}{F} = \frac{1}{d}$$

$$D_{25} = -\frac{1}{f_{25}}$$

$$\boxed{D_\infty = -\frac{2}{f_{25}}}$$

$\Downarrow$

$$D_\infty = \frac{1}{d} - \frac{1}{F} = -\frac{1}{f_{\text{без очков}}}$$

$\Downarrow$

$$\frac{1}{f_{\text{без очков}}} = \frac{2}{f_{25}} \Rightarrow f_{\text{без очков}} = 12{,}5 \text{ см}, \quad D_\infty = -8 \text{ дптр}$$

$D_{25} = 2D_\infty$

$$2D_\infty + \frac{1}{F} = \frac{1}{d} + \frac{1}{f_{25}}$$

$$D_\infty + \cancel{\frac{1}{d}} = \cancel{\frac{1}{d}} + \frac{1}{f_{25}}$$

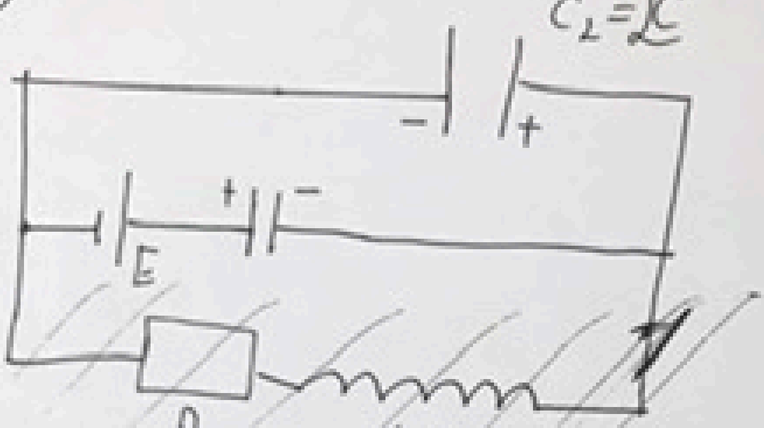
Но $D_\infty < 0$

Противоречие

При $f = 50 \text{ см} = \frac{1 \text{м}}{2} \Rightarrow \frac{1}{F} + D_{50} = \frac{1}{d} + \frac{1}{f_{50}}$

$$D_{50} = \frac{1}{d} + \frac{1}{f_{50}} - \frac{1}{F} = D_\infty + \frac{1}{f_{50}} = (2-8) \text{ дптр} = -6 \text{ дптр}$$

Задача 3 Чистовик



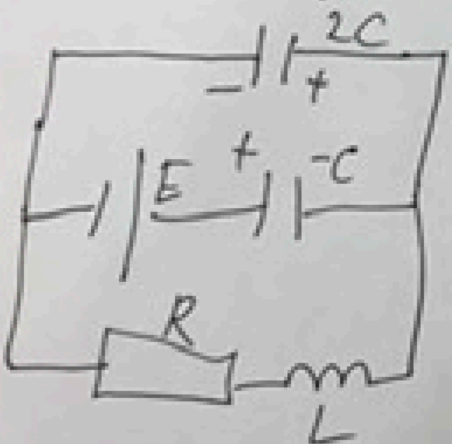
Без замыкания ключа на обкладках конденсаторов будут всюду равные по модулю заряды

$$\frac{q_0}{C}+\frac{q_0}{2C}=E$$

$$\frac{3}{2C}q_0=E$$

После замыкания

$$q_0=\frac{2CE}{3}$$



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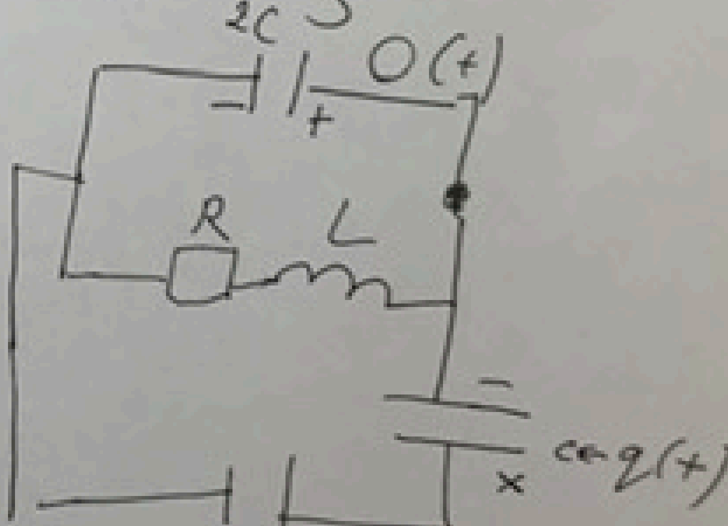


$$\frac{Q(t)}{2C}+\frac{q(t)}{C}=E \Rightarrow \dot{Q}=-2\dot{q}$$

$$R(\dot{q}-\dot{Q})+L(\ddot{q}-\ddot{Q})+\frac{q}{C}=E$$

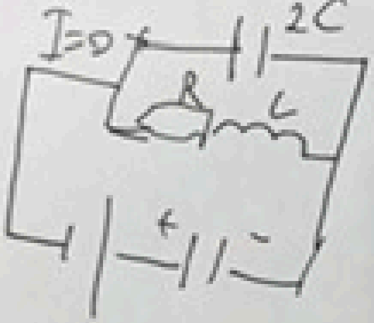
$$3Rq+3Lq+\frac{q}{C}=E$$

$3L\ddot{q} + 3R\dot{q} + \frac{q}{c} = E$

В начале $\dot{q} = 0$

$\ddot{q} = \frac{E - q/c}{3L}$ $\quad \dot{I}_L = 3\frac{E - q/c}{3L} = E/3L$

Через длительный промежуток времени конденсатор C зарядится до непряжение E.



ЗСЭ:

$W_0 + A_{ист} = W_1 + Q$

$W_0 = \frac{1}{2}\left(\frac{q_0^2}{2c} + \frac{q_0^2}{c}\right) = \frac{1}{2}q_0\left(\frac{q_0}{2c} + \frac{q_0}{c}\right) = \frac{1}{2}Eq_0 =$

$= \frac{CE^2}{3}$ $\quad W_1 = \frac{CE^2}{2}$

$A_{ист} = (q_1 - q_0)E = \left(CE - \frac{2EC}{3}\right)E =$

$= \frac{E^2C}{3}$

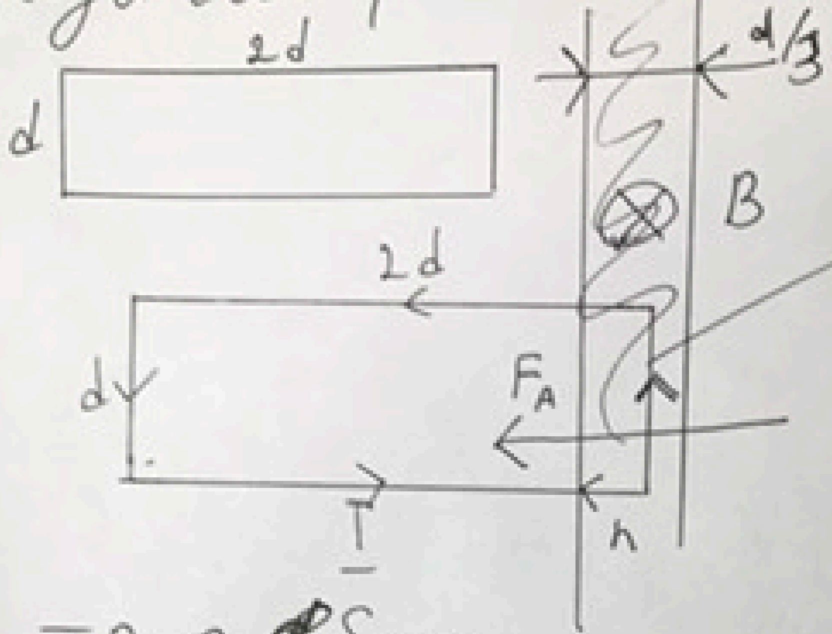
$Q = \frac{CE^2}{3} + \frac{CE^2}{3} - \frac{CE^2}{2} = \frac{CE^2}{6}$

$I_L = \dot{q} - Q = 3\dot{q} = 3I_0$ Ответы.

1.) $\frac{E}{3L}$ 2.) $\frac{CE^2}{6}$ 3.) $3I_0$

3

Задача 4 Чистовик.



$$IR = B\frac{dS_{внутр}}{dt} = Bd\frac{dh}{dt} = BdV \text{ (ЭДС индукции)}$$

$(a \uparrow\downarrow V)$

$$F_A = IdB = ma = \frac{BdV}{R}dB$$

Ответ на I вопрос → $a(0) = \frac{B^2d^2V_0}{Rm}$ ← против скорости

$$m\dot{V} = -\frac{B^2d^2}{R}V \qquad \alpha = \frac{B^2d^2}{Rm}$$

$$\dot{V} = -\alpha V \Rightarrow \Delta V = -\alpha\Delta x = -\alpha h = V_1 - V_0$$

$$V_1 = V_0 - \alpha h = V_0 - \frac{B^2d^2}{Rm}h = \boxed{V_0 - \frac{B^2d^3}{3Rm}}$$

Второй вопрос

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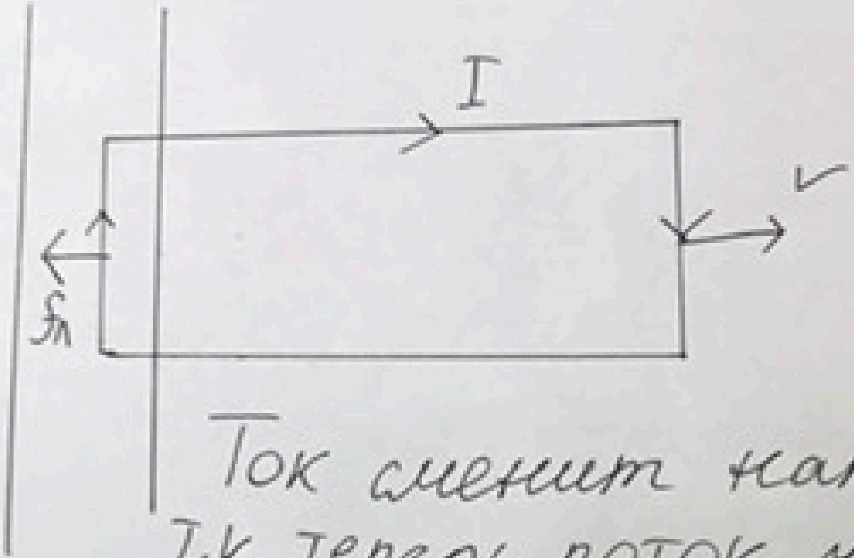
4

Чистовик

При неизменности потока тока в рамке не будет. При выходе рамки из поля:



Ток сменит направление, т.к теперь поток через рамку убывает.

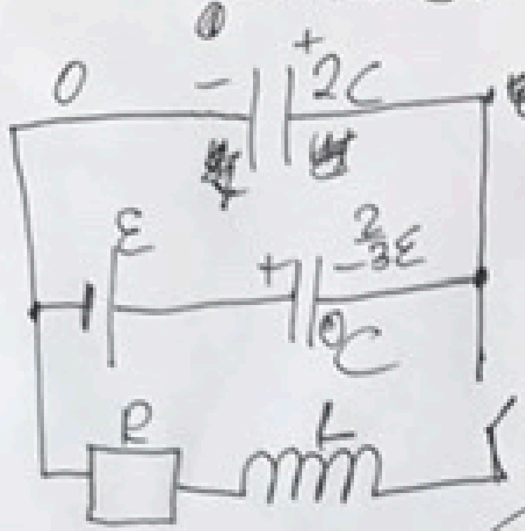
$$m\dot{v} = -\frac{B^2 d^2}{R} v \qquad v_2 - v_1 = -\frac{B^2 d^2}{R} H$$

$$v_2 = v_0 - \frac{2B^2 d^2}{R} H = \boxed{v_0 - \frac{2B^2 d^3}{3e}}$$

Ответ на 3 вопрос

ЧЕРНОВИК

$I'(0) = ?$



$-U_1 - U_2 + \mathcal{E} = 0$

$\mathcal{E} = U_1 + U_2$

$2CU_1 - CU_2 = 0$

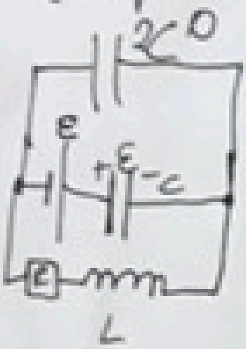
$U_2 = 2U_1$

$3U_1 = \mathcal{E}$

$U_1 = \frac{\mathcal{E}}{3}$

$U_L(0) = LI' = \frac{\mathcal{E}}{3} \Rightarrow I' = \frac{\mathcal{E}}{3L}$

уст. реж.:



$W_0 = \frac{2C}{2} \cdot \frac{\mathcal{E}^2}{9} + \frac{C}{2} \cdot \frac{4\mathcal{E}^2}{9} = \frac{C\mathcal{E}^2}{9} + \frac{2C\mathcal{E}^2}{9} = \boxed{\frac{C\mathcal{E}^2}{3}}$

$W_K = \frac{C\mathcal{E}^2}{2}$

$q_{нач}: +\frac{2}{3}C\mathcal{E}$

$q_{кон}: C\mathcal{E}$

$\Delta q = \frac{C\mathcal{E}}{3}$

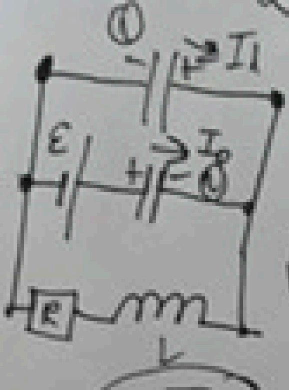
$A_{ист} = \frac{C\mathcal{E}^2}{3}$

$\int I dt = \frac{}{}$

$\int q$ ~~...~~

$W_0 + A_{ист} = W_K + Q$

$Q = W_0 - W_K + A_{ист} = \frac{C\mathcal{E}^2}{3} - \frac{C\mathcal{E}^2}{2} + \frac{C\mathcal{E}^2}{3} = \frac{2C\mathcal{E}^2}{3} - \frac{C\mathcal{E}^2}{2} = \frac{4C\mathcal{E}^2}{6} - \frac{3C\mathcal{E}^2}{6} = \frac{C\mathcal{E}^2}{6}$



$q = CU$

$I_1 = CU'$ $\quad U_1' = \frac{I_0}{C}$

$I_0 + I_1$

$U_1 = \mathcal{E} - U_2$

$U_1' = -U_2'$

$I_2 = 2C \cdot U' = 2I_0$

$3I_0$

ЧЕРНОВИК.

1) $d \to \infty$ $\quad \frac{D_1}{D_2} = 2$

$$\frac{1}{F^*} = \frac{1}{f}$$

$$\frac{1}{D_0 + D_1} = \frac{1}{f} \Rightarrow D_0 + D_1 = \frac{1}{f}$$

$$\frac{1}{d} + \frac{1}{f} = \frac{1}{F_0} + \frac{1}{F_2} = D_0 + D_2$$

$$\frac{1}{d} = D_0 + D_2 - D_0 - D_1 = D_2 - D_1 = -D_2 = 4$$

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