Часть 1

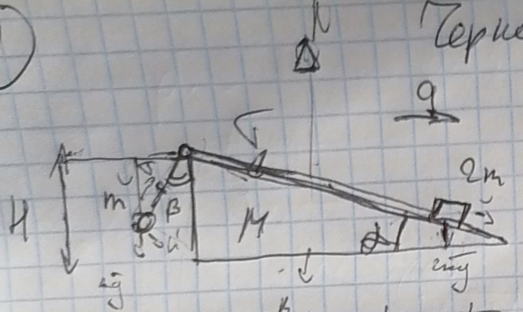
Олимпиада: **Физика, 11 класс (1 часть)**

Шифр: **21203807**

ID профиля: **369961**

Вариант 6

① Черновик



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

$\beta = \arccos\frac{12}{13}$

$Ma = \Sigma F$ Mg $F_{м} < F_{бр}$

Дано:

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

$\cos\beta = \frac{12}{13}$

$m, 2m, H$

1) $a_к$ - ?

2) $\frac{a_{бр}}{a_к}$ - ?

3) $t_м$ - ?

~~$O = -Mg + N$~~

~~$Oy: O = -(Mg + 2mg + mg)$~~

~~$N = 3m$~~

~~$Ox: O =$~~

$\frac{T}{\cos\beta} + mg - \frac{T}{\cos\alpha} + 2mg = 0$

$-T\left(\frac{1}{\cos\beta} + \frac{1}{\cos\alpha}\right) = -3mg$

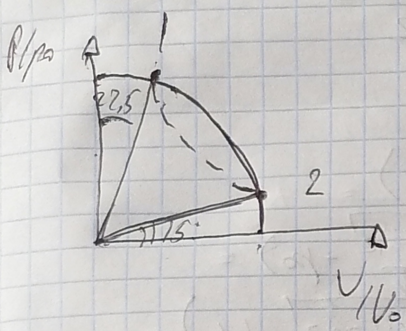
$T = \frac{3mg}{\frac{1}{\cos\beta} + \frac{1}{\cos\alpha}} = \frac{3mg\cos\alpha\cos\beta}{\cos\alpha + \cos\beta}$

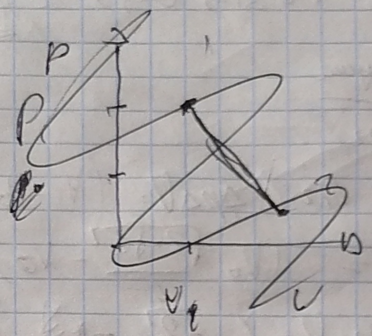
$T\cos\alpha + T = 2mg\cos\alpha$

$T = \frac{2mg\cos\alpha}{\cos\alpha + 1}$

$(M + 2m)a = Ma_к + m$

② Чертеж №2





~~$V_1 = V_0 \cos 15^\circ = V_0 \frac{\sqrt6+\sqrt2}{4}$~~

~~$\cos 15^\circ = \frac{\sqrt{2+\sqrt3}}{2} = \frac{\sqrt6+\sqrt2}{4}$~~

$V_1 = V_0 \cos 15^\circ$

$\cos 15^\circ = \frac{\sqrt{2+\sqrt3}}{2} = \frac{\sqrt6+\sqrt2}{4}$

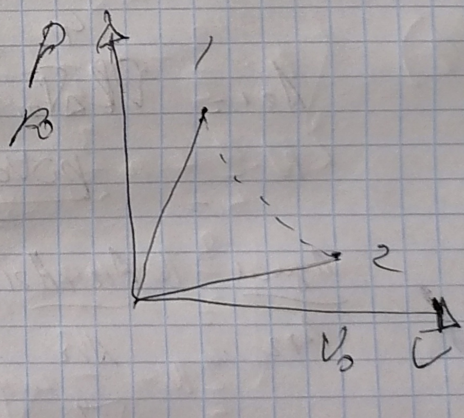
$\cos 15 = \frac{1+\cos 30^\circ}{2} = \frac{2+\sqrt3}{4}$

$V_1 = V_0 \cdot \frac{\sqrt6+\sqrt2}{4}$

$P_2 = P_0 \sin 15^\circ = P_0 \frac{\sqrt6-\sqrt2}{4}$

$\sin 15^\circ = \frac{1-\cos 30^\circ}{2} = \frac{2-\sqrt3}{4} = \frac{\sqrt6-\sqrt2}{4}$

$\frac{V_1}{V_2} = \frac{\frac{\sqrt2}{4}}{\frac14} = \sqrt2$



1. $V_1 = V_0 \cos 67{,}5 = V_0 \cdot \frac{\sqrt{2-\sqrt2}}{2}$

$\cos 67{,}5 = \frac{1-\cos 135^\circ}{2} = \frac{1-\frac{\sqrt2}{2}}{2} = \frac{\sqrt{2-\sqrt2}}{4}$

Черновик (28)

$$p_1 = p_0 \sin 67{,}5^\circ = p_0 \frac{\sqrt{2+\sqrt{2}}}{2}$$

3) $\frac{A_{цикл}}{A_{12}}$

$$A_{12} = \Delta p \Delta V = (V_1 - V_0)(p_1 - p_0) =$$

$$= \left(V_0 \frac{\sqrt{2-\sqrt{2}}}{4} - V_0\right)\left(p_0 \frac{\sqrt{2+\sqrt{2}}}{4} - p_0\right) =$$

$$= p_0 V_0 \left(\frac{\sqrt{2}}{4} - \frac{\sqrt{2+\sqrt{2}}}{4} - \frac{\sqrt{2-\sqrt{2}}}{4} + 1\right) =$$

$$= p_0 V_0 \left(\frac{\sqrt{2} - \sqrt{2+\sqrt{2}} - \sqrt{2-\sqrt{2}} + 4}{4}\right) =$$

$$= \left(\frac{1{,}414 - 1{,}847 - 0{,}765 + 4}{4}\right) p_0 V_0$$

$$= 0{,}7005\, p_0 V_0$$

$$\cancel{A_{12} = V_1 p_1 - p_1 V_0 - V_1 p_0 + V_0 p_0} =$$

$$= A_{12} = \nu R \Delta T_{12} = \nu R (T_2 - T_1) =$$

$$= \nu R \left(\frac{\sqrt{2}\, p_0 V_0}{4 \nu R} + \frac{p_0 V_0}{4 \nu R}\right) =$$

$$= \frac{\sqrt{2}\, p_0 V_0 + p_0 V_0}{4} = \frac{p_0 V_0 (\sqrt{2} + 1)}{4}$$

$$A_{21} = \nu R \Delta T_{21} = \nu R (T_1 - T_2) = \sqrt{2} \frac{p_0 V_0}{4} - \frac{p_0 V_0}{4} =$$

$$= \frac{p_0 V_0 (\sqrt{2} - 1)}{4}$$

$A_{цикл} = A_{12} + A_{21}$

$$\frac{A_{цикл}}{A_{12}} = \frac{A_{12} + A_{21}}{A_{12}} = 1 + \frac{A_{21}}{A_{12}} = 1 + \frac{\frac{p_0 V_0 (\sqrt{2} - 1)}{4}}{\frac{p_0 V_0 (1 - \sqrt{2})}{4}} =$$

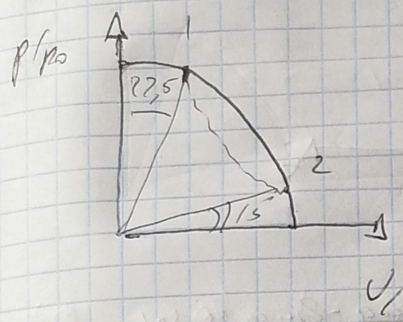
$$= 1 + \frac{\sqrt{2} - 1}{1 - \sqrt{2}} = \frac{1 - \sqrt{2} + \sqrt{2} - 1}{1 - \sqrt{2}} =$$

$$= \cancel{\infty}$$

(1)

Чистовик

№2



$V_1 = V_0 \cos 15$

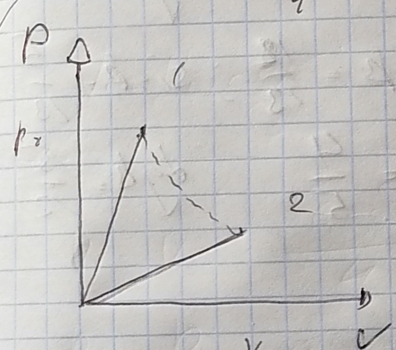
$\cos 15 = \frac{\sqrt{2+\sqrt{3}}}{2} = \frac{\sqrt{6}+\sqrt{2}}{4}$

$V_1 = V_0 \frac{\sqrt{6}+\sqrt{2}}{4}$

$p_2 = p_0 \sin 15 = p_0 \frac{\sqrt{6}-\sqrt{2}}{4}$

Получаем (1) и (2)

1) $\frac{T_1}{T_2} = \frac{\frac{\sqrt{2}}{4}}{\frac{1}{4}} = \sqrt{2} \approx \underline{1{,}414}$



1. $V_1 = V_0 \cos 67{,}5°$

$\cos 67{,}5 = \frac{1-\cos 135}{2} = \frac{1-\frac{\sqrt{2}}{2}}{2} = \frac{\sqrt{2-\sqrt{2}}}{4}$

$V_1 = V_0 \cdot \frac{\sqrt{2-\sqrt{2}}}{4}$

$p_1 = p_0 \sin 67{,}5 = p_0 \frac{\sqrt{2+\sqrt{2}}}{4}$

$p_1V_1 = \nu R T_1 \Rightarrow T_1 = \frac{p_1V_1}{\nu R} = \frac{1}{\nu R} p_0V_0 \frac{\sqrt{4-2}}{4} =$

$= \frac{\sqrt{2}}{4} \frac{p_0V_0}{\nu R}$ (1)

$T_2 = \frac{p_2V_2}{\nu R} = \frac{p_0V_0}{\nu R} \cdot \frac{\sqrt{6}+\sqrt{2}}{4} \cdot \frac{\sqrt{6}-\sqrt{2}}{4} =$

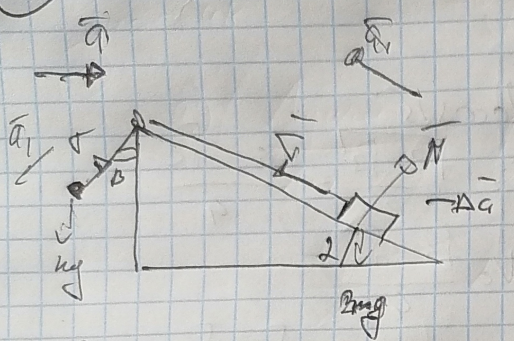
$= \frac{p_0V_0}{16\nu R} \cdot 4 = \boxed{\frac{p_0V_0}{4\nu R}}$ (2)

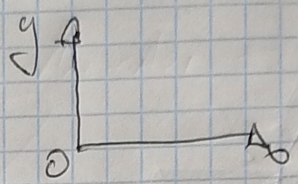
Отв: Нее 1-вет идет $\sqrt{2} \approx 1{,}414$

2

Чистовик

№1





1) для бруска: $\begin{cases} N\sin\alpha - T\cos\alpha = 2ma - 2ma_1\cos\alpha & Ox \\ N\cos\alpha + T\sin\alpha - 2mg = 2ma_1\sin\alpha & Oy \end{cases}$

для шарика: $\begin{cases} T\sin\beta = ma - ma_1\sin\beta & Ox \\ T\cos\beta - mg = -ma_1\cos\beta & Oy \end{cases}$

$T = m\left(\frac{a}{\sin\beta} - a_1\right)$ $\cos\beta = \frac{12}{13}$; $\sin\beta = \frac{5}{13}$

$T = m\left(\frac{g}{\cos\beta} - a_1\right)$ $\cos\alpha = \frac{4}{5}$ $\operatorname{tg}\beta = \frac{5}{12}$

$\frac{a}{\sin\beta} - a_1 = \frac{g}{\cos\beta} - a_1$

1) $a = g\operatorname{tg}\beta = 10\cdot\frac{5}{12} \approx 4{,}17$ м/с²

2) $\begin{cases} N\cdot\frac{3}{5} - m\frac{4}{5}\left(\frac{g}{\cos\beta} - a_1\right) = 2mg\operatorname{tg}\beta - 2ma_1\cdot\frac{4}{5} \\ N\cdot\frac{4}{5} + m\frac{3}{5}\left(\frac{g}{\cos\beta} - a_1\right) - 2mg = 2ma_1\cdot\frac{3}{5} \end{cases}$

$\begin{cases} \frac{3}{5}N - mg\cdot\frac{13}{15} + \frac{4}{5}ma_1 = \frac{5}{6}mg - \frac{8}{5}ma_1 \\ \frac{4}{5}N + \frac{13}{20}mg - \frac{3}{5}ma_1 - 2mg = \frac{6}{5}ma_1 \end{cases}$

am/is/are + playing

am not/isn't/aren't + playing

haven't + V_3 (played/gone)

hasn't

③ Чистовик

Задача 1

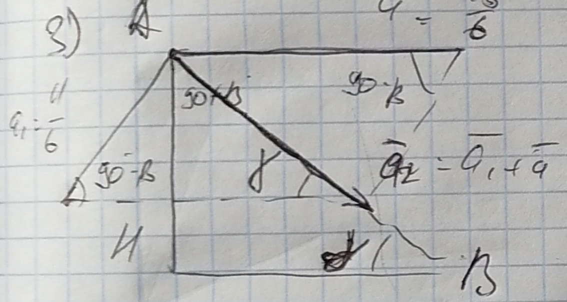
$$\begin{cases} \frac{3}{5}N = \frac{12}{10}mg - \frac{12}{5}ma_1 \\ \frac{4}{5}N = \frac{27}{20}mg + \frac{9}{5}ma_1 \end{cases}$$

$$\begin{cases} N = \frac{17}{6}mg - 4ma_1 \\ N = \frac{27}{16}mg + \frac{9}{4}ma_1 \end{cases}$$

$$\frac{55}{48}\cancel{m}g = \frac{25}{4}\cancel{m}a_1$$

2) $a_1 = \frac{11}{60}g = \frac{11}{60}\cdot 10 = \frac{11}{6} \approx \underline{1{,}83\ м/с^2}$

3) $\bar{a} = \frac{25}{6}$



$a_2^2 = a_1^2 + a^2 - 2aa_1\cos(90-\beta) = \left(\frac{11}{6}\right)^2 + \left(\frac{25}{6}\right)^2 - 2\cdot\frac{11}{6}\cdot\frac{25}{6}\sin\beta$

$\sin\beta = \cos(90-\beta)$

$= \frac{121}{36} + \frac{625}{36} - \frac{550}{36}\sin\beta =$

$= \frac{746}{36} - \frac{550}{36}\cdot\sin\beta = \frac{193}{13}$

$a_2 = \sqrt{\frac{193}{13}} \approx 3{,}85\ м/с^2$

$AB = S = \frac{H}{\sin\gamma} = \frac{Ha_2}{a_1\cos\beta} = \frac{a_2 t^2}{2}$

$\frac{a_1}{\sin\gamma} = \frac{a_2}{\sin(90-\beta)} = \frac{a_2}{\cos\beta} \Rightarrow \sin\gamma = \frac{a_1\cos\beta}{a_2}$

3) $t = \sqrt{\frac{2H}{a_1\cos\beta}} = \underline{\frac{\sqrt{143H}}{11}}$

Ответ: 1) $4{,}17\ м/с^2$
2) $1{,}83\ м/с^2$
3) $\frac{\sqrt{143H}}{11}$

Черновик Задача 2

(4)

3) $\frac{A_{цикл}}{A_{12}}$ $A_{цикл} = A_{12} + A_{21} \Rightarrow$

$\Rightarrow \frac{A_{цикл}}{A_{12}} = 1 + \frac{A_{21}}{A_{12}}$

$A_{21} = \nu R \Delta T_{21} = \nu R (T_1 - T_2) = \frac{\sqrt{2} p_0 V_0}{4} - \frac{p_0 V_0}{4}$

Черновик Задача 2

(4)

$~~p = p_0 \sin \alpha~~$

$~~V = V_0 \cos t~~$

$~~dV = -V_0 \sin \alpha \, d\alpha~~$

$A_{12} =$

$A_{общ} = A_{12} + A_{21} = \frac{p_0 V_0}{2} \left(\frac{5\pi}{24} - \frac{\sqrt{2}-1}{4} \right) +$

$+ \frac{5(1-\sqrt{2})}{8} p_0 V_0 = p_0 V_0 \left(\frac{5\pi}{48} - \frac{\sqrt{2}-1}{8} + \frac{5-5\sqrt{2}}{8} \right)$

$= p_0 V_0 \left(\frac{5\pi}{48} + \frac{3(1-\sqrt{2})}{4} \right)$

$\frac{A_{общ}}{A_{12}} = \frac{p_0 V_0 \left(\frac{5\pi}{48} + \frac{3(1-\sqrt{2})}{4} \right)}{\frac{p_0 V_0}{2} \left(\frac{5\pi}{48} - \frac{\sqrt{2}-1}{4} \right)} =$

$=$

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Часть 2

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

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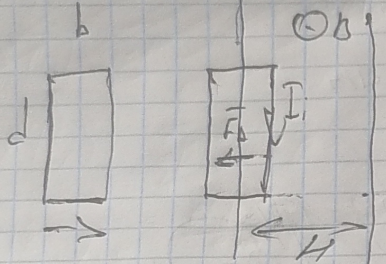
Вариант 6

2

Чистовик

Задача 4



$$|\varepsilon_i| = \frac{\Delta\Phi}{\Delta t} = \frac{B\Delta S}{\Delta t} = \frac{B \cdot d \cdot v_0 \cdot t}{t} = B d v_0$$

$$I_i = \frac{\varepsilon_i}{R} = \frac{B d v_0}{R}$$

$$F_A = BIL \sin\alpha = BIL = B\,\frac{B d v_0}{R}\,d = \frac{B^2 d^2 v_0}{R}$$

$$a = \frac{F_A}{m} = \frac{B^2 d^2 v_0}{Rm}$$

$$a(0) = \frac{B^2 d^2 v_0}{Rm}$$

$$v(0) = v_0$$

$$\varepsilon_i(t) = B d v(t)$$

$$I(t) = \frac{Bd}{R} v(t)$$

$$F_A(t) = -\frac{B^2 d^2}{R} v(t)$$

$$a(t) = -\frac{B^2 d^2}{Rm} v(t) = v'(t)$$

$$\frac{dv}{dt} = -\frac{B^2 d^2 v(t)}{Rm}$$

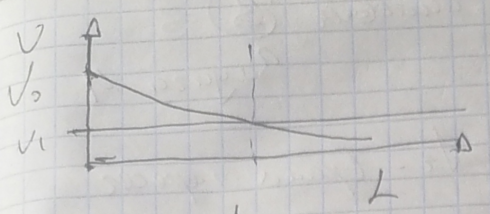
$$\int_0^t -\frac{B^2 d^2}{Rm}\,dt = \int_0^v \frac{1}{v}\,dv$$

$$C - \frac{B^2 d^2 t}{Rm} = \ln v$$

$$v(t) = e^C \cdot e^{-\frac{B^2 d^2 t}{Rm}} = C \cdot e^{-\frac{B^2 d^2 t}{Rm}}$$

$$v(0) = v_0 \Rightarrow v_0 = C \cdot e^0 \Leftrightarrow C = v_0$$

$$v(t) = v_0 \cdot e^{\left(-\frac{B^2 d^2 t}{Rm}\right)}$$



t_1 – время полного вхождения рамки в поле

Чистовик

(2)

Задача 4

$$x(t) = \int_0^{t_1} v(t) = v_0 \int_0^t e^{-\frac{B^2d^2t}{Rm}}\,dt =$$

$$= -\frac{v_0 Rm}{B^2d^2}\cdot e^{-\frac{B^2d^2t}{Rm}}\Big|_0^t =$$

$$= -\frac{v_0 Rm}{B^2d^2}\cdot e^{-\frac{B^2d^2t}{Rm}} + \frac{v_0 Rm}{B^2d^2}$$

$$x(t) = \frac{v_0 Rm}{B^2d^2}\cdot\left(-e^{-\frac{B^2d^2t}{Rm}} + 1\right)$$

$$x(t_1) = \frac{d}{4}$$

$$\frac{d}{4} = \frac{v_0 Rm}{B^2d^2}\cdot\left(-e^{-\frac{B^2d^2t}{Rm}} + 1\right) \Rightarrow$$

$$\Rightarrow -\frac{B^2d^3}{4v_0Rm} + 1 = e^{-\frac{B^2d^2t_1}{Rm}}$$

$$-\frac{B^2d^2t_1}{Rm} = \ln\left(1 - \frac{B^2d^3}{4v_0Rm}\right)$$

$$t_1 = -\frac{Rm}{B^2d^2}\ln\left(1 - \frac{B^2d^3}{4v_0Rm}\right)$$

$$v_1 = v(t_1) = v_0 e^{\frac{B^2d^2}{Rm}\cdot\frac{Rm}{B^2d^2}\cdot\ln\left(1 - \frac{B^2d^3}{4v_0Rm}\right)}$$

$$v_1 = v_0\left(1 - \frac{B^2d^3}{4v_0Rm}\right)$$

Выход из рамки

$$F_A = BIL = \frac{B^2d^2v(t)}{R}$$

$$a(t) = -\frac{B^2d^2v(t)}{Rm} = v'(t)$$

Чистовик (3)

Задача 4

t_2 – время пересеч. правой границы.

$$V(0) = V_1 = V_0\left(1 - \frac{B^2 d^3}{4V_0 Rm}\right)$$

$$x(0) = 0$$

$$x(t_2) = \frac{d}{4}$$

$$V(t) = V_1 e^{-\frac{B^2 d^3 t}{Rm}}$$

$$x(t) = -\frac{V_1 Rm}{B^2 d^3} e^{-\frac{B^2 d^2 t}{Rm}}\Big|_0^t =$$

$$= \frac{V_1 Rm}{B^2 d^2}\left(1 - e^{-\frac{B^2 d^2 t}{Rm}}\right)$$

$$x(t_2) = \frac{d}{4} \Rightarrow$$

$$\frac{d}{4} = \frac{V_1 Rm}{B^2 d^2}\left(1 - e^{-\frac{B^2 d^2 t_2}{Rm}}\right)$$

$$-\frac{B^2 d^2 t_2}{Rm} = 1 - \frac{B^2 d^3}{4V_1 Rm}$$

$$\frac{-B^2 d^2 t_2}{Rm} = \ln\left(1 - \frac{B^2 d^3}{4V_1 Rm}\right)$$

$$t_2 = -\frac{Rm}{B^2 d^2} \ln\left(1 - \frac{B^2 d^3}{4V_1 Rm}\right)$$

$$V_2 = V(t_2) = V_1 \cdot e^{\ln\left(1 - \frac{B^2 d^3}{4V_1 Rm}\right)} = V_1\left(1 - \frac{B^2 d^3}{4Rm}\right) =$$

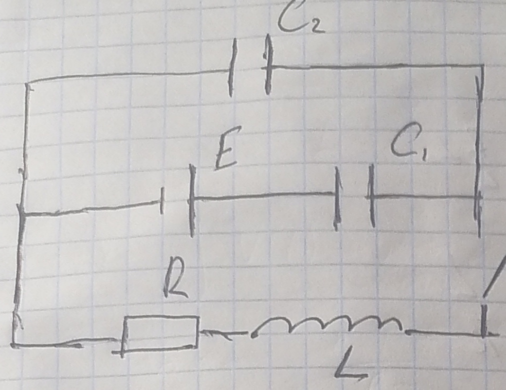
$$= V_1 - \frac{B^2 d^3}{4Rm} = V_0 - \frac{B^2 d^3}{4Rm} - \frac{B^2 d^3}{4Rm} \Rightarrow$$

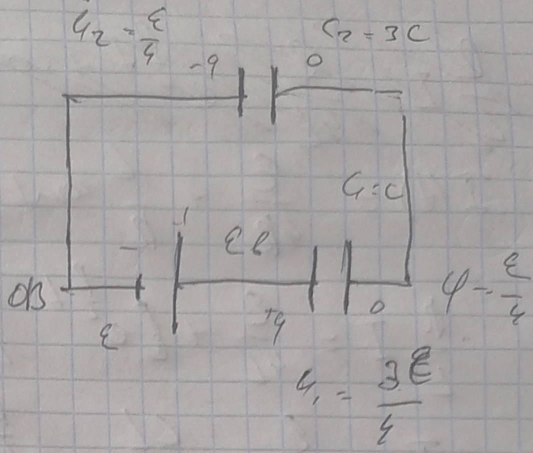
$$\Rightarrow V_2 = V_0 - \frac{B^2 d^3}{Rm}$$

Ответ: 1) $a = \frac{B^2 d^2 V_0}{Rm}$; 2) $V_1 = V_0\left(1 - \frac{B^2 d^3}{4V_0 Rm}\right)$

3) $V_2 = V_0 - \frac{B^2 d^3}{Rm}$

Чистовик (4) Задача 3





1) $q = q_2 = q$

$C_1 U_1 = C_2 U_2$

$C U_1 = 3 C U_2 \Rightarrow U_1 = 3 U_2$

$U_1 + U_2 = \mathcal{E} \Rightarrow U_1 = \frac{3}{4}\mathcal{E}$; $U_2 = \frac{\mathcal{E}}{4}$

$U_R + U_L = \frac{\mathcal{E}}{4}$ $I(0) = 0$

$IR - L\frac{dI}{dt} = -\frac{\mathcal{E}}{4}$

$LI' - RI = -\frac{\mathcal{E}}{4}$

$I' = \frac{R}{L}I - \frac{\mathcal{E}}{4L}$

$$\int_0^I \frac{dI}{\frac{R}{L}I - \frac{\mathcal{E}}{4L}} = \int_0^t dt$$

$\ln\left(\frac{R}{L}I - \frac{\mathcal{E}}{4L}\right)\cdot\frac{L}{R} = t + const$

$\ln\left(\frac{R}{L}I - \frac{\mathcal{E}}{4L}\right) = \frac{R}{L}(t + const)$

$\frac{R}{L}I - \frac{\mathcal{E}}{4L} = e^{\frac{R}{L}t + const} = const\, e^{\frac{R}{L}t}$

Чистовик (5) Задача 3

~~$\frac{dI}{dt} - \frac{\mathcal{E}}{4L} = e^{\frac{R}{L}t} + const$~~

$$I(t) = \frac{\mathcal{E}}{4R} + \frac{L}{R} const\, e^{\frac{R}{L}t}$$

$$\frac{R}{L} I = \frac{\mathcal{E}}{4L} + C e^{\frac{R}{L}t} \quad / \cdot \frac{L}{R}$$

$$I = \frac{\mathcal{E}}{4R} + \frac{CL}{R} \cdot e^{\frac{R}{L}t}$$

$$I(0) = 0 \Rightarrow 0 = \frac{\mathcal{E}}{4R} + \frac{const \cdot L}{R} \Rightarrow$$

$$const = -\frac{\mathcal{E}}{4L}$$

$$I(t) = \frac{\mathcal{E}}{4R}(1 - e^{-\frac{R}{L}t})$$

$$I'(t) = \frac{\mathcal{E}}{4R}(-\frac{R}{L} e^{-\frac{R}{L}t}) \Rightarrow$$

$$I'(t) = -\frac{\mathcal{E}}{4L} e^{-\frac{R}{L}t}$$

$$I'(0) = -\frac{\mathcal{E}}{4L}$$

$$|I'(0)| = \frac{\mathcal{E}}{4L}$$

2) До: $q_1 = \frac{3C\mathcal{E}}{4}$ $\quad q_2 = \frac{3C\mathcal{E}}{4}$

$$W_1 = \frac{3C \cdot (\frac{\mathcal{E}}{4})^2}{2} = \frac{3C\mathcal{E}^2}{32}$$

$$W_2 = \frac{C \cdot (\frac{3\mathcal{E}}{4})^2}{2} = \frac{9C\mathcal{E}^2}{32}$$

$$W_1 + W_2 = \frac{12}{32} C\mathcal{E}^2 = \frac{3}{8} C\mathcal{E}^2$$

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Чистовик (6) Задача 3

После:

~~$q_1 = 0 \quad q_2 \neq 0$~~

~~$W = W_1 = W_2 \neq 0$~~

~~$Q = \frac{3}{8} C\varepsilon^2$~~

$q_1 = \varepsilon C \qquad q_2 = 0$

$W_1 = \frac{C\varepsilon^2}{2} \qquad W_2 = 0$

$W_1 = \frac{1}{2} C\varepsilon^2$

$\Delta q = C\varepsilon - \frac{3C\varepsilon}{4} = \frac{1}{4} C\varepsilon$

$A_{ист} = \varepsilon \cdot \Delta q = \frac{1}{4} C\varepsilon^2 > 0$

$W_{до} + A_{ист} = W_{после} + Q$

$\frac{3}{8} C\varepsilon^2 + \frac{1}{4} C\varepsilon^2 = \frac{1}{2} C\varepsilon^2 + Q$

$Q = \frac{1}{8} C\varepsilon^2$

Ответ: 1) $|I'(0)| = \frac{\varepsilon}{4L}$ 2) $Q = \frac{1}{8} C\varepsilon^2$