Часть 1

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

Шифр: **21201193**

ID профиля: **353742**

Вариант 1

Чистовик Вариант 11-01

2. $i=3$ (He)

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

$T_0 \to T_1 = \frac{5}{6}T_0$

1) $Q_1 - ?$

2) $A_{min}: T_2 - ?$

3) $A_{min} - ?$

1) $-Q_1 = \int\limits_{T_0}^{T_1} c(T)\,\nu\, dT = \frac{2\nu R}{T_0}\int\limits_{T_0}^{T_1} T\, dT =$

$= \nu R \frac{T_1^2 - T_0^2}{T_0} = \nu R\left(\frac{25}{36} - \frac{36}{36}\right)T_0 =$

$= -\frac{11}{36}\nu R T_0$

$Q_1 = \frac{11}{36}\nu R T_0$

2) $Q = A + \Delta U$

$A = Q - \Delta U = \nu R \frac{T_2^2 - T_0^2}{T_0} - \frac{3}{2}\nu R (T_2 - T_0) =$

$= \frac{\nu R}{T_0}\left(T_2^2 - \frac{3}{2}T_2 T_0 + \frac{1}{2}T_0^2\right)$

A_{min}, при $\left(T_2^2 - \frac{3}{2}T_2 T_0 + \frac{1}{2}T_0^2\right)_{min}$

$\Downarrow$

$T_2 = \frac{-\left(-\frac{3}{2}T_0\right)}{2} = \frac{3}{4}T_0$ (абсцисса вершины параболы)

3) $A_{min} = \frac{\nu R}{T_0}\cdot\left(\frac{9}{16} - \frac{9}{8} + \frac{1}{2}\right)T_0^2 = -\frac{1}{16}\nu R T_0$

Ответ: 1) $Q_1 = \frac{11}{36}\nu R T_0$ 2) $T_2 = \frac{3}{4}T_0$ 3) $A_{min} = -\frac{1}{16}\nu R T_0$

3

$\frac{17}{18} - \frac{18}{16}$

Черновик

$c(T) = 2R\frac{T}{T_0}$ $Q = c\nu\Delta T$

$Q = \frac{2\nu R}{T_0}\int_{T_0}^{T} T\,dT =$

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

$T = \frac{5}{6}T_0$ $Q = \int_{T_0}^{T} c\nu\,dT = \frac{2\nu R}{T_0}\int_{T_0}^{T} T\,dT =$

$\frac{C_p}{C_v} = \gamma = \frac{i+2}{i}$ $= \frac{2\nu R}{2T_0}\left(T^2 - T_0^2\right) =$

$Q = A + \Delta U$ $\boxed{\frac{+\frac{3}{2}}{2} = \frac{3}{4}T_0}$ $= \nu R\frac{11}{36}T_0$ ΔU He

$\frac{1}{2}T_0$ T_0 $\boxed{\frac{3}{4}T_0}$

$A = Q - \Delta U$

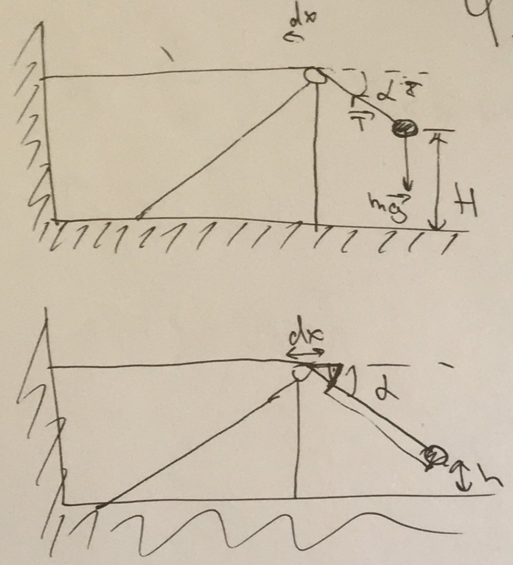
$Q = \nu R\left(\frac{T^2 - T_0^2}{T_0}\right)$ $T = T_0 = \frac{1}{2}T_0$ $Q_{отд} = \frac{11}{36}\nu R T_0$

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

$Q - \Delta U = \nu R\left(\frac{T^2 - \frac{3}{2}TT_0 + \frac{T_0^2}{2}}{T_0}\right)$ $pV = \nu RT$ $\Delta(pV) = \nu R\Delta T$

2. i=3 (He) Вариант 11-01

Черновик



$$\frac{H}{\cancel{\sin\beta}} = \frac{at^2}{2} = \frac{gt^2}{2}\cdot\frac{3}{5}\cdot\frac{1}{\cancel{\sin\beta}}$$

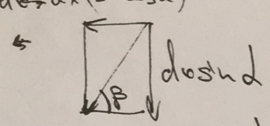
$$H = \frac{3}{10}gt^2$$

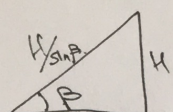
$$t = \sqrt{\frac{10H}{3g}}$$

2)

$$a_M = \frac{6\sqrt{5}}{5(\sqrt{17}-1)}$$

$dx \cdot dx(1-\cos\alpha)$





$$\frac{\sin\beta}{\cos\beta} = 2 \quad ?$$

$$\sin\beta = 2(1-\sin^2\beta)$$

$$2\sin^2\beta + \sin\beta - 2 = 0$$

$$D = 1 + 16 = 17$$

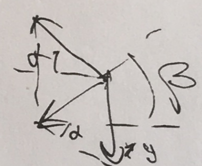
$$\frac{-1 \pm \sqrt{17}}{4}$$

$$\sin\beta = \frac{\sqrt{17}-1}{4}$$

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

$$\operatorname{tg}\alpha = \frac{4}{3}$$

$$\boxed{\operatorname{tg}\beta = 2}$$



$$a_m = \frac{3}{5\sin\beta}g$$

$$mgH = \frac{M(a_m t)^2}{2} + \frac{m(a_m t)^2}{2}$$

$dx =$

$$T\cos\alpha = (mg - y)\,/\,\operatorname{tg}\beta = y/\operatorname{tg}\alpha$$

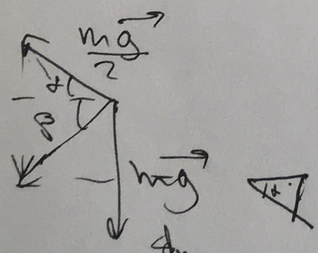
$$mg = F\left(\frac{\sqrt{17}-1}{4}\right) + mg\frac{2}{5}$$

$F = \cancel{\dots}\, mg$

$$mg = F\sin\beta + \frac{mg\sin\alpha}{2}$$

$$\frac{3}{5}T = (mg - y)/2$$

$$F = \frac{3}{5}\frac{mg}{\sin\beta}$$



$$\frac{3}{5}T = \frac{3}{4}y$$

$$\frac{dx}{dx\sqrt{\frac{4}{5}}} = \frac{a_m}{a_m} = \frac{a_m}{\frac{3g}{5\sin\beta}}$$

$$y = \frac{4}{5}T \qquad \frac{3}{5}T = \frac{mg - \frac{4}{5}T}{2}$$

$$\frac{\sqrt{5}}{2} = \frac{a_m 5\sin\beta}{3g}$$

$$dx\sqrt{2-2\cos\alpha} = dx\sqrt{\frac{4}{5}}$$

$$2T = mg$$

$$a_m = \frac{4\cdot 3\cdot\sqrt{5}}{2\cdot 5(\sqrt{17}-1)}g$$

2. $i=3$ (He)

Черновик

$\frac{17}{18} - \frac{18}{16}$

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

$Q = c\nu\Delta T$

$\cancel{Q = \frac{2\nu R}{T_0}\int_{T_0}^{T} T \ldots dT} =$

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

$T = \frac{5}{6}T_0$

$Q = \int_{T_0}^{T} c\nu\, dT = \frac{2\nu R}{T_0}\int_{T_0}^{T} T\, dT =$

$\frac{C_p}{C_v} = \gamma = \frac{i+2}{i}$

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

$Q = A + \Delta U$ $\boxed{\frac{+\frac{3}{2}}{2} = \frac{3}{4}T_0}$

$= \frac{\nu R}{\ldots}\nu R\frac{11}{36}T_0$ ΔU He

$A = Q - \Delta U$ $\frac{1}{2}T_0$ T_0 $\boxed{\frac{3}{4}T_0}$

$T = T_0 = \frac{1}{2}T_0$

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

$Q_{отд} = \frac{11}{36}\nu R T_0$

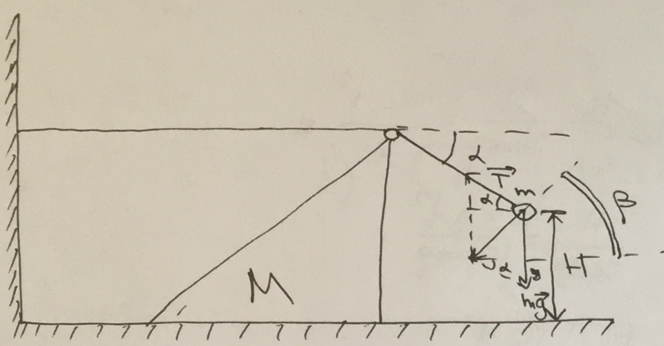
$\Delta U = \frac{3}{2}\nu R(T - T_0)$

$Q - \Delta U = \nu R\left(\frac{T^2 - \frac{3}{2}TT_0 + \frac{T_0^2}{2}}{T_0}\right)$

$pV = \nu RT$ $\Delta(pV) = \nu R\Delta T$

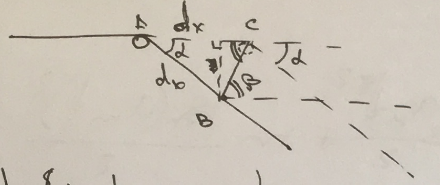
Чистовик Вариант 11-01

1.



$\cos\alpha = \frac{3}{5}$
$\Downarrow$
$\sin\alpha = \frac{4}{5}$

1)



AC – путь клина

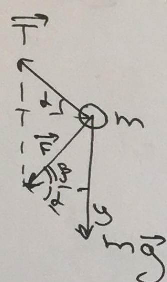
BC – путь шара

$AC = dx$

$BC = dx\sqrt{2-2\cos\alpha} = dx\sqrt{\frac{4}{5}}$

$$tg\beta = \frac{dx\sin\alpha}{dx(1-\cos\alpha)} = \frac{\frac{4}{5}}{1-\frac{3}{5}} = 2$$

2)



$tg\beta = 2 = \frac{\sin\beta}{\cos\beta}$

$2\cos\beta = 1-\cos^2\beta$

$\cos^2\beta + 2\cos\beta - 1 = 0$

$D = 4+4 = 8$

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

$$T\cos\alpha = \frac{y}{tg\alpha} = \frac{mg-y}{tg\beta}$$

$y = T\sin\alpha$

$$T\cos\alpha = \frac{mg - T\sin\alpha}{2}$$

$$T = \frac{mg}{2\left(\cos\alpha + \frac{\sin\alpha}{2}\right)} = \frac{mg}{2}$$

$$F = T\cos\alpha / \cos\beta = \frac{mg}{2}\cdot\frac{3}{5}\cdot\frac{1}{\sqrt{2}-1} = \frac{3}{10(\sqrt{2}-1)}mg$$

$F = ma_m \quad a_m = \frac{3}{10(\sqrt{2}-1)}g$ из 1) $\frac{AC}{BC} = \frac{a_M}{a_m} = \frac{\sqrt{5}}{2} \quad a_M = \frac{\sqrt{5}}{2}a_m = \frac{3\sqrt{5}}{20(\sqrt{2}-1)}g$

1

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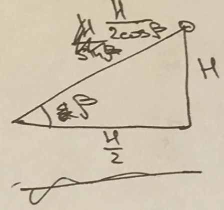
Чистовик Вариант 11-01

1. (продолжение)

4) 

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

$$\frac{H}{\cos\beta} = \frac{3gt^2}{10\cos\beta}$$

$$t = \sqrt{\frac{10H}{3g}}$$

3) $$mgH = M\frac{v_M^2}{2} + m\frac{v_m^2}{2} = M\frac{(a_M t)^2}{2} + m\frac{(a_m t)^2}{2}$$

$$mgH = M\frac{\frac{10H}{3g}\cdot\frac{9\cdot 5}{400\cdot(\sqrt{2}-1)^2}g^2}{2} + m\frac{\frac{10H}{3g}\cdot\frac{9}{100(\sqrt{2}-1)^2}g^2}{2}$$

$$\frac{m}{M} = \frac{2\left(1 - \frac{10}{3}\cdot\frac{9}{100(\sqrt{2}-1)^2}\right)}{\frac{10}{3}\cdot\frac{9\cdot 5}{400(\sqrt{2}-1)^2}}$$

Ответ: 1) $\operatorname{tg}\beta = 2$ 2) $a_M =$

②

Часть 2

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

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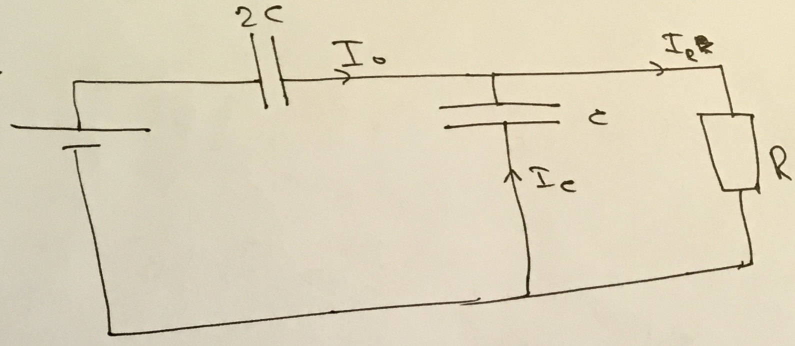
Вариант 1

Чистовик В 11-01

3.



до замыкания:

$\mathcal{E} = U_{2C} + U_C = \frac{q_0}{2C} + \frac{q_0}{C} = \frac{3}{2}\frac{q_0}{C}$

1) I_{R0} - ? $I_{R0}R = U_C = \frac{q_0}{C}$

$\mathcal{E} = \frac{3}{2} I_{R0} R$

$I_{R0} = \frac{2}{3}\frac{\mathcal{E}}{R}$

2) Q - ? Было: $\mathcal{E} = \frac{q_0}{2C} + \frac{q_0}{C}$ $\mathcal{E} = \frac{3}{2}\frac{q_0}{C}$ $q_0 = \frac{2}{3}C\mathcal{E}$

Стало: $U_C = 0$ $U_{2C} = \mathcal{E}$ $\mathcal{E} = \frac{q_1}{2C}$ $q_1 = 2C\mathcal{E}$

ЗСЭ:

$$(q_1 - q_0)\mathcal{E} + \frac{q_0^2}{2(2C)} + \frac{q_0^2}{2C} = Q + \frac{q_1^2}{2\cdot(2C)}$$

$$\frac{4}{3}C\mathcal{E}^2 + \frac{C\mathcal{E}^2}{9} + \frac{2C\mathcal{E}^2}{9} = Q + C\mathcal{E}^2$$

$$\left(\frac{8}{9} + \frac{1}{9} + \frac{2}{9}\right)C\mathcal{E}^2 = Q + C\mathcal{E}^2$$

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

3) $I_{2C} = I_0$, I_R - ?

Малые приращения:

$\mathcal{E} = U_{2C} + I_R R$

$I_R = I_C + I_0$ $I_C = I_R - I_0$

$\mathcal{E} = U_{2C} + dU_{2C} + (I_R - dI_R)R$

$dU_{2C} = dI_R R$

$U_C = I_R R$

$U_C - dU_C = (I_R - dI_R)R$

$dU_C = dI_R R$

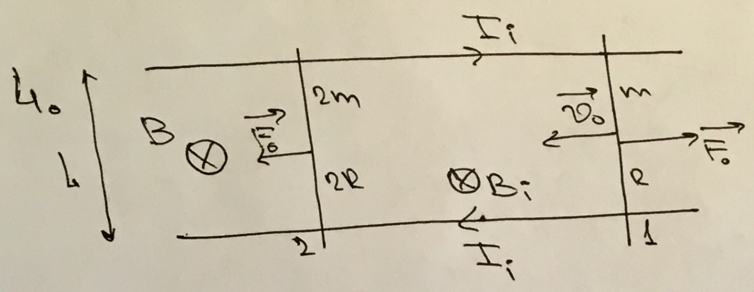
$dU_C = dU_{2C}$ $\frac{I_0 dt}{2C} = \frac{(I_R - I_0)dt}{C}$ $I_R = \frac{3}{2}I_0$

(1)

Чистовик В 11-01

3. (продолжение)

Ответ: 1) $I_{R0} = \frac{2}{3}\frac{\mathcal{E}}{R}$ 2) $Q = \frac{2}{9}C\mathcal{E}^2$ 3) $I_R = \frac{3}{2} I_0$



$\Delta\Phi < 0 \Rightarrow \vec{B_i} \uparrow\uparrow \vec{B}$

1) $F_0 = BI_iL$ $\quad \mathcal{E}_i = \frac{d\Phi}{dt} = \frac{BdS}{dt} = \frac{BLv_0 dt}{dt} = BLv_0$

$\mathcal{E}_i = I_i \cdot 3R \quad I_i = \frac{BLv_0}{3R}$

$F_0 = \frac{B^2L^2v_0}{3R}$

$F_0 = 2m a_{02}$ $\quad a_{02} = \frac{F_0}{2m} = \frac{B^2L^2v_0}{6Rm}$

2) Через продолжительный промежуток времени

$d\Phi = 0 \Rightarrow BdS = 0 \Rightarrow v_1 = v_2$

модули сил $|F|$ действующих на 1ую перемычку и на 2ую перемычку равны, значит $|\Delta\vec{P_1}| = |\Delta\vec{P_2}| = \Delta P$

$mv_0 - \Delta P = mv_1$

$\Delta P = 2mv_2$

$mv_0 = mv_1 + 2mv_2$, $v_1 = v_2$

$mv_0 = 3mv_1$

$v_1 = v_2 = \frac{v_0}{3}$

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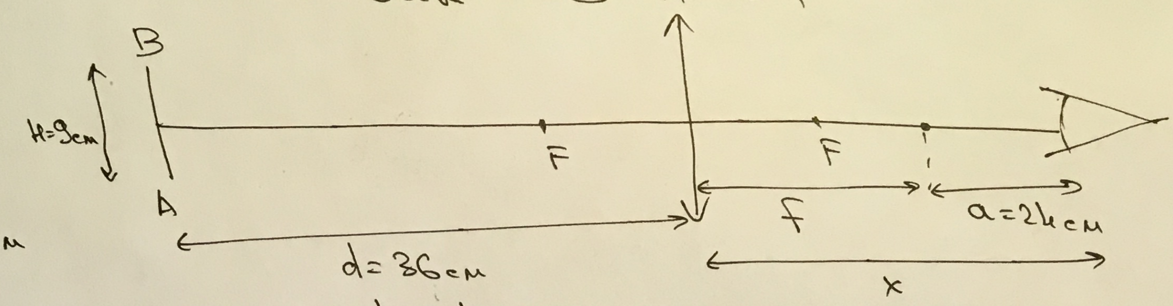
4. (продолжение) Пусть $v_1 - v_2 = v_p$

3) $$S = S_0 - \int_{v_0}^{0} v_p(t)\,dt$$

$$v_p(t) = v_1 - v_2 = v_0 - \int_{\frac{B^2 L^2 v_0}{3mR}}^{0} a_1(t)\,dt - \int_{\frac{B^2 L^2 v_0}{6mR}}^{0} a_2(t)\,dt$$

Чистовик В 11-01

5.



F=9см

1) $x = f + a$ $\quad \cancel{Б}\ \frac{1}{f} = \frac{1}{F} - \frac{1}{d}$

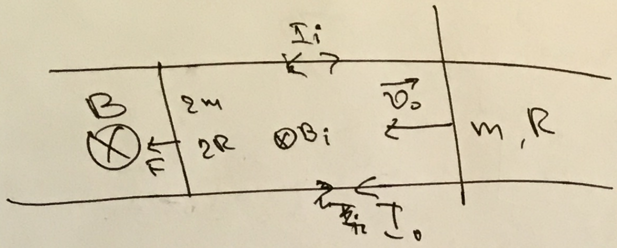
$$f = \frac{Fd}{d-F} = 12\text{см}$$

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

2) $\frac{D_м}{H} = \frac{F}{d-F}$ $\quad D_м = H\frac{F}{d-F} = 3\text{см}$

Ответ: $x = 36\text{см}$, $D_м = 3\text{см}$

Черновик



$S_0 \to S$, S?

$\Delta\Phi < 0$

$$S = \int_0^{\tau} v\,dt$$

$$\mathcal{E}_i = \frac{\Delta\Phi}{\Delta t} = \frac{B\Delta S}{\Delta t} = \frac{BLv_0\Delta t}{\Delta t} = BLv_0$$

$$I_i = \frac{\mathcal{E}_i}{3R} = \frac{BLv_0}{3R}$$

$$F = 2ma_2 = BL\frac{BLv_0}{3R} =$$

$$\Rightarrow a_2 = \frac{B^2L^2v_0}{6mR}$$

$\Phi = const \Rightarrow v_1 = v_2$

$a_1 = 2a_2$

$$mv_1 = mv_0 - \int F\,dt$$

$$F = \frac{B^2L^2v}{3R}$$

$\cancel{m}a_1 = 2\cancel{m}a_2$

$v =$

$$mv_1 = mv_0 - \Delta p$$

$$2mv_2 = \Delta p$$

$$v_0 = \int_0^{\tau}(a_1 + a_2)\,dt =$$

$v_1 = v_2$

$$v_0 = \int (a_1 + a_2)\,dt$$

$$mv_1 = mv_0 - 2mv_2$$

$v_0 = 3a_2 t$

$a_2 t = v_2$

$= 3\int_0^{\tau_0}$

$3mv_1 = mv_0$

$v_1 = v_2 = \frac{v_0}{3}$

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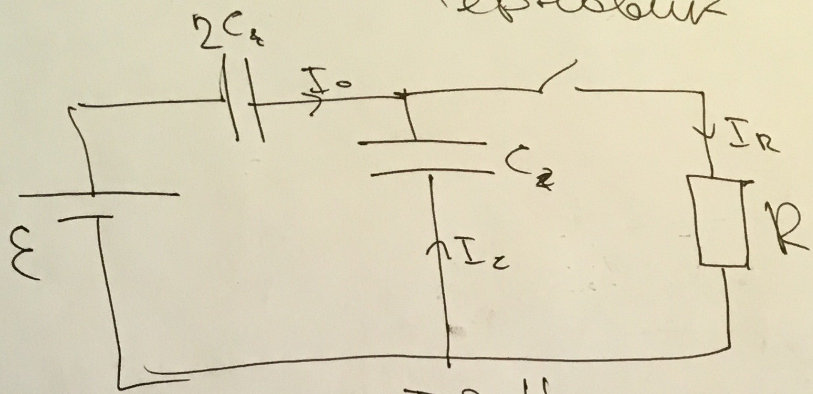
Черновик 11-01



I_0

$I_0 = I_R + I_c$

$I_R R = U_c$

U_{c}

$dq_{2c} =$

$I_{2c} = I_0$

$U_{2c} + IR = \mathcal{E}$

$dq_{2c} = I_0 dt$

$dq_c = I_c dt$

$dU_c = \frac{I_c dt}{C}$

$dU_{2c} = \frac{I_0 dt}{2c}$

$U_c = \mathcal{E}$

$\mathcal{E} = U_{2c} + U_c =$

$U_c = I_R R$

$(I_R - dI_R)$

$\mathcal{E} = U_{2c} + dU_{2c} + I_R R$

$= \frac{q_0}{2c} + \frac{q_0}{c} = \frac{3q_0}{2c}$

$\mathcal{E} = U_{2c} + I_R R$

$\frac{q_1}{2c} = \mathcal{E}$

$q_0 = \frac{2}{3} c\mathcal{E}$

$dU_{2c} = dI_R$

$q_1 =$

$I_0 R = \frac{q_0}{c} = \frac{2}{3}\mathcal{E}$

$\frac{I_0 dt}{2c} = dI_R R$

$q_1 = 2c\mathcal{E}$

$I_0 = \frac{2\mathcal{E}}{3R}$

$I_R R = U_c$

$dI_R R = \frac{(I_R - I_0) dt}{c}$

$\frac{q_0^2}{2 \cdot 2c} + \frac{q_0^2}{2c}$

$\frac{I_0 dt}{2c} = \frac{(I_R - I_0) dt}{c}$

$(q_1 - q_0)\mathcal{E} + \cancel{\frac{2 \cdot q_0^2}{9c}} + \frac{4c\mathcal{E}^2}{9} = Q + \frac{q_1^2}{2 \cdot 2c}$

$I_R = \frac{3}{2} I_0$

$Q = \frac{2}{9} c\mathcal{E}^2$

$\cancel{\frac{4}{3} c\mathcal{E}^2 + \frac{2}{9} c\mathcal{E}^2 + \frac{4}{9} c\mathcal{E}^2 = Q + 2c\mathcal{E}^2}$

$\cancel{\frac{12+2+4}{9} c\mathcal{E}^2 = Q + 2c\mathcal{E}^2}$

$\left(\frac{8}{9} + \frac{1}{9} + \frac{2}{9}\right) c\mathcal{E}^2 = Q + c\mathcal{E}^2$

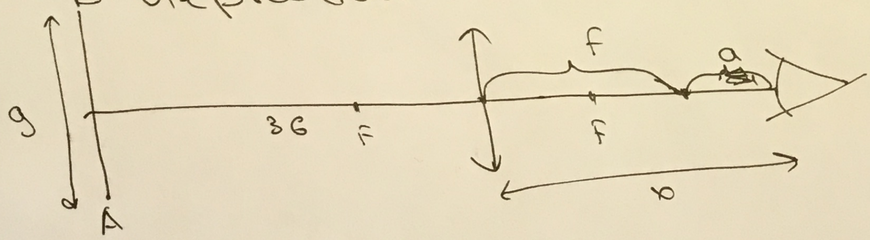
Черновик

$F = 9$ см

$AB = 9$ см

$d = 36$ см

$a = 24$ см



$x = f + 24$ см $x = 12 + 24 = 36$ см

$$f = \frac{Fd}{d-F} = 12 \text{ см}$$

$\frac{9}{3}$ $\boxed{3}$

$m v_1 + 2m v_2 = m v_0$

$m v_0$