Часть 1

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

Шифр: **21202903**

ID профиля: **76248**

Вариант 2

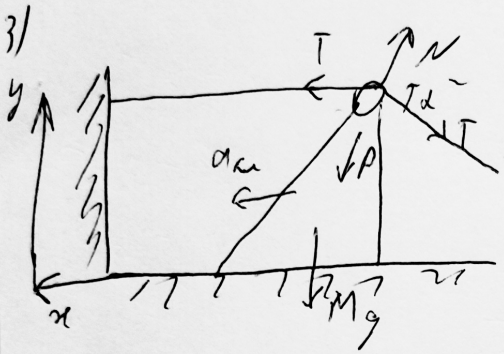
Чистовик. Лист 2 / 3

№ 1 продолж.

$$a_{кл} = \frac{g\cos\alpha}{\sin\alpha} = \frac{4}{3}g$$

$$\cos\alpha = \frac{4}{5} \Rightarrow \sin\alpha = \sqrt{1-\cos^2\alpha} = \frac{3}{5}$$

3)



Для клина: $Ox: T(1-\cos\alpha) = M a_{кл}$

$$T = \frac{M a_{кл}}{1-\cos\alpha}$$

подставим в 1: $m a_{кл}\cos\alpha + mg\sin\alpha - \frac{M a_{кл}}{1-\cos\alpha} = m a_{отн}$

$a_{отн} = a_{кл} = \frac{4}{3}g$

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

$\sin\alpha = \frac{3}{5}$

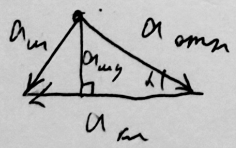
$m\frac{4}{3}g\cdot\frac{4}{5} + mg\frac{3}{5} - M\frac{4}{3}g\cdot 5 = m\cdot\frac{4}{3}g$

$M\cdot\frac{16}{15} + \frac{9}{15}m - \frac{200}{15}m = \frac{20}{3}M$

$\frac{1}{3}m = \frac{20}{3}M$

$\frac{M}{m} = 20$

4)



$a_{кл y} = a_{отн}\sin\alpha = a_{кл}\sin\alpha = \frac{4}{3}g\cdot\frac{3}{5} =$

$= \frac{4}{5}g$

$H = v_0 t + \frac{a_{кл y}t^2}{2} \Rightarrow a_{кл y}t^2 = 2H$

$t = \sqrt{\frac{2H}{a_{кл y}}} = \sqrt{\frac{2H\cdot 5}{4g}} \Rightarrow$

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

Ответ: 1) $\cos\beta = \sqrt{0,5}$ $\beta = 0,3\pi/5$ 2) $a_{кл} = \frac{4}{3}g$ 3) $\frac{m}{M} = 20$ 4) $t = \sqrt{\frac{5H}{2g}}$

Чистовик. лист 3/3

№ 2

ν $\quad PV = \nu RT$

T_0

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

$T_1 = T_0$

$T_2 = \frac{1}{2} T_0$

$Q_1 - ?$

$T - ?$

$A_{min} - ?$

1) $dQ = \nu C\, dT \Leftrightarrow Q = \int \nu C\, dT$

$$Q_2 = \int_{\frac{T_0}{2}}^{T_0} \nu \frac{5}{2} R \frac{T}{T_0}\, dT = \frac{T^2}{2} \cdot \frac{5R\nu}{2T_0} \Big|_{\frac{T_0}{2}}^{T_0} =$$

$$= -\frac{T_0^2}{2} \cdot \frac{5R\nu}{2T_0} + \frac{T_0^2}{8} \cdot \frac{5R\nu}{2T_0} = -\frac{3}{8} \frac{T_0^{\cancel{2}} \cdot 5R\nu}{2\,\cancel{T_0}} =$$

$$= -\frac{15}{16} \nu R T_0 \Rightarrow Q_1 = -Q_2 = \frac{15}{16} \nu R T_0$$

2) $Q = U + A \Rightarrow$

$$\nu \int \frac{5R}{2T_0} T\, dT - \int_{T_0}^{T} \nu R\, dT = A - min$$

$$\frac{T^2}{2} \cdot \frac{5R\nu}{2T_0} \Big|_{T_0}^{T} - \frac{3}{2} \nu R (T - T_0) = A - min$$

$$\frac{5\nu R}{4T_0} T^2 - \frac{T_0^{\cancel{2}} \cdot 5R\nu}{4\,\cancel{T_0}} - \frac{3}{2} \nu R T + \frac{3}{2} \nu R T_0 - min$$

$$\frac{5\nu R}{4T_0} T^2 - \frac{3}{2} \nu R T + \frac{\nu R T_0}{4} - min$$

(парабола с ветвями вверх имеет max)

производная = 0

$$\frac{5\nu R}{2T_0} T - \frac{3}{2} \nu R = 0 \Leftrightarrow 5T - 3T_0 = 0$$

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

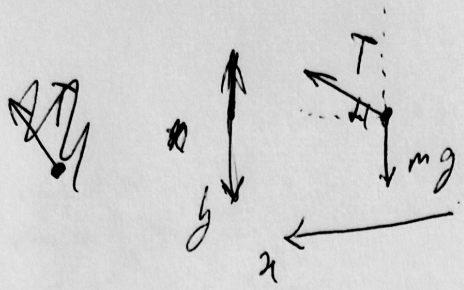
$$A_{min} = \frac{5\nu R}{4T_0} \cdot \frac{9}{25} T_0^2 - \frac{3\nu R}{2} \cdot \frac{3}{5} T_0 + \frac{\nu R T_0}{4} = \frac{9\nu R T_0}{20} - \frac{9\nu R T_0}{10} +$$

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

Ответ: ① $\frac{15}{16} \nu R T_0 = Q_1$ ② $T = \frac{3}{5} T_0$ ③ $A_{min} = -\frac{\nu R T_0}{5}$

Для шара в ИСО:

Черновик 1



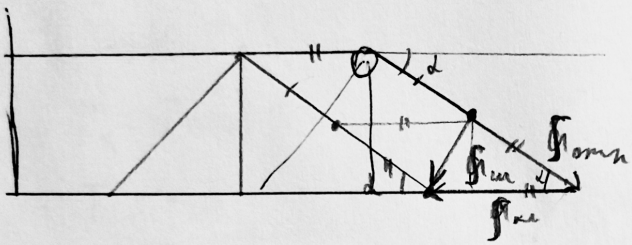
$Ox: T\cos\alpha = m a_{шx}$

$Oy: mg - T\sin\alpha = m a_{шy}$

$$a_ш = \sqrt{a_{шx}^2 + a_{шy}^2} = \sqrt{\frac{T^2\cos^2\alpha}{m^2} + \frac{(mg - T\sin\alpha)^2}{m^2}} =$$

$$= \sqrt{\frac{T^2\cos^2\alpha + m^2g^2 - 2mgT\sin\alpha + T^2\sin^2\alpha}{m^2}}$$

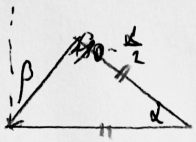
(1)



$S_{отн} = S_ш$

$\Rightarrow a_{отн} = a_ш$

(из геометрии)



$\beta = 90 - (90 - \frac{\alpha}{2}) = \frac{\alpha}{2}$

$\cos\alpha = \frac{4}{5}$ $\alpha = 0,6435$

$0,32175$

$\cos 2\alpha = \cos^2\alpha - \sin^2\alpha = 2\cos^2\alpha - 1$

$2\cos^2\frac{\alpha}{2} - 1 = \cos\alpha = \frac{4}{5}$

$2\cos^2\frac{\alpha}{2} = \frac{9}{5}$

$\cos\frac{\alpha}{2} = \sqrt{0,9}$

1) $\cos\beta = \sqrt{0,9}$ $\beta = \frac{\alpha}{2} = 0,32175$

2) $a_ш = \frac{4}{3}g = 13,33\ м/с^2$

3)

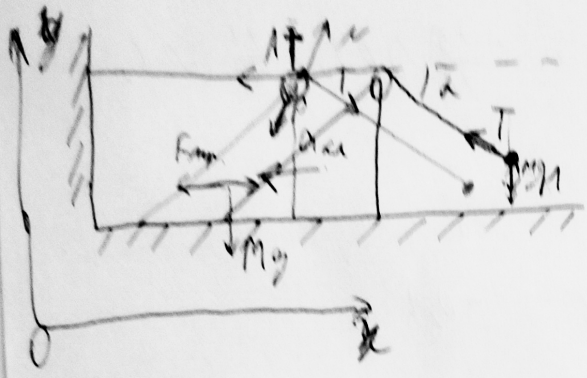
$$= -\frac{5QR}{4}T_0 + \frac{6QR}{4}T_0$$

$$\frac{9QRT_0}{20} - \frac{10QRT_0}{20} + \frac{5QRT_0}{20} =$$

$$= -\frac{4QRT_0}{20} = -\frac{QRT_0}{5}$$

Черновик 2

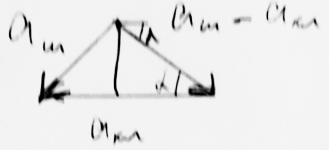
№ 1



В СО "шар-клин" шар движется вдоль нити

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

$\sin\alpha = \sqrt{\frac{25-16}{25}} = \frac{3}{5}$



A: $\bar T_1 + \bar T_2 + \bar N = 0$

$\begin{cases} N_x = T_2 - T\cos\alpha \\ N_y = T\sin\alpha \end{cases}$

$N = \sqrt{T^2(1-\cos\alpha)^2 + T^2\sin^2\alpha} = T\sqrt{1 - 2\cos\alpha + \cos^2\alpha + \sin^2\alpha} =$

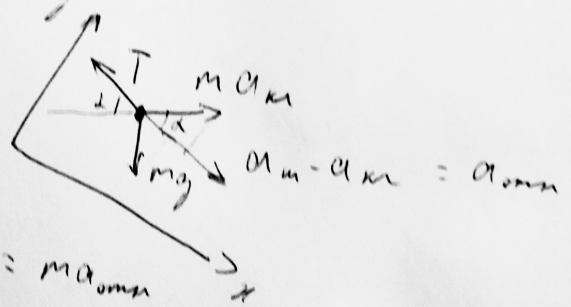
$= T\sqrt{2(1-\cos\alpha)}$

клин: $\bar P + \bar F_{тр} + \bar M g + \bar N_x = M\bar a_{кл}$

Ox: $N_x - F_{тр} = M a_{кл} \Rightarrow T(1-\cos\alpha) - F_{тр} = M a_{кл}$

Oy: $N_x = Mg + T\sin\alpha$

(2) В СО "шар-клин": шар:



$\bar T + m\bar a_{кл} + m\bar g = m\bar a_{отн}$

$\begin{cases} Ox: m a_{кл}\cos\alpha + mg\sin\alpha - T = m a_{отн} \\ Oy: -mg\cos\alpha + m a_{кл}\sin\alpha = 0 \end{cases}$

$a_{кл} = \frac{g\cos\alpha}{\sin\alpha} = g\frac{4\cdot 5}{5\cdot 3} = \frac{4}{3}g$

пусть $F_{тр} = 0$

$\begin{cases} M a_{кл} = T(1-\cos\alpha) \\ m a_{кл}\cos\alpha + mg\sin\alpha - T = m a_{отн} \end{cases}$

$\frac{5M}{2g}$

Черновик 3

$A_1 = Q - U \qquad U = \frac{3}{2} \nu R \left(\frac{T_0}{2} - T_0 \right) = -\frac{3}{4} \nu R T_0$

$A_1 = -\frac{15}{16} \nu R T_0 + \frac{3}{4} \nu R T_0 = -\frac{15}{16} \nu R T_0 + \frac{12}{16} \nu R T_0 =$

$= -\frac{3}{16} \nu R T_0 \qquad -\frac{3}{16} \qquad -\frac{1}{5}$

$-0,1875 \qquad -0,2$

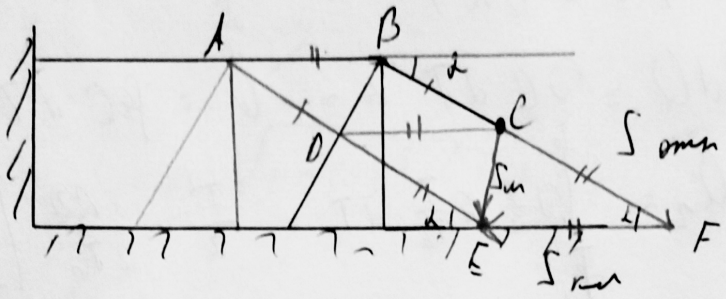
Чистовик. Лист 1/3

Вариант 11-02

№ 1

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

1)



- т.к. α - const в СО „тар - клин" тар движется вдоль пола
- нарисуем момент, когда шар достиг пола (обозначен на рис) $AB = DE$ (клин неразрезной)

$AE \parallel BF$ (α - const)

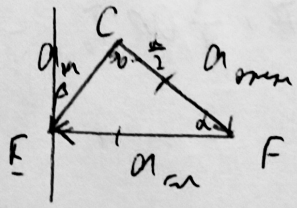
$\Rightarrow ABCD$ и $CDEF$ - пар-мы $\Rightarrow$

$AB = DC = EF$; $DE = CF$

$\Rightarrow DC = CF = EF = DE$. $\overline{CF} = \bar{S}_{отн}$, пройд. шаром

$\overline{FE} = \bar{S}_{ст}$

$\rightarrow S_{отн} = S_{ст} \Rightarrow a_{отн} = a_{ст}$ (из кинем. связи)



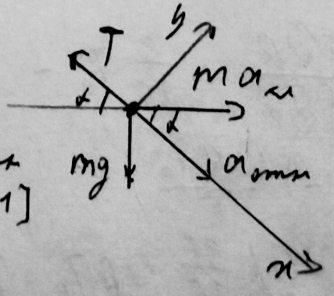
т.к. $FC = FE$, $\angle F = \alpha$ $\Rightarrow \angle ECF = \angle CEF = \frac{180 - \alpha}{2}$

$\Rightarrow \angle\beta = 90 - (90 - \frac{\alpha}{2}) = \frac{\alpha}{2}$

$2\cos^2\frac{\alpha}{2} - 1 = \cos\alpha = \frac{4}{5}$

$2\cos^2\frac{\alpha}{2} = \frac{9}{5}$ $\Leftrightarrow \cos\frac{\alpha}{2} = \sqrt{0,9} = \cos\beta$

2) В СО „тар - клин": тар:



II З. Ньютона:

Ox: $ma_{ст}\cos\alpha + mg\sin\alpha - T = ma_{отн}$

Oy: $-mg\cos\alpha + ma_{ст}\sin\alpha = 0$ [1]

Часть 2

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

Шифр: **21202903**

ID профиля: **76248**

Вариант 2

Чистовик 1/4

(Вариант 11.02)

№ 3

$C_2 = C$

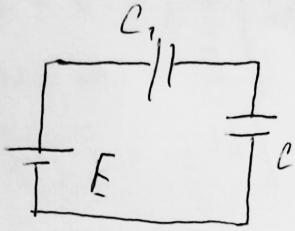
$C_1 = 3C$

$I_{R0} - ?$

$Q - ?$

I_0

$U_R - ?$

1) 

уст. режим до замыкания ключа:

$\frac{1}{C_0} = \frac{1}{C_1} + \frac{1}{C_2}$

$\frac{1}{C_0} = \frac{1}{3C} + \frac{1}{C} \Leftrightarrow \frac{1}{C_0} = \frac{4}{3C}$

$C_0 = \frac{3}{4} C$

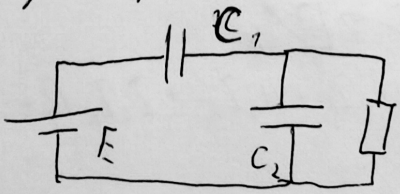
$q_0 = C_0 U \Rightarrow q_0 = \frac{3}{4} CE$

$U_1 = \frac{q_0}{C_1} = \frac{E}{4}$, $U_2 = \frac{q_0}{C_2} = \frac{3E}{4}$

2) в момент замыкания ключа:

$U_R = U_2 = \frac{3E}{4} \Rightarrow I_{R0} R = \frac{3E}{4} \Rightarrow I_{R0} = \frac{3E}{4R}$

3) уст. режим: ток в цепи не течет



$\begin{cases} E - U_1' = R \cdot 0 \\ U_2' = R \cdot 0 \end{cases} \Rightarrow \begin{cases} U_1' = E \\ U_2' = 0 \end{cases}$

(2-ой конденсатор разряд. т/з резистор)

$q = C U \Rightarrow q_1 = C_1 E \Rightarrow \Delta q = q_1 - q_0 = 3CE - \frac{3}{4} CE =$

$q_1 = 3CE \quad = \frac{9}{4} CE$

ЗСЭ: $W_1 + A - Q = W_2$

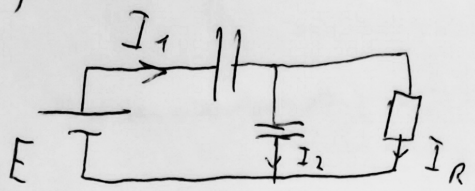
$\frac{C_1 U_1^2}{2} + \frac{C_2 U_1}{2} + \Delta q E - Q = \frac{C_1 U_1'^2}{2} + \frac{C_2 U_2'^2}{2}$

$Q = \frac{C_1 U_1^2}{2} + \frac{C_2 U_1}{2} - \frac{C_1 U_1'^2}{2} + \Delta q E =$

$= \frac{3CE^2}{32} + \frac{C \cdot 3E^2}{32} - \frac{3CE^2}{2} + \frac{3CE^2}{4} = \frac{9}{8} CE^2$

Чистовик 2/4

4) в некоторый момент после замыкания ключа:



3 Кирхгофа: $\begin{cases} I_2 + I_R = I_1 \\ E = U_1 + U_2 \\ U_2 = I_R R \end{cases}$

ЗСЭ: $E I_1 dt = \frac{q_1}{C_1} dq_1 + \frac{q_2}{C_2} dq_2 + I_R^2 R dt$

$\left(dW_p = \frac{q_2^2}{2C} - \frac{q_1^2}{2C} = \frac{(q_2 - q_1)(q_2 + q_1)}{2C} = \frac{q}{C} dq \right)$ (сум. $dq = I dt$)

$\Rightarrow E I_1 dt = \frac{I_1 q_1}{C_1} dt + \frac{I_2 q_2}{C_2} dt + I_R^2 R dt$

$E I_1 = I_1 U_1 + I_2 U_2 + I_R^2 R$ $\left(\frac{q}{C} = U \right)$

подставим $I_2 = I_0$:

$\begin{cases} I_0 + I_R = I_1 \\ E = U_1 + U_2 \\ U_2 = I_R R \\ E I_1 = I_1 U_1 + I_0 U_2 + I_R^2 R \end{cases}$ $\Leftrightarrow$ $U_1 = E - I_R R$

$E I_0 + E I_R = U_1 I_0 + U_1 I_R + I_0 I_R R + I_R^2 R$

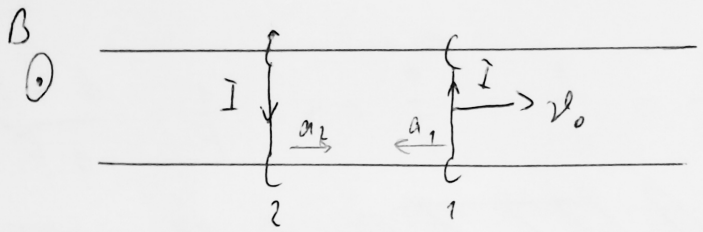
$\Rightarrow E I_0 + E I_R = E I_0 - I_R I_0 R + E I_R - I_R^2 R + I_0 I_R R + I_R^2 R$

$0 = 0$

Ответ: $I_{R0} = \frac{3E}{4}$, $Q = \frac{3}{8} C E^2$

Вариант 3/4

№ 4



1/ $\mathcal{E} = v_0 B l$

$I(R_1 + R_2) = \mathcal{E} \Leftrightarrow I = \frac{v_0 B l}{5R}$

для 2 : $F_A = m_2 a$

$BIl = m_2 a \Leftrightarrow a_2 = \frac{2B^2 l^2 v_0}{5Rm}$

$\Phi = BS\cos\beta = BS \quad \Phi' = -\mathcal{E}_i$

$v_1 = v_2$ т/к больше, прош вр. иначе $\mathcal{E} \neq 0$, =>

$I \neq 0 \Rightarrow a_1 \neq 0, \ a_2 \neq 0$

ЗС: $\frac{v_0^2 m}{2} = m v_1^2 + Q \qquad Q = \int I^2 (R_1 + R_2)\, dt$

Ответ: $a_2 = \frac{2B^2 l^2 v_0}{5Rm}$

Чистовик 4/4

№ 5

$F = 12$ см

$H = 9$ см

$d = 48$ см

$d_1 = 24$ см

$f_1 - ?$

$D - ?$

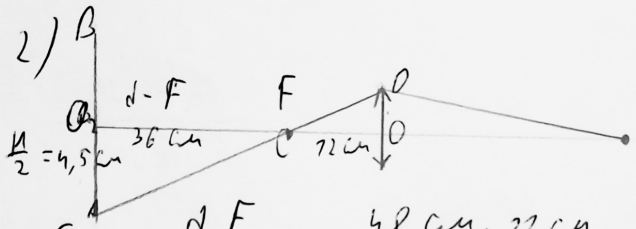
$f - ?$

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

~~$f_1 = \frac{24 \text{ см} \cdot 24 \text{ см} \cdot 12 \text{ см}}{24 \text{ см} - 12 \text{ см}} = 48 \text{ см}$~~

$f_1 = \frac{d_1 F}{d_1 - F} = \frac{24 \text{ см} \cdot 12 \text{ см}}{24 \text{ см} - 12 \text{ см}} = 24 \text{ см}$

2)



$f = \frac{dF}{d_1 - F} = \frac{48 \text{ см} \cdot 12 \text{ см}}{36 \text{ см}} = 16 \text{ см}$

поместим на место щели точечный источник света: лучи пройдут через F и достигнут AB

$\triangle AO_2C \sim \triangle DOC \Rightarrow \frac{CO}{CO_2} = \frac{OD}{O_2A} \Rightarrow \frac{12 \text{ см}}{36 \text{ см}} = \frac{r}{4,5 \text{ см}} \Rightarrow$

$r = 1,5$ см $\Rightarrow D = 2r = 3$ см

3) Экран стоит поместить в f:

$f = \frac{dF}{d_1 - F} = \frac{48 \text{ см} \cdot 12 \text{ см}}{36 \text{ см}} = 16 \text{ см}$

Ответ: $f_1 = 24$ см ; $D = 3$ см ; $F = 16$ см.

~~Чистовик 1~~ Черновик 1

N 3 (~~Вар 11.02~~)

$C_2 = C$

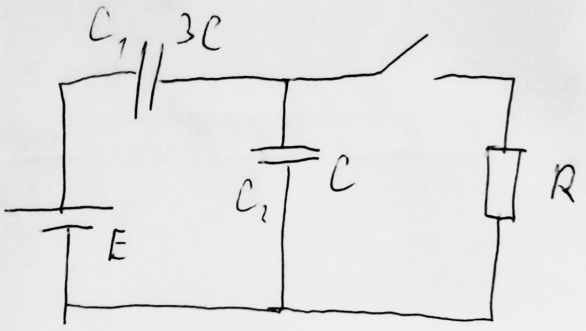
$C_1 = 3C$

$I_{R0} - ?$

$Q - ?$

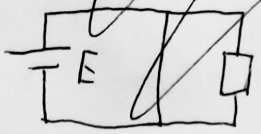
I_0

$U_R - ?$



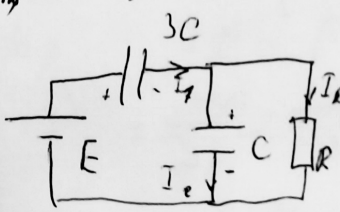
1) Сразу после замыкания конденсаторы представляют проводник

и весь ток течет через C_2



$\Rightarrow I_{R0} = 0$ А

2) Изнач.



$\frac{1}{C_0} = \frac{1}{3C} + \frac{1}{C} \Leftrightarrow \frac{1}{C_0} = \frac{4}{3C} \Rightarrow C_0 = \frac{3}{4}C$

$q = CU \Rightarrow q = \frac{3}{4}CE$

$U_1 = \frac{q}{C_1} = \frac{E}{4}$

$U_2 = \frac{q}{C_2} = \frac{3E}{4}$

в момент замык ключа

$U_R = U_2 = \frac{3E}{4}$ $\quad I_{R0}R = \frac{3E}{4} \Leftrightarrow I_{R0} = \frac{3E}{4R}$

(2) уст. режим: ток в цепи не течет

$E - U_1' = R \cdot 0 \Rightarrow U_1' = E$

$U_2' = R \cdot 0 \Rightarrow U_2' = 0$ (2-ой конденс. разряж ч/з резистор.

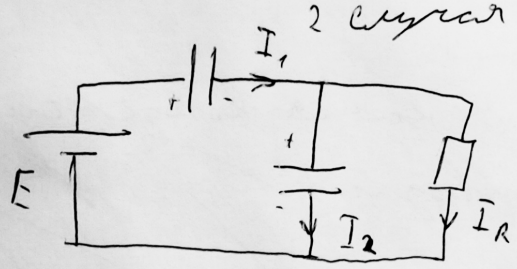
черновик 2

$W_1 + A - Q = W_2$

$\frac{C_1 U_1^2}{2} + \frac{C_2 U_2^2}{2}$

$\frac{3CE^2}{32} + \frac{9CE^2}{32} - \frac{48CE^2}{32} + \frac{12CE^2}{32} = \frac{36CE^2}{32} = \frac{9}{8}CE^2$

3) 2 случая



$q = CU$

$\begin{cases} I_2 + I_R = I_1 \\ E = U_1 + U_2 \\ U_2 = I_R R \end{cases}$

$\frac{CU_2^2}{2} - \frac{CU_1^2}{2} = \frac{C(U_2 - U_1)(U_2 + U_1)}{2} = CU\,dU$

$E I_1\,dt = \frac{q_1}{C_1} dq_1 + \frac{q_2}{C_2} dq_2 + I_R^2 R\,dt \quad \frac{q_2^2}{2C} - \frac{q_1^2}{2C} = \frac{(q_2 - q_1)(q_2 + q_1)}{2C} =$

$E I_1\,dt = \frac{I_1 q_1}{C_1} dt + \frac{I_2 q_2}{C_2} dt + I_R^2 R\,dt = \frac{q}{C} dq$

$E I_1 = \frac{I_1 q_1}{C_1} + \frac{I_2 q_2}{C_2} + I_R^2 R$

$\begin{cases} E I_1 = I_1 U_1 + I_2 U_2 + I_R^2 R \end{cases}$

$\begin{cases} I_0 + I_R = I_1 \\ E = U_1 + U_2 \\ U_2 = I_R R \\ E I_1 = I_1 U_1 + I_0 U_1 + I_R^2 R \end{cases}$

Черновик 4.

№ 4

L

$m_1 = m$

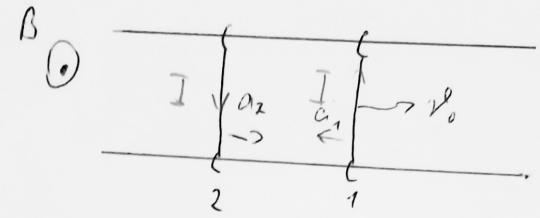
$R_1 = R$

$m_2 = \frac{m}{2}$

$R_2 = 4R$

V_0

B



$\mathcal{E}_1 = v_0 B l \sin 30°$

$I R_2 = \mathcal{E}_1 \Rightarrow I = \frac{v_0 B l}{4R}$

$\mathcal{E}_1 - \mathcal{E}_2 = (v_1 - v_2) B l$

$I (R_1 + R_2) = \mathcal{E}_1 - \mathcal{E}_2$

$I = \frac{(v_1 - v_2) B l}{R_1 + R_2} = \frac{v_{отн} B l}{5R}$

$F dt = d v m$

$U = v B l \sin \phi$

$U_1 = v_0 B l$

$U_1 = U_2$

$I_1 = \frac{U_1}{R_1} = \frac{v_0 B l}{R}$

Черновик 3

$F_л = q v B = F_м = E q$

$v B l = U$

$F_A = B I l \sin\alpha$

$\mathcal{E} = v_0 B l$

$I(R_1 + R_2) = \mathcal{E} \Rightarrow I = \frac{v_0 B l}{5R}$

для 2: $F_A = m_2 a_2$

$BIl = m_2 a_2 \Leftrightarrow a_2 = \frac{2B^2 l^2 v_0}{5Rm}$ $\quad a_1 = \frac{B^2 l^2 v_0}{5Rm}$

$v_2, v_1 - const \Rightarrow a_2, a_1 = 0 \Rightarrow F_A = 0 \Rightarrow I = 0 \Rightarrow$

$\varphi' = 0 \Rightarrow v_1 = v_2$

$\varphi = BS\cos\beta$ $\quad d\varphi = B\,dS = B(v_1 - v_2)L$

$\frac{d\varphi}{dt} = \frac{B(v_1 - v_2)L}{dt} = BL(a_1 - a_2)$

$-\mathcal{E} = B^2 L^2 \left(\frac{I}{m_1} - \frac{I}{m_2}\right) = B^2 L^2 \left(\frac{I}{m} - \frac{2I}{m}\right)$

$\mathcal{E} = \frac{B^2 l^2}{m} I \Leftrightarrow I \cdot 5R = \frac{B^2 l^2}{m} I$

$v_{отн}$ $\quad a_{отн} = \frac{3B^2 l^2 v_{отн}}{5Rm} = \dot{v}_{отн}$

$f = \frac{48 \cdot 12}{36} = 16$

3