Часть 1

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

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Вариант 1

Черновик

1. Дано

H, $\cos\alpha = \frac{3}{5}$

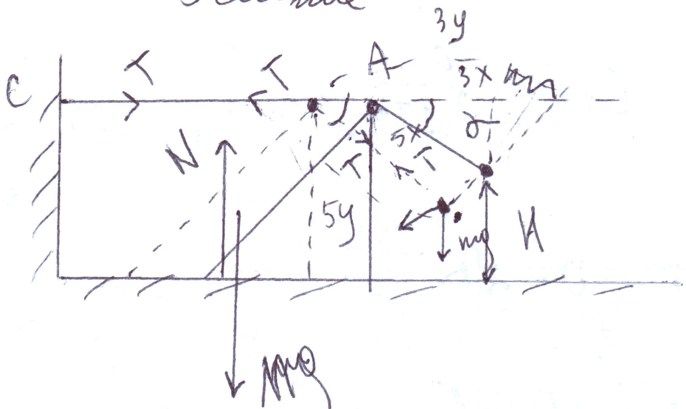
1) β - ?

2) $a_{кл}$ - ?

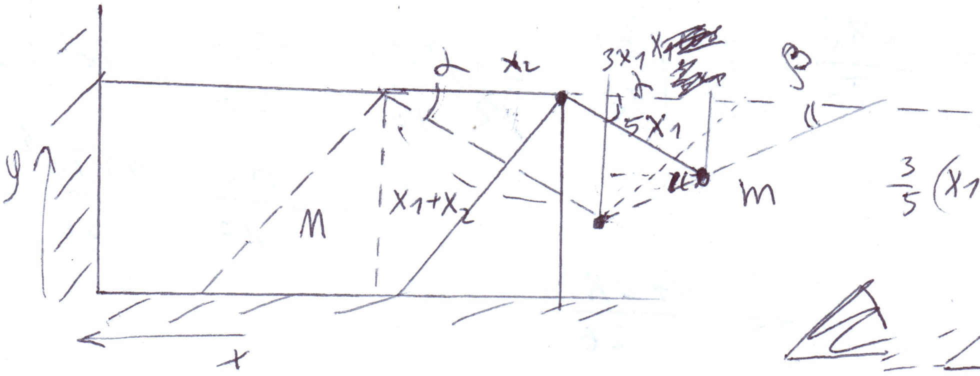
3) $\frac{m_ш}{m_{кл}}$

4) $t_ш$ - ?

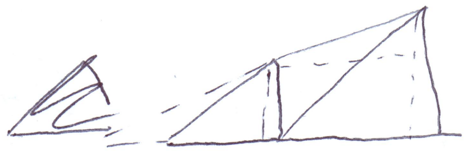
Решение



1) $m\vec{a} = \vec{T} + m\vec{g}$ $\quad T = const$



$\frac{3}{5}(x_1+x_2) = x_2$



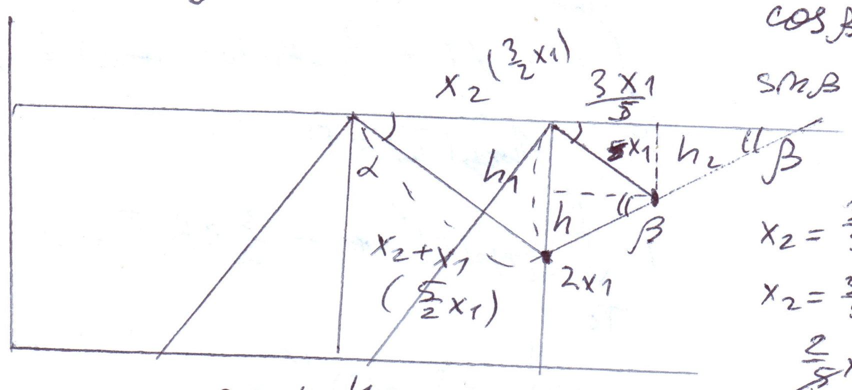
2) $x:\ M\cdot a_x = T - T\cdot\cos\alpha$

$y:\ M a_y = 0$

$1 + 4 = \frac{1}{\cos^2\beta}$ $\quad \frac{1}{5}$

$\cos\beta = \frac{1}{\sqrt{5}}$

$\sin\beta = \frac{2}{\sqrt{5}}$

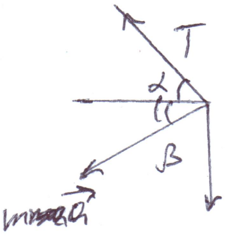


$x_2 = \frac{3}{5}(x_2 + x_1)$

$x_2 = \frac{3}{5}x_2 + \frac{3}{5}x_1$

$\frac{2}{5}x_2 = \frac{3}{5}x_1$

$x_2 = \frac{3}{2}x_1$



$ma\cdot\cos\beta = T\cdot\cos\alpha$

$T = \ \ ma$

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

$h_1 = \frac{5}{2}x_1\cdot\frac{4}{5} = 2x_1$

$h_2 = x_1\cdot\frac{4}{5} = \frac{4}{5}x_1$

$h = h_1 - h_2 = 2x_1 - \frac{4}{5}x_1 = \frac{6}{5}x_1$

$\frac{3\sqrt{5}x_1}{5}$

$tg\,\beta = \frac{h}{\frac{3x_1}{5}} = \frac{\frac{6}{5}x_1}{\frac{3}{5}x_1} = 2$

$\frac{\sqrt{45}x_1}{5}$

$2aS = u^2 - \upsilon_0^2$

$a =$

$tg\,\beta = 2$

$a = \frac{u^2}{2S}$

$\frac{mu^2}{2} = \Delta\Pi = mg\cdot\frac{6}{5}x_1$ $\quad \frac{6}{5}x_1\cdot\frac{3}{5}x_1$

$a =$

$\frac{9+36}{25}x_1^2 = \frac{45}{25}x_1^2 = \frac{\sqrt{45}}{\cancel{25}}$

Чистовик

Решение

2. Дано

ν, T_0

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

1) Q_1 - ?

2) T_{min} - ?

3) A_{min} ?

1) $C(T) = \frac{\delta Q}{\nu dT} \Rightarrow \cancel{\delta Q} = \quad Q = \nu\int_{T_1}^{T_2} C(T)\, dT$

~~$-Q_1 = \int \nu \cdot \frac{2}{R}$~~

$-Q_1 = \nu\int_{T_0}^{\frac{5T_0}{6}} 2R\cdot\frac{T}{T_0}\cdot dT = \frac{2R\nu}{T_0}\cdot\left\{\frac{T^2}{2}\right|_{T_0}^{\frac{5}{6}T_0} =$

$= \frac{R\nu}{T_0}\left(\frac{25}{36}T_0^2 - T_0^2\right) = -\frac{11T_0R\nu}{36}$

$Q_1 = \frac{11\nu RT_0}{36}$

2) Из первого начала термодинамики

$-Q = A + \Delta U$

Работа минимальна, если $A'(T) = 0$

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

Продифференцируем обе части равенства:

$\frac{2R\nu T}{T_0} - \frac{3}{2}\nu R = 0 \quad |:\nu R$

$\frac{2T}{T_0} = \frac{3}{2} \Rightarrow T = \frac{3T_0}{4}$

1

3) $A\left(\frac{3T_0}{4}\right) = \frac{R\nu}{T_0}\cdot\left(\frac{9T_0^2}{16} - T_0^2\right) + \frac{3}{2}\nu R\left(T_0 - \frac{3T_0}{4}\right) =$

$= -\frac{\nu RT_0}{16}$

Ответ: $\frac{11\nu RT_0}{36}$; $\frac{3T_0}{4}$; $-\frac{\nu RT_0}{16}$

Чистовик

1.

Дано

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

M

1) β – ?

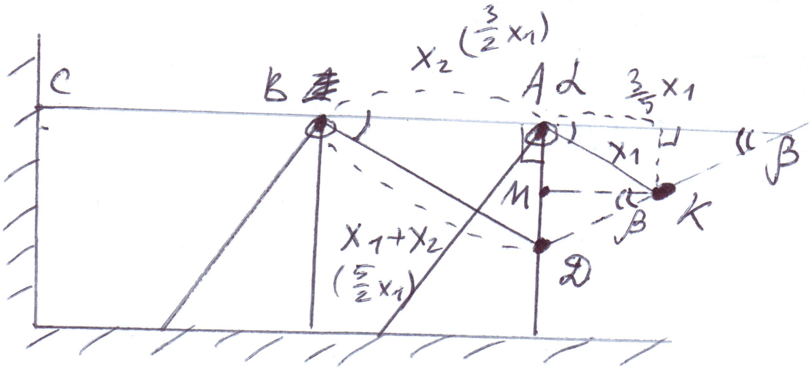
2) $a_{кл}$ – ?

3) $\frac{m}{M}$ – ?

4) t – ?

Решение

1)



В силу нерастяжимости нити $BD = x_1 + x_2$

$x_2 = \frac{3}{5}(x_1+x_2) \Rightarrow x_2 = \frac{3}{2}x_1$

$AD = \frac{5}{2}x_1 \cdot \frac{4}{5} = 2x_1$

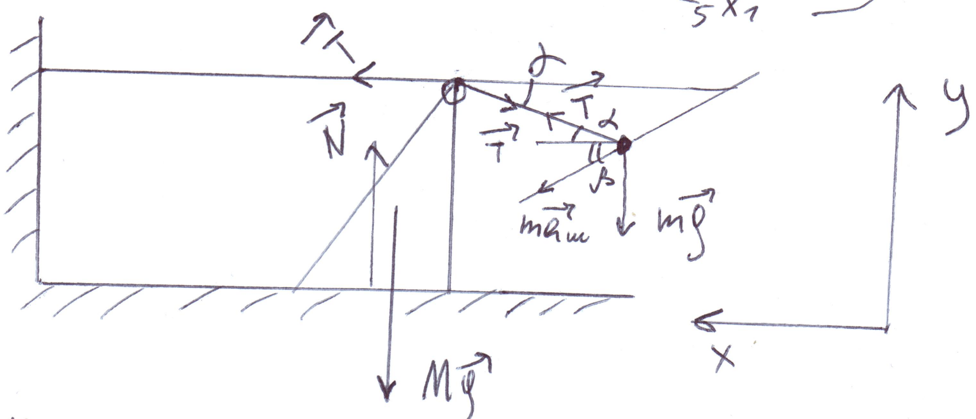
$AM = x_1 \cdot \frac{4}{5} = \frac{4x_1}{5}$

$\Rightarrow MD = AD - AM = 2x_1 - \frac{4}{5}x_1 = \frac{6}{5}x_1$

ΔMDK:

$\cancel{\beta = \angle DK}$ $tg\beta = tg\angle MKD = \frac{\frac{6}{5}x_1}{\frac{3}{5}x_1} = 2$

2)



2

2ЗН для клина: $x: Ma_{x_к} = T - T\cos\alpha = \frac{2}{5}T$

$y: Ma_{y_к} = 0$

2ЗН для шара: $m\vec{a}_ш = \vec{T} + m\vec{g}$

$x: ma_ш \cdot \cos\beta = T \cdot \cos\alpha$

$\cancel{2a_ш \cdot DK = v_ш^2 - v_0^2 \Rightarrow a_ш = \frac{v_ш^2}{2DK}}$

ЗСЭ для системы:

$\frac{Mv_к^2}{2} + \frac{mv_ш^2}{2} - mg \cdot MD = 0$, $v_к = a_к \cdot t$; $v_ш = a_ш \cdot t$

$\frac{M}{2} \cdot a_{кл}^2 \cdot t^2 + \frac{m}{2} \cdot a_ш^2 \cdot t^2 = mg \cdot \frac{6}{5}x_1$, $\frac{6}{5}x_1 = \frac{a_ш \cdot \sin\beta \cdot t^2}{2}$

$$\frac{M}{2}\cdot a_{кл}^2\cdot t^2+\frac{m}{2}\cdot a_m^2\cdot t^2=mg\cdot\frac{a_m\cdot\sin\beta\cdot t^2}{2}\quad\Big|\cdot\frac{2}{t^2}$$

$$\begin{cases} Ma_{кл}^2+ma_m^2=mg\cdot a_m\cdot\frac{2}{\sqrt5}\\ Ma_{кл}=\frac{2}{3}T\\ ma_m\cdot\frac{1}{\sqrt5}=T\cdot\frac{3}{5}\quad\Big|\cdot\sqrt5\end{cases}$$

3

Черновик

Дано

ν; T_0

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

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1) Q_1 - ?

2) T_{min} - ?

3) A_{min} - ?

Решение

1) ~~$-Q_1$~~ $C(T) = \frac{\delta Q}{\nu \Delta T} \Rightarrow \delta Q = \nu C(T) \cdot \Delta T =$

$\overset{\parallel}{Q_1}$

$\cancel{= 2R \frac{T}{T_0} \cdot \frac{1}{6} T_0 =}$

$\cancel{-Q_1 = \nu C(T) \cdot \Delta T = \nu \cdot 2R \cdot \frac{\frac{5T_0}{6}}{T_0} \cdot \left(\frac{5T_0}{6} - T_0\right) =}$ $=$

$$-Q_1 = \nu \int_{T_0}^{\frac{5T_0}{6}} c(T) \cdot dT = \frac{2R\nu}{T_0} \int_{T_0}^{\frac{5}{6}T_0} T\,dT =$$

$$= \frac{2R\nu}{T_0} \cdot \frac{T^2}{2} \Bigg|_{T_0}^{\frac{5}{6}T_0} = \frac{1}{\cancel{2}} \frac{\cancel{2}R\nu}{T_0} \cdot \left(\frac{25T_0^2}{36} - T_0^2\right) =$$

$$= -\frac{R\nu}{\cancel{T_0}} \cdot \frac{11T_0^{\cancel{2}}}{36} = -\frac{11T_0 R\nu}{36}$$

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

2) $-Q = A_{min} + \Delta U$ $\qquad -Q = \int_{T_0}^{T_{min}} c(T)\,dT$

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

$$\int_{T_0}^{T} c(T)\,dT + \frac{3}{2}\nu R(T_0 - T) = A$$

$A'(T) = 0$

$$\left(\int_{T_0}^{T} c(T)\,dT\right)' - \frac{3}{2}\nu R T = 0$$

$$\left(\frac{2R\nu}{T_0}\left(\frac{T^2}{2} - \frac{T_0^2}{2}\right)\right)' - \frac{3}{2}\nu R = 0$$

$$\cancel{\frac{R\nu}{T_0} T^2} \left(\frac{R\nu}{T_0} T^2 - \frac{R\nu}{T_0} T_0^2\right)' = \frac{2R\nu}{T_0} \cdot T - \frac{3}{2}\nu R = 0$$

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

$$\frac{2T}{T_0} = \frac{3}{2} \Rightarrow T = \frac{3T_0}{4}$$

$$A_{min} = \frac{R\nu}{T_0}(T^2 - T_0^2) - \frac{3}{2}\nu R(T_0 - T) = \frac{R\nu}{T_0}(T^2 - T_0^2) + \frac{3}{2}\nu R(T - T_0)$$

$$\frac{R\nu}{\cancel{T_0}}\left(-\frac{7T_0^{\cancel{2}}}{16}\right) + \frac{3}{2}\nu R \cdot \frac{1}{4}T_0 = \nu R\left(-\frac{7T_0}{16} + \frac{6}{16}T_0\right)$$

$\frac{6}{16}T_0 \qquad \frac{3}{8}T_0$

Часть 2

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

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Вариант 1

3.

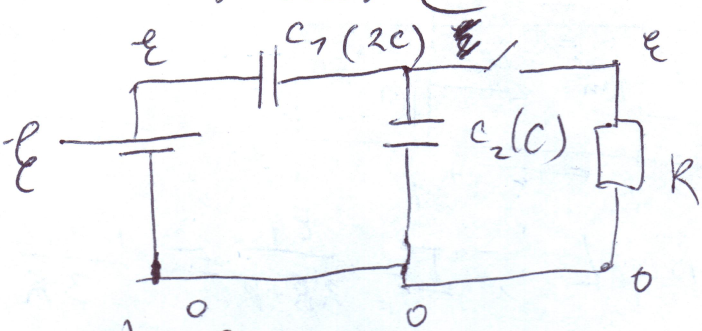
Дано

1) I_R - ?

2) Q - ?

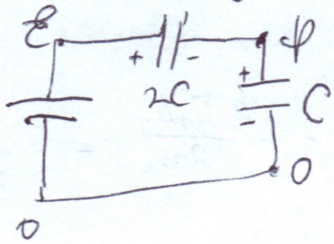
3)

Решение



} метод потенциалов

1)



$0 = -2C\cdot(\mathcal{E}-\varphi) + C\cdot\varphi$

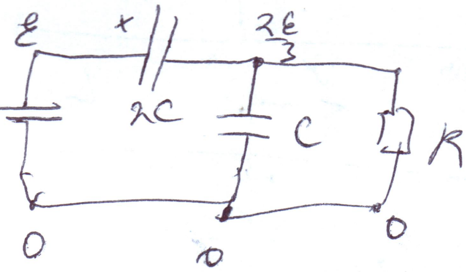
$2\mathcal{E} = 2\varphi + \varphi$

$\varphi = \dfrac{2\mathcal{E}}{3}$

$\cancel{I_{2C} = 2C\cdot U_C'}$

$I_0 = I_{2C} + I_R$

$I_0 = 2C\cdot U_C' + I_R$



$I = \dfrac{2\mathcal{E}}{3R}$

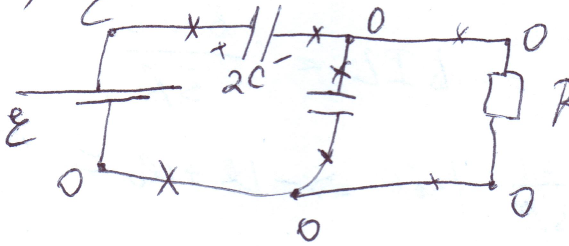
$W(t_{н.у.}) = \dfrac{2C\cdot\frac{\mathcal{E}^2}{9}}{2} + \dfrac{C\cdot 4\mathcal{E}^2}{2\cdot 9} = \dfrac{C\mathcal{E}^2}{3}$

$\begin{cases} I_0 = 2C\cdot U_{2C}' \\ I_0 = I_R + C\cdot U_C' \end{cases}$

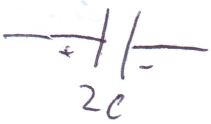
$I_R = 2C\cdot U_{2C}' - C U_C'$

$U_C' = \dfrac{dU_C}{dt} = \dfrac{d\frac{q_C}{C}}{dt}$

2)



$W(t_{уст.}) = 2C\cdot\dfrac{\mathcal{E}^2}{2} = C\mathcal{E}^2$



было: $+2C\cdot\dfrac{\mathcal{E}}{3} = \dfrac{2C\mathcal{E}}{3}$

стало: $2C\cdot\mathcal{E}$

$\Delta q = 2C\mathcal{E} - \dfrac{2\mathcal{E}C}{3} = \boxed{\dfrac{4C\mathcal{E}}{3}}$

$dU_{2C} = \mathcal{E} - \varphi - \Delta\varphi - (\mathcal{E} - \varphi) - \Delta\varphi$

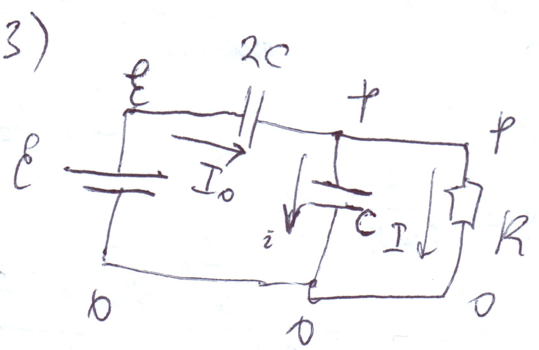
$A_{ист} = \Delta W + Q$

$\dfrac{4C\mathcal{E}^2}{3} = C\mathcal{E}^2 - \dfrac{C\mathcal{E}^2}{3} + Q$

$Q = \dfrac{2C\mathcal{E}^2}{3}$

3)

$\varphi + \Delta\varphi - \varphi$



$q = CU \quad \Delta q = C\Delta U$

$I_C = C\cdot U_C'$

$I_0 = i + I \quad \dfrac{\varphi}{R}$

$\dfrac{\Delta q}{\Delta t} = C\cdot\dfrac{(\mathcal{E} - \varphi_1 - \mathcal{E} + \varphi_2)}{\Delta t} = C\,\dfrac{\varphi_2 - \varphi_1}{\Delta t}$

$U_{2C}' = \dfrac{I_0}{2C}$

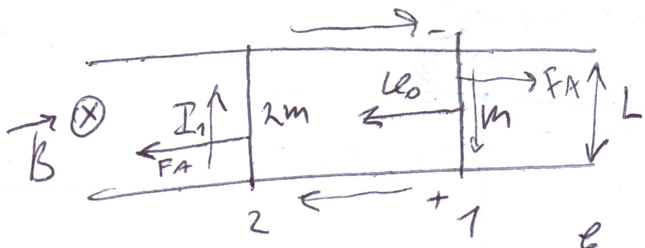
$I_0 = I_R - C\cdot\dfrac{I_0}{2C} \quad I_R = \dfrac{I_0}{3}$

$\mathcal{E} - \varphi_1 + \Delta U = \mathcal{E} - \varphi_2$

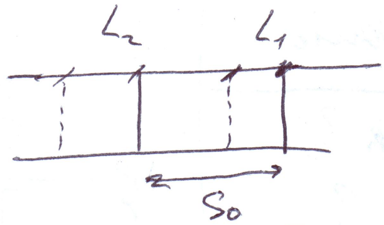
$\varphi_2 - \varphi_1$

Чернови

Дано	Решение
1) a_2 - ?	
2) v - ?	
3) S - ?	



$S_0-(L_1-L_2)$

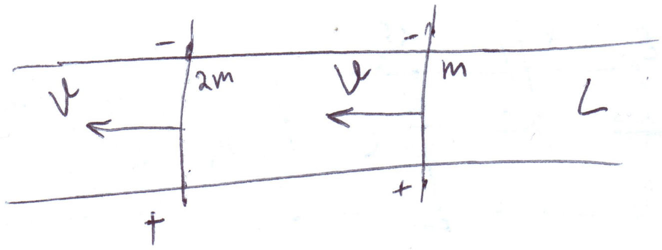


1) $\mathcal{E}_{i1} = B v_0 L$, $I_1 = \frac{\mathcal{E}_1}{2R+R} = \frac{B v_0 L}{3R}$ $\quad x = S_0 + L_2 - L_1$

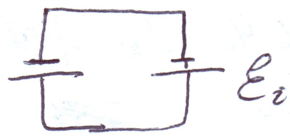
$2m\cdot a_2 = F_A = \cancel{BI_1L} =$

$a_2 = \frac{BI_1L}{2m} = \frac{B^2L^2\cdot v_0}{2m\cdot 3R} = \frac{B^2L^2v_0}{6mR}$

2)



$\equiv$



$I=0$

$\mathcal{E}_i = B v_1 L$

$\mathcal{E}_{i2} = B v_2 L$

$\mathcal{E}_1 = B v L$

$dv_1 = v - v_0$

$I = \frac{\mathcal{E}_i - \mathcal{E}_i}{R}$

$m: \; m\frac{dv}{dt} = F_A = BIL = \frac{BvL}{3R}$

$\frac{dv}{dt} = \frac{BvL}{3R} \Big| \cdot dt \Rightarrow -v + v_0 = \frac{BL}{3R}\cdot \cancel{vdt}$

$2m: \; 2m\cdot\frac{dv}{dt} = BIL = \frac{BvL}{3R}$ $\qquad dv_1 = \frac{BL}{3Rm}\cdot vdt$

$\frac{dv_2}{dt} = \frac{BvL}{6mR}$ $\qquad dv_2 = \frac{BL}{6mR}\cdot v\cdot dt$

$\frac{3Rm\cdot(v_0-v)}{BL} = \frac{6mR\cdot v}{BL}$ $\qquad v - v_0$ $\qquad \frac{3Rm\, dv_1}{BL} = \frac{6mR\cdot dv_2}{BL}$

$3v_0 - 3v = 6v$ $\qquad v = \frac{v_0}{3}$ $\qquad L_1 - L_2 > 0$

3) $2m\cdot\frac{dv}{dt} = \frac{BvL}{3R} \Rightarrow dv = \frac{BL}{6mR}\cdot \underbrace{vdt}_{L_2}$

$m\cdot\frac{dv}{dt} = \frac{BvL}{3R}$

$L_2 = \frac{6mR\cdot v}{BL} = \frac{6mR\cdot\frac{v_0}{3}}{BL} = \frac{2mRv_0}{BL}$

$v_0 - v = \frac{BL}{3mR}\cdot \underbrace{vdt}_{L_1}$ $\qquad L_1 = \frac{3mR(v_0-v)}{BL} = \frac{3mR\cdot\frac{2}{3}v_0}{BL}$

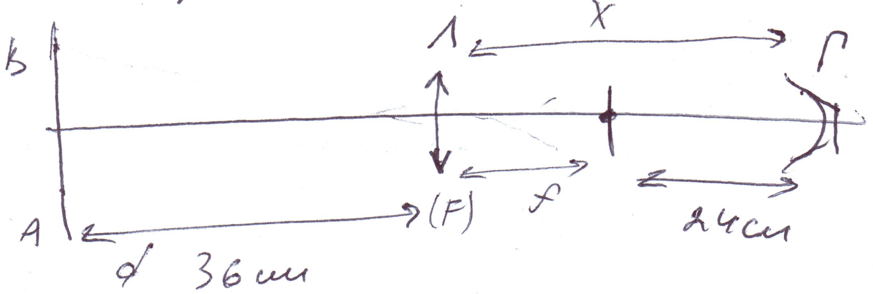
Цитовик

1. Дано

1) x - ?

2) Дм - ?

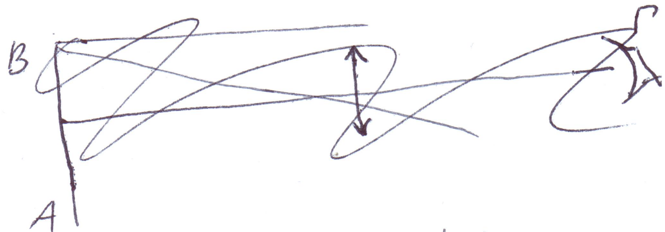
3)

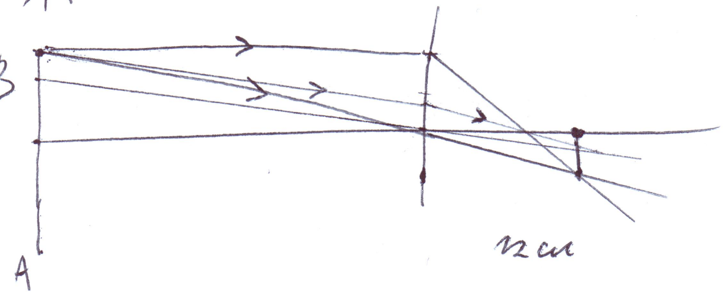


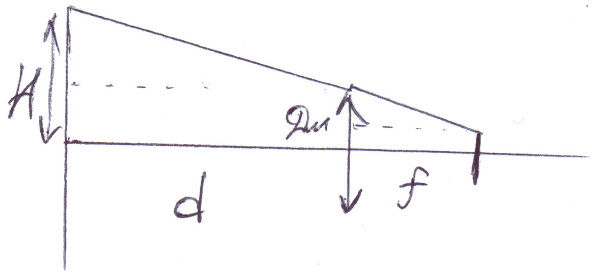
1) $\frac{1}{F} = \frac{1}{d} + \frac{1}{f} \Rightarrow \frac{1}{9} = \frac{1}{36} + \frac{1}{f}$ $f = 12$ см

$X = 12 + 24 = 36$ см

2) Дм - ?







Чистовик

Вариант 11-01

Дано: $C_1 = 2C$, $C_2 = C$

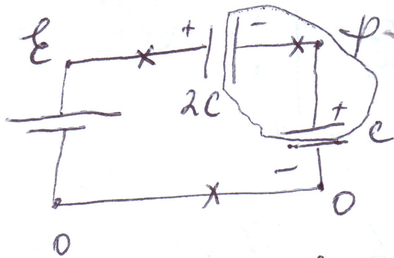
1) $I_R(0)$ – ?

2) Q – ?

3) $I_R(\tau)$ – ?

Решение

1) До замыкания ключа цепь в установ. режиме выглядит так



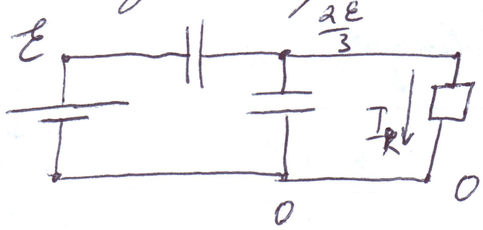
} используем метод потенциалов

для изолированной области ЗСЗ:

$$0 = -2C(\mathcal{E} - \varphi) + C\cdot\varphi$$

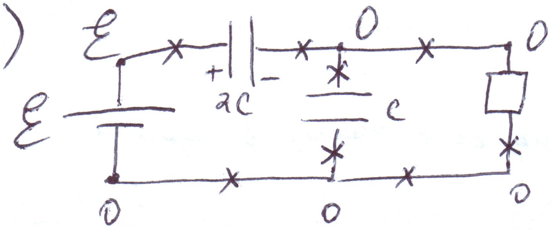
$$\varphi = \frac{2\mathcal{E}}{3}$$

После замыкания ключа напряжение на конденсатор скачком не меняется



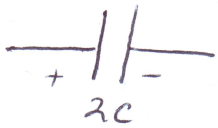
$$I_R(0) = \frac{2\mathcal{E}}{3R}\ ;\ W(0) = \frac{C\mathcal{E}^2}{3}$$

2)



В установившемся состоянии в цепи тока нет.

$$W(t_{уст}) = \frac{2C\mathcal{E}^2}{2} = C\mathcal{E}^2$$



было: $q_1 = 2C\cdot\frac{\mathcal{E}}{3} = \frac{2C\mathcal{E}}{3}$

стало: $q_2 = 2C\cdot\mathcal{E}$

$$\Delta q = \frac{4C\mathcal{E}}{3}$$

1

ЗСЭ: $A_{ист} = \Delta W + Q$

$$+\frac{4C\mathcal{E}}{3}\cdot\mathcal{E} = C\mathcal{E}^2 - \frac{C\mathcal{E}^2}{3} + Q \Rightarrow Q = \frac{2C\mathcal{E}^2}{3}$$

3)
$$\begin{cases} I_0 = 2C\cdot U'_{2C} \\ I_0 = I_R + C\cdot U'_C \ (ЗСЗ) \end{cases},\quad U'_C = +U'_{2C}$$

$$\begin{cases} U'_{2C} = \frac{I_0}{2C} \\ I_0 = I_R + \cancel{C}\cdot\frac{I_0}{2\cancel{C}} \end{cases} \Rightarrow I_R = \frac{I_0}{2}$$

Ответ: $\frac{2\mathcal{E}}{3R}$; $\frac{2C\mathcal{E}^2}{3}$; $\frac{I_0}{2}$

Чистовик

4. Дано

B; υ_0; L;
m; $2m$; R; $2R$

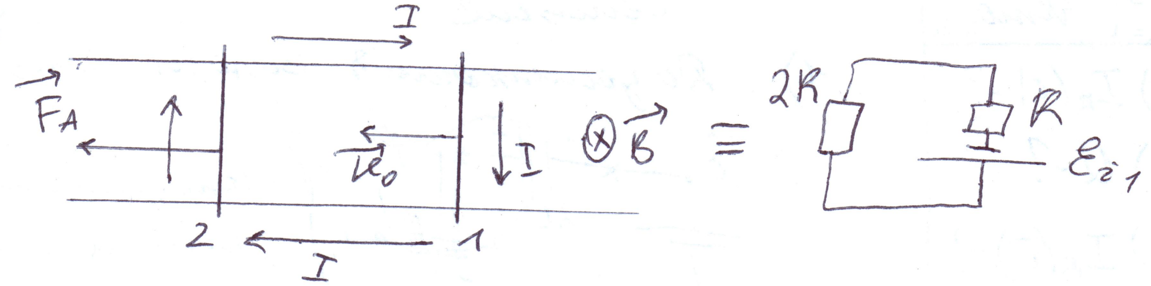
1) a_2 – ?

2) υ – ?

3) S – ?

Решение

1)



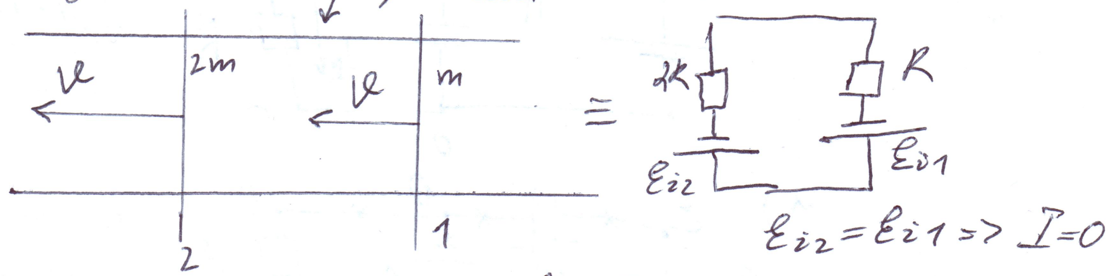
$$\mathcal{E}_{i1} = B\upsilon_0 L, \quad I_1 = \frac{\mathcal{E}_{i1}}{3R} = \frac{B\upsilon_0 L}{3R}$$

2ЗН для 2 перемычки:

$$2m \cdot a_2 = F_A = BI_1 \cdot L$$

$$a_2 = \frac{BI_1L}{2m} = \frac{B^2L^2\upsilon_0}{6mR}$$

2) установившийся режим



$\mathcal{E}_{i2} = \mathcal{E}_{i1} \Rightarrow I = 0$

2ЗН для 1 перемычки в ~~про~~ момент разгона

$$-\frac{m\,d\upsilon_1}{dt} = BIL \ (1), \quad I = \frac{\mathcal{E}_{i1} - \mathcal{E}_{i2}}{3R} = \frac{BL(\upsilon_1 - \upsilon_2)}{3R}$$

2ЗН для 2 перемычки в произвольный момент разгона:

$$\frac{2m\,d\upsilon_2}{dt} = BIL = \frac{B^2L^2(\upsilon_1 - \upsilon_2)}{3R} \ (2)$$

2

Т.к. на перемычки действуют равные силы, то

$$-\frac{m\,d\upsilon_1}{dt} = \frac{2m\,d\upsilon_2}{dt} \Big| \cdot \frac{dt}{m}; \quad -d\upsilon_1 = 2d\upsilon_2;$$

Просуммируем до уст. сост.

$$\upsilon_0 - \upsilon = 2\upsilon$$

$$\upsilon = \frac{\upsilon_0}{3}$$

3) (2): $\dfrac{2m \cdot d\upsilon_2}{dt} = \dfrac{B^2L^2(\upsilon_1 - \upsilon_2)}{3R} \Big| \cdot dt$

$$2m \cdot d\upsilon_2 = \frac{B^2L^2}{3R}(\underbrace{\upsilon_1 dt}_{dL_1} - \underbrace{\upsilon_2 dt}_{dL_2});$$

Просуммируем обе части от начала движения до уст. состояния

Чистовик

$$2m\cdot\frac{v_0}{\cancel{3}} = \frac{B^2L^2}{\cancel{3}R}\cdot(L_1-L_2) \Rightarrow L_1-L_2 = \frac{2mv_0R}{B^2L^2}$$

Искомое расстояние между перемычками

$$S = S_0 - (L_1-L_2) = S_0 - \frac{2mv_0R}{B^2L^2}$$

Ответ: $\frac{B^2L^2v_0}{6mR}$; $\frac{v_0}{3}$; $S_0 - \frac{2mv_0R}{B^2L^2}$

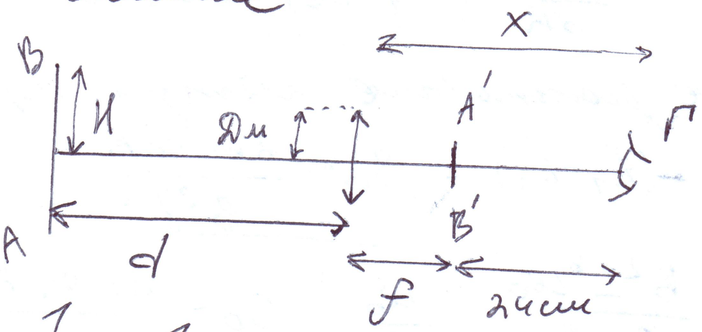
Чистовик

5.

Дано
$F = 9$ см
$H = 9$ см
$d = 36$ см

1) x - ?
2) Дм - ?
3) y - ?

Решение

1) 

$$\frac{1}{F} = \frac{1}{d} + \frac{1}{f} \; ; \; \frac{1}{9} = \frac{1}{36} + \frac{1}{f} \Rightarrow f = 12 \text{ см}$$

$$x = f + 24 = \underline{36 \text{ (см)}}$$

2) Наблюдатель еще может видеть четкое изображение при условии, что

$$\frac{H}{Дм} = \frac{d}{f} \Rightarrow Дм = \frac{f \cdot H}{d} = \frac{12}{36} \cdot 9 = \underline{3 \text{ см}}$$

3)

Ответ: 36 см; 3 см

4