Часть 1

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

Шифр: **21201392**

ID профиля: **832163**

Вариант 2

Чистовик

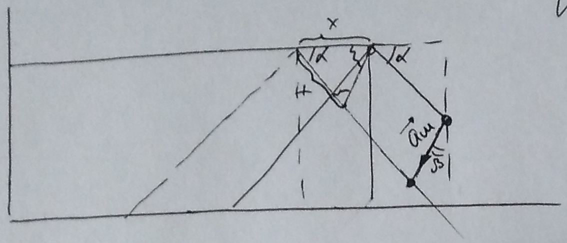
Задача 1.

Дано:
$\cos\alpha = \frac{4}{5}$
H

1) β – ?
2) $a_{кл}$ – ?

Решение:

1) Пусть шина сдвинулся влево на некоторую величину x, нить осталась параллельна самой себе (т.к α = const) и удлинилась на x.



Из геометрии находим
$\beta = \frac{\alpha}{2}$

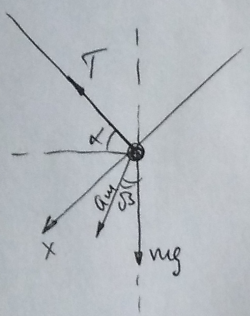
$\cos\beta = \cos\frac{\alpha}{2} = \sqrt{\frac{\cos\alpha + 1}{2}} =$

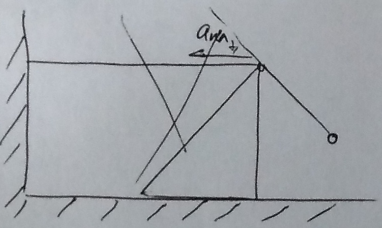
$= \sqrt{\frac{\frac{4}{5}+1}{2}} = \sqrt{0{,}9} \approx 0{,}95$

2) Найдем ускорение шарика

2 З.Н: $Ox: m a_ш \cdot \cos(\alpha - \beta) = mg\cos\alpha$

$a_ш = \frac{g\cos\alpha}{\cos(\alpha-\beta)}$





Чистовик

Задача 2.

Дано:

ν, T_0

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

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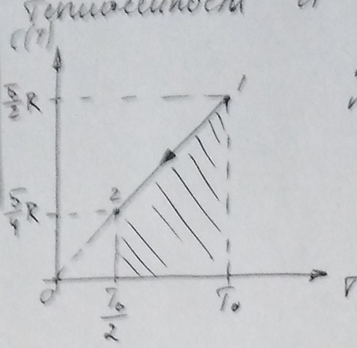
1) Q_1 - ? $T_k = \frac{1}{2} T_0$

2) T^* - ? когда $A = A_{min}$

3) A_{min} - ?

Решение:

1) Построим график зависимости молярной теплоемкости от температуры $C(T) = \frac{5R}{2T_0} \cdot T$



Найдем кол-во теплоты, полученное газом в процессе 1-2:

$$Q = C(T) \cdot \nu \Delta T$$

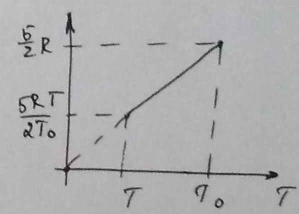
$$Q = \nu(-S_{тр})$$

$$S_{тр} = \frac{1}{2}\left(\frac{5}{4}R + \frac{5}{2}R\right)\left(T_0 - \frac{T_0}{2}\right) = \frac{15}{16} R T_0$$

$Q = -\frac{15}{16} \nu R T_0 < 0$, т.к. $T\downarrow$.

Т.к. Q_1 - кол-во теплоты, отданное газом $\Rightarrow$ $Q_1 = -Q = \frac{15}{16} \nu R T_0$

2) В общем случае количество теплоты, полученное газом $Q(T) = \frac{1}{2}\nu\left(\frac{5RT}{2T_0} + \frac{5}{2}R\right)(T - T_0)$



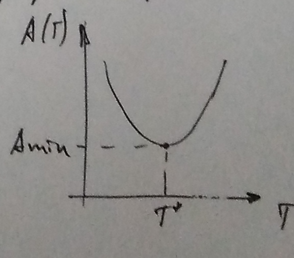
$$\Delta U = \frac{3}{2}\nu R (T - T_0)$$

По I началу термодинамики:

$$Q = A + \Delta U \Rightarrow A = Q - \Delta U$$

$$A(T) = \frac{1}{2}\nu\left(\frac{5RT}{2T_0} + \frac{5}{2}R\right)(T - T_0) - \frac{3}{2}\nu R(T - T_0) = \frac{5\nu R}{4T_0} \cdot T^2 - \frac{3\nu R}{2} \cdot T + \frac{1}{4}\nu R T_0$$

квадратичная зависимость, график парабола, ветви вверх



$A = A_{min}$ при $T = T^*$ в вершине параболы

$$T^* = \frac{-b}{2a} = \frac{3\nu R \cdot 4T_0}{2 \cdot 2 \cdot 5\nu R} = \frac{3}{5} T_0$$

3) $A_{min} = A(T^*) = \frac{5\nu R}{4T_0}\left(\frac{3}{5}T_0\right)^2 - \frac{3\nu R}{2} \cdot \frac{3}{5} T_0 + \frac{1}{4}\nu R T_0 = -\frac{\nu R T_0}{5}$

Ответ:

1) $Q_1 = \frac{15}{16} R T_0$

2) $T^* = \frac{3}{5} T_0$

3) $A_{min} = -\frac{\nu R T_0}{5}$

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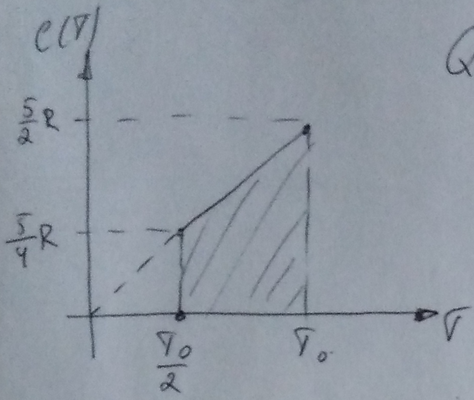
1) 1 моль

$T_0 \to \frac{1}{2}T_0$

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



$Q = C(T)\nu\Delta T$

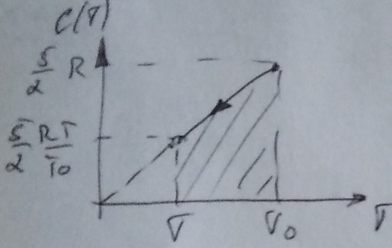
$\frac{Q}{\nu} = C(T)\Delta T = S_{тр}$

$Q = \nu\cdot S_{тр} = \nu\cdot\frac{\frac{5}{4}R + \frac{10}{4}R}{2}\cdot\frac{T_0}{2} =$

$= \frac{1}{2}\nu\cdot\frac{\frac{15}{4}R\cdot T_0}{2} = \frac{15}{16}\nu R T_0$

2) T – ?

$Q = \frac{1}{2}\cdot\nu\cdot\left(\frac{5RT}{2T_0} + \frac{5}{2}R\right)\cdot(T - T_0)$



$Q = A + \Delta U$

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

$A = Q - \Delta U =$

$\frac{1}{2}\nu\left(\frac{5RT^2}{2T_0} - \frac{5RT}{2} + \frac{5RT}{2} - \frac{5RT_0}{2}\right) =$

$= \frac{5}{4}\nu\frac{RT^2}{T_0} - \frac{5\nu RT_0}{4}$

~~$Q = \frac{1}{2}\nu\left(\frac{5RT T_0}{2T_0}\right.$~~

$Q = \frac{1}{2}\nu\left(\frac{5RT^2}{2T_0} - \frac{5RT}{2} + \frac{5RT}{2} - \frac{5}{2}RT_0\right) =$

$= \frac{5\nu RT^2}{4T_0} - \frac{5\nu RT_0}{4}$

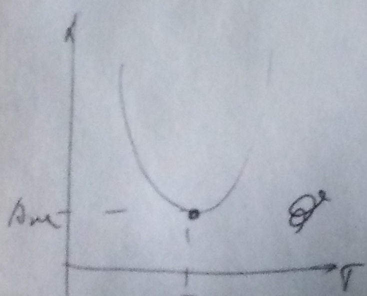
$\frac{5}{4}\nu\frac{RT^2}{T_0} - \frac{5RT_0}{4} - \frac{3}{2}\nu RT + \frac{6}{4}\nu RT_0 =$

$A(T) = \frac{5\nu RT^2}{4T_0} - \frac{5\nu RT_0}{4} - \frac{3}{2}\nu RT + \frac{6}{4}\nu RT_0 =$

$= \frac{5}{4}\frac{\nu R}{T_0}\cdot T^2 - \frac{3}{2}\nu RT + \frac{\nu RT_0}{4}$

$= \frac{5\nu R}{4T_0}T^2 - \frac{3}{2}\nu R\cdot T + \frac{1}{4}\nu RT_0$

$\frac{-b}{2a} = \frac{3\nu R\cdot 4T_0}{2\cdot 2\cdot 5\nu R} = \frac{3}{5}T_0$



$\frac{5+10}{4}$

$\frac{1}{2}\cdot\frac{15}{4}R\cdot\frac{T_0}{2} = \frac{15}{16}RT_0$

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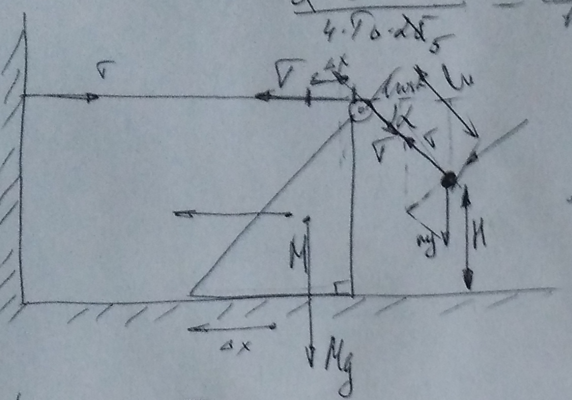
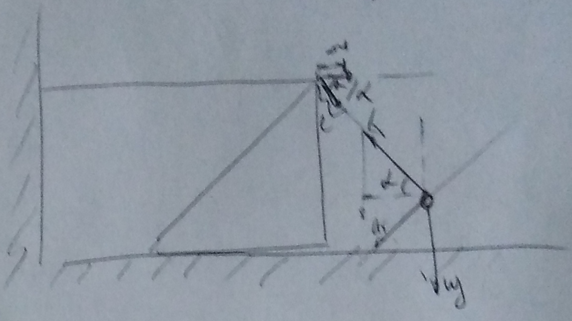
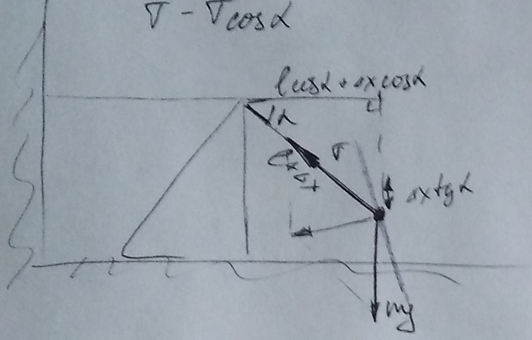
$$\frac{5 \cdot g \sqrt{R} T_0^2}{4 \cdot T_0 \cdot 2 T_0 \, 5} - \frac{9\sqrt{R} T_0}{10} + \frac{\sqrt{R} T_0}{4} = \frac{9 - 18 + 5}{20} = -\frac{4}{20}$$

$\alpha = const$



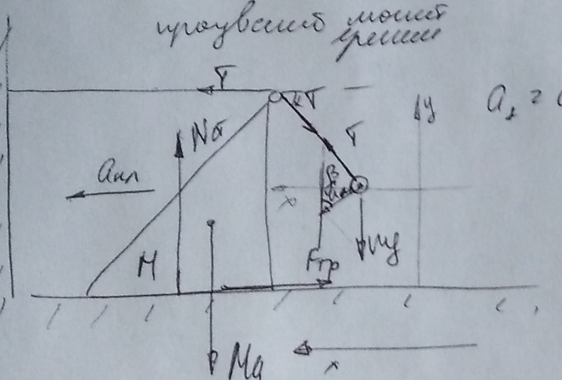


$T - T\cos\alpha$



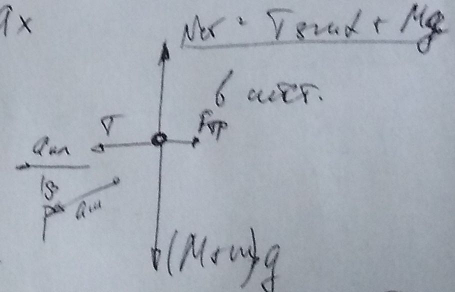
$$a_\tau = \frac{mg\sin\alpha}{m} = g\sin\alpha$$

$$a_n = \frac{T - mg\cos\alpha}{m}$$



$a_2 = const$

a_x



$T\sin\alpha + Mg = N_{ст}$

$m\, a_m\cos\beta = Mg + mg - T\sin\alpha - Mg = mg - T\sin\alpha$

ox: $T\cos\alpha = a_m \cdot \sin\beta \cdot m$

oy: $mg - T\sin\alpha = a_m\cos\beta \cdot m$

$m\, a_m \sin\beta = T\cos\alpha$

$m\, a_m \cos\beta$

$$T = \frac{a_m \sin\beta \cdot m}{\cos\alpha}$$

$$mg - \frac{a_m \sin\beta \cdot m \sin\alpha}{\cos\alpha} = a_m \cos\beta \cdot m$$

$$g = a_m(\cos\beta + \sin\beta\, tg\,\alpha)$$

$$a_m = \frac{g}{\cos\beta + \sin\beta\, tg\,\alpha} = const.$$

$$\frac{5\sqrt{R} \cdot g T_0^2}{4 T_0 \cdot 2 T_0 \, 5} - \frac{9\sqrt{R} T_0}{10} + \frac{\sqrt{R} T_0}{4} = \frac{9\sqrt{R} T_0 - 18\sqrt{R} T_0 + 5\sqrt{R} T_0}{20} = -\frac{4\sqrt{R} T_0}{20} = -\frac{\sqrt{R} T_0}{5}$$

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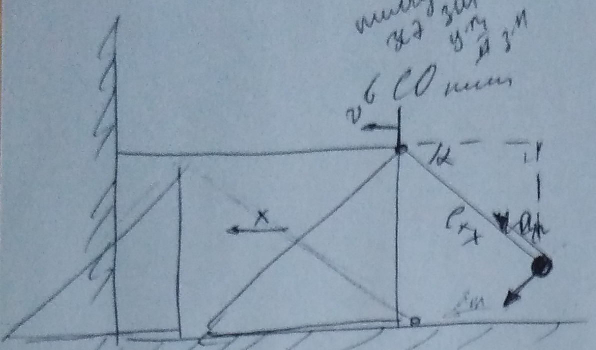
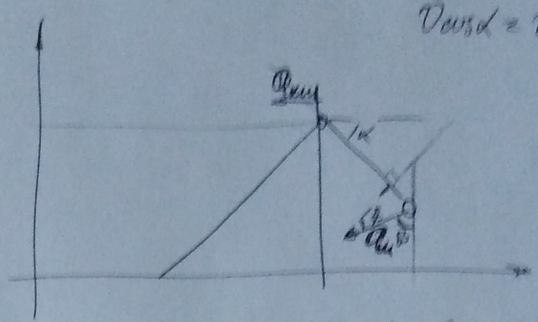
$v = const$





$v\cos\alpha = v_{и}$

$a_{ин} \cdot \cos\alpha = a_{ш} \cdot \sin(\alpha - \beta)$

$a_{ин} = \dfrac{v - v\cos\alpha}{\Delta t}$ $\beta = \varphi - 90 + \alpha$

$\dfrac{v(1-\cos\alpha)}{\Delta t}$ $\cos\alpha =$

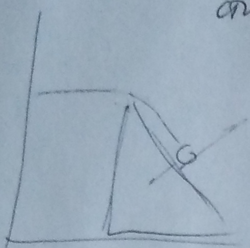
$\varphi = \dfrac{180-\alpha}{2} = 90 - \dfrac{\alpha}{2}$

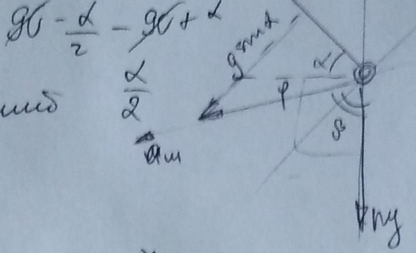
$\beta = 90 - \dfrac{\alpha}{2} - 90 + \alpha$

$\varphi = 90 - \beta$

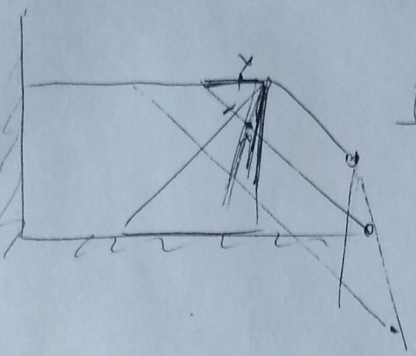
$a_{ш} \cdot \cos(\alpha + 90 - \beta) =$

$= a_{ш} \cdot \sin(\alpha - \beta)$



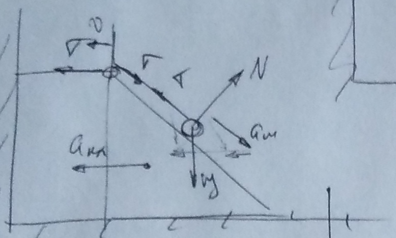


$a_{ш} \cdot \sin(\alpha - \beta + 90) = g\sin\alpha$

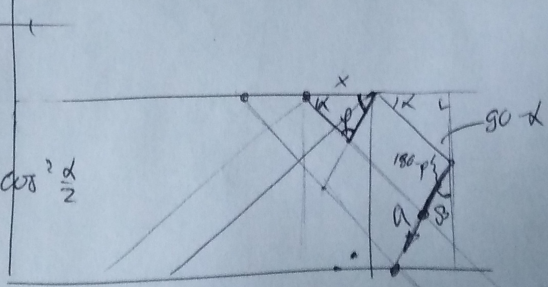


$a_{ш} = \dfrac{g\sin\alpha}{\cos(\alpha - \beta)}$

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



$90 - \alpha + 180 - \varphi + \beta = 180$



$\sin^2\alpha + \cos^2\alpha = \sin^2\dfrac{\alpha}{2} + \cos^2\dfrac{\alpha}{2}$

$\varphi = \dfrac{180-\alpha}{2}$

$90 + \beta = \alpha + \varphi$

$\sin(90+\beta) = \sin(\alpha+\varphi)$

$\beta = 180 - ($ $\cos\beta = \sin\left(\alpha + 90 - \dfrac{\alpha}{2}\right) =$

$(180 - \varphi + 90 - \alpha)$ $= \sin\left(90 + \dfrac{\alpha}{2}\right) =$

$\cos\beta = 0{,}84$ 36,869

$\varphi = 71{,}5655$

$\alpha + \varphi = 108{,}43$

$= \cos\left(\dfrac{\alpha}{2}\right) = \sqrt{\dfrac{\cos\alpha + 1}{2}}$

$\cos(90+\beta) = \cos\left(90 + \dfrac{\alpha}{2}\right)$

$= \sqrt{\dfrac{\frac{4}{5}+1}{2}} = \sqrt{\dfrac{9}{10}} = \dfrac{3}{\sqrt{10}}$

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

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

$\cos\alpha = \sqrt{\dfrac{\cos 2\alpha + 1}{2}}$

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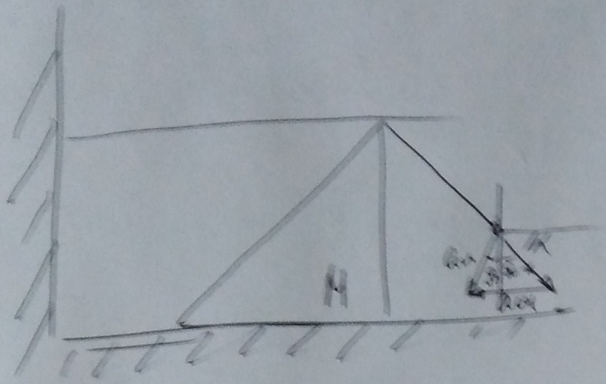
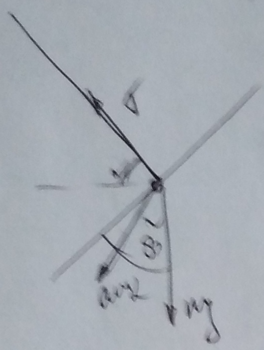


$$a_{mx} = a_m \cdot \sin\beta + a_m \cdot \cos\beta \; tg(90-\alpha) =$$
$$= a_m(\sin\beta + \cos\beta \; ctg\,\alpha)$$



$$m a_m \cdot \cos(\alpha - \beta) = mg\cos\alpha$$

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Часть 2

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

Шифр: **21201392**

ID профиля: **832163**

Вариант 2

Чистовик

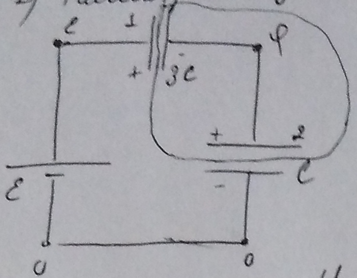
Задание 3.

Дано:
$C_2 = C$
$C_1 = 3C$

1) I_1 - ?
2) Q - ?
3) U_R - ?

Решение:

1) Рассмотрим цепь до замыкания ключа. Используем метод узловых потенциалов (см. рисунок)



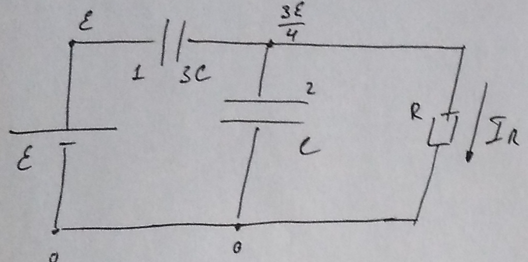
ЗСЗ для центрированной обл:

$$0 = -3C(\mathcal{E}-\varphi) + C\cdot\varphi$$

$$3\mathcal{E} - 3\varphi = \varphi \Rightarrow \varphi = \frac{3\mathcal{E}}{4}$$

$$U_{10} = \mathcal{E} - \varphi = \frac{\mathcal{E}}{4} \qquad U_{20} = \varphi = \frac{3}{4}\mathcal{E}$$

Рассмотрим цепь сразу после замыкания ключа: Напряжения на конденсаторах скачком не поменялось.

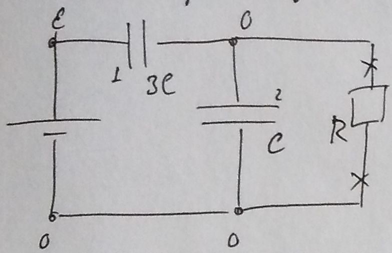


По з. Ома: $I_1 = I_R = \frac{\frac{3\mathcal{E}}{4}}{R} = \frac{3\mathcal{E}}{4R}$

2) До замыкания ключа $W_0 = \frac{3C\cdot(U_{10})^2}{2} + \frac{C\cdot(U_{20})^2}{2} =$

$$= \frac{3C\cdot\left(\frac{\mathcal{E}}{4}\right)^2}{2} + \frac{C\cdot\left(\frac{3}{4}\mathcal{E}\right)^2}{2} = \frac{3C\mathcal{E}^2}{8}$$

Рассмотрим цепь в установившемся режиме:



Ток через резистор не течёт, значит потенциалы на его концах равны (см. рисунок) $U_2 = 0$, $U_1 = \mathcal{E}$

Тогда $W = \frac{3C\cdot U_1^2}{2} = \frac{3C\mathcal{E}^2}{2}$

Вначале заряд на левой обкладке первого конденсатора был $q_0 = 3C\cdot U_{10} = \frac{3C\mathcal{E}}{4}$, а стал $q = 3CU_1 = 3C\mathcal{E} \Rightarrow \Delta q = q - q_0 = \frac{9C\mathcal{E}}{4}$

ЗСЭ: $A_{ист} = \Delta W + Q$

$$\mathcal{E}\Delta q = W - W_0 + Q \Rightarrow Q = \mathcal{E}\cdot\frac{9C\mathcal{E}}{4} - \frac{3C\mathcal{E}^2}{2} + \frac{3C\mathcal{E}^2}{8} = \frac{9}{8}C\mathcal{E}^2$$

Ответ: 1) $I_1 = \frac{3\mathcal{E}}{4R}$
2) $Q = \frac{9}{8}C\mathcal{E}^2$

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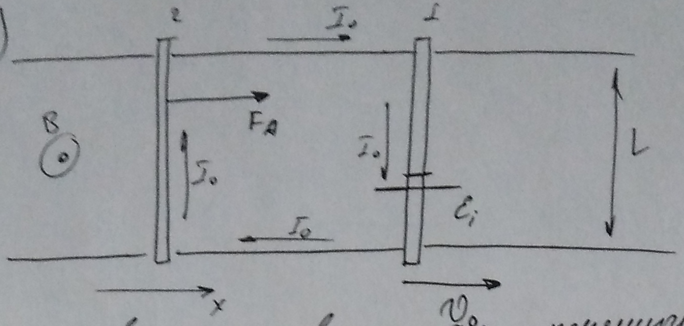
Задание 4. Чистовик

Дано:
B
L
$m_1 = m$
$R_1 = R$
$m_2 = \frac{m}{2}$
$R_2 = 4R$
v_0

1) $a_0 - ?$

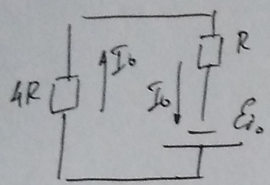
Решение:

1)



Из-за движения в первой перемычке возникает ЭДС индукции $\mathcal{E}_{i0} = Bv_0L$

Имеем следующую цепь:



По з. Ома для полн. цепи:

$$I_0 = \frac{\mathcal{E}_{i0}}{4R + R} = \frac{Bv_0L}{5R}$$

Т.к. через вторую перемычку, находящуюся в МП, потечёт ток I_0, то на неё будет действовать сила Ампера $F_A = BI_0L\sin\alpha = BI_0L$

По 2 з Н: $\quad OX: \; F_A = \frac{m}{2}a_0 \Rightarrow a_0 = \frac{2F_A}{m} = \frac{2BLI_0}{m} = \frac{2B^2L^2v_0}{5mR}$

Ответ: $a_0 = \frac{2B^2L^2v_0}{5mR}$

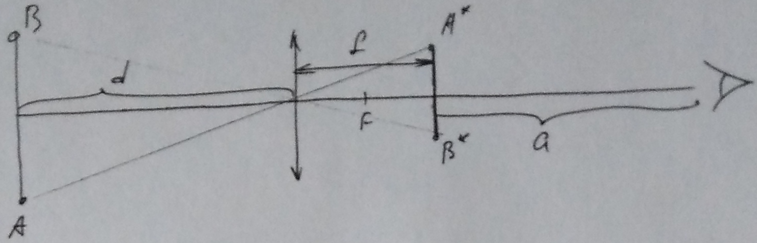
Задание 5

Чистовик

Дано:
F = 12 см
H = 9 см
d = 48 см
a = 24 см

1) x - ?

Решение:

1)


По формуле тонкой линзы:

$$\frac{1}{d} + \frac{1}{f} = \frac{1}{F} \Rightarrow \frac{1}{48} + \frac{1}{f} = \frac{1}{12} \Rightarrow f = 16 \text{ см}$$

$$x = f + a = 16 + 24 = 40 \text{ см}$$

Ответ: x = 40 см

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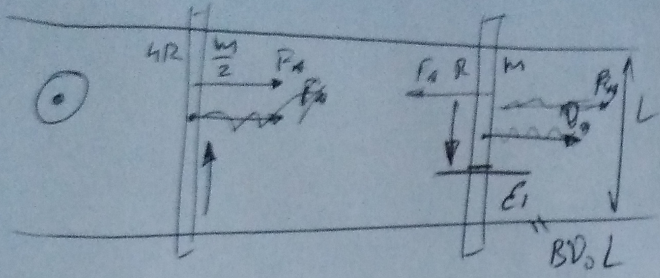
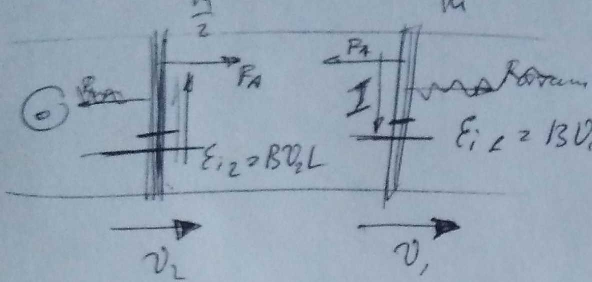


$$I = \frac{BV_0L}{5R}$$

$$F_A = BIL$$

$$\frac{2BLBV_0L}{m5R} = 2\frac{B^2L^2V_0}{5mR}$$

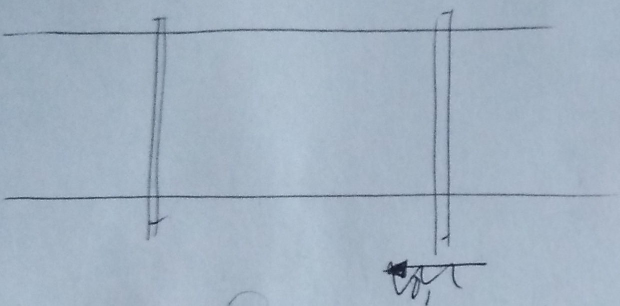


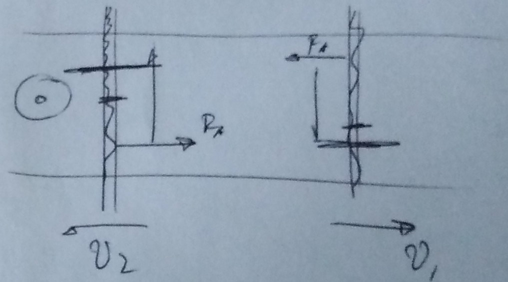
$V_{отн}$

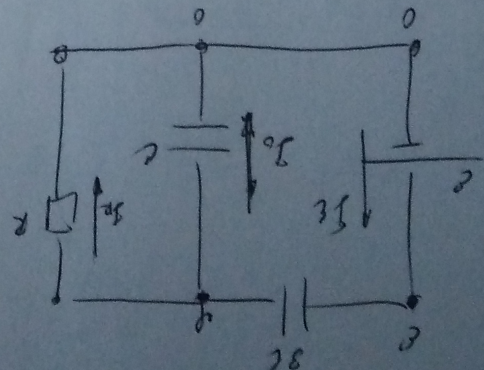
$$I = \frac{E_{i1} - E_{i2}}{5R} = \frac{BL(V_1 - V_2)}{5R}$$

$F_A =$

$$\frac{mV_1^2}{2} + \frac{mV_2^2}{4} = \frac{mV_0^2}{2}$$







$q = CU$

$I = CU'$

$I_E + I_0 = I_R$

$3C - \varphi' + C\varphi' = I_R$

$\varphi - ?$

$I_E = 3C\cdot(E-\varphi)'$

$$I_E = 3C\frac{\Delta(E-\varphi)}{\Delta t} = 3C\frac{\Delta E - \Delta\varphi}{\Delta t}$$

$$I_0 = \frac{C\Delta\varphi}{\Delta t} \qquad \Delta\varphi = \frac{I_0\Delta t}{C}$$

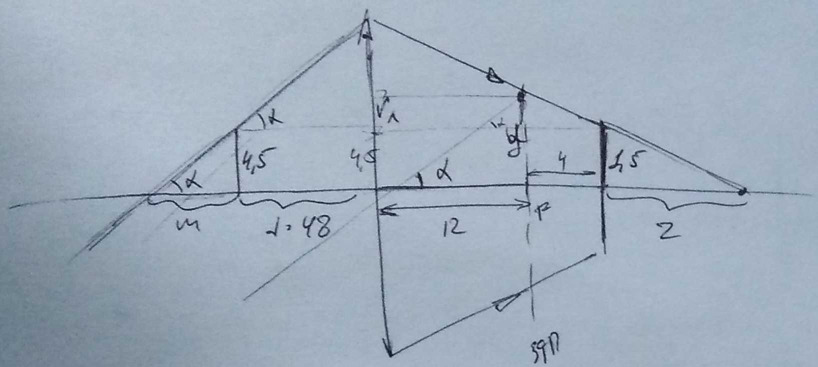
$$I_E = 3C\frac{I_0\Delta t}{C\Delta t} = 3I_0$$

$I_0 = C\cdot\varphi' = C\varphi'$

$$\frac{\Delta\varphi}{\Delta t} = \frac{I_0}{C}$$

$I_E = 3C\cdot(E-\varphi)' = 3C\cdot -\varphi'$

$$I_R = 3C - \varphi' + C\varphi' = -2C\varphi' = \frac{\varphi}{R}$$



$$\frac{1,5}{r_1} = \frac{z}{z+16}$$

$$r_1 \cdot z = 1,5z + 24$$

$$z = \frac{24}{r_1 + 1,5}$$

$$\frac{1,5}{y} = \frac{z}{z+4}$$

$$y = \frac{1,5z + 6}{z} = \frac{\frac{36}{r_1+1,5} + 6}{\frac{24}{r_1+1,5}} = \frac{\left(\frac{36}{r_1+1,5} + 6\right) \cdot (r_1 + 1,5)}{24} = \frac{36 + 6r_1 + 9}{24} = \frac{45 + 6r_1}{24}$$

$$tg\,\alpha = \frac{y}{12} = \frac{45 + 6r_1}{24 \cdot 12} = \frac{3(15 + 2r_1)}{24 \cdot 6}$$

$$\frac{3(15 + 2r_1)}{24 \cdot 6} = \frac{4,5}{m}$$

$$m = \frac{24 \cdot 9 \cdot 3}{3(15 + 2r_1)}$$

$$tg\,\alpha = \frac{r_1}{m + 48} = \frac{r_1}{\frac{24 \cdot 27}{15 + 2r_1} + 48}$$

$$tg\,\alpha = \frac{r_1 - 4,5}{48} = \frac{15 + 2r_1}{24 \cdot 3}$$

$$3r_1 - 13,5 = 15 + 2r_1$$

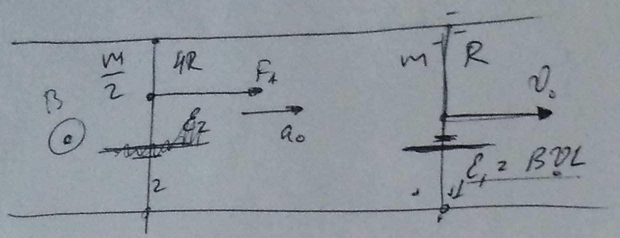
$$r_1 = 28,5$$

$$\frac{9 \cdot 6^3}{2_1}$$

$$\frac{4 \cdot 3}{2_1} \quad \frac{24 \cdot 3}{2_1} \quad \frac{6 \cdot 3}{2_1}$$

$$4,5 \times 3 = 13,5$$

21201392 (U832163 M1268561)

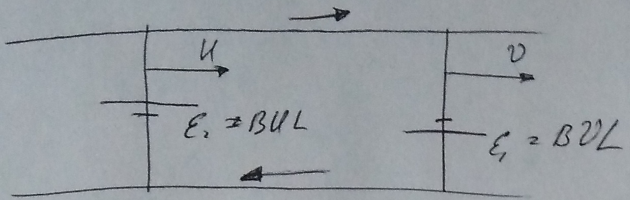


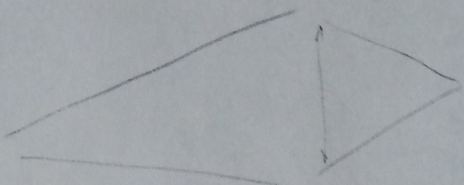
$F_A = I L \cdot B$

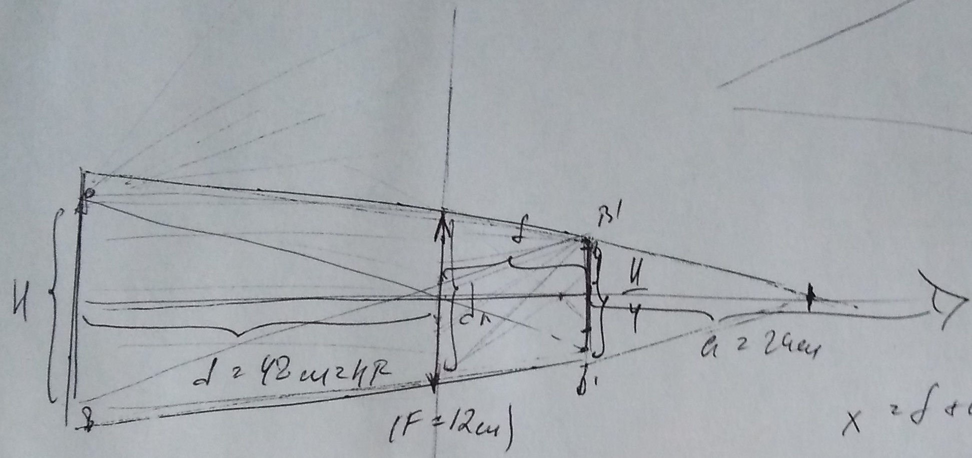
$I = \frac{\mathcal{E}}{R+4R} = \frac{\mathcal{E}}{5R}$ $= B\upsilon L$

$F_A = \frac{\mathcal{E}}{5R} L B = \frac{m}{2} a_0$

$a_0 = \dots$





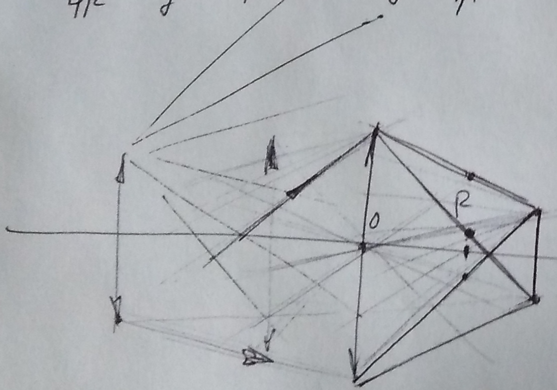


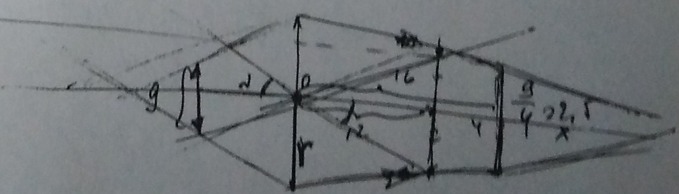
$\Gamma = \frac{f}{d} = \frac{16}{48} = \frac{1}{3}$

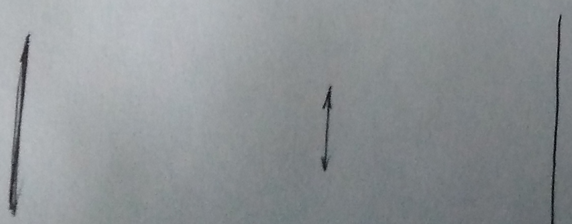
$x = f + a = 24 + 16 = 40$

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

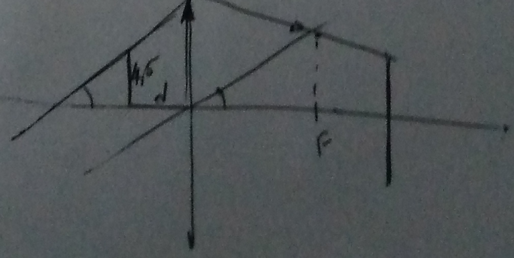
$\frac{1}{4F} + \frac{1}{f} = \frac{1}{F} \Rightarrow \frac{1}{f} = \frac{4}{4F} - \frac{1}{4F} = \frac{3}{4F} \Rightarrow f = \frac{4F}{3} = \frac{12 \cdot 4}{3} = 16$



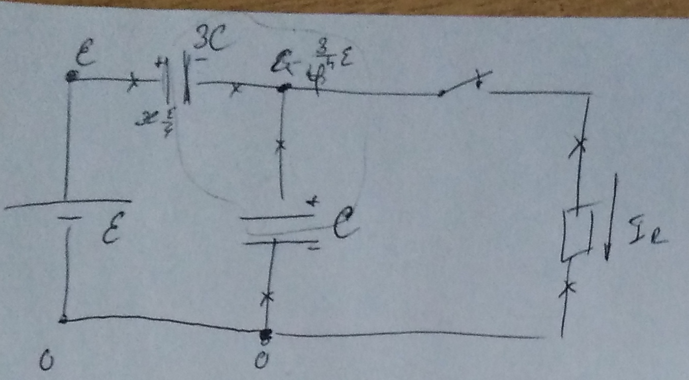




$\frac{X}{X+4} = \frac{2{,}5}{y}$



21201392 (U832163 M1268561)



I_R

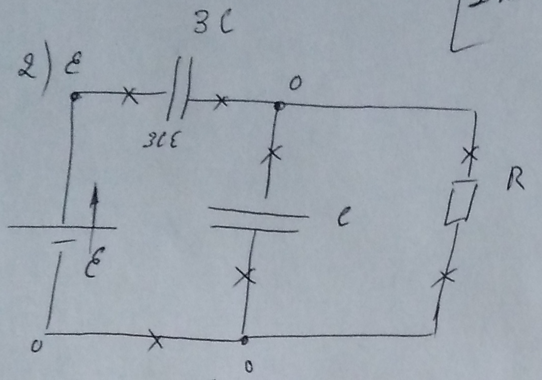
1) $0 = -3C(ℰ-\varphi) + C\cdot\varphi$

$3C(ℰ-\varphi) = C\varphi$

$3ℰ - 3\varphi = \varphi$

$3ℰ = 4\varphi \Rightarrow \varphi = \frac{3}{4}ℰ$

$I_R = \frac{\frac{3}{4}ℰ}{R} = \frac{3ℰ}{4R}$



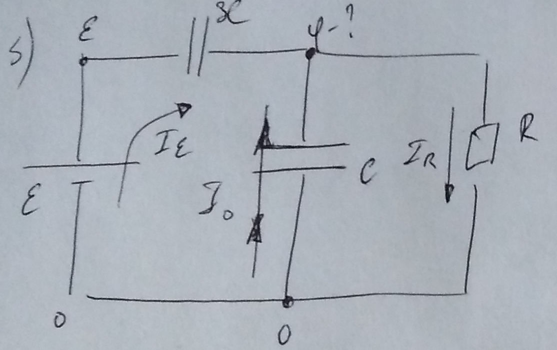
$W_0 = 3C\left(\frac{ℰ}{4}\right)^2 + C\left(\frac{3ℰ}{4}\right)^2$

$W = 3C\cdot ℰ^2$

$A_{ист} = ℰ\Delta q = ℰ\cdot\left(3Cℰ - \frac{3}{4}Cℰ\right)$

$I_ℰ = \frac{\Delta q}{\Delta t}$

$I = \frac{\Delta q}{\Delta t}$



$I_ℰ + I_0 = I_R$

$q = CU$

$\frac{q}{\Delta t} = \frac{CU}{\Delta t}$

$I = \frac{CU}{\Delta t}$

$I = (CU)' = CU' = I = C\frac{\Delta U}{\Delta t}$

$(1-x)' = -1$

$I_ℰ + I_0 = I_R$

$I_ℰ = 3C\cdot U_1' = 3C\cdot(ℰ-\varphi)'$

$I_0 = C U_2' = C\varphi'$

$\varphi = I_R R$

$(ℰ-\varphi)' = ℰ'(-\varphi) + (-\varphi)'\cdotℰ = -ℰ$

$I_ℰ = 3C(ℰ - I_R R)' =$

$I_0 = C\cdot(I_R R)' = CR I_R'$

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

$\frac{12Cℰ^2}{4} - \frac{3Cℰ}{4} = \frac{9Cℰ}{4}$

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

21201392 (U832163 M1268561)