Часть 1

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

Шифр: **21202194**

ID профиля: **850341**

Вариант 4

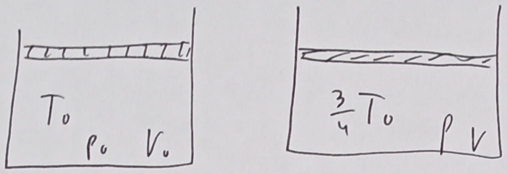
Чистовик

№2.

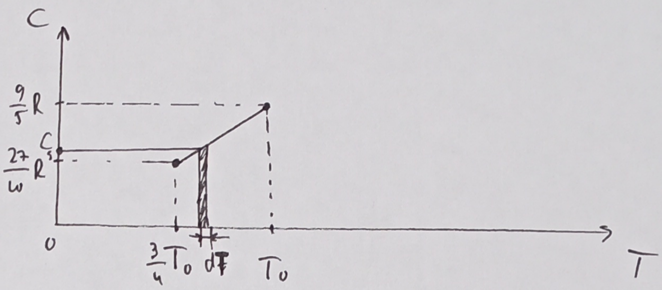
1) Q_1 - ?

2) T' - ?

3) A_{min} - ?



1) $dQ_1 = \nu C dT$



$$C(T_0) = \frac{9}{5}R\frac{T_0}{T_0} = \frac{9}{5}R$$

$$C\left(\frac{3}{4}T_0\right) = \frac{9}{5}R \cdot \frac{3}{4} = \frac{27}{20}R$$

$$S_{\text{малого столбика}} = C_s dT$$

$$S_{\text{под графиком}} = C_\Delta T = \frac{\frac{27}{20}R + \frac{9}{5}R}{2} \cdot \frac{1}{4}T_0 = \frac{63}{160}RT_0$$

$$Q_1 = \nu C_\Delta T = \nu R T_0 \cdot \frac{63}{160} = \frac{63}{160}\nu R T_0$$

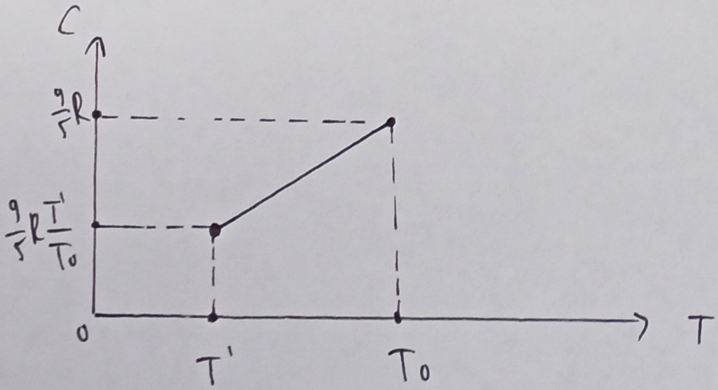
$$Q_1 \approx 0{,}394\ \nu R T_0$$

2) $A_{газа} = -Q - U_{газа} = - \left(Q + \frac{3}{2}\nu R(T' - T_0)\right)$

здесь $Q > 0$

$$dQ = \nu C dT$$

$$Q = \nu \cdot \frac{\frac{9}{5}R + \frac{9}{5}R\frac{T'}{T_0}}{2}(T_0 - T')$$



1

см. лист 2

Чистовик

$$Q = \frac{\nu}{2}\cdot\frac{9}{5}R\left(1+\frac{T'}{T_0}\right)(T_0-T') = \frac{9\nu R}{10T_0}(T_0+T')(T_0-T') =$$

$$= \frac{9\nu R}{10T_0}\left(T_0^2 - T'^2\right)$$

$$A_{газа} = -\left(\frac{9\nu R T_0^2}{10T_0} - \frac{9\nu R T'^2}{10T_0} + \frac{3\nu R T'}{2} - \frac{3}{2}\nu R T_0\right) =$$

$$= -\nu R\left(\frac{9T_0}{10} - \frac{9T'^2}{10T_0} + \frac{3}{2}T' - \frac{3}{2}T_0\right) =$$

$$= \nu R\left(0{,}6T_0 + \frac{0{,}9}{T_0}T'^2 - 1{,}5T'\right) = \frac{0{,}9\nu R}{T_0}T'^2 - 1{,}5\nu R T' + 0{,}6T_0\nu R$$

$$A'_{газа} = 0 \Rightarrow \frac{0{,}9\nu R}{T_0}\cdot 2T' - 1{,}5\nu R = 0 \quad \Big|:\frac{\nu R}{T_0}$$

$$1{,}8T' - 1{,}5T_0 = 0$$

$$T' = \frac{1{,}5T_0}{1{,}8}$$

$$T' = \frac{5}{6}T_0$$

3) $$A_{газа\,min} = \left(\frac{0{,}9T'^2}{T_0} - 1{,}5T' + 0{,}6T_0\right)\nu R = \left(\frac{0{,}9\cdot 25T_0}{36} + 0{,}6T_0 - \frac{1{,}5\cdot 5}{6}T_0\right)\nu R = (0{,}625T_0 + 0{,}6T_0 - 1{,}25T_0)\nu R =$$

$$= -0{,}025\nu R T_0$$

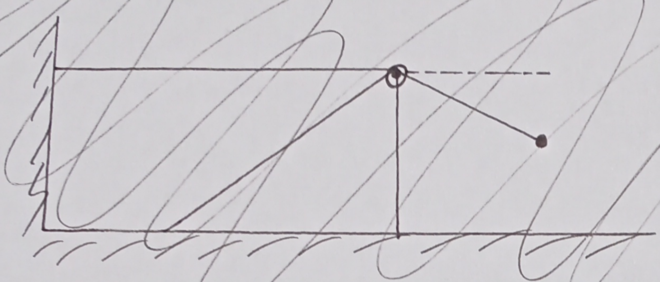
2

Чистовик

Работа A_{min} газа < 0, т.к. газ охлаждают, т.е. над ним совершается работа.

Ответ: 1) $Q_1 = \frac{63}{160} \nu R T_0$; 2) $T' = \frac{5}{6} T_0$; 3) $A_{min} = -\frac{1}{40} \nu R T_0$

~~№1.~~



~~Дано: H; $\cos\alpha = \frac{8}{17}$~~

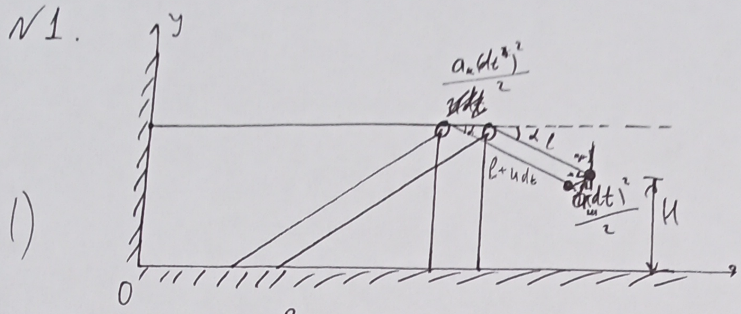
~~1) 2) 3) $\frac{m}{M}$ - ? 4) t - ?~~

№1 см. на листе 4

Чистовик

№1.

1)



Дано: H; $\cos\alpha = \frac{8}{17}$

β – ?

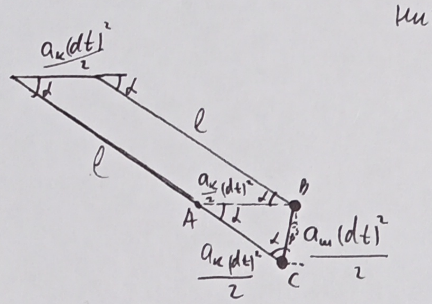
$a_к$ – ?

$\frac{m}{M}$ – ?

t – ?

Рассмотрим систему ч/з dt:

нить вытянется на $\frac{a_к (dt)^2}{2}$ =>



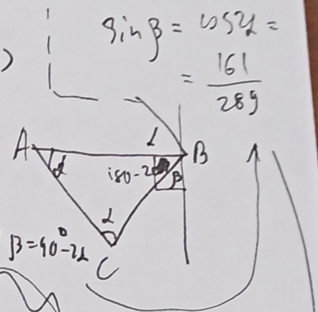
=> $\triangle ABC$ – р/б с осн. AC =>

$\angle ABC = 180° - 2\alpha$

$\beta = 90° - 180° + 2\alpha = 2\alpha - 90°$

~~$\sin(2\alpha - \frac{\pi}{2}) = -\cos 2\alpha$~~

~~$\sin\beta = -\frac{161}{289}$~~



$\sin\beta = \cos 2\alpha = \frac{161}{289}$

$\cos\beta = \frac{240}{289}$

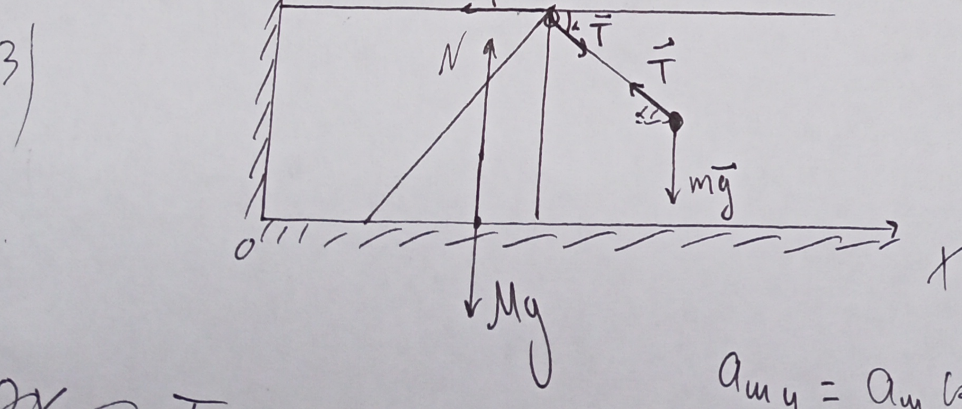
$$\frac{a_к^2 (dt)^4}{4} = \frac{a_к^2 (dt)^4}{4} + \frac{a_m^2 (dt)^4}{4} - 2\frac{a_к a_m (dt)^4}{4}\cos\alpha$$

$$a_m^2 (dt)^4 = 2 a_к a_m (dt)^4 \cos\alpha$$

$$a_m = 2a_к \cos\alpha \Rightarrow \frac{a_m}{a_к} = 2\cos\alpha$$

т.к. на сист. не действуют внеш. силы $X_{ц.м.1} = X_{ц.м.2}$

3)



~~$OX: -T\cos\alpha = m a_x$~~

~~$T\cos\alpha - T = M a_x$~~

$a_{my} = a_m \cos\beta$

$a_{mx} = a_m \sin\beta$

Чистовик

для шара:

OX: $-T\cos\alpha = ma_{шx} \Rightarrow a_{шx} = -\frac{T\cos\alpha}{m} = -a_ш\cos\beta$ (1)

OY: $T\sin\alpha - mg = ma_{yш} \Rightarrow a_{шy} = \frac{T\sin\alpha}{m} - g$

для клина: OX: $T\cos\alpha - T = Ma_{кx}$ (2)

$$a_{кx} = -a_к$$

$$T(1-\cos\alpha) = Ma_к$$

$$\frac{T\cos\alpha}{T(1-\cos\alpha)} = \frac{a_ш m\cos\beta}{Ma_к}\ ; \quad \frac{\cos\alpha}{1-\cos\alpha} = \frac{m\cos\beta}{M}\cdot 2\cos\alpha$$

$$\frac{m}{M} = \frac{\cos\alpha}{(1-\cos\alpha)\cos\beta\cdot 2\cos\alpha} = \frac{1}{\cos\beta(1-\cos\alpha)} \approx 2{,}27$$

2) $\cancel{a_ш = \sqrt{a_x^2 + a_y^2} = 8}$

$$H = \frac{a_ш t^2}{2}\ ; \quad t = \sqrt{\frac{2H}{a_ш}} = \frac{2H}{\sqrt{a_{шx}^2 + a_{шy}^2}}$$

Ответ: 1) ______________

$$|A| = |Q| - |U|$$

$$|A| = |Q| - \frac{3}{2}\nu R$$

$$A = -Q - \frac{3}{2}\nu R(T_0 - T')$$

$$0{,}\frac{025}{1000} \quad \frac{1}{40}$$

40

21202194 (U850341 M1265333)

Черновик

№2.

Дано: ν, T_0 - начальн. темп.; $C(T) = \frac{9}{5} R \frac{T}{T_0}$; $T' = \frac{3}{4} T_0$; $i = 3$.

1) Q_1 - ?

2) A_{min}, T_A - ?

3) A_{min} - ?

$\frac{63}{20}$

Решение:

$dQ_1 = \nu dC dT$

$\nu C_{\Delta T}^{\,const}$

$Q_1 = \nu (C_{T'} - C_{T_0}) \cdot |T' - T_0|$

$Q_1 = \nu \cdot \frac{1}{4} T_0 \cdot \left(\frac{27}{20} R - \frac{9}{5} R\right) = \frac{1{,}8 R \nu T_0}{4} =$

$= 0{,}45 R \nu T_0$

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

$T_A = T_{A max}$

$= Q_1 - \frac{3}{2} \nu R (T_A - T_0)$

$\nu R (\quad T_0 - \frac{3}{2} T_A + \frac{3}{2} T_0$

1,2625

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Q

Черновик

He

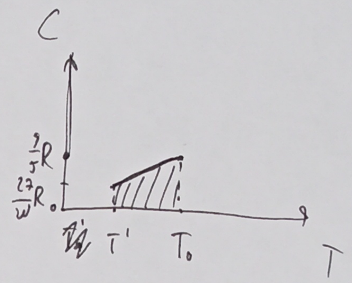
$$C_{T'} = \frac{9}{5} R \frac{T'}{T_0} = \frac{9}{5} R \frac{3T_0}{4T_0} = \frac{9R \cdot 3}{5 \cdot 4} = 1{,}35R$$

$$C_{T_0} = \frac{9}{5} R \frac{T_0}{T_0} = \frac{9}{5} R$$

2

7,8

$$Q = \int C\,dT$$



$$X_{у.м.1} = \frac{X_к M + X_м m}{M + m}$$

$$X_{у.м.2} = \left(X_к - \frac{a_к (dt)^2}{2}\right) M + \left(X_м - \right.$$

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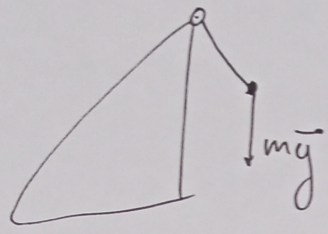

$mg = ma$

$a_м = g$

$1 - \frac{8}{17} = \frac{9}{17}$

$\frac{289 \cdot 17}{240 \cdot 9}$

$Q_{норм} = \partial -$

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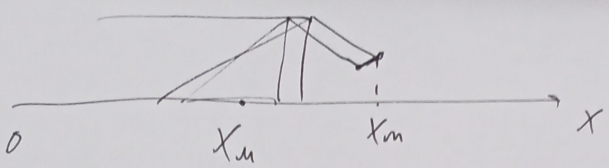
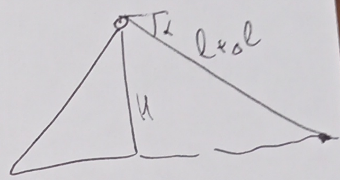


$$T\left(\frac{\cos\alpha}{M}-\frac{1}{M}\right)=\frac{T(\cos\alpha-1)}{M}=a_x$$

$$T=\frac{a_x M}{\cos\alpha-1}$$



$$\cancel{a_x}=\frac{\cancel{a_x}M\cos\alpha}{(1-\cos\alpha)m}$$

$$\frac{m}{M}=\frac{\cos\alpha}{1-\cos\alpha}$$

$$\frac{p_0V_0}{pV}=\frac{1}{3}$$

$$a_y=a\cos\beta \qquad \cos\beta=\frac{a_y}{\sqrt{a_y^2+a_x^2}}$$

$$\cancel{\frac{T^2}{m^2}\cos^2\alpha+\frac{T^2}{m^2}\sin^2\alpha+g^2-2\frac{T}{m}g\sin\alpha}$$

$$p_0V_0=\nu RT_0$$
$$pV=\nu RT_?$$

$$X_{ц.м.}=\frac{Mx_к+mx_m}{M+m}$$

$$X_{ц.м.}=\frac{M\left(x_к-\frac{a_к(dt)^2}{2}\right)+m\left(x_m-\frac{a_m(dt)^2}{2}\sin\beta\right)}{M+m}$$

$$M\cancel{x_к}+m\cancel{x_m}=M\cancel{x_к}-M\frac{a_к(dt)^2}{2}+\cancel{mx_m}-m\frac{a_m(dt)^2}{2}$$

$$\boxed{Ma_к=-m\sin\beta\, a_m}$$

~~Чистовик~~ Черновик

№2. Дано: ν; T_0; $i=3$; $T' = \frac{3}{4}T_0$; $C(T) = \frac{9}{5}R\frac{T}{T_0}$

$\frac{9}{10} + \frac{3}{2}$

Найти: 1) Q_1 - ?

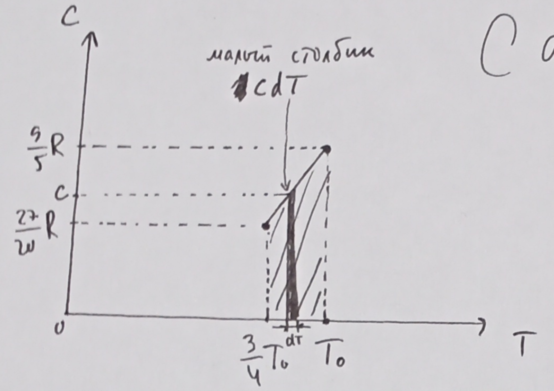
2) $A_{min} \rightarrow T_A$ - ?

3) A_{min} - ?

$$dQ = \underbrace{dC}\,dT$$

$\frac{15}{18} = \frac{3}{\ldots} = \frac{5}{6}$

Решение:



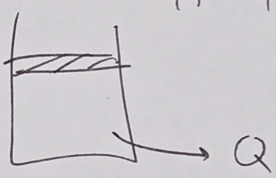
$C\,dT$ $C(T_0) = \frac{9}{5}R\frac{T_0}{T_0} = \frac{9}{5}R$

$C(T') = C(T_0 \cdot \frac{3}{4}) =$

$= \frac{9}{5}R \cdot \frac{3}{4} = \frac{27}{20}R$

$\frac{63}{40}R \cdot \frac{1}{4}$ $\frac{63}{160}R T_0$

$\frac{17-8}{17} = \frac{9}{17}$



$$S_{\text{под граф.}} = \sum C\,dT = \frac{\frac{27}{20}R + \frac{9}{5}R}{2} \cdot \left(T_0 - \frac{3}{4}T_0\right) = 1,575R \cdot 0,25T_0 =$$

$$= 0,39375\,RT_0$$

$\frac{5}{2}\nu RT_0 = \frac{3}{2}\nu RT_A$

Тогда $\underline{Q_1 = 0,39375\,\nu RT_0}$

$Q -$ $\frac{63}{160}\nu RT_0 - \frac{3}{2}\nu RT_A + \frac{3}{2}\nu R\ldots$

$0 = Mu - mv$ $T_A = \frac{5}{3}$

$u = \frac{m}{M}v$

$\frac{\cos\alpha}{M} - \frac{1}{M} + \frac{\cos\alpha}{m} = 0 \;|\cdot m$

$\frac{m}{M}\cos\alpha + \cos\alpha = \frac{m}{M}$ $mg-$

$\frac{63}{160}T_0 -$

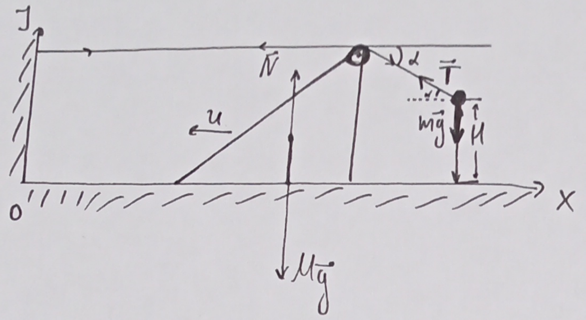
$\frac{400}{160} = \frac{40}{16} = \frac{10}{4} = \frac{5}{2}$

$\frac{m}{M} = \frac{\cos\alpha}{1-\cos\alpha} = \frac{8 \cdot 17}{17 \cdot 9} = \frac{8}{9}$

$-\frac{T}{m}\cos\alpha = \frac{T}{M}\cos\alpha - \frac{T}{M}$

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

№1.



Дано: $\cos\alpha = \frac{8}{17}$

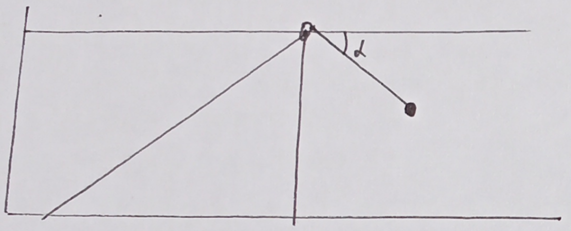
H

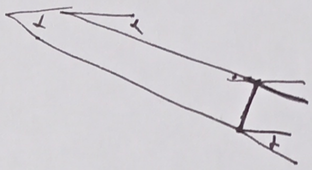
$\sqrt{57600}$ $\quad \frac{240}{285}$

$OX: \ -T\cos\alpha = m a_x \qquad a_x = -\frac{T}{m}\cos\alpha$

$OY: \ T\sin\alpha - mg = m a_y \qquad a_y = \frac{T}{m}\sin\alpha - g$

$\xrightarrow{a_{\text{отн}}}$





$\left(\frac{\pi}{2} - 2\alpha\right) =$

$= \cos 2\alpha$

$\cos ($

$OX: \ T\cos\alpha - T = M a_x \qquad a_x = \frac{T}{M}\cos\alpha - \frac{T}{M}$

$\frac{a_x}{a_y} =$

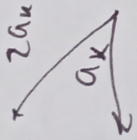
$-\frac{T}{m}\cos\alpha = \frac{T}{M}\cos\alpha - \frac{T}{M}$

$a_ш = 2a_x\cos\alpha$

$mg - T\sin\alpha = m a_y$

$a_y = a_ш \sin\beta$

$2\cdot\frac{64}{17^2} - 1 = -\frac{161}{17^2} = -\frac{161}{289}$



$H = \frac{a_ш t^2}{2}$

$t = \sqrt{\frac{2H}{a_ш}}$

$180 - 2\alpha$

$180 - \alpha$


β

Часть 2

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

Шифр: **21202194**

ID профиля: **850341**

Вариант 4

Чистовик

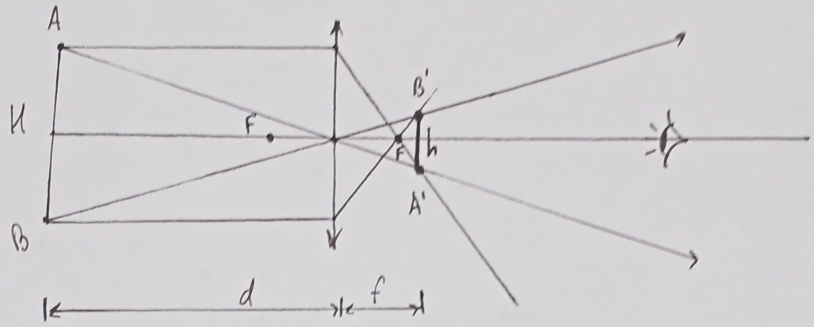
№5. Дано: $F = 24$ см, $H = 9$ см, $d = 96$ см, дейст. изобр., $d_г = 24$ см

1) x – ?

2) D_{min} – ?

3) S – ?

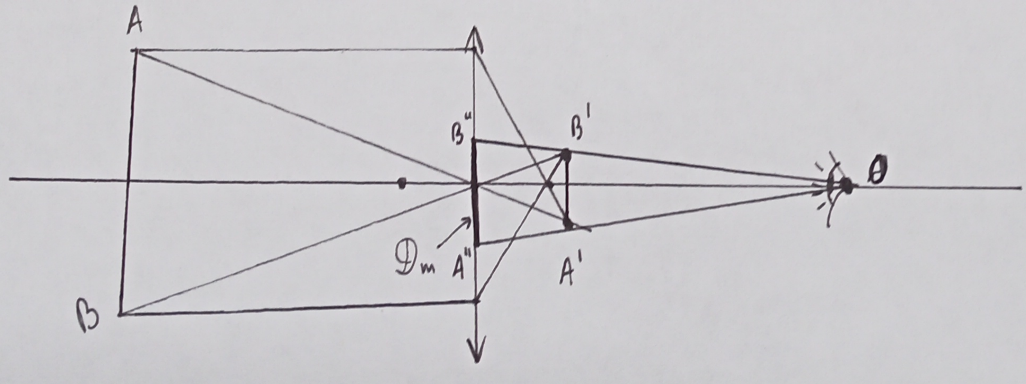
Решение:



1) $$\frac{1}{F} = \frac{1}{d} + \frac{1}{f} \; ; \quad f = \frac{dF}{d-F} = 32 \text{ см}$$

$$x = f + d_г = 32 \text{ см} + 24 \text{ см} = 56 \text{ см}$$

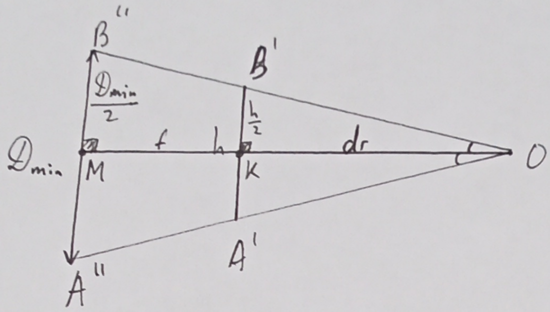
2) $$Г = \frac{f}{d} = \frac{32}{96} = \frac{1}{3} \; ; \quad h = ГH = \frac{H}{3} = 3 \text{ см}$$



См. лист 7

Чистовик

рассмотрим $\triangle A'B'O$ и $\triangle A''B''O$:



$OK = d_r$

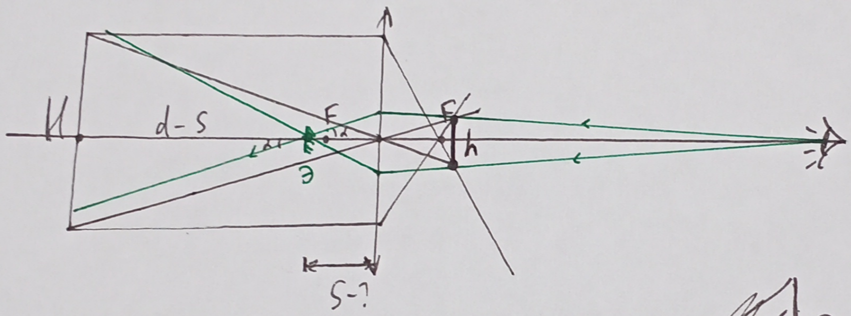
$MK = f$

$OM = d_r + f$

$$\triangle A'B'O \sim \triangle A''B''O \Rightarrow \frac{D_{min} \cdot 2}{2h} = \frac{f + d_r}{d_r} \; ; \quad D_{min} = \frac{f + d_r}{d_r} h$$

$$D_{min} = \frac{32 + 24}{24} \cdot 3 = 7 \text{ см}$$

3)



$$\frac{1}{F} = \frac{1}{x} + \frac{1}{S}$$

$$S = \frac{xF}{x - F} = 42 \text{ см}$$

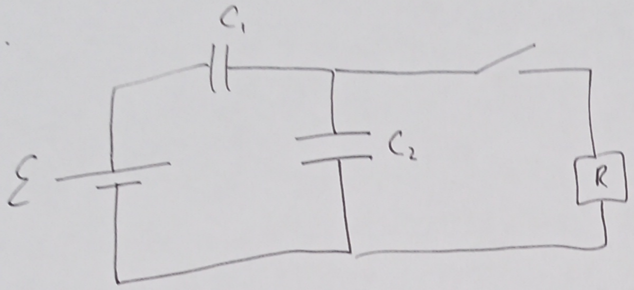
Ответ: 1) $x = 56$ см; 2) $D_m = 7$ см; 3) $S = 42$ см

7

См. лист 8

Чистовик

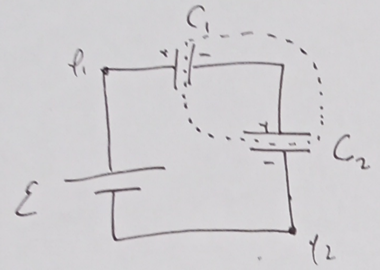
№3.



Дано:
$C_1 = 5C$
$C_2 = C$ $\quad I_0$

1) I_R - ?
2) Q - ? $\quad$ 3) I_R' - ?

1)



$$\left.\begin{aligned} \varphi_1 - \varphi_2 &= \mathcal{E} \\ \varphi_1 - \varphi_2 &= U_{C1} + U_{C2} \end{aligned}\right\} \Rightarrow \mathcal{E} = U_{C1} + U_{C2}$$

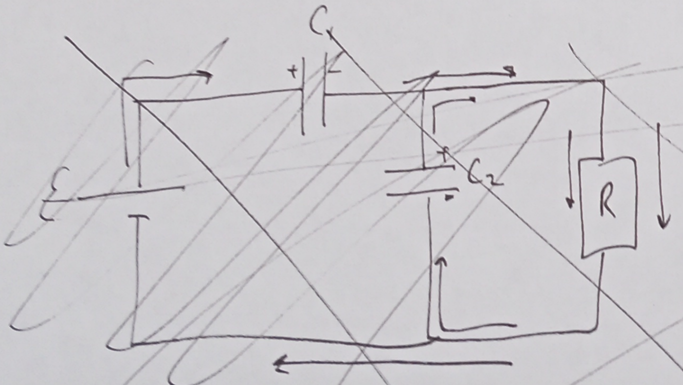
ЗС Заряда: $-C_1 U_{C1} + C_2 U_{C2} = 0$

$$C U_{C2} = 5 C U_{C1}$$

$$U_{C2} = 5 U_{C1}$$

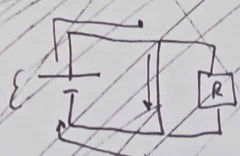
Тогда $U_{C1} + U_{C2} = 6 U_{C1} = \mathcal{E}$

$$\boxed{U_{C1} = \frac{\mathcal{E}}{6} \qquad U_{C2} = \frac{5}{6}\mathcal{E}}$$



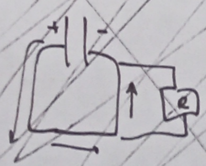
~~Решим пункт 1 методом наложения токов~~

~~1.1)~~

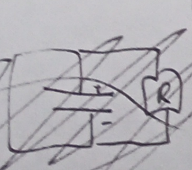


~~$I_{R\mathcal{E}} = 0$~~

~~1.2)~~



~~1.3)~~



8

ЫМ лист 9

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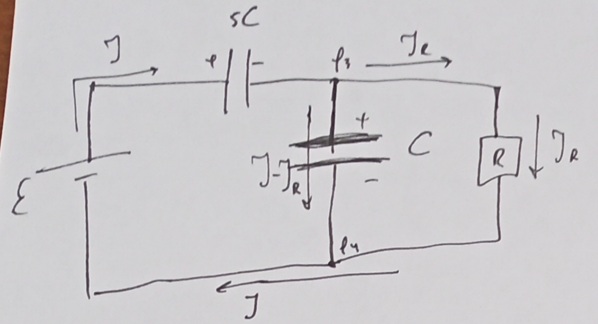
Чистовик

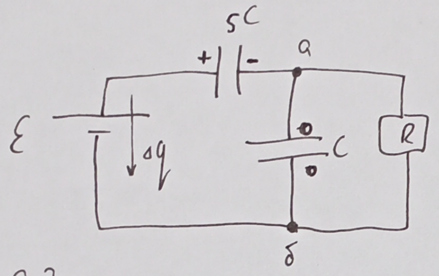


$\varphi_3 - \varphi_4 = U_{c2} = I_R R$

$I_R = \frac{U_{c2}}{R} = \frac{5\mathcal{E}}{6R}$

2) ЗСЭ: $\frac{5CU_{c1}^2}{2} + \frac{CU_{c2}^2}{2} + A_{ист} = Q + \frac{5CU_{c1}'^2}{2}$

уст. режим:



$\cancel{\varphi_a - \varphi_б = \mathcal{E} - U_{c2}'}$

$\varphi_a - \varphi_б = 0 = \mathcal{E} - U_{c1}'$

$U_{c1}' = \mathcal{E}$

ЗСЗ:

~~рассмотрим~~ $0 = -\Delta q + (-5C\mathcal{E})$

$\Delta q = -5C\mathcal{E}$; $A_{ист} = -\Delta q\,\mathcal{E} = 5C\mathcal{E}^2$

$5CU_{c1}^2 + CU_{c2}^2 + 10C\mathcal{E}^2 = 2Q + 5CU_{c1}'^2$

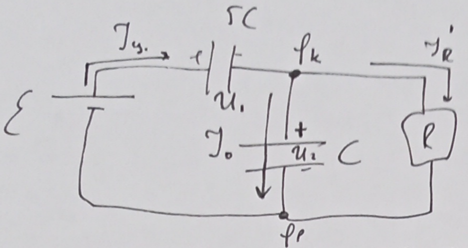
$\frac{1}{2}\left(5C\cdot\frac{\mathcal{E}^2}{36} + C\cdot\frac{25\mathcal{E}^2}{36} + 10C\mathcal{E}^2 - 5C\mathcal{E}^2\right) = Q$

$Q = \frac{1}{2}\left(\frac{5}{6}C\mathcal{E}^2 + 5C\mathcal{E}^2\right) = \frac{C\mathcal{E}^2}{2}\cdot\frac{35}{6} = \frac{35}{12}C\mathcal{E}^2$

см. лист 10

Чистовик

3)



$J_y = J_0 + J_R'$

Т.к. ток ч/з конд. $C_2 = C$ равен J_0, то ток ч/з конд. $C_1 = 5C$ равен $5J_0$.

$J_R' = 5J_0 - J_0 = 4J_0$

Ответ: 1) $J_R = \frac{5\mathcal{E}}{6R}$

2) $Q = \frac{35}{12} C\mathcal{E}^2$

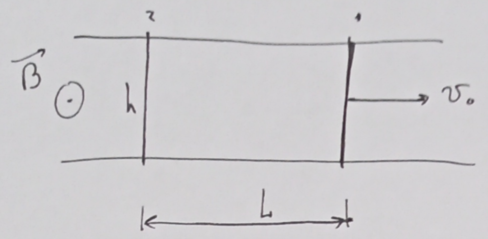
3) $J_R' = 4J_0$.

См. лист 11

10

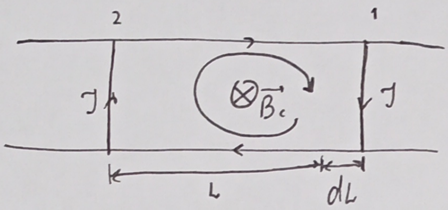
Чистовик

№4.



Дано:
$m_1 = 2m$, $R_1 = R$
$m_2 = \frac{m}{2}$, $R_2 = 5R$
$v_{01} = v_0$, B, L

1) a_0 - ?



$\Delta S_{\text{контура}} \uparrow \Rightarrow \vec{B_c} \uparrow\downarrow \vec{B}$

по г правилу Кирхгофа: $\mathcal{E}_i = I(5R+R) = 6IR$

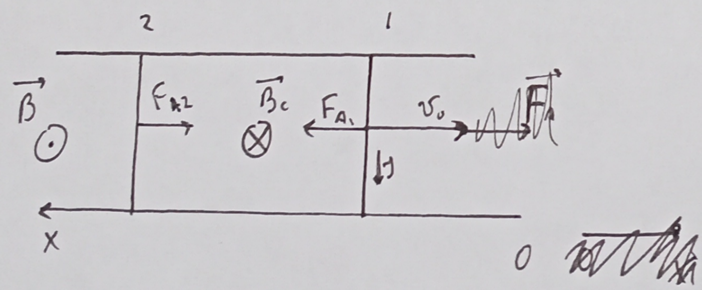
$\mathcal{E}_i = \frac{d\varphi}{dt}$; $d\varphi = B\,dS$

$dS = dL\,h$

$dL = v_0 dt + \cancel{\frac{a_0 (dt)^2}{2}}^{\,0}$

$6IR = \frac{B h v_0 dt}{dt} = B h v_0$

$\cancel{B}h = \frac{6IR}{v_0 B}$

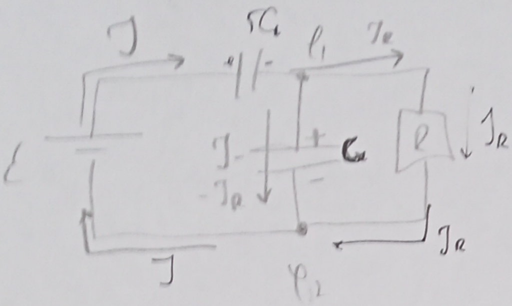


$OX:\ F_{A_1} = 2ma_0$

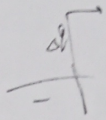
$IBh = 2ma_0$

$$a_0 = \frac{IBh}{2m} = \frac{IB\cdot 6IR}{2m\cdot v_0 B} = \frac{3I^2R}{mv_0}$$

11



$I_R' = I - I_0$

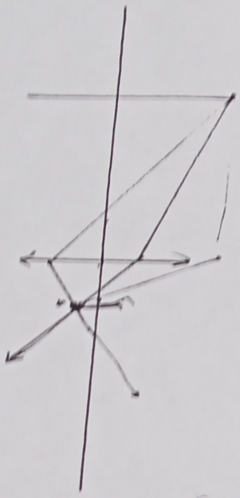


$5C\mathcal{E} - \frac{5}{6}C\mathcal{E}$

$U_{C2} = I_R R = -U_{C1}' + \mathcal{E}$

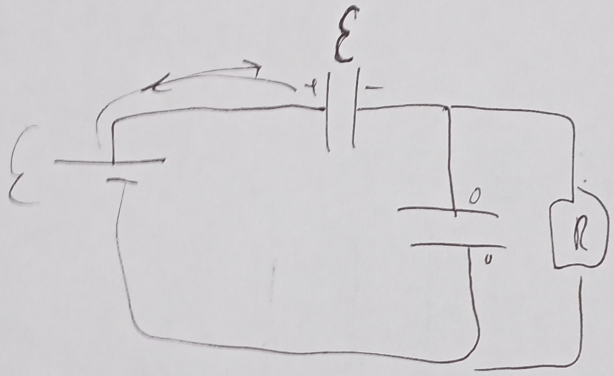
C_1

$\Delta q \; \frac{25}{6} C\mathcal{E}$



$\frac{5\mathcal{E}C}{6}$ $\quad \frac{25}{3}C\mathcal{E}$

$5C\frac{\mathcal{E}}{6}$ $\quad 0 \quad -5C\mathcal{E}$



$\frac{5}{6}\mathcal{E}C$

$\mathcal{E}C$

32

$\mathcal{E}C - \frac{5}{6}\mathcal{E}C$

$\frac{5C\mathcal{E}}{6}$ $\quad 5C\mathcal{E}$

$\frac{1}{6}\mathcal{E}C$

npu $\quad -5C$

$A = \frac{\mathcal{E}^2 C}{6}$

$\Delta q = -5C\mathcal{E}$

$\Delta q = -5C\mathcal{E} - 0$

$q = 0 + \Delta q$

δ ...

$0 =$

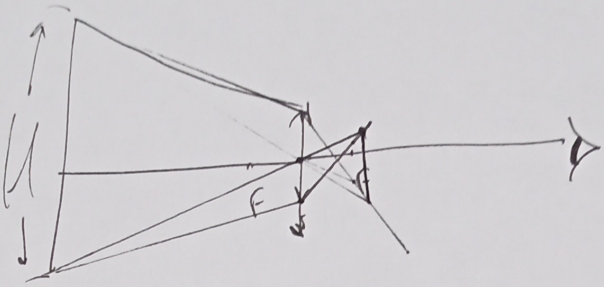
$\frac{5}{6} + \frac{5 \cdot 6}{6}$

$\frac{5}{36} + \frac{25}{36} = \frac{30}{36} = \frac{5}{6}$ $\quad -5C\mathcal{E}$

Черновик

$H = AB$

$\otimes \vec{B}_{инд.}$



$\frac{1}{C_{1,5ч}} = \frac{5}{5C} + \frac{1}{5C} = \frac{6}{5C}$

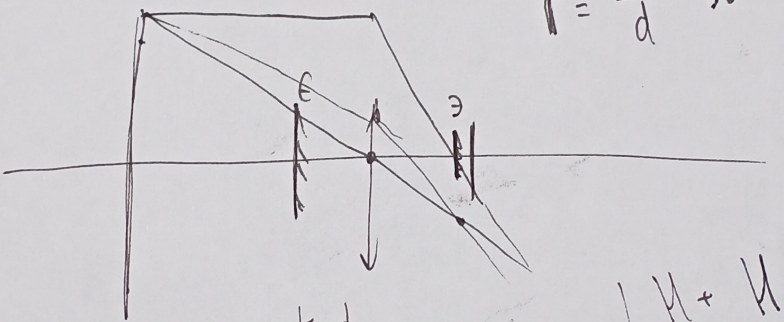
$\frac{5}{6} C$

$d_г = 24 см$

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

$f = \frac{Fd}{d-F} = \frac{24 \cdot 96}{96-24} = 32 см$

$Г = \frac{f}{d} = \frac{32}{96} = \frac{1}{3}$



$S - ?$

$LH + H$

$dL = v_0 dt + \frac{a(dt)^2}{2}$

$\varepsilon_i = Blv =$

$6JR = Bvh$ $\frac{6JR}{v}$

$=$

$\frac{6RJ^2}{v_0}$

$a_0 = JBh$

~~Чистовик~~

Черновик

$C \to J_0$

$5C \to 5J_0$

Чарновик

2) $v_{к1} = 0$

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$F_{A2} = IBh = \frac{m}{2} a_2$

$IBh = Ih \cdot B$ $\qquad$ $IhB = \frac{6 I^2 R}{v_0}$

$I_2 R$ $\quad 6 I R = B h v_0$ $\qquad$ $\frac{6 I^2 R}{v_0}$

$I_0 \, dt = C U_2$ $\qquad$ $0 = I_0 \, dt$

$I \, dt = 5 C U_1$ $\qquad$ $I(dt)$

$\frac{I}{I_0} = \frac{5 U_1}{U_2}$

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