Часть 1

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

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ID профиля: **227794**

Вариант 4

Чистовик

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

1) По модулю величина Q_1 такая же, как и при нагревании от $\frac{3}{4}T_0$ до T_0

$$dQ = C(T) \cdot \nu \cdot dT$$

$$Q_1 = \int_{\frac{3}{4}T_0}^{T_0} C(T) \cdot \nu \cdot dT = \int_{\frac{3}{4}T_0}^{T_0} \frac{9}{5} R \frac{T}{T_0} \nu dT = \frac{9}{5} \cdot \frac{R\nu}{T_0} \int_{\frac{3}{4}T_0}^{T_0} T dT =$$

$$= \frac{9}{5} \frac{R\nu}{T_0} \left(\frac{T_0^2}{2} - \frac{\left(\frac{3}{4}T_0\right)^2}{2} \right) = \frac{9}{10} \frac{R\nu}{T_0} \left(T_0^2 - \frac{9}{16} T_0^2 \right) = \frac{9}{10} \frac{R\nu}{T_0} \cdot \frac{7}{16} T_0^2 =$$

$$= \frac{63}{160} R\nu T_0 ; \quad \text{Ответ: } \frac{63}{160} R\nu T_0$$

2) $A = Q + \Delta U = C\nu_0 T + \frac{i}{2} \nu R_0 T = \nu \left(C(T)_0 T + \frac{3}{2} R_0 T \right)$; $Q > 0$, $\Delta U < 0$

$$\frac{A(T)}{\nu} = \int_{T_1}^{T_0} \frac{9}{5} R \frac{T}{T_0} dT + \frac{5}{2} R (T_0 - T_1), \text{ продифференцируем по } dT:$$

T_1

Отсюда

$$A' = \left(\frac{9}{5} \frac{R}{T_0} \cdot \left(\frac{T_0^2 - T_1^2}{2} \right) \right)' + \left(\frac{5}{2} R (T_0 - T_1) \right)' =$$

$$= -\frac{9}{10} \frac{R}{T_0} \cdot 2T_1 + \frac{5}{2} R \cdot 0 = -\frac{9}{5} \frac{R}{T_0} \cdot T_1 - \frac{5}{2} R$$

$A'(T_1) = 0$, $T_1 =$

$$\frac{A(T)}{\nu} = \int_{T_1}^{T_0} \frac{9}{5} R \frac{T}{T_0} dT + \frac{5}{2} R (T_1 - T_0), \text{ продифференцируем по } dT$$

$$\frac{A'(T)}{\nu} = -\frac{9}{5} \frac{R}{T_0} \cdot T_1 + \frac{5}{2} R; \quad A'(T_1) = 0 \text{ (минимум)}$$

$$\frac{9}{5} \frac{R}{T_0} T_1 = \frac{5}{2} R; \quad T_1 = \frac{5}{2} \cdot \frac{5}{9} T_0 = \frac{15}{18} T_0$$

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Ответ: $T_1 = \frac{15}{18} T_0$

Чистовик

3) $T_1 = \frac{15}{16} T_0$

$$A = \int_{\frac{15}{16}T_0}^{T_0} \frac{2}{5} R \frac{T\nu}{T_0} dT + \nu R \left(\frac{15}{16} T_0 - T_0\right) =$$

$$= \frac{9}{10} R \frac{\nu}{T_0} \left(T_0^2 - \frac{15^2}{16^2} T_0^2\right) + \nu R \left(-\frac{3}{16} T_0\right) = \frac{9}{10} R\nu \frac{99}{324} T_0 - \frac{9}{324} \nu R T_0 =$$

$$= \nu R T_0 \left(0{,}275 - \frac{3}{16}\right) \approx \nu R T_0 \cdot 0{,}108 = 0{,}108 \nu R T_0$$

Ответ: $A_{мин} = 0{,}106 \nu R T_0$

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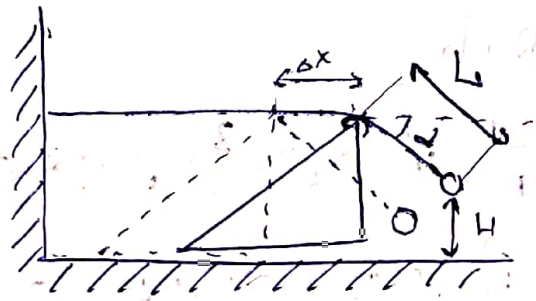
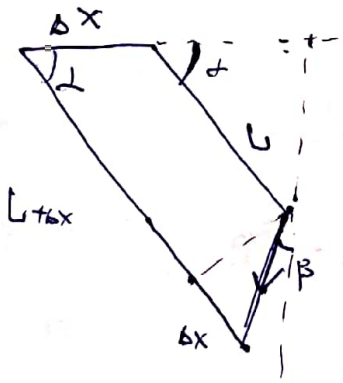




1) $\operatorname{tg}\beta = \frac{(\Delta x + L_1 \cos\alpha) - (L + \Delta x)\cos\alpha)}{(L+\Delta x)\sin\alpha - L\sin\alpha} =$

$$= \frac{\Delta x (1 - \cos\alpha)}{\Delta x \sin\alpha} = \frac{1-\cos\alpha}{\sin\alpha} =$$

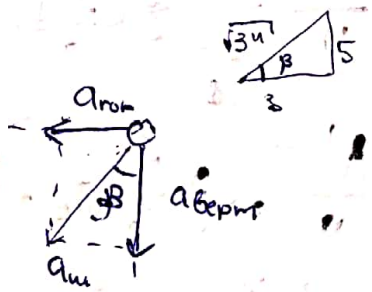
$$= \frac{1-\cos\alpha}{\sqrt{1-\cos^2\alpha}} = \frac{\frac{8}{17}}{\sqrt{1-\left(\frac{8}{17}\right)^2}} = \frac{\frac{8}{17}}{0{,}8823} =$$

$$= \frac{8}{15} = \frac{3}{5}$$

Ответ: $\operatorname{tg}\beta = \frac{3}{5}$

2. Пусть M - масса клина, m - масса шарика

$$\begin{cases} M a_{клин} = T(1-\cos\alpha) \\ m a_{верт} = mg - T\sin\alpha \\ m a_{гор} = T\cos\alpha \end{cases}$$



$a_м = \sqrt{a_{верт}^2 + a_{гор}^2}$, $a_{гор} = \frac{3}{\sqrt{34}} a_м$, $a_{верт} = \frac{5}{\sqrt{34}} a_м$

Пусть Δy - смещение шара $\Rightarrow \Delta y = \sqrt{(\Delta x(1-\cos\alpha))^2 + (\Delta x \sin\alpha)^2} =$ (2)

$$= \sqrt{2 - \frac{16}{17}}\Delta x = \sqrt{\frac{34-16}{17}}\Delta x = \sqrt{\frac{18}{17}}\Delta x \Rightarrow |a_{шар}| = \frac{\sqrt{18}}{\sqrt{17}} |a_{клина}|$$

Чистовик

$$\begin{cases} \text{Машина} \\ \frac{3}{\sqrt{34}} m a_{шара} = \frac{(1-\cos\alpha)}{\cos\alpha} = \frac{8}{8} = \frac{g}{b} \\ \frac{g - \frac{5}{\sqrt{34}} a_{шар}}{\frac{3}{\sqrt{34}} a_{шар}} = tg\alpha = \frac{15}{8}; \Rightarrow a_{шар}\left(\frac{5}{\sqrt{34}} + \frac{15}{8} + \frac{3}{\sqrt{34}}\right) = g \Rightarrow \end{cases}$$

$$a_{шар} = \frac{\sqrt{34}\cdot g}{5\left(1+\frac{3}{8}\right)} = \frac{8\sqrt{34}}{5\cdot 17} g$$

$$a_{клина} = \sqrt{\frac{17}{28}}\, a_ш = \frac{\sqrt{17}}{\sqrt{16}} \cdot \frac{8}{5} \cdot \frac{\sqrt{34}}{17} g = \frac{8\sqrt{34}g}{5\sqrt{17}\cdot 16} = \frac{46,6476}{87,4642} g =$$

$$0,5(3)g = \frac{8}{15} g \; ! \quad \text{Ответ: } a_{клина} = \frac{8}{15} g \approx \frac{78,4}{15} \approx 5,23$$

3) $$\frac{M}{m} = \frac{g\cdot 3\cdot a_{шара}}{8\cdot\sqrt{34}\cdot a_{клина}} = \frac{3\cdot 8}{8\sqrt{34}} \cdot \sqrt{\frac{16}{17}} = \frac{27}{8\cdot 17} = \frac{27}{136}$$

$$\frac{m}{m} = \frac{136}{27} \; ! \quad \text{Ответ: } \frac{m}{M} = \frac{136}{27} \approx 5,037$$

4) $$a_{верт} = \frac{5}{\sqrt{34}} a_{шар} = \frac{5}{\sqrt{34}} \cdot \frac{8\sqrt{34}}{5\cdot 17} g = \frac{8}{17} g$$

$$\frac{\frac{8}{17} g t^2}{2} = H \Rightarrow t = \sqrt{\frac{17}{4}} \cdot \frac{H}{g}$$

Ответ: $t = \frac{\sqrt{17}}{2} \cdot \frac{H}{g}$

Часть 2

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

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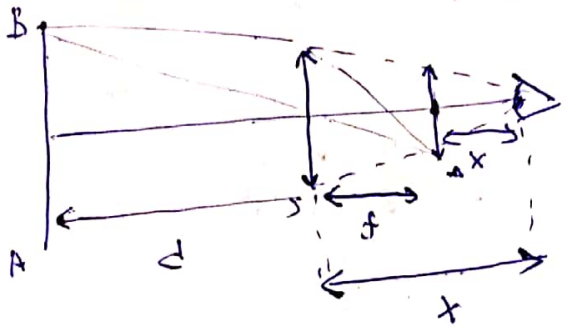
Вариант 4

Чистовик

5.

1) 

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

$f = \frac{1}{\frac{1}{F} - \frac{1}{d}} = \frac{1}{\frac{1}{24} - \frac{1}{96}} =$

$= \frac{96}{3} = 32$ см

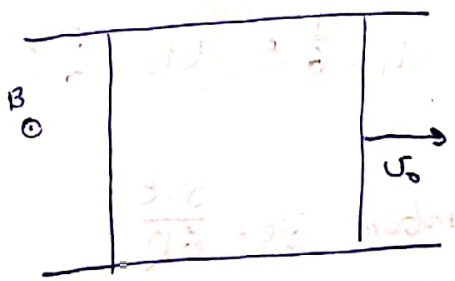
$x = f + \Delta x = 32 + 24 = 56$ см

Ответ: 56 см

2) $\frac{2D_m}{x} = \frac{2rH}{2\Delta x}$, $r = \frac{f}{d}$ (2 из подобных треугольников)

$D_m = \frac{x}{\Delta x} \cdot \frac{f}{d} \cdot H = \frac{56}{24} \cdot \frac{32}{96} \cdot 9 = 7$ см, Ответ: 7см

4.



1) $\frac{dq}{dt} = \mathcal{E} = Bv_0L$; $\mathcal{E} = \gamma \cdot 6R$; $\gamma = \frac{\mathcal{E}}{6R}$

$2ma = F_A = B\gamma L = B \cdot \frac{\mathcal{E}}{6R} \cdot L$;

$a = \frac{B\mathcal{E}L}{2m \cdot 6R} = \frac{B\mathcal{E}L}{12mR} = \frac{B^2v_0L^2}{12mR}$

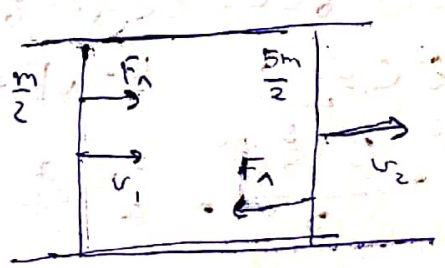
Ответ. $\frac{(BL)^2 v_0}{12mR}$

2) Заметим, что для системы из двух перемычек импульс сохраняется, так как $F_{A1} = -F_{A2} = B\gamma L$.

ЗСИ: $2mv_0 = 2{,}5mv_2$;

$v_2 = \frac{2}{2{,}5} v_0 = \frac{4}{5} v_0$; Ответ: $\frac{4}{5} v_0$

3) $\begin{cases} \frac{dq}{dt} = BL(v_1 - v_2) = 6\gamma R \\ 2mv_1' = -B\gamma L \\ \frac{m}{2} v_2' = B\gamma L \end{cases}$



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Чистовик

$v_1' - v_2' = -2{,}5\,\frac{BJL}{m}$; $J = -\frac{2}{5}\frac{m}{BL}v_{отн}'$, $v_{отн} = v_1 - v_2$

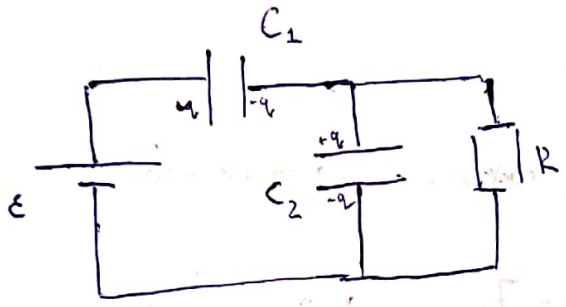
$BL\frac{dJ}{dt} = 6R\left(-\frac{2}{5}\frac{m}{BL} - \frac{dv_{отн}}{dt}\right)$;

$\Delta S = -\Delta v_{отн}\cdot\frac{12}{5}\cdot\frac{m}{(BL)^2} \Rightarrow \Delta S = \frac{12}{5}\frac{mv_0}{B^2L^2}$

$\Delta v_{отн} = -v_0$

Ответ: $\Delta S = \frac{12\,m v_0}{5\,B^2L^2}$

3.



1) Сразу после замыкания

$\begin{cases} J_1 R = \varepsilon - \frac{q_1'}{C_1} \\ J_R R = \frac{q_2}{C_2} \end{cases}$

$\varepsilon = \frac{q_1'}{C_1} + \frac{q_2}{C_2} = \frac{q_1'}{5C} + \frac{q_2}{C}$, $q_2 = \varepsilon C - \frac{q_1'}{5}$, $q_1 = q_2 = q$

$\varepsilon = \frac{q}{5C} + \frac{q}{C}$, ~~$U_1 = \frac{5}{6}\varepsilon$, $U_2 = \frac{1}{6}\varepsilon$~~ $U_1 = \frac{1}{6}\varepsilon$, $U_2 = \frac{5}{6}\varepsilon$

$\begin{cases} J_R R = \varepsilon - \frac{1}{6}\varepsilon = \frac{5}{6}\varepsilon \\ J_R = \frac{5\varepsilon}{6R} \end{cases}$; Ответ: $J_R = \frac{5\varepsilon}{6R}$

2) ~~$P = J_R^2(t)R$, $Q = J_R^2(t)R\cdot t$~~

~~$E_0 = C_1\left(\frac{1}{6}\varepsilon\right)^2 : 2 + C_2\left(\frac{5}{6}\varepsilon\right)^2 : 2$~~

В равновесной ситуации:

$\varepsilon = \frac{q_1(t^*)}{5C}$, $q_1(t^*) = \varepsilon\cdot 5C$; $q_1(t_0) = \frac{5}{6}\varepsilon C$

$\Delta q = 5\varepsilon C - \frac{5}{6}\varepsilon C = \varepsilon C\left(5 - \frac{5}{6}\right) = \frac{25}{6}\varepsilon C$

$A_\varepsilon = \frac{25}{6}\varepsilon^2 C = q\varepsilon$; $A = \Delta E + Q$

$\frac{5C\cdot\left(\frac{1}{6}\varepsilon\right)^2}{2} + \frac{C\cdot\left(\frac{5}{6}\varepsilon\right)^2}{2} + \frac{25}{6}\varepsilon^2 C = Q + \frac{\left(\frac{5}{6}\varepsilon\right)^2 C}{2}$

(2)

Чистовик

$$5C \cdot \frac{1}{36}\mathcal{E}^2 + C \cdot \frac{25}{36}\mathcal{E}^2 + \frac{25}{3}\mathcal{E}^2 C - \frac{25}{36}\mathcal{E}^2 C = Q$$

$$Q = \mathcal{E}^2 C\left(\frac{5}{36} + \frac{25}{3}\right) = \frac{305}{36}\mathcal{E}^2 C$$