Часть 1

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

Шифр: **21200353**

ID профиля: **291808**

Вариант 4

Чистовик

2. Дано:

ν; T_0; $T_x = \frac{3}{4}T_0$;

$i=3$

1) $Q_1 = \left| C(T_x)\nu(T_x - T_0) \right| =$

$= \left| \frac{9}{5}R \cdot \frac{T_x}{T_0} \cdot \nu(T_x - T_0) \right| =$

$= \left| \frac{9}{5}R \cdot \frac{3}{4} \cdot \nu \cdot \left(-\frac{1}{4}\right) \cdot T_0 \right| =$

$= \left| \left(-\frac{27}{80}\right) \nu R T_0 \right| = \frac{27}{80}\nu R T_0$

2) $Q = \Delta U + A$

$$\frac{9}{5}\nu R \frac{T(T-T_0)}{T_0} = \frac{3}{2}\nu R(T-T_0) + A$$

$$A = \nu R(T-T_0)\left(\frac{9}{5}\frac{T}{T_0} - \frac{3}{2}\right) = \frac{9}{5}\nu R\frac{T^2}{T_0} - \frac{3}{2}\nu RT -$$

$$-\frac{9}{5}\nu RT + \frac{3}{2}\nu RT_0 = \frac{9}{5}\nu R\frac{T^2}{T_0} - \frac{33}{10}\nu RT + \frac{3}{2}\nu RT_0$$

$A(T)$ — парабола с ветвями вверх; $T_{min} = \dfrac{\frac{33}{10}\nu R}{\frac{18}{5}\frac{\nu R}{T_0}} =$

$$= \frac{\frac{33}{10}\nu R \cdot 5T_0}{18\nu R} = \frac{33 \cdot 5T_0}{18 \cdot 10} = \frac{11}{12}T_0$$

3) $A_{min} = \frac{9}{5}\frac{\nu R}{T_0} \cdot \frac{121}{144}T_0^2 - \frac{33}{10}\nu R \cdot \frac{11}{12}T_0 + \frac{3}{2}\nu RT_0 =$

$$= \frac{121}{80}\nu RT_0 - \frac{121}{40}\nu RT_0 + \frac{3}{2}\nu RT_0 =$$

$$= -\frac{1}{80}\nu RT_0$$

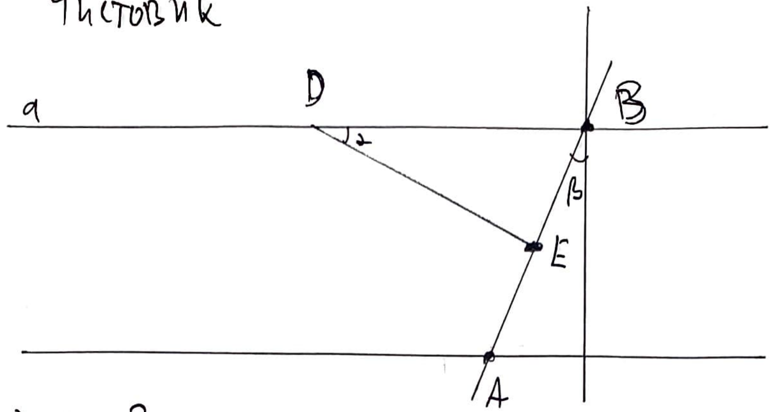
Ответ: 1) $\frac{27}{80}\nu RT_0$; 2) $\frac{11}{12}T_0$; 3) $-\frac{1}{80}\nu RT_0$

1

Чистовик

1. Дано:

$\cos\alpha = \frac{8}{17}$; M



1) $\beta = ?$

Если передвигать точку D по прямой a, а точку E по отрезку AB так, чтобы $\angle EDB = const = \alpha$, то можно выбрать такое расположения точек, чтобы $DE = DB$. Тогда $\angle DBE = 90^\circ - \frac{\alpha}{2}$; $\beta = \frac{\alpha}{2}$.

$\sin\beta = x$

$\frac{15}{17} = 2x\sqrt{1-x^2}$

$\frac{225}{289} = 4x^2(1-x^2) \to 4x^2 - 4x^4 = \frac{225}{289}$

$t = x^2$

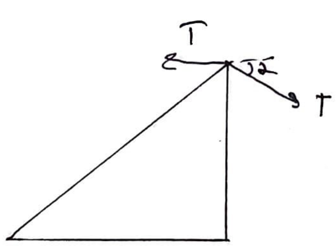
$4t^2 - 4t + \frac{225}{289} = 0$

$D = 16 \cdot \frac{64}{289}$

$t = \frac{4 \pm \frac{32}{17}}{8} = \frac{1}{2} \pm \frac{4}{17} \to \sin\beta = \frac{3}{\sqrt{34}} \to \operatorname{tg}\beta = \frac{3}{5}$

2

2)



$Ma = T(1-\cos\alpha)$

$T\cos(\alpha-\beta) = mg\sin\beta$

$T\cos\beta = mg\sin\beta$

$T = mg\operatorname{tg}\beta$

M – масса клина
m – масса шара
a – ускорение клина

Чистовик

~~a_m - ускорение клина~~

a_m - ускорение шара

$$ma_m = mg\cos\beta - T\sin(\alpha-\beta) = mg\cos\beta - T\sin\beta$$

$$a_m = a\frac{\sin\alpha}{\cos\beta}$$

$$\begin{cases} ma\dfrac{\sin\alpha}{\cos\beta} = mg\cos\beta - T\sin\beta \\ Ma = T(1-\cos\alpha) \\ T = mg\,tg\,\beta \end{cases}$$

$$ma\frac{\sin\alpha}{\cos\beta} = mg\cos\beta - mg\,tg\,\beta\sin\beta$$

$$a = g\frac{\cos^2\beta}{\sin\alpha} - g\frac{tg\,\beta\sin\beta\cos\beta}{\sin\alpha}$$

$$a = \frac{g}{\sin\alpha}(\cos^2\beta - \sin^2\beta) =$$

$$= \frac{g}{\sin\alpha}\cdot\cos 2\beta = \frac{g}{tg\,\alpha} = \frac{8}{15}g$$

3) $Ma = mg\,tg\,\beta(1-\cos\alpha)$

$$\frac{m}{M} = \frac{a}{g\,tg\,\beta(1-\cos\alpha)} = \frac{\frac{8}{15}}{\frac{3}{5}\cdot\frac{9}{17}} = \frac{\frac{8}{15}\cdot 5\cdot 17}{3\cdot 9} = \frac{8\cdot 5\cdot 17}{15\cdot 3\cdot 9} =$$

$$= \frac{136}{81}$$

3

4) $$a_m = \frac{8}{15}g\cdot\frac{\frac{15}{17}}{\frac{5}{\sqrt{34}}} = g\cdot\frac{8}{15}\cdot\frac{15\cdot\sqrt{34}}{5\cdot 17} = g\cdot\frac{8}{5}\cdot\frac{\sqrt{2}\cdot\sqrt{17}}{\sqrt{17}\sqrt{17}} =$$

$$= \frac{8}{5}\cdot\sqrt{\frac{2}{17}}\,g \qquad S = \frac{H}{\cos\beta} = \frac{\sqrt{34}}{5}\cdot H$$

$$S = \frac{a_m t^2}{2} \qquad t = \sqrt{\frac{2S}{a_m}} = \sqrt{\frac{\frac{2}{5}\sqrt{34}\cdot H}{\frac{8}{5}\cdot\frac{\sqrt{2}}{\sqrt{17}}g}} = \sqrt{\frac{H}{g}}\cdot\sqrt{\frac{2\sqrt{2}\sqrt{17}\cdot 5\cdot\sqrt{17}}{8\cdot 5\cdot\sqrt{2}}} =$$

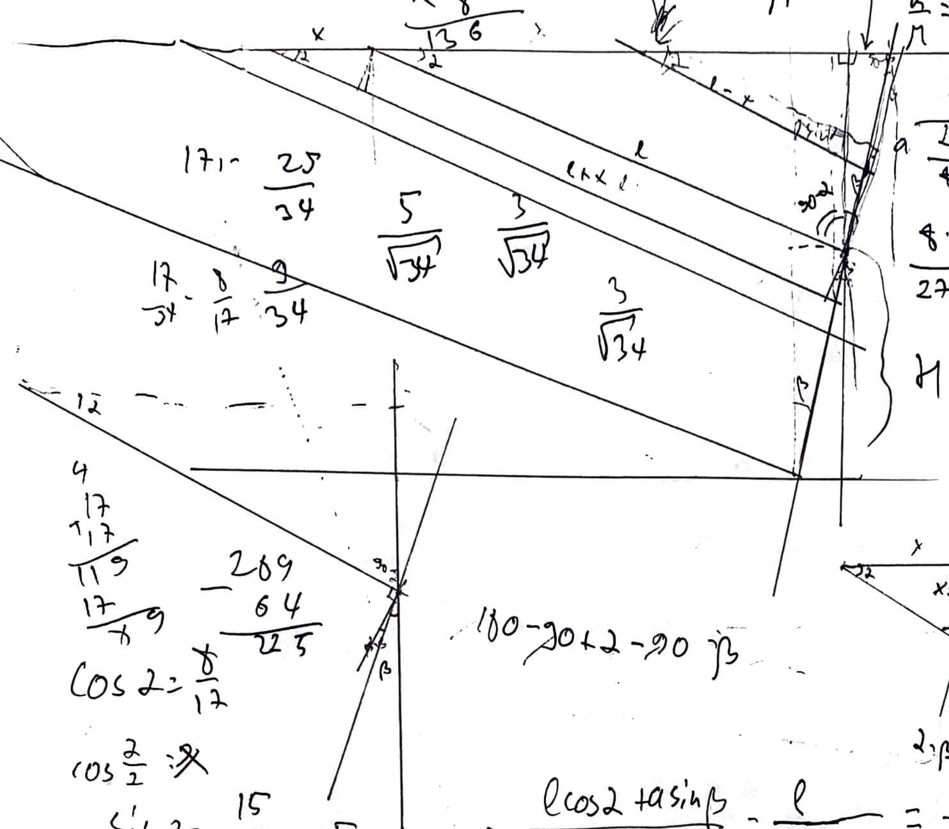
$$= \sqrt{\frac{H}{g}}\cdot\sqrt{\frac{17}{4}} = \frac{\sqrt{17}}{2}\sqrt{\frac{H}{g}}$$

Ответ: 1) $tg\,\beta = \frac{3}{5}$; 2) $a = \frac{8}{15}g$; 3) $\frac{m}{M} = \frac{136}{81}$; 4) $\frac{\sqrt{17}}{2}\sqrt{\frac{H}{g}}$

$M \cdot \frac{8}{15} g = mg \cdot \frac{3}{5} \cdot \frac{9}{17}$ $\quad \frac{15}{31} \quad \frac{30}{34} \quad \frac{15}{17}$

$\frac{3}{16} \quad \frac{9}{5} \quad \frac{27}{80} \qquad \frac{\sin\beta}{\cos\beta} \cdot \cos\beta \cdot \sin\beta$

$l\cos\alpha \qquad \frac{m}{M} = a\sin\beta \qquad \frac{m}{M} = \frac{\frac{8}{15}}{\frac{3}{5}\cdot\frac{9}{17}} \qquad \sin\alpha = \frac{15}{17} \qquad \cos\alpha = \frac{8}{17} \qquad \tan\alpha = \frac{15}{8}$



$\frac{\frac{8}{15}}{\frac{27}{85}} \qquad \frac{8 \cdot 85}{27 \cdot 15} \quad 317 \qquad \frac{136}{81} = 2x\sqrt{1-x^2}$

$17 - \frac{25}{34} \qquad \frac{5}{\sqrt{34}} \qquad \frac{3}{\sqrt{34}} \qquad \frac{3}{\sqrt{34}}$

$\frac{17}{34} \cdot \frac{8}{17} \quad \frac{9}{34}$

M

$\sin\cos\beta = x\sin\alpha$

$x\sin\alpha \qquad \sin = \frac{x\sin\alpha}{\cos\beta} \qquad \frac{x\sin\alpha}{\cos\beta} = x \qquad a_n = \frac{a\sin\alpha}{\cos\beta}$

$\frac{17 \cdot 17}{119}$

$289 - 64 = 225$

$180 - 90 + \alpha - 90 \quad \beta$

$\cos\alpha = \frac{8}{17}$

$\cos\frac{\alpha}{2} =$

$S_a = x$

$S_m = x$

$\sin\alpha = \frac{15}{17}$

$\frac{15}{17} = 2\sin\frac{\alpha}{2}\cos\frac{\alpha}{2}$

$\frac{l\cos\alpha + a\sin\beta}{\sin(90-\alpha+\beta)} = \frac{l}{\sin(90-\beta)} = \frac{a}{\sin\alpha}$

$\sin\frac{\alpha}{2} = x$

$\cos\beta = \frac{l}{a}\sin\alpha$

$\frac{l\cos\beta + a\sin\beta}{\cos(\beta - \beta)} \qquad \frac{l\cos\alpha + a\sin\beta}{\cos(\beta - \alpha)} = \frac{l}{\cos\beta}$

$\sin(90 - (\alpha - \beta))$

$\frac{l\cos\alpha + a\sin\beta}{\cos(\alpha - \beta)} = \frac{l}{\cos\beta} = \frac{a}{\sin\alpha} \qquad \frac{2 \cdot 5 \cdot \sqrt{2} \cdot \sqrt{17}}{8 \cdot 5 \cdot \sqrt{2}} = \frac{17}{4}$

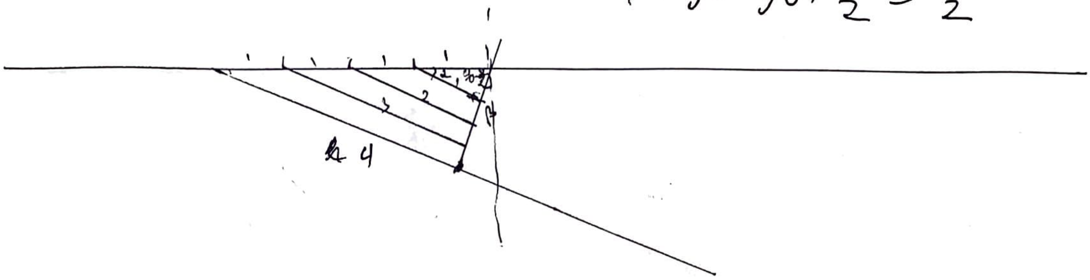
$l\cos\alpha + a\sin\beta \qquad a = \frac{\sin\alpha}{\cos\beta} l$

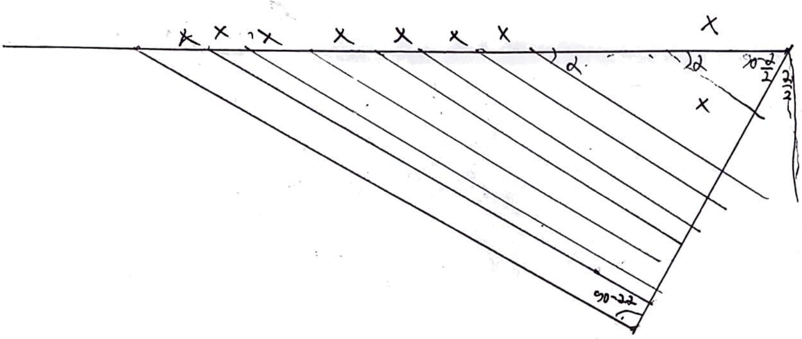
$16 - 4 \cdot 4 \cdot \frac{225}{289} \qquad \frac{l\cos\alpha + l\sin\alpha \cdot \tan\beta}{\cos\alpha\cos\beta + \sin\alpha\sin\beta} = \frac{l}{\cos\beta} \qquad \frac{\sin\beta}{\cos\beta} \cdot \cos\beta$

$16\left(1 - \frac{225}{289}\right) =$

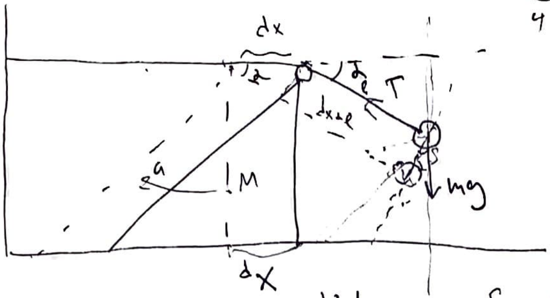
$= 16 \cdot \frac{64}{289} \qquad l\cos\alpha\cos\beta + l\sin\alpha\sin\beta$

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





$\frac{11}{4} \cdot \frac{11}{10} \quad \frac{121}{?}$



$m\bar{a} = \bar{T} + m\bar{g}$

$\bar{a} = \frac{\bar{T}}{m} + \bar{g}$

$S = dx \sin\alpha$

$m\bar{a}_\perp =$

$-\frac{121}{80} + \frac{3}{2}$

$\frac{-121+120}{80}$

$121-2$

$-\frac{1}{80}$

$\frac{144}{12}$ $\frac{3}{148}$ $\frac{3}{170}$ $\frac{1}{16}$ $\frac{121}{5 \cdot 16}$ $\frac{121}{80}$

$C(T) =$

$\frac{3}{2} + \frac{9}{5} \quad \frac{15+18}{10} = \frac{33}{10}$

$\frac{\cancel{33}^{11} \cdot \cancel{5}^{1}}{\cancel{18}_{6} \cdot \cancel{10}_{2}} = \frac{11}{12}$

$\frac{Q}{\nu T} = \frac{9}{5} R \frac{T}{T_0}$

$Q = \frac{9}{5} R \nu \frac{T^2}{T_0}$

$\frac{Q}{\nu(T-T_0)} = \frac{9}{5} R \frac{T}{T_0}$

$Q = \frac{9}{5} \nu R \frac{T(T-T_0)}{T_0}$

$Q = \frac{9}{5} \nu R \cdot \frac{\frac{3}{4}T_0 (T_0 - \frac{3}{4} T_0)}{T_0} =$

$C(T) =$

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

$\frac{27}{20} R T_0$

$\frac{9}{5} R \rightarrow \frac{27}{20} R$

$= \frac{3}{4} \cdot \frac{1}{4} T_0 = \frac{9}{5} \cdot \frac{3}{16} \nu R T_0 =$

$= \frac{27}{80} \nu R T_0$

$- \nu R \cancel{T_0} \cdot \frac{9}{5} \frac{T}{\cancel{T_0}}$

$-\frac{9}{5} \nu R T$

$\frac{9}{5} \nu R \frac{T(T-T_0)}{T_0} = \frac{3}{2} \nu R (T - T_0) + A_{min}$

$\frac{3}{2} - \frac{9}{5} \quad \frac{15-18}{10} = -\frac{3}{10}$

$A_{min} = \nu R (T - T_0) \left(\frac{9}{5} \frac{T}{T_0} + \frac{3}{2}\right)$

$A_{min} = (\nu R T - \nu R T_0)\left(\frac{9}{5}\frac{T}{T_0} + \frac{3}{2}\right) = \frac{9}{5} \nu R \frac{1}{T_0} \cdot T^2 - \frac{9}{5} \nu R T +$

$+ \frac{3}{2} \nu R T - \frac{3}{2} \nu R T_0$

$\frac{9}{5} \frac{\nu R}{T_0} T^2 - \frac{3}{10} \nu R T - \frac{3}{2} \nu R T_0$

$\frac{3}{36} \quad \frac{180}{18} \quad \frac{5}{60}$

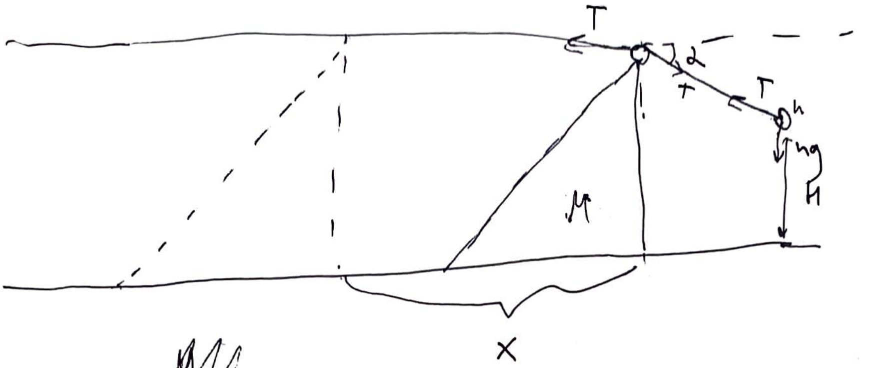
$T_{min} = \frac{\frac{3}{10} \nu R}{\frac{18}{5} \frac{\nu R}{T_0}} = \frac{\frac{3}{10} \nu R \cdot 5 T_0}{18 \nu R} = \frac{15 \nu R T_0}{180 \nu R} = \boxed{\frac{1}{12} T_0}$

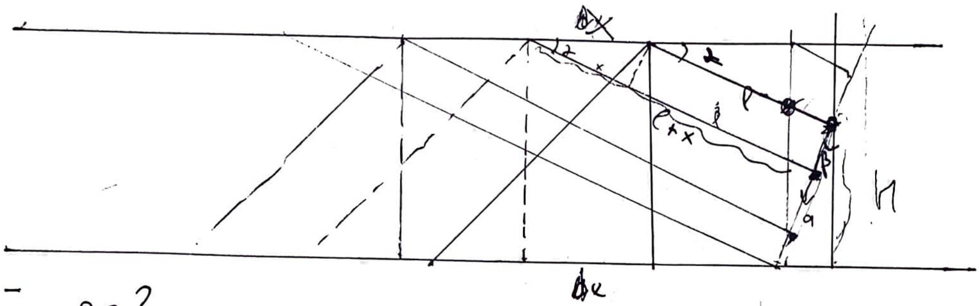
$\frac{180}{20} \quad \frac{5}{36}$

$A_{min} =$

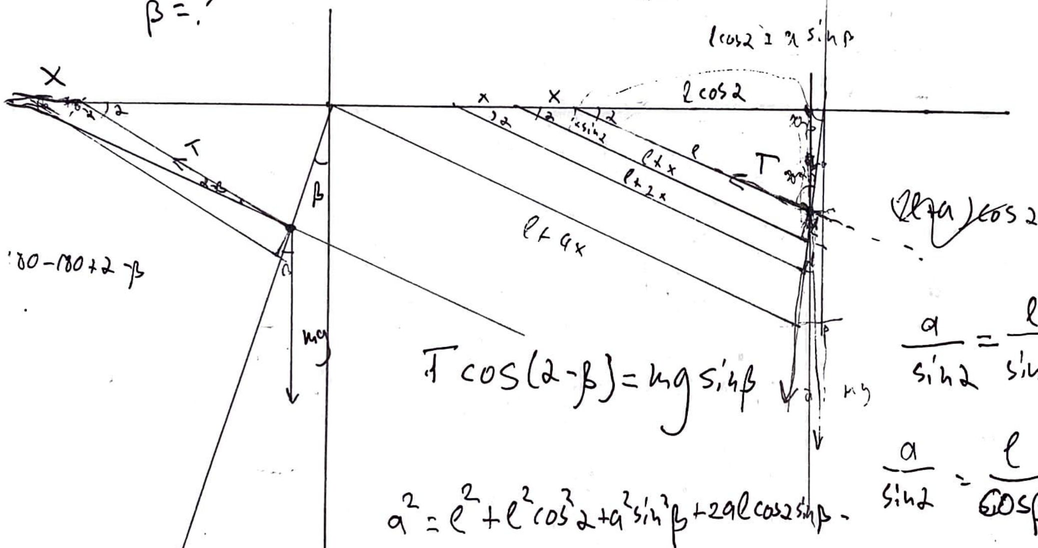
$$ma_m = mg\cos\beta - T\sin\beta$$

$$a_m = g\cos\beta - \frac{T}{m}\sin\beta$$





$\beta = ?$



$$T\cos(\alpha-\beta) = mg\sin\beta$$

$$\frac{a}{\sin\alpha} = \frac{l}{\sin(90-\beta)}$$

$$\frac{a}{\sin\alpha} = \frac{l}{\cos\beta}$$

$$a^2 = l^2 + l^2\cos^2\alpha + a^2\sin^2\beta + 2al\cos\alpha\sin\beta - 2l(l\cos\alpha + a\sin\beta)\cos\alpha$$

$$\cos\beta = \frac{l}{a}\sin\alpha$$

$$a^2 = l^2 + l^2\cos^2\alpha + a^2\sin^2\beta + \cancel{2al\cos\alpha\sin\beta} - 2l^2\cos^2\alpha - \cancel{2al\sin\beta}\cos\alpha$$

$$a^2 = l^2 - l^2\cos^2\alpha + a^2\sin^2\beta$$

$$a^2\cos^2\beta = l^2\sin^2\alpha$$

$$a\cos\beta = l\sin\alpha$$

$$\cos\beta = \frac{l}{a}\sin\alpha$$

$$\frac{l}{a} = \frac{l+x}{a+d} = \frac{l+2x}{a+2d}$$

Часть 2

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

Шифр: **21200353**

ID профиля: **291808**

Вариант 4

Чистовик

3. 1) I_1 → ток через 1-ый конденсатор

I_2 – ток через 2-ой конденсатор

I – ток через резистор

q_1 – заряд на 1-ом конд-ре. до замыкания ключа

$q_1 = q_2$ $\quad 5Cu_1 = Cu_2$

$u_2 = 5u_1$

$\mathcal{E} = u_1 + u_2$

$u_1 = \frac{\mathcal{E}}{6} \quad u_2 = \frac{5\mathcal{E}}{6}$

$u_2 = I_0 R$

$I_0 = \frac{u_2}{R} = \frac{5\mathcal{E}}{6R}$

2) $A_Б = Q + \Delta W$

$\mathcal{E} \cdot \frac{5}{6} C\mathcal{E} = Q - \frac{5C\frac{\mathcal{E}^2}{36}}{2} - \frac{C\frac{25}{36}\mathcal{E}^2}{2}$

$Q = \frac{5}{6}C\mathcal{E}^2 + \frac{5}{12}C\mathcal{E}^2 = \frac{5}{4}C\mathcal{E}^2$

1

3)

Ответ: 1) $\frac{5\mathcal{E}}{6R}$; 2) $\frac{5}{4}C\mathcal{E}^2$

Чистовик

4. 1) $2ma_1 = BIL \qquad a_1 = \frac{BL}{2m} I$

$dS = \cancel{\ }\ v_1 dt \cdot L$

$d\varphi = \cancel{\ }\ BdS = B v_1 L dt$

$\mathcal{E}_{i_1} = \cancel{\ }\ B v_1 L$

$\mathcal{E}_{i_2} = -B v_2 L$

$\mathcal{E}_{i_1} + \mathcal{E}_{i_2} = 6R \cdot I$

$I = \frac{B(v_1 - v_2)L}{6R} \qquad I(0) = \frac{B v_0 L}{6R}$

$a_1(0) = \frac{BL}{2m} \cdot \frac{B v_0 L}{6R} = \frac{B^2 v_0 L^2}{12mR}$

2) $a_1 = \frac{B^2 (v_1 - v_2) L^2}{12mR} \qquad a_2 = -\frac{B^2 (v_1 - v_2) L^2}{3mR}$

$\frac{a_1}{a_2} = \frac{1}{4} \qquad 4a_1 = a_2$

$4\frac{dv_1}{dt} = -\frac{dv_2}{dt}$

$4\,dv_1 = -dv_2$

$4\int_{v_0}^{v_x} dv_1 = -\int_0^{v_x} dv_2$

$4(v_x - v_0) = -v_x \qquad 4v_x - 4v_0 = -v_x$

$5v_x = 4v_0$

$v_x = \frac{4}{5} v_0$

3) $a_{отн} = \frac{5}{12} \frac{B^2 v_{отн} L^2}{mR} \qquad c = \frac{5}{12} \frac{B^2 L^2}{mR} \qquad a_{отн} = c\, v_{отн}$

$\frac{dv}{dx} = v\frac{dv}{dt} = cv^2 \qquad \frac{dv}{v^2} = c\,dx$

$c\int^{x_1} dx = \int^{0} \frac{1}{v^2} dv \qquad c\Delta x =$

Ответ: 1) $\frac{B^2 L^2 v_0}{...}$; 2) $\frac{4}{5} v_0$

21000353 (U291808 M1263598)