Часть 1

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

Шифр: **21203599**

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Вариант 4

№1

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

H

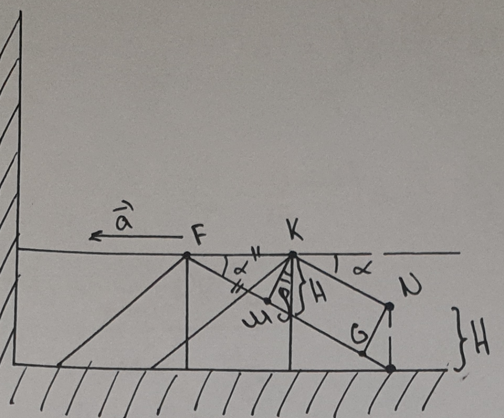
$\varphi = ?$

$a = ?$

$\frac{m}{M} = ?$

$t = ?$

Чистовик



$FM = FK$;

$KN = MG$;

$\vec{a} \parallel KM$

$\cos\varphi = \cos\frac{\alpha}{2} = \sqrt{\frac{1+\cos\alpha}{2}} = \frac{5}{\sqrt{34}}$

ЗСЭ:

$mgH = \frac{mv^2}{2}$, где v – скорость шарика перед падением

~~$H = \frac{at^2}{2}$~~

$v = \sqrt{2gH}$;

$\cos\varphi = \frac{a_{шарика}}{g} \Rightarrow a_{шарика} = \frac{5}{\sqrt{34}} g$;

$H = \frac{a_{шарика} t^2}{2} \Rightarrow t = \sqrt{\frac{2H\sqrt{34}}{5g}}$;

$tg\,\alpha = \frac{15}{8}$;

$tg\,\alpha = \frac{H}{FK}$;

$FK = \frac{at^2}{2}$;

$\frac{at^2}{2} = \frac{8}{15} H \Rightarrow a = \frac{16}{15} H \cdot \frac{5g}{2H\sqrt{34}} = \frac{8}{3\sqrt{34}} g$;

Ответ: $\cos\varphi = \frac{5}{\sqrt{34}}$

$t = \sqrt{\frac{2H\sqrt{34}}{g}}$

$a = \frac{8}{3\sqrt{34}} g$

№2

Чистовик

$T_0;\ \nu$

$c(T)=\frac{9}{5}R\cdot\frac{T}{T_0}$

$T_1=\frac{3}{4}T_0$

$Q_1=?$

$T=?$

$A_{min}=?$

$$Q_1=-\nu\int_{T_0}^{T_1}c(T)\,dT=\int_{T_1}^{T_0}\frac{9}{5}\cdot\frac{\nu R}{T_0}T\,dT=\frac{9}{5}\cdot\frac{\nu R}{T_0}\cdot\int_{\frac{3}{4}T_0}^{T_0}T\,dT=\frac{9}{5}\cdot\frac{\nu R}{T_0}\cdot\frac{1}{2}T^2\Big|_{\frac{3}{4}T_0}^{T_0}=$$

$$=\frac{9}{10}\cdot\frac{\nu R}{T_0}\left(T_0^2-\frac{9}{16}T_0^2\right)=\frac{9}{10}\cdot\frac{\nu R}{T_0}\cdot\frac{7}{16}\cdot T_0^2=\frac{63}{160}\nu RT_0;$$

$$Q_1=\frac{63}{160}\nu RT_0$$

I начало т/д:

~~$Q=A+\Delta U;$~~

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

~~$Q=\nu\int_{T_0}^{T}c(T)\,dT=\frac{9}{10}\cdot\frac{\nu R}{T_0}(T^2-T_0^2);$~~

~~$A=\nu R\Delta T=\nu R(T-T_0);$~~

~~$\frac{9}{10}\cdot\frac{\nu R}{T_0}(T-T_0)(T+T_0)=\frac{3}{2}\nu R(T-T_0)+\nu R(T-T_0)$~~

~~$T+T_0=\frac{10}{9}T_0.$~~

~~$T=$~~

~~$T=$~~

$c_V=\frac{3}{2}R$, при $c(T)=c_V$ достигается экстремальный объем $\Rightarrow$ работа минимальна

$$\frac{3}{2}R=\frac{3\cdot 3}{5}R\cdot\frac{T}{T_0}\Rightarrow T=\frac{5}{6}T_0;$$

$$A=\nu R\Delta T=-\frac{1}{6}\nu RT_0;$$

$$T=\frac{5}{6}T_0$$

$$A=-\frac{1}{6}\nu RT_0$$

Ответ:

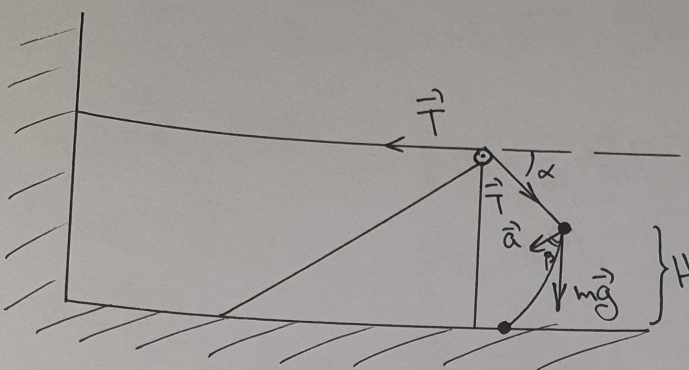
$$Q_1=\frac{63}{160}\nu RT_0$$

$$T=\frac{5}{6}T_0$$

$$A=-\frac{1}{6}\nu RT_0$$

1) $\int^{T} c(T)\,dT = \frac{9}{5}\cdot\frac{\nu R}{T_0}\int^{T} T\,dT = \frac{9}{10}\cdot\frac{\nu R}{T_0}\left(T^2 - T_0^2\right)$ $pV = \nu RT$ $p\,dV = \nu R\,dT$

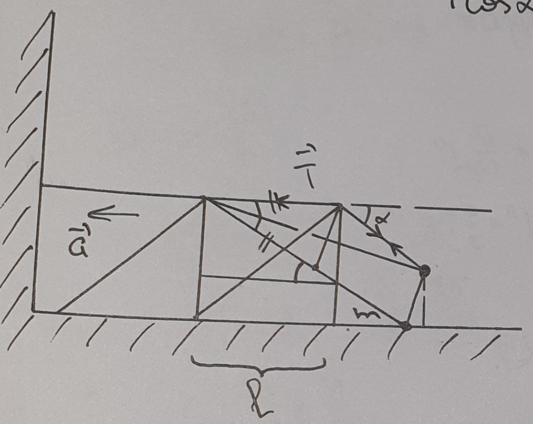
$\cos\alpha = \frac{8}{17}$



mgH

$T\sin\alpha - mg = \pm ma\cos\beta$

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



$mgH = \frac{mv^2}{2}$

$v = \sqrt{2gH}$

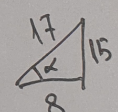
$H = \frac{gt^2}{2}$

$t = \sqrt{\frac{2H}{g}}$

1) 0°
2)
3)
4) $t = \sqrt{\frac{2H}{g}}$

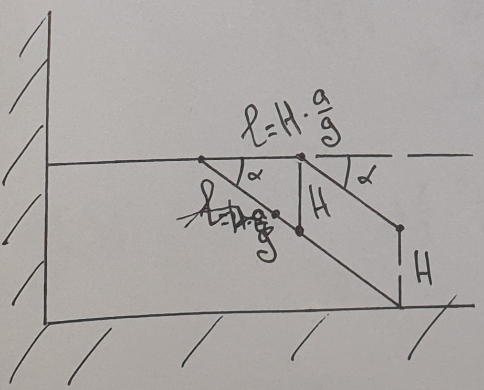
$\sin\alpha = \frac{15}{17}$

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



$tg\,\alpha = \frac{15}{8}$

$l = \frac{a\cdot\frac{2H}{g}}{2} = H\cdot\frac{a}{g}$



$tg\,\alpha = \frac{H}{l} = \frac{H}{H\cdot\frac{a}{g}} = \frac{g}{a}$

$a = \frac{g}{tg\,\alpha} = \boxed{\frac{8}{15}g}$

$Q = \nu \int_{T_0}^{T} c(T)\,dT = \frac{9}{5}\cdot\frac{\nu R}{T_0}\int_{T_0}^{T} T\,dT = \frac{9}{10}\cdot\frac{\nu R}{T_0}(T^2 - T_0^2)$

$pdV = \nu R dT$

$pV = \nu RT$

$Q = A + \Delta U$ $\quad A = \int p\,dV = \nu R \Delta T$

$\frac{9}{10}\cdot\frac{\nu R}{T_0}(T - T_0)(T + T_0) = \nu R(T - T_0) + \frac{3}{2}\nu R(T - T_0)$

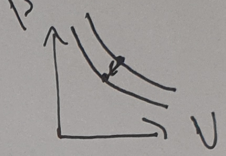
$T\downarrow$ $pV\downarrow$

$pV = \nu RT$ $\quad \frac{3}{2} = \frac{9}{5}\cdot\frac{T}{T_0}$

$(T+T_0)\frac{9}{10}\cdot\frac{\nu R}{T_0} = \frac{5}{2}\nu R$ $\quad \frac{1}{2}\nu R = \frac{9}{10}\cdot\frac{\nu R}{T_0}(T+T_0)$ $\quad \int p\,dV$ $\quad \frac{15}{18} = \frac{T}{T_0}$

$T + T_0 = \frac{25}{9}T_0$ $\quad \frac{5}{9}T_0 = T + T_0$

$T = \frac{16}{9}T_0$



$\cos(90^\circ - \alpha) = \sin\alpha$ $\quad -\frac{5}{9}T_0 = T + T_0$

$c_p = \frac{5}{2}R$

$c_V = \frac{3}{2}R$

$pV = \nu RT$

$d(x f(x)) = f(x)dx + x\,df(x)$

$\frac{T}{T_0} + 1 = \frac{10}{9}k$ $\quad -T - T_0 = \frac{25}{9}T_0$ $\quad T = \left(\frac{25}{9} - 1\right)T_0 = \frac{16}{9}T_0$

$\frac{10}{9}k - 1 < 1$ $\quad A = \nu R\cdot\frac{7}{9}T_0 = \frac{7}{9}\nu RT_0$ $\quad +\frac{5}{2}\nu R\cdot\frac{10}{9}\cdot\frac{T_0}{\nu R} = T + T_0$

$\frac{10}{9}k < 2$ $\quad \frac{5}{2}$ $\frac{25}{10}$ $\quad +\frac{9}{10}\cdot\frac{\nu R}{T_0}(T - T_0)(T + T_0) = \nu R(T - T_0) + \frac{3}{2}\nu R(T - T_0)$

$k < \frac{18}{10} = \frac{9}{5}$ $\quad +\frac{9}{5}\cdot\frac{\nu R}{T_0}\cdot\frac{1}{2}(T_0^2 - T^2) = A + \frac{3}{2}\nu R(T_0 - T)$

$\cos\frac{\alpha}{2} = \sqrt{\frac{1+\cos\alpha}{2}}$ $\quad A = \nu R \Delta T$

$\sqrt{\frac{8+17}{17\cdot 2}} = \frac{5}{\sqrt{34}}$ $\quad Q = A + \Delta U$

$= \frac{9}{5}\cdot\frac{\nu R}{T_0}\cdot\frac{1}{2}T_0^2\left(1 - \frac{9}{16}\right) = \frac{9\cdot 7}{5\cdot 2\cdot 16}\nu RT_0 = \frac{63}{160}\nu RT_0$

$Q_1 = \nu\int_{T_0}^{\frac{3}{4}T_0} c(T)\,dT = \nu\int_{T_0}^{\frac{3}{4}T_0}\frac{9}{5}\cdot\frac{R}{T_0}T\,dT = \frac{9}{5}\nu R\cdot\frac{1}{T_0}\cdot\frac{1}{2}T^2\Big|_{T_0}^{\frac{3}{4}T_0} = \frac{9}{5}\cdot\frac{\nu R}{T_0}\left(\frac{1}{2}T_0^2 - \frac{1}{2}\cdot\frac{9}{16}T_0^2\right)$

$T_0 \to \frac{3}{4}T_0$

T_0 $\quad c(T) = \frac{9}{5}R\frac{T}{T_0}$

ν

21203599 (U283804 M1265631) $\quad u = \frac{\ldots}{3\sqrt{34}g}$

Часть 2

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

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Вариант 4

№3

Чистовик.

$C_2 = C$

$C_1 = 5C$

$\mathcal{E}$

R

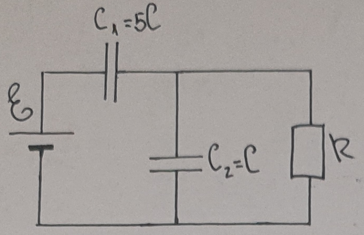
I_0

$I_1 = ?$

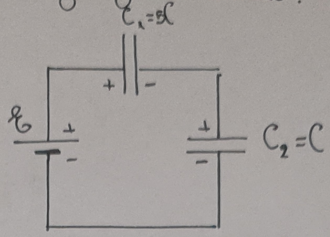
$I_2 = ?$

$Q = ?$

после замыкания:



до замыкания:



$U_1 + U_2 = \mathcal{E};$

$\frac{U_1}{U_2} = \frac{\frac{q}{5C}}{\frac{q}{C}} = \frac{C}{5C} = \frac{1}{5};$

$U_1 = \frac{1}{6}\mathcal{E};$

$U_2 = \frac{5}{6}\mathcal{E};$

сразу после замыкания:

по II правилу Кирхгофа для правого контура:

$U_2 = I_1 R;$

$I_1 = \frac{5}{6} \cdot \frac{\mathcal{E}}{R};$

ЗСЭ:

$\Delta W = Q;$

$\Delta W = Q = \frac{2CU_2^2}{2} = CU_2^2 = \frac{25}{36}C\mathcal{E}^2;$

$Q = \frac{25}{36}C\mathcal{E}^2;$

$I_2 = I_0;$

ответ: $I_1 = \frac{5}{6} \cdot \frac{\mathcal{E}}{R}$

$Q = \frac{25}{36}C\mathcal{E}^2$

$I_2 = I_0$

№5

Чистовик

$F = 24$ см

$H = 9$ см

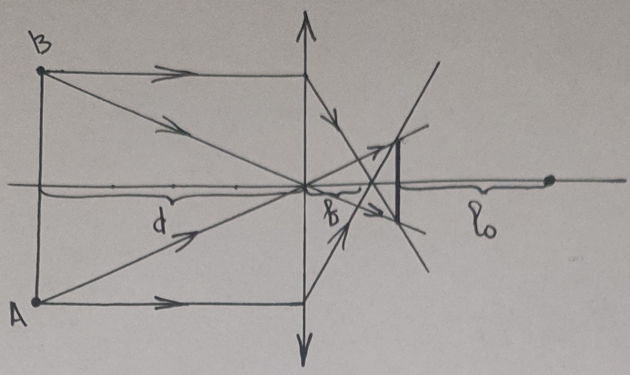
$d = 96$ см

$l_0 = 24$ см

$x = ?$

$D_m = ?$

$S = ?$



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

$$\frac{1}{f} = \frac{d-F}{dF};$$

$$x = f + l_0 = \frac{dF}{d-F} + l_0;$$

$$x = \frac{96 \cdot 24}{96-24} + 24 = 56 \text{ см};$$

$x = 56$ см

$$\Gamma = \frac{f}{d} = \frac{1}{3};$$

$D_u = \frac{1}{3} D_m$, где D_u - диаметр изображения

...

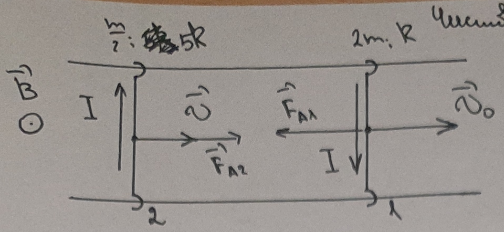
Ответ: 56 см

№4

Дано: m, R, l, v_0, B

$a = ?$
$u = ?$
$\Delta l = ?$

Чистовик



в начальный момент времени:

$$\mathcal{E}_i = -\frac{d\Phi}{dt};$$

$$d\Phi = B\,dS = B l v_0 dt;$$

$$\mathcal{E}_i = -B l v_0;$$

по з-ну Ома:

$$I = \frac{|\mathcal{E}_i|}{R + 5R} = \frac{B l v_0}{6R};$$

$$F_A = 2ma;$$

$$a = \frac{F_A}{2m};$$

$$F_A = BIl = \frac{B^2 l^2 v_0}{6R};$$

$$a = \frac{B^2 l^2 v_0}{12mR};$$

спустя продолжительный промежуток времени: система пришла в равновесие и скорости перемычек сравнялись.

τ – время установления равновесия

$$dv = \frac{B^2 l^2 v_0}{12mR} dt;$$

$$dv_0 = \frac{B^2 l^2 v_0}{12mR} dt;$$

$$u = \frac{B^2 l^2 v_0}{12mR}\tau;$$

$$v_0 - u = \frac{B^2 l^2 v_0}{12mR}\tau;$$

$$v_0 - u = u \Rightarrow u = \frac{1}{2} v_0;$$

$$\frac{1}{2} v_0 = \frac{B^2 l^2 v_0}{12mR}\tau \Rightarrow \tau = \frac{6mR}{B^2 l^2};$$

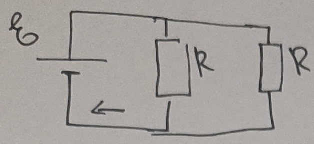
$$\Delta l = \frac{u + v_0}{2}\tau - \frac{u}{2}\tau = \frac{1}{2}\tau v_0 = \frac{1}{2} v_0 \cdot \frac{6mR}{B^2 l^2} = \frac{3 v_0 mR}{B^2 l^2};$$

$$\Delta l = \frac{3 v_0 mR}{B^2 l^2};$$

Ответ: $a = \frac{B^2 l^2 v_0}{12mR}$

$u = \frac{1}{2} v_0$

$\Delta l = \frac{3 v_0 mR}{B^2 l^2}$



$$\alpha = \frac{B^2 l^2}{12mR}$$

$$d v_0 = dt \cdot a_1$$

$$d v = a_2 dt$$

$$\frac{dv}{dt} = \frac{B^2 l^2}{3mR} v_0 - \frac{B^2 l^2}{3mR} v$$

$$d v_0 = \alpha (v_0 - v) dt$$

$$d v = 4\alpha (v_0 - v) dt$$

$$\int_{v_0}^{v'} d v_0 = \alpha \int_0^t (v_0 - v) dt$$

$$d v_0 = \alpha v_0 dt - \alpha v dt$$

$$d v = 4\alpha v_0 dt - 4\alpha v dt$$

$$d v - d v_0 = 3\alpha (v_0 - v) dt$$

$$3\alpha dt = \frac{v_0 - v}{d(v - v_0)}$$

$$dv = \frac{B^2 l^2 v_0}{12mR} dt$$

$$u = \frac{B^2 l^2 v_0}{12mR} t$$

$$\frac{1}{2} v_0 = \frac{B^2 l^2 v_0}{12mR} \tau$$

$$\tau = \frac{6mR}{B^2 l^2}$$

$$\int_a^b f(x) dx = F(b) - F(a)$$

$$\frac{3}{4} v_0 \tau - \frac{1}{4} v_0 \tau = \frac{1}{2} v_0 \tau$$

$$1 + \frac{1}{2} = \frac{3}{2}$$

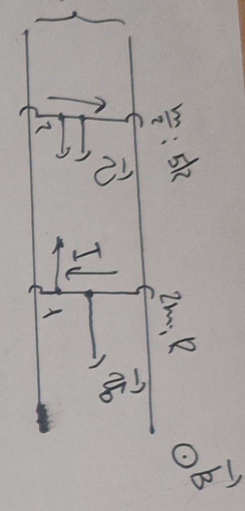
①

$\mathcal{E}_i = \frac{d\Phi}{dt} = B v_0 l \qquad I = \frac{\mathcal{E}_i}{6R}$

$d\Phi = B dS = B v_0 dt\, l$

$F_A = BIl = Bl \cdot \frac{\mathcal{E}_i}{6R} = \frac{B^2 l^2 v_0}{6R} = 2ma$

$a = \frac{B^2 l^2 v_0}{12mR}$



$\mathcal{E}_i = B(v_0 - v) l$

$a_1 = \frac{F_{A1}}{2m} = \frac{B \mathcal{E}_i l}{12mR} = \frac{B^2 (v_0 - v) l^2}{12mR}$

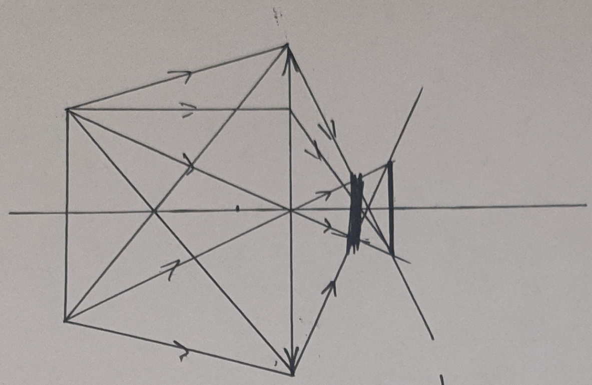
$a_2 = \frac{F_{A2}}{\frac{1}{2}m} = \frac{2 B \mathcal{E}_i l}{36mR} = \frac{B^2 (v_0 - v) l^2}{3mR}$

$v_0 - a_1 dt = v + a_2 dt$

$v_0 - v = (a_1 + a_2) dt$

$v_0 - v = \frac{5B^2 (v_0 - v) l^2}{12mR} dt$

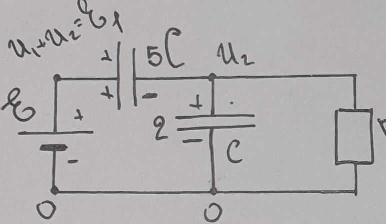
~~$\frac{12mR}{5B^2 l^2} = dt$~~



$\frac{1}{d} + \frac{1}{f} = \frac{1}{F} \qquad f = \left(\frac{-F + d}{Fd}\right)^{-1} = 32\,cm$

$l = f + l_0$ $\qquad$ $l) \; 56\,cm$

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



$\downarrow I_0$

$\downarrow I_0 + I'$

$U = I' R$

$I' = \frac{U}{R}$

$U = (I_0 + I') R$

$U_1 + U_2 = \mathcal{E}$

~~$\frac{q}{5C} + \frac{q}{C} = \mathcal{E}$~~

$\frac{U_1}{U_2} = \frac{q/5C}{q/C} = \frac{1}{5}$

$U_1 = \frac{1}{5} U_2$

$\frac{6}{5} U_2 = \mathcal{E}$

$U_2 = \frac{5}{6} \mathcal{E}$

$U_1 = \frac{1}{6} \mathcal{E}$

$\frac{5}{6} \mathcal{E} = IR$

$\frac{5}{6} \cdot \frac{\mathcal{E}}{R} = I$

$\frac{C U_2^2}{2} = Q$

$Q = \frac{C \cdot \frac{25}{36} \mathcal{E}^2}{2} = \frac{25 C \mathcal{E}^2}{72}$

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