Часть 1

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

Шифр: **21202079**

ID профиля: **211402**

Вариант 3

Чистовик

2. 1) Так как теплоёмкость зависит от температуры линейно, то

$C_{ср.} = \frac{C(T_0) + C(T)}{2}$ – средняя молярная теплоёмкость за весь процесс

$$C_{ср.} = \frac{3R\frac{\cancel{T_0}}{\cancel{T_0}} + 3R\frac{\frac{3}{5}\cancel{T_0}}{\cancel{T_0}}}{2} = \frac{3}{2}R\left(1+\frac{3}{5}\right) = \frac{3}{2}R\cdot\frac{8}{5} = \frac{24}{10}R = 2{,}4R$$

$Q_1 = \nu C_{ср.}(T_0 - \frac{3}{5}T_0)$

$Q_1 = \nu\cdot 2{,}4R\cdot 0{,}4T_0 = 0{,}96\,\nu R T_0$

2) $Q = A + \Delta U \Rightarrow A = Q - \Delta U$; $\Delta U = \frac{3}{2}\nu R\Delta T = \frac{3}{2}\nu R(T_0 - T)$

$Q = \nu C_{ср}(T_0 - T) = \nu\cdot\frac{3}{2}R\left(1+\frac{T}{T_0}\right)(T_0 - T)$

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

$A' = \frac{3}{2}\nu R\left(T - \frac{T^2}{T_0}\right)' = \frac{3}{2}\nu R\left(1 - \frac{2T}{T_0}\right)$

A_{min} при $A' = 0 \Rightarrow \frac{3}{2}\nu R\left(1 - \frac{2T}{T_0}\right) = 0$; $\frac{2T}{T_0} = 1$; $T = \frac{T_0}{2}$

3) $A_{min} = \frac{3}{2}\nu R\left(\frac{T_0}{2} - \frac{T_0^{\cancel{2}}}{4\cancel{T_0}}\right) = \frac{3}{2}\nu R\cdot\frac{T_0}{4} = \frac{3}{8}\nu R T_0 = 0{,}375\,\nu R T_0$

Ответ: 1) $Q_1 = 0{,}96\,\nu R T_0$; 2) $T = \frac{T_0}{2}$; 3) $A_{min} = 0{,}375\,\nu R T_0$.

Черновик

$\nu, T_0, C(T) = 3R\frac{T}{T_0}$

$\Delta T = \frac{2}{5}T_0$ $\quad Q_1 - ?$

1) $C(T_0) = 3R$

$C(\frac{3}{5}T_0) = 3R\frac{3}{5} = \frac{9}{5}R$

$C_{ср.} = \frac{3R + \frac{9}{5}R}{2} = \frac{15+9)R}{10} = 2{,}4R$

$Q_1 = \nu c_{ср.}\Delta T = 2{,}4R \cdot 0{,}4T_0\nu = \boxed{0{,}96 T_0\nu}$

2) $Q = A + \Delta U$

$A = Q - \Delta U$

$A = C_{ср.}\Delta T - \frac{3}{2}\nu R\Delta T$

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

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

$A' = \frac{dA}{dT} = \frac{3}{2}R\left((T_0 - T)(\frac{T_0+T}{T_0} - \nu)\right)'$

$\left((T_0 - x)(1 + \frac{x}{T_0} - \nu)\right)' = (T_0 - x)'(1 - \nu + \frac{x}{T_0}) + (1 - \nu + \frac{x}{T_0})'(T_0 - x) =$

$= -(1 - \nu + \frac{x}{T_0}) + \frac{1}{T_0}(T_0 - x) = \nu \cancel{-1} - \frac{x}{T_0} \cancel{+1} - \frac{x}{T_0} = \nu - \frac{2T}{T_0}$

$A' = \frac{3}{2}R(\nu - \frac{2T}{T_0})$ $\quad A' = 0$ при $\nu = \frac{2T}{T_0}$ $\quad \boxed{T = \frac{\nu T_0}{2}}$

3) $A_{min} = \frac{3}{2}R(T_0 - \frac{\nu T_0}{2})(1 + \frac{\nu T_0}{2T_0} - \nu) = \frac{3}{2}R(T_0 - \frac{\nu T_0}{2})(1 - \frac{\nu}{2}) =$

$= \frac{3}{2}RT_0(1 - \frac{\nu}{2})^2 = \frac{3}{2}RT_0(1 + \frac{\nu^2}{4} - \nu) = \frac{3}{2}RT_0(\frac{\nu}{2} - 1)^2 =$

$= \boxed{\frac{3}{8}RT_0(\nu - 2)^2}$

$1 - \nu + \frac{\nu^2}{4} - \frac{1}{T_0^2}$

$(1 - \frac{\nu}{2} - \cancel{\frac{1}{T_0}} - \frac{\nu}{2} + \frac{\nu^2}{4} + \frac{\nu}{2T_0} + \cancel{\frac{1}{T_0}} - \cancel{\frac{\nu}{2T_0}} - \frac{1}{T_0^2})$

$\frac{\nu T_0}{2} - 1$

$\frac{3}{2}R(T_0 - \frac{\nu T_0}{2} + 1)(1 + \frac{\nu T_0 - 2}{2T_0} - \nu) =$

$= \frac{3}{2}R(T_0 - \frac{\nu T_0}{2} + 1)(1 - \nu + \frac{\nu}{2} - \frac{1}{T_0}) =$

$= \frac{3}{2}RT_0(1 - \frac{\nu}{2} + \frac{1}{T_0})(1 - \frac{\nu}{2} - \frac{1}{T_0})$

$(\frac{x}{T_0})' = \frac{x'T_0 - T_0'x}{T_0^2} = \frac{T_0}{T_0^2} = \frac{1}{T_0}$

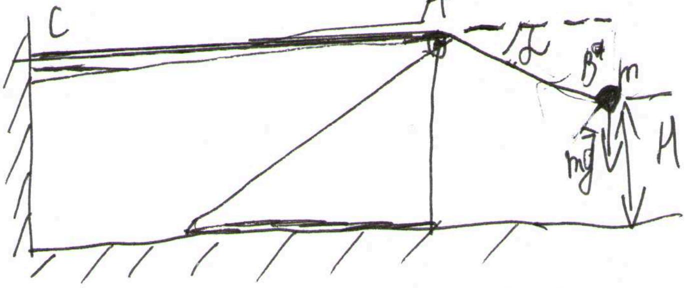
$(const - x)' = -1$

$(\frac{T^2}{T_0} - T)' = \frac{2T}{T_0} - 1 = 0 \quad T = \frac{T_0}{2}$

$(1 - \nu)' = 0$

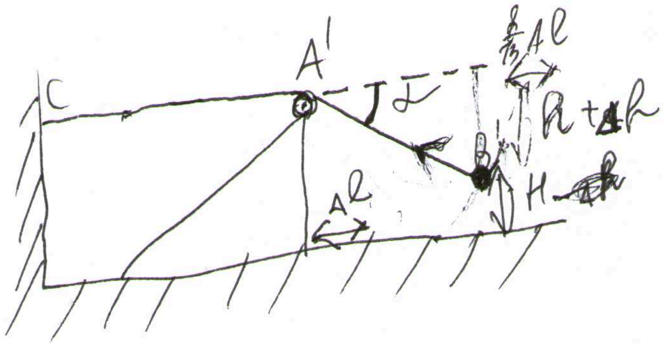
21202079 (U211402 M1266734)

Черновик



$\cos\alpha = \frac{5}{13}$

$l_{пр.} = AC + \frac{5}{13}AB$

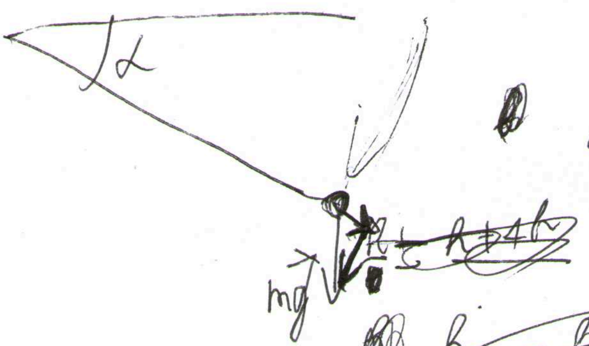


$l = AC + AB$

$l = AC - \Delta l + AB + \Delta l$

$l'_{пр.} = AC - \Delta l + \frac{5(AB+\Delta l)}{13}$

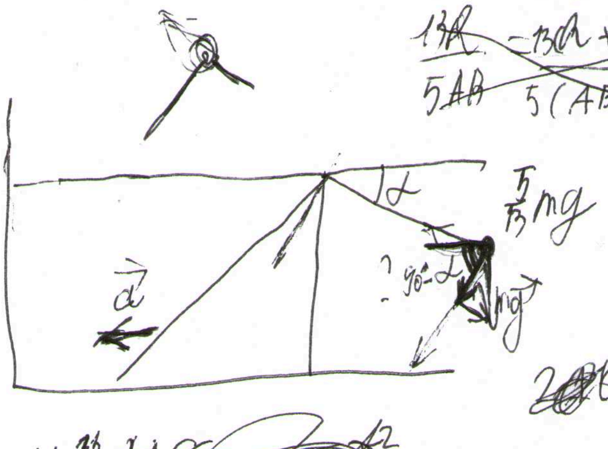
$l_{пр} - l'_{пр} = \cancel{AC + \frac{5}{13}AB - AC + \Delta l - \frac{5}{13}AB - \frac{5}{13}\Delta l} = \frac{8}{13}\Delta l$



$\frac{5}{13}(AB+\Delta l)$ $mgH =$

$\cancel{\frac{13h}{5AB} = \frac{13h+\Delta h}{5(AB+\Delta l)}}$

$mg = \frac{ma\sqrt{313}}{12} + \frac{169Ma}{12\sqrt{313}}$



$\Delta l = \frac{at^2}{2}$ $\frac{12}{5} = \frac{13h}{5AB}$

$12AB = 13h$ $h = \frac{12}{13}AB$

$\frac{2\Delta l}{t^2} = a$ $a = \frac{2\Delta l}{\frac{24\Delta l\sqrt{313}}{5g}} = \frac{5g}{\sqrt{313}}$

$\frac{12}{5} = \frac{12AB + 13\Delta h}{5AB + 5\Delta l}$

$a = \frac{2\Delta l\, 13a}{24\Delta l\sqrt{313}}$

$169 + 144$
$300+9+4=313$

$v = at$ $L = \frac{13}{12}H$

$\frac{ma^2t^2}{2}$

$\frac{5}{13}gt^2 = \Delta l\frac{\sqrt{313}}{13}$ $12AB + 12\Delta l = 12AB + 13\Delta h$

$\Delta h = \frac{12}{13}\Delta l$

$\frac{at^2}{2} = \Delta l\frac{\sqrt{313}}{13}$

21202079 (U211402 M1266734)

$\frac{ma^2}{13a}\sqrt{313}\,\Delta l + \frac{13Mal}{\sqrt{313}}$ $2{,}5gt^2 = \Delta l\sqrt{313}$

$t = \sqrt{\frac{24\Delta l\sqrt{313}}{5g}}$ $\sqrt{\Delta l^2 + \frac{144}{169}\Delta l^2} = \Delta l\sqrt{\frac{313}{13}}$

$t^2 = \frac{24\sqrt{313}}{13a}$

Часть 2

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

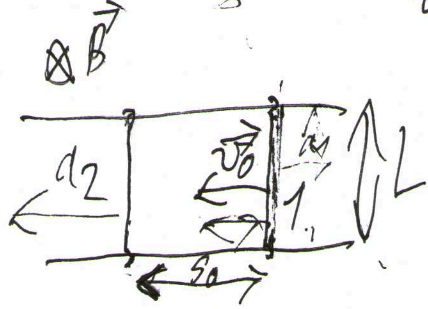
Шифр: **21202079**

ID профиля: **211402**

Вариант 3

Черновик

4.



1: $2m$, R

2: m, $3R$

$$v_0 - \frac{B^2L^2v_0}{16mR} = \frac{B^2L^2v_0}{8mR}$$

$$R_{общ} = R + 3R = 4R$$

1) $F_A = BIL \sin\alpha$; $\sin\alpha = 1$

$\mathcal{E}_i = BvL \sin\alpha$; $\sin\alpha = 1$

$\mathcal{E}_i = BvL$; $I = \frac{\mathcal{E}_i}{4R} = \frac{BvL}{4R}$

$$F_A = \frac{B^2L^2v_0}{4R}$$

$$F_{A_1} = 2ma_0 \Rightarrow a_0 = \frac{F_A}{2m} = \boxed{\frac{B^2L^2v_0}{8mR}}$$

$$F_{A_2} = ma_{02} \Rightarrow a_{02} = \frac{F_A}{m} = \frac{B^2L^2v_0}{4mR}$$

2) $v_1 = v_2 = v'$

~~$\mathcal{E}_i = Bv'L$~~

$I = \frac{\mathcal{E}_i}{4R}$

~~$F_{A_1} = F_{A_2} = \frac{B^2L^2v'}{4R}$~~

~~$v_2 > v_1$~~

$$v_0 - \frac{a_0}{2}t = v$$

$$v = v_0 - \frac{B^2L^2v_0}{16mR} = v_0\left(1 - \frac{B^2L^2}{16mR}\right) = 18 см$$

$$\frac{B^2 v_{отн} L^2}{4R}$$

$$a_{отн} = a_2 + a_1 = 3a_1$$

$$v = \frac{a_{02}t}{2} = \frac{B^2L^2v_0}{8mR}$$

$$\frac{B^2(a_{отн.}t - v_0)L^2}{8Rm} = a_1$$

$$-B^2L^2v_0 + 3B^2L^2a_1t = a_1 8R$$

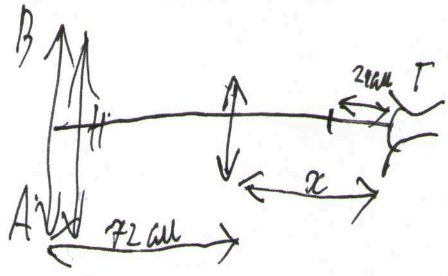
$$a_1(3B^2L^2t - 8Rm) = B$$

$$a_1 = \frac{B^2L^2v_0}{3B^2L^2t - 8Rm}$$

$B^2L^2v_0$

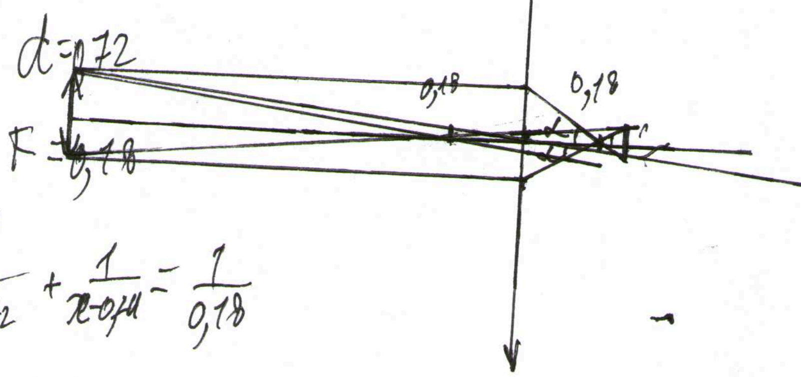
B^2L^2

5.



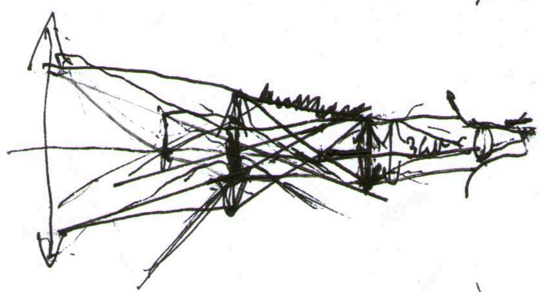
$H = 9 см$

$f = (x - 0{,}24)$



$$Г = \frac{H}{h} = \frac{f}{d} = \frac{0{,}24}{0{,}72} = \frac{1}{3}$$

$$\frac{1}{0{,}72} + \frac{1}{x - 0{,}24} = \frac{1}{0{,}18}$$



$$\frac{100}{18} - \frac{100}{72} = \frac{1}{x - 0{,}24}$$

$$\frac{300}{72} = \frac{1}{x - 0{,}24}$$

$$x - 0{,}24 = \frac{72}{300}$$

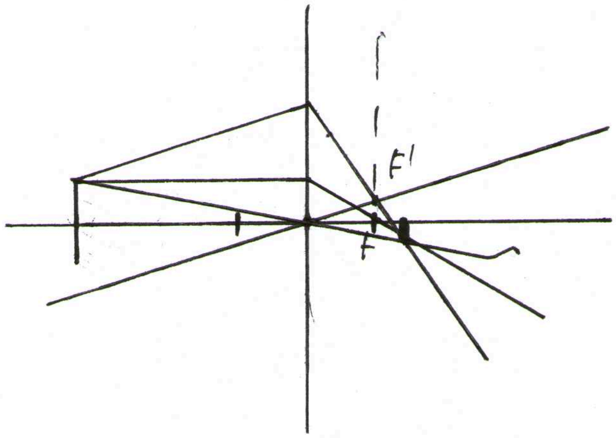
$$x - 0{,}24 = 0{,}24$$

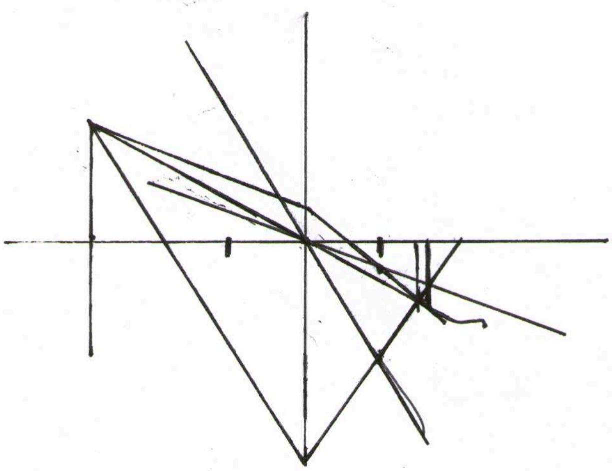
$$x = 0{,}48$$

$$\frac{\mathcal{E}_i}{R} = I$$

21202079 (U211402 M1266735)

Черновик





$$\frac{\frac{C_1C_2}{C_1+C_2}\mathcal{E}^2}{2}=Q$$

21202079 (U211402 M1266735)

Чистовик

4. 1) $\mathcal{E} = B v_0 L \sin\alpha$; $\sin\alpha = 1$ — ЭДС самоиндукции

$I = \frac{\mathcal{E}}{R+3R} = \frac{B v_0 L}{4R}$;

$F_A = BIL \sin\alpha$; $\sin\alpha = 1$ — сила Ампера

$F_A = \frac{B^2 L^2 v_0}{4R}$; по II закону Ньютона $F = 2ma \Rightarrow a = \frac{F}{2m} = \frac{B^2 L^2 v_0}{8mR}$

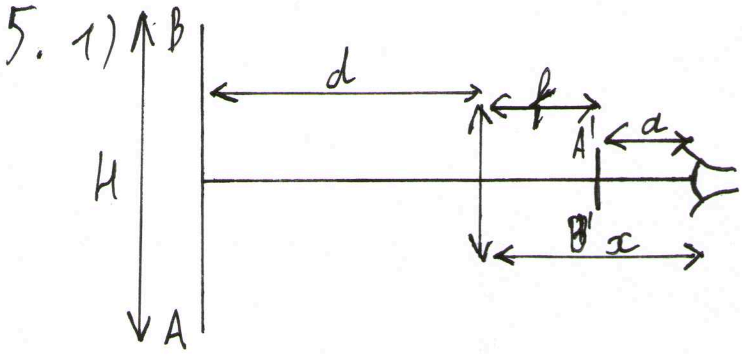
2) Чтобы скорости обоих перемычек установились, они должны покоиться друг относительно друга, в противном случае в контуре будет возникать ЭДС самоиндукции => сила Ампера => ускорение ~~будет~~ => скорости будут изменяться.

Начальная энергия, сообщённая системе, равна $\frac{2mv_0^2}{2}$. По ЗСЭ:

$\frac{2mv_0^2}{2} = \frac{2mv^2}{2} + \frac{mv^2}{2}$; $2\cancel{m}v_0^2 = 3\cancel{m}v^2$; $v = v_0\sqrt{\frac{2}{3}}$; $v_1 = v_2 = v_0\sqrt{\frac{2}{3}}$

Чистовик

5. 1)



$a = 24см = 0{,}24м$; $H = 9см = 0{,}09м$;

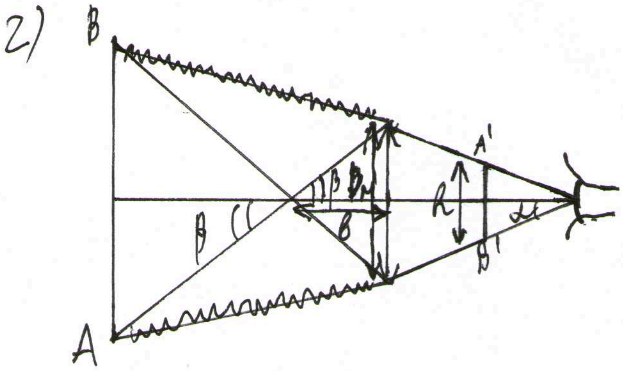
$d = 72см = 0{,}72м$; $F = 18см = 0{,}18м$.

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

$x = f + a$; $x = \frac{Fd}{d-F} + a$;

$x = \frac{0{,}18м \cdot 0{,}72м}{0{,}72м - 0{,}18м} + 0{,}24м = 0{,}48м$

2)



$\Gamma = \frac{h}{H} = \frac{f}{d}$; $\frac{f}{d} = \frac{0{,}24м}{0{,}72м} = \frac{1}{3} \Rightarrow \frac{h}{H} = \frac{1}{3} \Rightarrow$

$h = \frac{H}{3}$

$h = \frac{0{,}09м}{3} = 0{,}03м$

$tg\,\alpha = \frac{h}{2a} = \frac{0{,}03м}{2 \cdot 0{,}24м} = 0{,}0625$

$tg\,\alpha = \frac{D_M}{2x} \Rightarrow D_M = 2x\,tg\,\alpha = 2 \cdot 0{,}48м \cdot 0{,}0625 =$

$= 0{,}06м$

3) $\frac{D_M}{2b} = \frac{H}{2(d-b)} = tg\,\beta$; $2bH = 2D_M d - 2D_M b$; $b(H + D_M) = D_M d$;

$b = \frac{D_M d}{H + D_M} = \frac{0{,}06м \cdot 0{,}72м}{0{,}09м + 0{,}06м} = 0{,}288м$