Часть 1

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

Шифр: **21200106**

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Вариант 1

Чистовик.

№ 2. Вариант 11-01.

Дано: ν, T_0, $C_\nu(T) = 2R\frac{T}{T_0}$; $T_1 = \frac{5}{6}T_0$.

Найти: 1) Q_1 ($Q_1 > 0$) (при $T_0 \to T_1$)

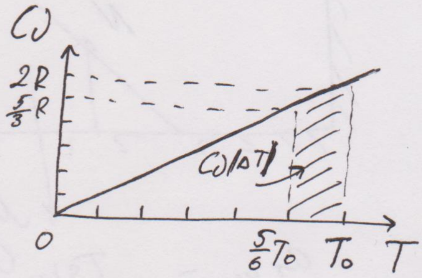
2) T_2 (при $A_{2\,min}$) 3) $A_{2\,min}$.

Решение:

1) $Q = C_\nu \cdot \nu \cdot |\Delta T|$.

$C_\nu(T) = 2R\frac{T}{T_0} \Rightarrow$

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



$C_\nu|\Delta T|$ – площадь под графиком $C_\nu(T)$ от $\frac{5}{6}T_0$ до $T_0 \Rightarrow$

$C_\nu|\Delta T| = \left(-\frac{5}{6}T_0 + T_0\right)\cdot\frac{1}{2}\left(\frac{5}{3}R + 2R\right) = \frac{1}{6}T_0\cdot\frac{11}{6}R = \frac{11}{36}RT_0$

$Q_1 = C_\nu|\Delta T|\cdot\nu = \frac{11}{36}RT_0\cdot\nu = \frac{11}{36}\nu RT_0$.

2) $Q = A_2 + \Delta U$; $\Delta U = \frac{3}{2}\nu R\Delta T$ (гелий - одноатомный газ);

$C_\nu = \frac{Q}{\nu\Delta T} = \frac{A_2 + \Delta U}{\nu\Delta T} = 2R\frac{T}{T_0} \Rightarrow$

$A_2 = 2R\nu\Delta T\cdot\frac{T}{T_0} - \Delta U = 2\nu R\cdot\frac{T(T-T_0)}{T_0} - \frac{3}{2}\nu R(T - T_0) =$

$= \frac{2\nu R}{T_0}\cdot T^2 - 2\nu R\cdot T - \frac{3}{2}\nu R\cdot T + \frac{3}{2}\nu RT_0 = \frac{2\nu R}{T_0}\cdot T^2 - \frac{7}{2}\nu R\cdot T + \frac{3}{2}\nu RT_0$

ф-ия квадратичная $\Rightarrow$ $A_{2\,min} = A_2(T_в) \Rightarrow$

$T_2 = T_в = \frac{-\left(-\frac{7}{2}\nu R\right)}{2\cdot\frac{2\nu R}{T_0}} = \frac{7}{8}T_0 \Rightarrow A_{2\,min} = \frac{2\nu R}{T_0}\cdot\frac{49}{64}T_0^2 - \frac{7}{2}\nu R\cdot\frac{7}{8}T_0 +$

$+ \frac{3}{2}\nu RT_0 = \nu RT_0\left(\frac{49}{32} - \frac{98}{32} + \frac{48}{32}\right) = -\frac{\nu RT_0}{32}$.

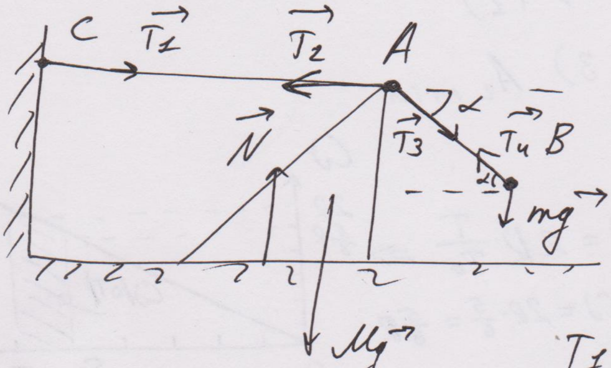
Ответ: 1) $Q_1 = \frac{11}{36}\nu RT_0$; 2) $T_2 = \frac{7}{8}T_0$; 3) $A_{2\,min} = -\frac{\nu RT_0}{32}$.

№1. Вариант 11-01.

Дано: $\cos\alpha = \frac{3}{5}$; H; $\alpha = const$.

Найти: 1) β (угол $\vec{a}_m$ к гор.) 2) a_k 3) $\frac{m}{M}$ 4) t_k

Решение:



1) $\sum \vec{F} = m\vec{a}$ $\Rightarrow$

$Oy| \; m a_{ym} = T_4 \sin\alpha - mg$

$Ox| \; m a_{xm} = -T_4 \cos\alpha$

$Oy| \; 0 = N - Mg - T_3 \sin\alpha$

$Ox| \; M a_{kx} = -T_2 + T_3 \cos\alpha$

$T_1 = T_2 = T_3 = T_4$ (одна и та же нить) $\Rightarrow$

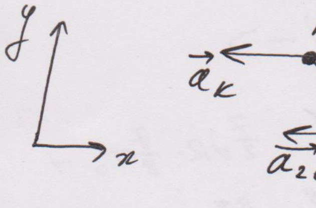
$a_{ym} = \frac{T\sin\alpha - mg}{m} = \left(\frac{T\sin\alpha}{m}\right) - g$; $a_{xm} = \frac{-T\cos\alpha}{m}$;

$a_{yk} = 0$, $a_{xk} = \frac{-T + T\cos\alpha}{M} = \frac{T(\cos\alpha - 1)}{M} < 0 \Big\}$ $\Rightarrow$

$a_k = |a_{xk}| = \frac{T(1-\cos\alpha)}{M}$, клин едет влево. ($\vec{a_k} \uparrow\downarrow Ox$)

Нить не поднимается, т.к. клин не поднимается (на него не действуют силы, поднимающие вверх (сила реакции опоры $\vec{N}$ этого не делает)); нить справа (AB) опускается (т.к. угол $\alpha = const$) $\Rightarrow$

$a_{ym} < 0 \Rightarrow \frac{T\sin\alpha}{m} - g < 0 \Rightarrow g - \frac{T\sin\alpha}{m} > 0$.



$a_{1m} = |a_{ym}| = g - \frac{T\sin\alpha}{m}$

$a_{2m} = |a_{xm}| = \frac{T\cos\alpha}{m}$

$a_k = \frac{T(1-\cos\alpha)}{M}$

$x(t) = x_0 + v_{0x} t + a_x \frac{t^2}{2}$

$x_A(t) = x_{0A} + 0 \cdot t - a_k \cdot \frac{t^2}{2} = x_{0A} - a_k \frac{t^2}{2}$

$x_B(t) = x_{0B} + 0 \cdot t - a_{2m} \frac{t^2}{2} = x_{0B} - a_{2m} \frac{t^2}{2}$

$y_A(t) = y_{0A} + 0 \cdot t + 0 \cdot \frac{t^2}{2} = y_{0A}$

$y_B(t) = H + 0 \cdot t - a_{1m} \cdot \frac{t^2}{2} = H - a_{1m} \frac{t^2}{2}$

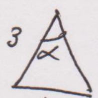
$tg\alpha = \frac{y_A - y_B}{x_B - x_A} = \frac{y_{0A} - H}{x_{0B} - x_{0A}} \Rightarrow y_{0A} - H = tg\alpha \, (x_{0B} - x_{0A})$.

№ 1. (продолжение) Вариант 11-01.

$$tg\alpha = \frac{y_{0A} - H + a_{1m}\frac{t^2}{2}}{x_{0B} - a_{2m}\frac{t^2}{2} - x_{0A} + a_K\frac{t^2}{2}} \Rightarrow \cancel{(y_{0A} - H)} + a_{1m}\frac{t^2}{2} = \cancel{tg\alpha(x_{0B} - x_{0A})} + tg\alpha \cdot \frac{t^2}{2}(a_K - a_{2m}) \Rightarrow$$

$$a_{1m} = (a_K - a_{2m})tg\alpha \Rightarrow g - \frac{T\sin\alpha}{m} = tg\alpha\frac{T(1-\cos\alpha)}{M} - tg\alpha\frac{T\cos\alpha}{m}$$

$$g - \cancel{\frac{T\sin\alpha}{m}} = tg\alpha\frac{T(1-\cos\alpha)}{M} - \cancel{\frac{T\sin\alpha}{m}} \Rightarrow T = \frac{Mg}{tg\alpha - \sin\alpha}$$

$\cos\alpha = \frac{3}{5} \Rightarrow \sin\alpha = \frac{4}{5} \Rightarrow tg\alpha = \frac{4}{3}$ (п/у Δ )

$$a_K = \frac{T(1-\cos\alpha)}{M} = \frac{Mg\cancel{(1-\cos\alpha)}}{tg\alpha\cancel{(1-\cos\alpha)}\cdot M} = \frac{g}{tg\alpha} = \frac{g}{\frac{4}{3}} = \frac{3}{4}g = \frac{3}{4}\cdot 10 = 7{,}5\ м/с^2$$

$$tg\beta = \frac{a_{1m}}{a_{2m}} = \frac{g - \frac{T\sin\alpha}{m}}{\frac{T\cos\alpha}{m}} = \frac{gm - T\sin\alpha}{T\cos\alpha} = \frac{gm - \frac{Mg\sin\alpha}{tg\alpha - \sin\alpha}}{\frac{Mg\cos\alpha}{tg\alpha - \sin\alpha}} =$$

$$= \frac{gm\,tg\alpha - gm\sin\alpha - Mg\sin\alpha}{Mg\cos\alpha} = \frac{m(tg\alpha - \sin\alpha) - M\sin\alpha}{M\cos\alpha} = \frac{\frac{m}{M}(tg\alpha - \sin\alpha) - \sin\alpha}{\cos\alpha}$$

$$y_B(t) = H - a_{1m}\frac{t^2}{2} \Rightarrow 0 = H - a_{1m}\frac{t_K^2}{2} \Rightarrow t_K = \sqrt{\frac{2H}{a_{1m}}} =$$

$$= \sqrt{\frac{2H}{g - \frac{T\sin\alpha}{m}}} = \sqrt{\frac{2H}{g - \frac{Mg\sin\alpha}{(tg\alpha - \sin\alpha)m}}} = \sqrt{\frac{2H}{g}}\cdot\sqrt{\frac{m(tg\alpha - \sin\alpha)}{m(tg\alpha - \sin\alpha) - M\sin\alpha}} =$$

$$= \sqrt{\frac{2H}{g}}\cdot\sqrt{\frac{\frac{m}{M}(tg\alpha - \sin\alpha)}{\frac{m}{M}(tg\alpha - \sin\alpha) - \sin\alpha}}$$

$$v_{yB}(t) = -a_{1m}t$$
$$v_{xB}(t) = -a_{2m}t$$

$\Delta E_K = A$ всех сил $\quad A = \vec{F}\cdot\vec{l}$

$$E_{K m_0} = 0\ ;\ E_{K m_K} = \frac{m v_m^2}{2} \Rightarrow \Delta E_{K m} = \frac{m v_m^2}{2}$$

$$v_m(t) = \sqrt{v_{yB}^2(t) + v_{xB}^2(t)} = \sqrt{(a_{1m}t)^2 + (a_{2m}t)^2} =$$

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$$= t\sqrt{\left(g - \frac{T\sin\alpha}{m}\right)^2 + \left(\frac{T\cos\alpha}{m}\right)^2} = t\sqrt{\left(\frac{gm - \frac{Mg\sin\alpha}{tg\alpha - \sin\alpha}}{m}\right)^2 + \left(\frac{Mg\cos\alpha}{(tg\alpha - \sin\alpha)m}\right)^2}$$

Листовик

№1 Вариант 11-01.

Ответ: 1) $tg\beta = \dfrac{\frac{m}{M}(tg\alpha - \sin\alpha) - \sin\alpha}{\cos\alpha}$; 2) $a_K = \frac{3}{4}g = 7{,}5$ м/с²;

4) $t_K = \sqrt{\dfrac{2h}{g}} \cdot \sqrt{\dfrac{\frac{m}{M}(tg\alpha - \sin\alpha)}{\frac{m}{M}(tg\alpha - \sin\alpha) - \sin\alpha}}$.

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Черновик.

№ 2.

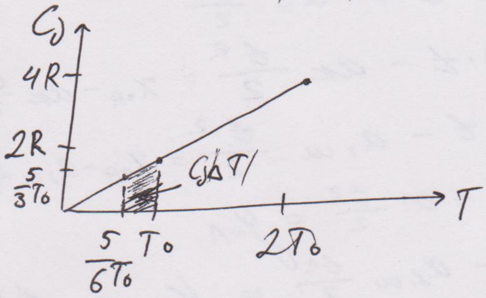
$\nu,\ T_0,\ C_\nu(T) = 2R\frac{T}{T_0}$.

1) $Q_1 > 0 = ?$ $(T_0 \to \frac{5}{6}T_0)$

2) $T_0 \to T_2 < T_0 = ?$ для $A_2\ min$

3) $A_2\ min = ?$

$Q = C_\nu \cdot \nu \cdot |\Delta T|$



1) $C_\nu|\Delta T| = (-\frac{5}{6}T_0 + T_0)\cdot\frac{1}{2}\left(2R\frac{T_0}{T_0} + 2R\frac{\frac{5}{6}T_0}{T_0}\right) =$
$= \frac{1}{6}T_0 \cdot R \cdot \frac{11}{6} = \frac{11}{36}T_0 R$

$Q = C_\nu\Delta T \cdot \nu = \frac{11}{36}T_0 R \cdot \nu = \frac{11}{36}\nu R T_0$

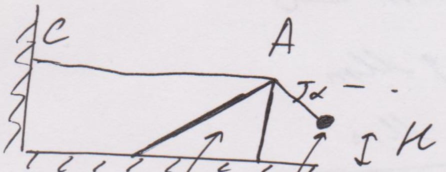
2) $Q = A_2 + \Delta U$; $C_\nu = \frac{Q}{\nu\cdot\Delta T} = \frac{A_2 + \Delta U}{\nu\cdot\Delta T} = \frac{A_2 + \frac{3}{2}\nu R\Delta T}{\nu\Delta T} =$
$= \frac{A_2}{\nu\Delta T} + \frac{3}{2}R = 2R\frac{T}{T_0} \Rightarrow A_2 = \frac{2RT}{T_0}\cdot\nu\Delta T - \frac{3}{2}R\nu\Delta T =$
$= 2\nu R\cdot\frac{T(T_0 - T_0)}{T_0} - \frac{3}{2}\nu R(T - T_0) = \frac{2\nu R}{T_0}T^2 - 2\nu R T - \frac{3}{2}\nu R T + \frac{3}{2}\nu R T_0 =$
$= \frac{2\nu R}{T_0}\cdot T^2 - \frac{7}{2}\nu R\cdot T + \frac{3}{2}\nu R T_0$. $T_в = \frac{\frac{7}{2}\nu R}{\frac{4\nu R}{T_0}} = \frac{7}{8}T_0$

$A_2\ min = A_2(T_в) = \frac{2\nu R}{T_0}\cdot\frac{49}{64}T_0^2 - \frac{7}{2}\nu R\cdot\frac{7}{8}T_0 + \frac{3}{2}\nu R T_0 =$
$= \frac{49}{32}\nu R T_0 - \frac{49}{16}\nu R T_0 + \frac{3}{2}\nu R T_0 = \nu R T_0\left(\frac{49 - 98 + 48}{32}\right) = -\frac{\nu R T_0}{32}$

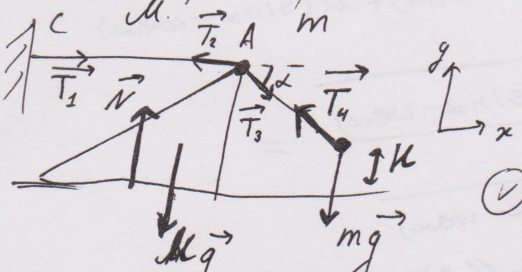
№ 1.

$\cos\alpha = \frac{3}{5}$; H; $\alpha = const$.

1) β (угол нак. н. к гор.)
2) $a_к$
3) $\frac{m}{M}$ – шар / – клин
4) t (шар на стол).



~~1) α = const шар падает } ⇒ клин едет влево~~



$Oy|\ ma_{шy} = T_4\sin\alpha - mg = T\sin\alpha - mg$

$Ox|\ ma_{шx} = -T_4\cos\alpha = -T\cos\alpha$

$Oy|\ 0 = N - Mg - T_3\sin\alpha = N - Mg - T\sin\alpha$

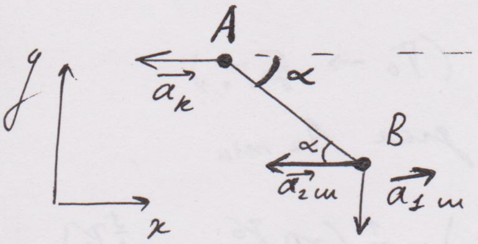
$Ox|\ Ma_{кx} = -T_2 + T_3\cos\alpha = -T + T\cos\alpha =$
$= T(\cos\alpha - 1) < 0$

$a_к = |a_{кx}| = \frac{T(1 - \cos\alpha)}{M}$; $\vec{a_к} \uparrow\downarrow Ox \Rightarrow$ клин едет влево $\Rightarrow$

нить не поднимается (клин не поднимается), $\alpha = const \Rightarrow$
нить справа опускается $\Rightarrow \vec{a_{1ш}} \uparrow\downarrow Oy$ (вниз)

Черновик

№ 1.



$$a_к = \frac{T(1-\cos\alpha)}{M}$$
$$a_{2м} = \frac{T\cos\alpha}{m}$$
$$a_{1м} = \frac{mg - T\sin\alpha}{m} = g - \frac{T\sin\alpha}{m}$$
$$x(t) = x_0 + v_{0x}t + a_x\frac{t^2}{2}$$
$$x_A(t) = x_{0A} + 0\cdot t - a_к\frac{t^2}{2} = x_{0A} - a_к\frac{t^2}{2}$$
$$x_B(t) = x_{0B} + 0\cdot t - a_{2м}\frac{t^2}{2} = x_{0B} - a_{2м}\frac{t^2}{2}$$
$$y_A(t) = y_{0A} + 0\cdot t + 0\cdot\frac{t^2}{2} = y_{0A}$$
$$y_B(t) = H + 0\cdot t - a_{1м}\frac{t^2}{2} = H - a_{1м}\frac{t^2}{2}$$

$$tg\,\alpha = \frac{y_A - y_B}{x_B - x_A} = \frac{y_{0A} - H + a_{1м}\frac{t^2}{2}}{x_{0B} - a_{2м}\frac{t^2}{2} - x_{0A} + a_к\frac{t^2}{2}} = \frac{\overbrace{y_{0A} - H}^{=c} + a_{1м}\frac{t^2}{2}}{x_{0B} - x_{0A} + \frac{t^2}{2}(a_к - a_{2м})} =$$

$$= \frac{y_{0A} - H + \left(\cancel{g} - \frac{T\sin\alpha}{m}\right)\frac{t^2}{2}}{\underbrace{x_{0B} - x_{0A}}_{=b} + \frac{t^2}{2}\left(\frac{T}{M} - \frac{T\cos\alpha}{M} - \frac{T\cos\alpha}{m}\right)} = \frac{\overbrace{y_{0A} - H}^{=c}}{\underbrace{x_{0B} - x_{0A}}_{=b}} = tg\,\alpha$$

$$\frac{c + a_{1м}\frac{t^2}{2}}{b + \frac{t^2}{2}(a_к - a_{2м})} = tg\,\alpha \quad c = b\,tg\,\alpha \Rightarrow$$

$$\cancel{c} + a_{1м}\frac{\cancel{t^2}}{\cancel{2}} = \cancel{b\,tg\,\alpha} + tg\,\alpha\frac{\cancel{t^2}}{\cancel{2}}(a_к - a_{2м}) \Rightarrow a_{1м} = tg\,\alpha\, a_к - tg\,\alpha\, a_{2м}$$

$$a_{1м} = a_к - a_{2м} \Rightarrow g - \frac{T\sin\alpha}{m} = \frac{T}{M} - \frac{T\cos\alpha}{M} - \frac{T\cos\alpha}{m} \,\Big|\cdot Mm$$

$$gMm - TM\sin\alpha = Tm - Tm\cos\alpha - TM\cos\alpha$$
$$Tm - Tm\cos\alpha - TM\cos\alpha + TM\sin\alpha - gMm = 0$$
$$T(m - m\cos\alpha - M\cos\alpha + M\sin\alpha) = gMm$$
$$T = \frac{gMm}{m - m\cos\alpha - M\cos\alpha + M\sin\alpha} = \frac{gMm}{m(1-\cos\alpha) + M(\sin\alpha - \cos\alpha)}$$

$$tg\,\beta = \frac{a_{1м}}{a_{2м}} = \frac{g - \frac{gM\sin\alpha}{m(1-\cos\alpha) + M(\sin\alpha - \cos\alpha)}}{\frac{gM\cos\alpha}{m(1-\cos\alpha) + M(\sin\alpha-\cos\alpha)}} =$$

$$= \frac{gm(1-\cos\alpha) + gM(\sin\alpha - \cos\alpha) - gM\sin\alpha}{gM\cos\alpha} = \frac{m(1-\cos\alpha) - M\cos\alpha}{M\cos\alpha}$$

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Черновик.

№ 1.

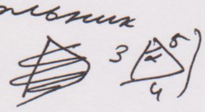
$$a_{1м} = tg\alpha \, a_к - tg\alpha \, a_{2м}$$

$$g - \frac{T\sin\alpha}{m} = tg\alpha \cdot \frac{T(1-\cos\alpha)}{M} - tg\alpha \cdot \frac{T\cos\alpha}{m}$$

$$g - \cancel{\frac{T\sin\alpha}{m}} = tg\alpha \cdot \frac{T(1-\cos\alpha)}{M} - \cancel{\frac{T\sin\alpha}{m}} \Rightarrow g = \frac{T}{M}(tg\alpha - \sin\alpha) \Rightarrow$$

$$\frac{T}{M} = \frac{g}{tg\alpha - \sin\alpha}. \Rightarrow T = \frac{Mg}{tg\alpha - \sin\alpha}$$

$$a_к = \frac{T(1-\cos\alpha)}{M} = \frac{\cancel{M}g\,\cancel{(1-\cos\alpha)}}{tg\alpha\cancel{(1-\cos\alpha)}\cdot \cancel{M}} = \frac{g}{tg\alpha} = \frac{g}{\frac{4}{3}} = \frac{3}{4}g$$

$\cos\alpha = \frac{3}{5} \Rightarrow \sin\alpha = \frac{4}{5} \Rightarrow tg\alpha = \frac{4}{3}$ (п/у треугольник )

$$tg\beta = \frac{a_{1м}}{a_{2м}} = \frac{g - \frac{T\sin\alpha}{m}}{\frac{T\cos\alpha}{m}} = \frac{gm - T\sin\alpha}{T\cos\alpha} =$$

$$= \frac{gm - \frac{Mg\sin\alpha}{tg\alpha - \sin\alpha}}{\frac{Mg\cos\alpha}{tg\alpha - \sin\alpha}} = \frac{gm\,tg\alpha - gm\sin\alpha - Mg\sin\alpha}{Mg\cos\alpha} =$$

$$= \frac{m(tg\alpha - \sin\alpha) - M\sin\alpha}{M\cos\alpha}$$

Часть 2

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

Шифр: **21200106**

ID профиля: **335868**

Вариант 1

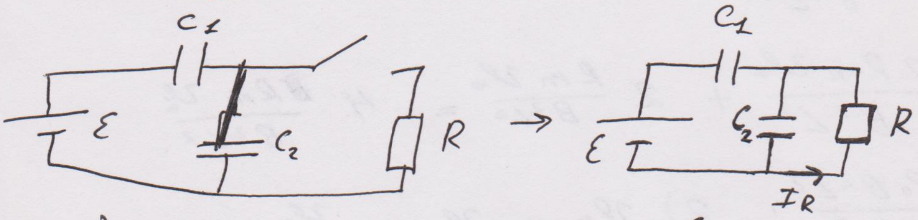
Чистовик.

№ 3. Вариант 11-01.

Дано: $C_1 = 2C$; $C_2 = C$; R; I_0.

Найти: 1) $I_{R_0} = ?$
2) $Q = ?$
3) $I_{R_1} = ?$

Решение:



1) C_1 послед. C_2 $\Rightarrow \frac{1}{C_{общ.}} = \frac{1}{C_1} + \frac{1}{C_2} \Rightarrow C_{общ} = \left(\frac{1}{C_1} + \frac{1}{C_2}\right)^{-1} =$
$= \left(\frac{1}{2C} + \frac{1}{C}\right)^{-1} = \frac{2}{3} C$. $\quad C = \frac{q}{U} \Rightarrow \frac{2}{3} C = \frac{q_0}{\mathcal{E}} \Rightarrow q_0 = \frac{2}{3} C\mathcal{E}$

$q_0 = q_1 = q_2$ (послед. соед.) $\Rightarrow U_2 = \frac{q_2}{C_2} = \frac{\frac{2}{3} C\mathcal{E}}{C} = \frac{2}{3}\mathcal{E} = U_{R_0}$ (паралл. соед.)

$I = \frac{U}{R} \Rightarrow I_{R_0} = \frac{U_{R_0}}{R} = \frac{\frac{2}{3}\mathcal{E}}{R} = \frac{2\mathcal{E}}{3R}$.

2) $\Delta W = A_{внеш} + A_{\mathcal{E}} + A_q$. $\quad A_{внеш} = 0$; $A_q = -Q$; $A_{\mathcal{E}} = \mathcal{E}\Delta q \Rightarrow$
$\Delta W = \mathcal{E}\Delta q - Q \Rightarrow Q = \mathcal{E}\Delta q - \Delta W$
$I = \frac{\Delta q}{\Delta t} \Rightarrow \Delta q = I\Delta t$

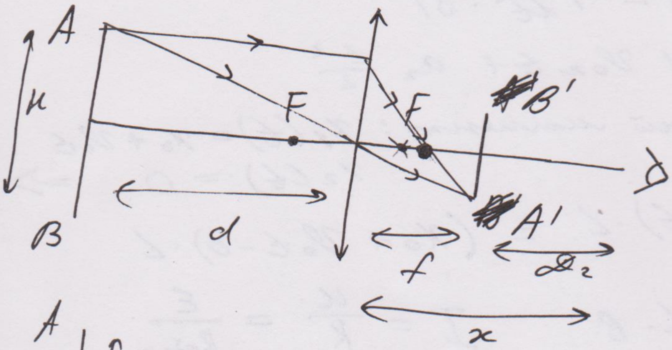
Ответ: 1) $I_{R_0} = \frac{2\mathcal{E}}{2R}$.

№ 5. Вариант 11-01.

Дано: $F = 9$ см; $H = 9$ см; $d = 36$ см; $D_2 = 24$ см.

Найти: 1) $x = ?$; 2) $D_{m\,min} = ?$; 3) $l = ?$

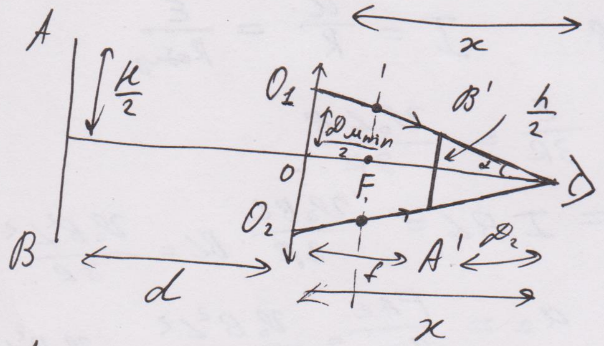
Решение:



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

$f = \left(\frac{1}{F} - \frac{1}{d}\right)^{-1} = \left(\frac{1}{9} - \frac{1}{36}\right)^{-1} = 12$ см

$x = f + D_2 = 12 + 24 = 36$ см

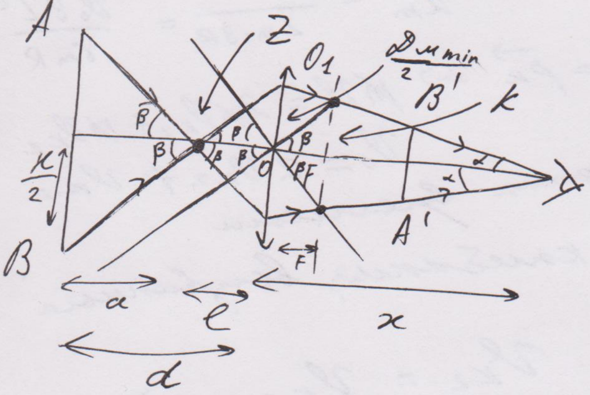


2) $\Gamma = \frac{h}{H} = \frac{f}{d} = \frac{12}{36} = \frac{1}{3} \Rightarrow h = \frac{1}{3}H$

$tg\,\alpha = \frac{h}{2} \Big/ D_2 = \frac{h}{2D_2}$

$tg\,\alpha = \frac{\frac{1}{2}D_{m\,min}}{x} = \frac{D_{m\,min}}{2x} \Rightarrow$

$\frac{h}{D_2} = \frac{D_{m\,min}}{x} \Rightarrow D_{m\,min} = \frac{hx}{D_2} = \frac{\frac{1}{3}Hx}{D_2} = \frac{\frac{1}{3}\cdot 9\cdot 36}{24} = 4{,}5$ см



3) $tg\,\alpha = \frac{K}{x-F} = \frac{h}{2D_2} = \frac{H}{6D_2} \Rightarrow$

$K = \frac{(x-F)H}{6D_2} = \frac{(36-9)\cdot 9}{6\cdot 24} = \frac{27}{16}$ см

Z – экран

р-м $\triangle ZO_1O$ (п/у): $tg\,\beta = \frac{OO_1}{OZ} = \frac{\frac{D_{m\,min}}{2}}{l} = \frac{D_{m\,min}}{2l}$.

$tg\,\beta = \frac{K}{F} \Rightarrow \frac{D_{m\,min}}{2l} = \frac{K}{F} \Rightarrow l = \frac{D_{m\,min}\cdot F}{2K} = \frac{\frac{9}{2}\cdot 9}{2\cdot\frac{27}{16}} = 12$ см

$a = d - l = 36 - 12 = 24$ см

Ответ: 1) $x = 36$ см; 2) $D_{m\,min} = 4{,}5$ см; 3) $l = 12$ см (от линзы) в сторону картины, в $a = 24$ см от картины.

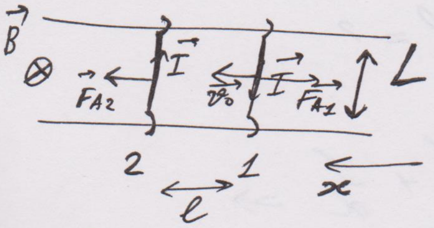
Чистовик.

№ 4. Вариант 11-01.

Дано: L, m, R, $2m$, $2R$, v_0, S_0.

Найти: 1) $a_{20} = ?$
2) $v_{к1}$, $v_{к2} = ?$
3) $l_к = ?$

Решение:



1) $\Phi = BS$ ($\vec{B} \perp$ плоск. контура)

$|\mathcal{E}| = \left|\frac{d\Phi}{dt}\right| = \left|\frac{dS}{dt} \cdot B\right|$

$x(t) = x_0 + v_{0x} t + a_x \frac{t^2}{2}$

~~в~~ начальный момент: $x_1(t) = x_0 + v_0 t$

$x_2(t) = 0$. $\Rightarrow$

$l(t) = x_2(t) - x_1(t)$; $S(t) = l(t) \cdot L = (x_0 + v_0 t - 0) \cdot L$

$|\mathcal{E}| = \left|\frac{d(x_0 L + v_0 L \cdot t)}{dt}\right| \cdot B = v_0 L \cdot B$. $I = \frac{U}{R} = \frac{\mathcal{E}}{R_{общ.}}$

$R_{общ.} = 2R + R = 3R \Rightarrow I = \frac{\mathcal{E}}{3R} = \frac{v_0 L B}{3R}$.

$F_A = IBL$ $(\vec{I} \perp \vec{B}) \Rightarrow F_{A2} = IBL = \frac{v_0 BL}{3R} \cdot BL = \frac{v_0 B^2 L^2}{3R}$.

$\sum \vec{F} = m\vec{a} \Rightarrow F_{A2} = 2m \cdot a_2 \Rightarrow a_2 = \frac{F_{A2}}{2m} = \frac{v_0 B^2 L^2}{2m \cdot 3R} = \frac{v_0 B^2 L^2}{6mR}$

2) система замкнута $\Rightarrow \vec{p_0} = \vec{p_к} \Rightarrow \cancel{m} v_0 = 2\cancel{m} v_{к2} + \cancel{m} v_{к1}$

$v_0 = 2v_{к2} + v_{к1}$

Через продолжительный промежуток времени скорости будут равны, т.к. колебания, вызванные силой Ампера затухнут $\Rightarrow v_{к2} = v_{к1} \Rightarrow$

$v_0 = 2v_{к1} + v_{к1} \Rightarrow v_{к1} = \frac{v_0}{3} \Rightarrow v_{к2} = \frac{v_0}{3}$.

3) $a = \frac{dv}{dt}$; $\frac{dS}{dt} = \frac{L \cdot dx}{dt} = L \cdot \frac{dx}{dt}$. $F_A = IBL = \frac{\mathcal{E}}{3R} \cdot BL =$

$= \frac{BL \cdot \frac{dx}{dt} \cdot BL}{3R} = ma = m\frac{dv}{dt}$ (для 1 рельса)

$\frac{BL \cdot \frac{dx}{dt} \cdot BL}{3R} = 2ma = 2m\frac{dv}{dt}$ (для 2 рельса)

(1): $dx = \frac{3Rm\,dv}{B^2 L^2} \Rightarrow l_1 = \int_0^{l_1} dx = \int_{v_0}^{\frac{v_0}{3}} \frac{3Rm}{B^2L^2} dv = \left(\frac{3Rm}{B^2L^2} v\right)\Big|_{v_0}^{\frac{v_0}{3}} =$

$= \frac{3Rm}{B^2L^2} \cdot \frac{v_0}{3} - \frac{3Rm}{B^2L^2} \cdot v_0 = -\frac{2}{3} \cdot \frac{3Rmv_0}{B^2L^2} = -2\frac{Rmv_0}{B^2L^2}$

Чистовик

№ 4 (продолжение) Вариант ~~04~~ 11-01

(2) $dx = \frac{6Rm\,d\vartheta}{B^2L^2} \Rightarrow l_2 = \int_0^{l_2} dx = \int_0^{\frac{\vartheta_0}{3}} \frac{6Rm}{B^2L^2}\,d\vartheta = \left(\frac{6Rm}{B^2L^2}\vartheta\right)\Big|_0^{\frac{\vartheta_0}{3}} =$

$= \frac{6Rm}{B^2L^2}\cdot\frac{\vartheta_0}{3} = \frac{2Rm\vartheta_0}{B^2L^2}$

$l_k = l_2 + l_1 = \frac{2Rm\vartheta_0}{B^2L^2} + 2\frac{Rm\vartheta_0}{B^2L^2} = 4\frac{Rm\vartheta_0}{B^2L^2}$.

Ответ: 1) $a_{20} = \frac{\vartheta_0 B^2L^2}{6mR}$; 2) $\vartheta_{k1} = \vartheta_{k2} = \frac{\vartheta_0}{3}$;

3) $l_k = \frac{4Rm\vartheta_0}{B^2L^2}$.

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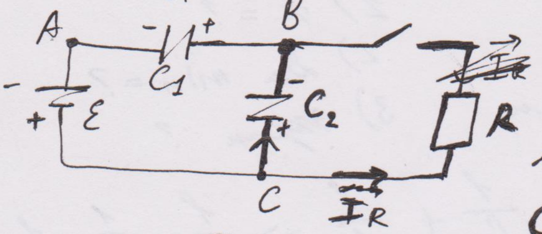
Черновик.

~~№~~ 3.



$C_1 = 2C$; $c_2 = c$.

1) $I_{R_0} = ?$ 2) $Q = ?$ 3) $I_R = ?$ при I_0 в C_1

1) C_1 посл. $C_2 \Rightarrow \frac{1}{C_{общ.}} = \frac{1}{C_1} + \frac{1}{C_2} \Rightarrow$

$C_{общ} = \left(\frac{1}{C_1} + \frac{1}{C_2}\right)^{-1} = \left(\frac{1}{2C} + \frac{1}{C}\right)^{-1} = \frac{2}{3}C$

$C = \frac{q}{U} \Rightarrow \frac{2}{3}C = \frac{q_0}{\mathcal{E}} \Rightarrow q_0 = \frac{2}{3}C\mathcal{E} = q_2 = q_1$

$U_2 = \frac{q_2}{C_2} = \frac{\frac{2}{3}\cancel{C}\mathcal{E}}{\cancel{C}} = \frac{2}{3}\mathcal{E} = U_{R0}$; $U_1 = \frac{q_1}{C_1} = \frac{\frac{2}{3}\cancel{C}\mathcal{E}}{2\cancel{C}} = \frac{1}{3}\mathcal{E}$.

$I = \frac{U}{R} \Rightarrow I_{R_0} = \frac{U_{R_0}}{R} = \frac{\frac{2}{3}\mathcal{E}}{R} = \frac{2}{3}\cdot\frac{\mathcal{E}}{R}$.

2) $\Delta W = A_{\mathcal{E}} + A_g + A_{внеш}$

$A_{\mathcal{E}} = \mathcal{E}\Delta q$; $A_g = -Q$
$A_{внеш} = 0$ $\} \Rightarrow$

$\Delta W = \mathcal{E}\Delta q - Q \Rightarrow Q = \mathcal{E}\Delta q - \Delta W$

$W_0 = \frac{C_1 U_1^2}{2} + \frac{C_2 U_2^2}{2} = \frac{\cancel{2}C\cdot\frac{1}{9}\mathcal{E}^2}{\cancel{2}} + \frac{C\cdot\frac{4}{9}\mathcal{E}^2}{2} = \frac{1}{3}C\mathcal{E}^2$

$-\varphi_A + \varphi_B = U_1$

$-\varphi_B + \varphi_C = U_R = U_2$

$-\varphi_A + \varphi_C = \mathcal{E}$

$I = \frac{\Delta q}{\Delta t}$

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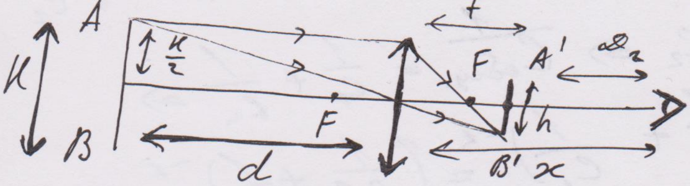
Черновик.

№5.

$F = 9$ см

$AB = H$; $H = 9$ см; $d = 36$ см; $D_2 = 24$ см

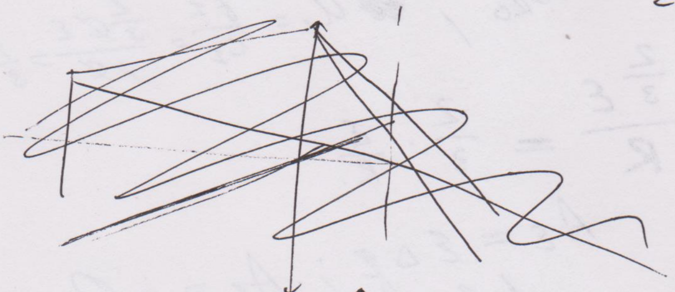
1) $x = ?$
2) $D_л$ min $= ?$
3) Экран ?

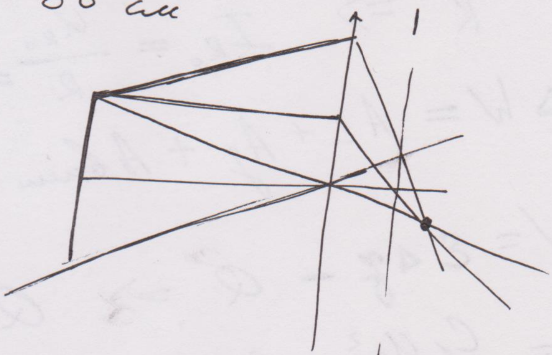


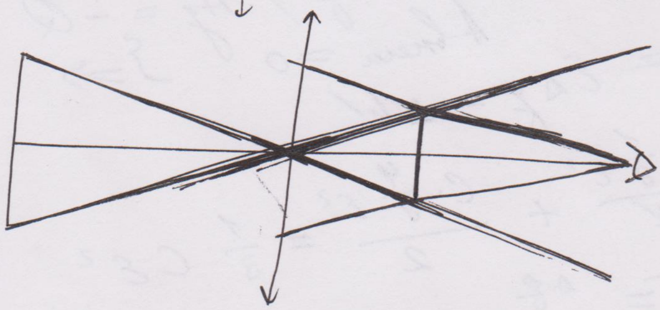
Г 1) $\frac{1}{F} = \frac{1}{f} + \frac{1}{d} \Rightarrow \frac{1}{f} = \frac{1}{F} - \frac{1}{d}$

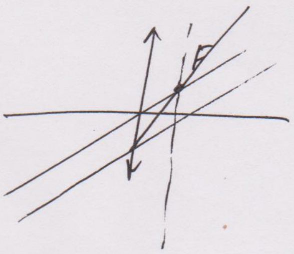
$f = \left(\frac{1}{F} - \frac{1}{d}\right)^{-1} = \left(\frac{1}{9} - \frac{1}{36}\right)^{-1} = \left(\frac{1}{9} - \frac{1}{4}\cdot\frac{1}{9}\right)^{-1} = \left(\frac{3}{4\cdot 9}\right)^{-1} = 12$ см

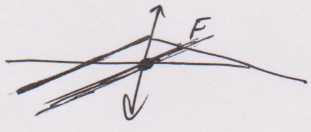
$f + D_2 = x \Rightarrow x = 12 + 24 = 36$ см











$\frac{3\cdot 36}{24} = \frac{3\cdot 3}{2} = \frac{9}{2}$

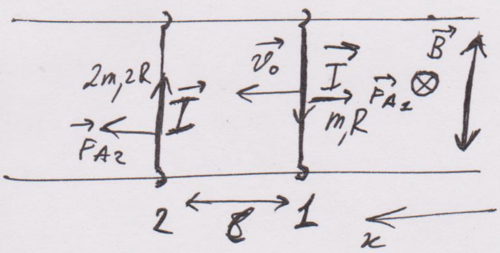
$\frac{27\cdot 9}{6\cdot 24} = \frac{9\cdot \cancel{3}\cdot 3}{\cancel{3}\cdot 2\cdot \cancel{3}\cdot 8} = \frac{27}{16}$

$\frac{9\cdot 9}{4\cdot \frac{27}{16}} = \frac{4\cdot 4\cdot 9\cdot 3\cdot 3}{4\cdot 9\cdot 3} = 12$

№4.

L, v_0, m, R.

1) $a_2 = ?$
2) $v_{к1}$, $v_{к2} = ?$
3) $S_к = ?$ (если S_0)



1) $\Phi = BS\cos\alpha$. $\vec{B} \perp$ плоск контура $\Rightarrow \alpha = 0 \Rightarrow$

$\Phi = BS$

$\mathcal{E} = -\frac{d\Phi}{dt} \Rightarrow |\mathcal{E}| = \left|\frac{d\Phi}{dt}\right| = \left|\frac{dS}{dt}\cdot B\right|$

~~S(t) = L~~ $x(t) = x_0 + v_{0x}t + a_x\frac{t^2}{2} \Rightarrow \ell = x_2(t) - x_1(t) =$

$a_{x1_0} = a_{x2_0} = 0$; $v_{2_0} = 0 \Rightarrow$

$= x_{20} - x_{10} - v_0 t = S_0 - v_0 t$; $S(t) = L\cdot \ell(t) = L\cdot(S_0 - v_0 t)$

$\mathcal{E} = \left|\frac{dS}{dt}\cdot B\right| = |B\cdot(-v_0 L)| = v_0 BL$ $\quad I = \frac{\mathcal{E}}{R} \Rightarrow$

Черновик

№ 4.

$$I = \frac{U}{R} = \frac{\mathcal{E}}{R_{общ}} = \frac{\mathcal{E}}{R+2R} = \frac{v_0 B L}{3R}$$

$$F_A = IBL \quad (\vec{I} \perp \vec{B}) \Rightarrow F_{A2} = IBL = \frac{v_0 B L}{3R} \cdot BL = \frac{v_0 B^2 L^2}{3R}$$

$$F_{A1} = IBL = \frac{v_0 B L}{3R} \cdot BL = \frac{v_0 B^2 L^2}{3R}. \qquad \sum \vec{F} = m\vec{a} \Rightarrow$$

$$F_{A1} = ma_1;\ F_{A2} = 2ma_2 \Rightarrow a_2 = \frac{F_{A2}}{2m} = \frac{v_0 B^2 L^2}{3R \cdot 2m} = \frac{v_0 B^2 L^2}{6Rm}$$

2) система замкнута $\Rightarrow$ $\cancel{W_0 = W_k}$; $\vec{p_0} = \vec{p_k}$.

$$Ox|\ p_{1} + p_{2} = const \Rightarrow \cancel{m}v_0 + 0 = 2\cancel{m}v_{2k} + \cancel{m}v_{1k}$$

$$v_0 = 2v_{2k} + v_{1k}$$

$$W_0 = \frac{mv_0^2}{2};\ W_k = \frac{mv_{1k}^2}{2} + \frac{2mv_{2k}^2}{2} \Rightarrow \frac{\cancel{m}v_0^2}{\cancel{2}} = \frac{\cancel{m}v_{1k}^2}{\cancel{2}} + \frac{2\cancel{m}v_{2k}^2}{\cancel{2}}$$

$$v_0^2 = v_{1k}^2 + 2v_{2k}^2$$

$$\begin{cases} v_0 = 2v_{2k} + v_{1k} \\ v_0^2 = 2v_{2k}^2 + v_{1k}^2 \end{cases} \qquad \begin{cases} v_0^2 = 4v_{2k}^2 + 4v_{2k}\cdot v_{1k} + v_{1k}^2 \\ v_0^2 = 2v_{2k}^2 + v_{1k}^2 \end{cases} \Rightarrow 2v_{2k}^2 + 4v_{2k}\cdot v_{1k} = 0$$

$$v_{2k} = -2v_{1k}$$

$$\Delta W = -Q$$

$$F_A(t) = I(t)BL = \frac{\mathcal{E}(t)}{3R}BL = \frac{dS}{dt} \cdot \frac{B^2L^2}{3R} = ma = \cancel{\ }$$

$$\frac{dS}{dt} = L \cdot \frac{dx}{dt} \Rightarrow \frac{dx}{dt} \cdot \frac{B^2L^2}{3R} = m \cdot \frac{dx}{dt \cdot dt} \Rightarrow \cancel{\int \frac{B^2L^2}{3R}dx = \int m\, dv}$$

$$\cancel{\frac{B^2L^2}{3R}x = mv} \qquad m = \cancel{\frac{B^2L^3}{3R}dt}$$

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