Часть 1

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

Шифр: **21201208**

ID профиля: **162782**

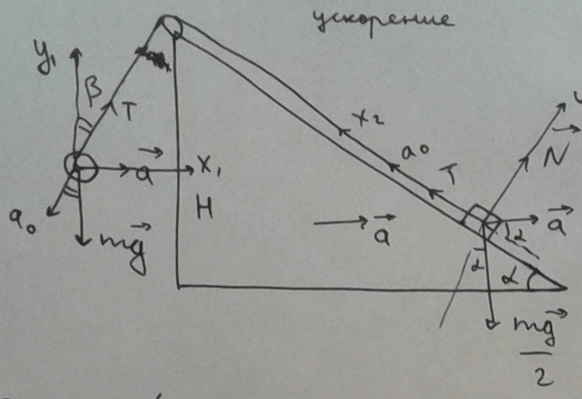
Вариант 7

~~Задача 1.~~ Чистовик.

Задача 1.

a – ускорение клина

a_0 – относительное ускорение



Для шарика:

$$m\vec{a}_ш = m\vec{g} + \vec{T}$$

$$m(\vec{a} + \vec{a}_{от}) = m\vec{g} + \vec{T}$$

Для бруска:

$$m\vec{a}_б = \frac{m\vec{g}}{2} + \vec{T} + \vec{N}$$

$$m(\vec{a} + \vec{a}_{об}) = \frac{m\vec{g}}{2} + \vec{T} + \vec{N}$$

a_0 одинаково по модулю для бруска и шарика, т.к. нить нерастяжима

$$\left.\begin{aligned} Ox_1&: m(a - a_0 \sin\beta) = T\sin\beta \\ Oy_1&: m(-a_0\cos\beta) = -mg + T\cos\beta \end{aligned}\right\} \text{шарик}$$

$$T = \frac{ma - ma_0\sin\beta}{\sin\beta} = \frac{ma}{\sin\beta} - ma_0 \Rightarrow -m\cancel{a_0\cos\beta} = -\cancel{m}g + \frac{\cancel{m}a\cos\beta}{\sin\beta} - m\cancel{a_0\cos\beta}$$

$$a = g\,\frac{\sin\beta}{\cos\beta} = g\,\mathrm{tg}\,\beta = g\cdot\frac{4}{3}$$

$$Ox_2: m(-a\cos\alpha + a_0) = -\frac{mg}{2}\sin\alpha + T \quad (\text{брусок})$$

Подставим T:

$$-\cancel{m}a\cos\alpha + \cancel{m}a_0 = -\frac{\cancel{m}g}{2}\sin\alpha + \frac{\cancel{m}a}{\sin\beta} - \cancel{m}a_0$$

$$2a_0 = a\cos\alpha + \frac{a}{\sin\beta} - \frac{g}{2}\sin\alpha = g\cdot\frac{4}{3}\cdot\frac{5}{13} + \frac{\cancel{4}}{3}\cdot g\cdot\frac{5}{\cancel{4}} - \frac{g}{\cancel{2}}\cdot\frac{\cancel{12}^{6}}{13} = g\left(\frac{20}{39} + \frac{5}{3} - \frac{6}{13}\right) = 1{,}72g$$

Значит, $a_0 = \frac{1{,}72g}{2} = 0{,}86g$

В с.о. клина шарик движется равноускоренно по нити:

$$S = \frac{H}{\cos\beta} = \frac{a_0 t^2}{2} \Rightarrow t^2 = \frac{2H}{a_0\cos\beta} \Rightarrow t = \sqrt{\frac{2H}{a_0\cos\beta}} = \sqrt{\frac{2H}{0{,}86g\cdot\frac{3}{5}}} \approx 2{,}0\cdot\sqrt{\frac{H}{g}}$$

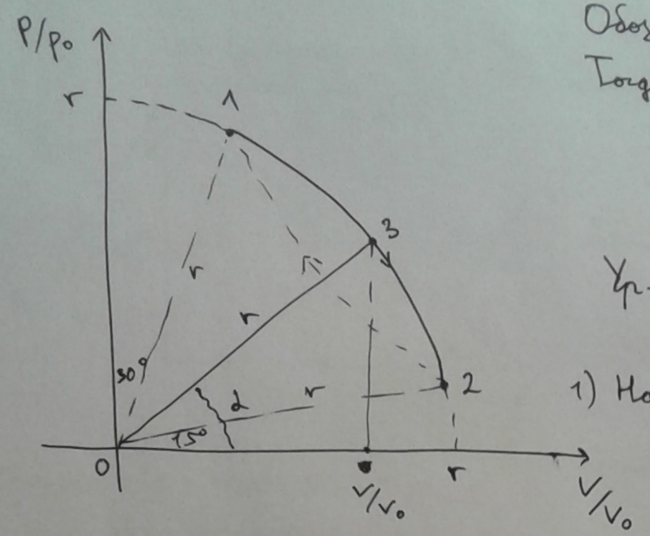
Ответ: $a = \frac{4}{3}g$

$a_0 = 0{,}86g$

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

Чистовик.

Задача 2.



Обозначим радиус окружности за r.

Тогда $p_1 = r\cos 30° \cdot p_0$

$V_1 = r \sin 30° \cdot V_0$

$p_2 = r \sin 15° \cdot p_0$

$V_2 = r\cos 15° \cdot V_0$

Ур-ия состояния: $p_1 V_1 = \nu R T_1$

$p_2 V_2 = \nu R T_2$

1) Найдем $\dfrac{T_1 - T_2}{T_2}$:

$$\frac{T_1 - T_2}{T_2} = \frac{p_1V_1 - p_2V_2}{p_2V_2} = \frac{\cancel{r^2} \cancel{p_0}\cancel{V_0} \cos 30° \sin 30° - \cancel{r^2}\cancel{p_0}\cancel{V_0}\sin 15° \cos 15°}{\cancel{r^2}\cancel{p_0}\cancel{V_0} \cdot \sin 15° \cos 15°} = \frac{\sin 60° - \sin 30°}{\sin 30°} = \sqrt{3} - 1$$

2) Пусть т. 3 - теплоемкость $= 0$

Тогда: $dQ = dA + dU = 0$ в т. 3

$$dA = p\,dV, \quad dU = \frac{i}{2}\nu R\,dT \Rightarrow p\,dV + \frac{i}{2}\nu R\,dT = 0$$

Ур-ие состояния для малых изменений: $p\,dV + V\,dp = \nu R\,dT \Big| \Rightarrow$

$$\Rightarrow p\,dV + \frac{i}{2}(p\,dV + V\,dp) = 0 \Rightarrow \frac{i+2}{\cancel{2}} p\,dV = -\frac{i}{\cancel{2}} V\,dp \Rightarrow \frac{i+2}{i} \cdot \frac{p}{V} = -\frac{dp}{dV}$$

Зависимость $p(V)$: $\left(\frac{p}{p_0}\right)^2 + \left(\frac{V}{V_0}\right)^2 = r^2 \Rightarrow p = \sqrt{r^2 - \left(\frac{V}{V_0}\right)^2} \cdot p_0$

$$\frac{dp}{dV} = p'_V = p_0 \cdot \frac{1}{\cancel{2}\sqrt{r^2 - \left(\frac{V}{V_0}\right)^2}} \cdot \left(-\cancel{2}\frac{V}{V_0^2}\right)$$

Подставим:

$$\frac{i+2}{i} \cdot \frac{\sqrt{r^2 - \left(\frac{V}{V_0}\right)^2} \cdot \cancel{p_0}}{V} = \frac{\cancel{p_0}}{\sqrt{r^2 - \left(\frac{V}{V_0}\right)^2}} \cdot \frac{V}{V_0^2} \Rightarrow \frac{i+2}{i} \cdot V_0^2 \left(r^2 - \left(\frac{V}{V_0}\right)^2\right) = V^2$$

$$V^2 = \frac{i+2}{i}\left(V_0^2 r^2 - V^2\right) \Rightarrow V^2 = \frac{i+2}{\cancel{i}} V_0^2 r^2 \cdot \frac{\cancel{i}}{2i+2} \Rightarrow V = \sqrt{\frac{i+2}{2i+2}}\, V_0 r$$

~~зная~~ $\cos\alpha = \frac{V}{V_0} : r = \frac{V}{V_0 r} = \sqrt{\frac{i+2}{2i+2}} = \sqrt{\frac{3+2}{2\cdot 3+2}} = \sqrt{\frac{5}{8}} \Rightarrow$ т. 3 существует и лежит на дуге 1-2

$\alpha \approx 37{,}8°$

$p_3 = p_0 r \sin\alpha = p_0 r \cdot \sqrt{\frac{3}{8}}$

$V_3 = V_0 r\cos\alpha = V_0 r \cdot \sqrt{\frac{5}{8}}$

Чистовик.

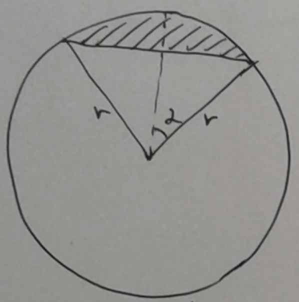
3) $\eta = \frac{A}{Q_{пол.}}$

$Q_{пол.} = Q_{13}$, т.к. в т. 3 $c=0$, а в процессе $2 \to 1$ $Q_{21} = 0$.

$A = A_{12} + A_{21} \Rightarrow \eta = \frac{A_{12} + A_{21}}{Q_{13}}$

$A_{12} \sim S_{под}$ графиком $\frac{p}{p_0}\left(\frac{V}{V_0}\right)$

Найдем, чему равна S сегмента:



$S_{сегм.} = S_{сект.} - S_{\Delta}$

$S_{сект.} = \pi r^2 \cdot \frac{2\alpha}{360^\circ} = \frac{\pi r^2 \alpha}{180^\circ}$, где α - в градусах

$S_{\Delta} = \frac{1}{2} \cdot r^2 \sin 2\alpha = r^2 \cos\alpha \sin\alpha$

$S_{сегм.} = \frac{\pi r^2 \alpha}{180^\circ} - r^2 \cdot \cos\alpha \sin\alpha = r^2\left(\frac{\pi\alpha}{180^\circ} - \cos\alpha\sin\alpha\right)$

Тогда: $A_{12} \sim \frac{1}{2}(S_{сегм.1} - S_{сегм.2}) = \frac{1}{2}\left[r^2\left(\frac{\pi \cdot 60^\circ}{180^\circ} - \cos 60^\circ \sin 60^\circ\right) - r^2\left(\frac{\pi \cdot 15^\circ}{180^\circ} - \frac{1}{2}\sin 30^\circ\right)\right] = \frac{1}{2} r^2\left[\left(\frac{\pi}{3} - \frac{\sqrt{3}}{4}\right) - \left(\frac{\pi}{12} - \frac{1}{4}\right)\right] = \frac{1}{2} r^2\left[\frac{\pi}{4} - \frac{\sqrt{3}}{4} + \frac{1}{4}\right] = \frac{1}{8} r^2 (\pi + 1 - \sqrt{3})$

$A_{12} = p_0 V_0 \cdot \frac{1}{8} r^2 (\pi + 1 - \sqrt{3})$

$A_{13} \sim \frac{1}{2}(S_{сегм.1} - S_{сегм.3}) = \frac{1}{2}\left[r^2\left(\frac{\pi \cdot 60^\circ}{180^\circ} - \cos 60^\circ \sin 60^\circ\right) - r^2\left(\frac{\pi \cdot 37{,}8^\circ}{180^\circ} - \cos 37{,}8^\circ \cdot \sin 37{,}8^\circ\right)\right] = \frac{1}{2} r^2\left[\left(\frac{\pi}{3} - \frac{\sqrt{3}}{4}\right) - \left(0{,}21\pi - \frac{\sqrt{15}}{8}\right)\right] = \frac{1}{2} r^2\left(0{,}12\pi - \frac{\sqrt{3}}{4} + \frac{\sqrt{15}}{8}\right)$

$A_{13} = p_0 V_0 \cdot \frac{1}{2} r^2 \left(0{,}12\pi - \frac{\sqrt{3}}{4} + \frac{\sqrt{15}}{8}\right)$

Найдем A_{21}:

$0 = A_{21} + \frac{i}{2}\nu R(T_1 - T_2) \Rightarrow A_{21} = -\frac{i}{2}\nu R T_2(\sqrt{3} - 1) = -\frac{i}{2}(\sqrt{3}-1) p_2 V_2 = -\frac{i}{2}(\sqrt{3}-1) \cdot p_0 V_0 r^2 \cdot \sin 15^\circ \cos 15^\circ = -p_0 V_0 r^2 \cdot \frac{3}{2}(\sqrt{3}-1) \cdot \frac{1}{4} = -p_0 V_0 r^2 \cdot \frac{1}{8} \cdot 3(\sqrt{3}-1)$

Найдем Q_{13}:

$Q_{13} = A_{13} + \frac{i}{2}\nu R(T_3 - T_1) = A_{13} + \frac{3}{2}(p_3 V_3 - p_1 V_1) = A_{13} + \frac{3}{2}\left(p_0 V_0 r^2 \frac{\sqrt{15}}{8} - p_0 V_0 r^2 \cdot \frac{\sqrt{3}}{2} \cdot \frac{1}{2}\right) = A_{13} + \frac{3}{2} p_0 V_0 r^2 \left(\frac{\sqrt{15}}{8} - \frac{\sqrt{3}}{4}\right)$

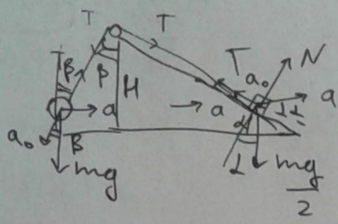
Значит:

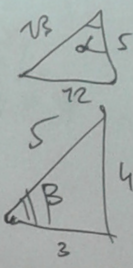
$$\eta = \frac{A_{12} + A_{21}}{Q_{13}} = \frac{\cancel{p_0 V_0} r^2 \cdot \frac{1}{8}(\pi + 1 - \sqrt{3}) - \cancel{p_0 V_0} r^2 \cdot \frac{1}{8} \cdot 3(\sqrt{3} - 1)}{\cancel{p_0 V_0} \cdot \frac{1}{2} \cancel{r^2} \left(0{,}12\pi - \frac{\sqrt{3}}{4} + \frac{\sqrt{15}}{8}\right) + \frac{3}{2}\cancel{p_0 V_0 r^2}\left(\frac{\sqrt{15}}{8} - \frac{\sqrt{3}}{4}\right)} = \frac{2(\pi + 1 - \sqrt{3}) - 6(\sqrt{3} - 1)}{0{,}96\pi - 2\sqrt{3} + \sqrt{15} + 3\sqrt{15} - 6\sqrt{3}} =$$

$$= \frac{2\pi + 8 - 8\sqrt{3}}{0{,}96\pi - 8\sqrt{3} + 4\sqrt{15}}$$

Ответ: $\sqrt{3} - 1$; $\cos\alpha = \sqrt{\frac{5}{8}}$; $\eta = \frac{2\pi + 8 - 8\sqrt{3}}{0{,}96\pi - 8\sqrt{3} + 4\sqrt{15}}$

Черновик.





$\cancel{T\cos\beta = mg}$
$\cancel{T\sin\beta = ma}$ $\Rightarrow \cancel{\frac{a}{g} = tg\beta} \Rightarrow \cancel{a = g\,tg\beta}$

$ma_0\cos\beta = mg - T\cos\beta$
$m(a - a_0\sin\beta) = T\sin\beta$

$\cancel{m}a_0\cos\beta = \cancel{m}g - \cancel{m}(a - a_0\sin\beta)\,ctg\beta$, $ctg\beta = \frac{\cos\beta}{\sin\beta}$

$a_0\cancel{\cos\beta} = g - a\cdot\frac{\cos\beta}{\sin\beta} + \cancel{a_0\cos\beta} \Rightarrow \boxed{a = g\,tg\beta} = \frac{4g}{3}$

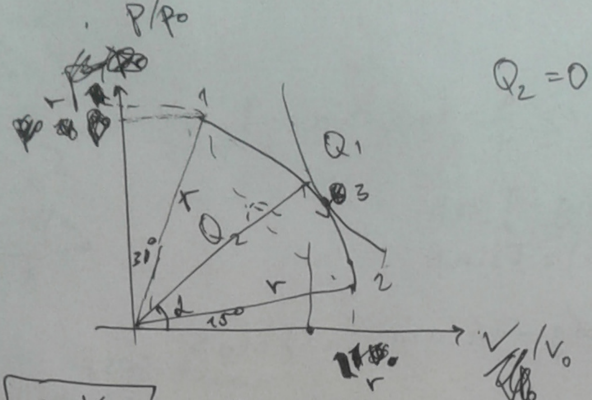
$m(a_0 - a\cos\alpha) = T - \frac{mg}{2}\cdot\sin\alpha$
$ma\sin\alpha = N - \frac{mg}{2}\cdot\cos\alpha$

$\cancel{m}a_0 - \cancel{m}a\cos\alpha = \frac{\cancel{m}a}{\sin\beta} - \cancel{m}a_0 - \frac{\cancel{m}g}{2}\cdot\sin\alpha$

$2a_0 = \frac{a}{\sin\alpha} - \frac{g\sin\alpha}{2} + a\cos\alpha = \frac{4g}{3}\cdot\frac{13}{12} - \frac{g}{2}\cdot\frac{12}{13} + \frac{4g}{3}\cdot\frac{5}{13} =$
$= \frac{13g}{9} - \frac{6g}{13} + \frac{20g}{39} \approx \boxed{1,5g}$

$S = \frac{a_0t^2}{2} = \frac{H}{\cos\beta} \Rightarrow t = \sqrt{\frac{2H}{a_0\cos\beta}} =$

$= \sqrt{\frac{2\cdot H}{\cancel{1,5}g\cdot\frac{3}{\cancel{5}}}} = \sqrt{2,22\frac{H}{g}}$
0,3



$Q_2 = 0$ $\quad p_1V_1 = \nu R T_1$ $\quad \dfrac{T_1 - T_2}{T_2} = \dfrac{p_1V_1 - p_2V_2}{p_2V_2}$

$p_2V_2 = \nu R T_2$

$\cancel{\dfrac{p_1^2}{p_0^2} + \dfrac{V_1^2}{V_0^2} = \dfrac{p_2^2}{p_0^2} + \dfrac{V_2^2}{V_0^2}}$

$\dfrac{1}{p_0^2}(p_1 - p_2)(p_1 + p_2) = \dfrac{1}{V_0^2}(V_2 - V_1)(V_2 + V_1)$

$\dfrac{p}{p_0} = \sqrt{r^2 - \left(\dfrac{V}{V_0}\right)^2}$ $\quad \left(\dfrac{p}{p_0}\right)^2 + \left(\dfrac{V}{V_0}\right)^2 = const = r^2$

$p_1 = r \cos 30° \cdot p_0$

$V_1 = r \sin 30° \cdot V_0$

$Q_2 = A_2 + \dfrac{i}{2}\nu R (T_1 - T_2) = 0$ $\quad p_2 = r \sin 15° \cdot p_0$ $\quad \sin 30° = \dfrac{1}{2}$

$V_2 = r \cos 15° \cdot V_0$

$$\frac{T_1 - T_2}{T_2} = \frac{2\cos 30° \cdot \sin 30° - 2\sin 15° \cos 15°}{2\sin 15° \cos 15°} = \frac{\sin 60° - \sin 30°}{\sin 30°} = \frac{\sqrt{3} - 1}{1} = \boxed{\sqrt{3} - 1}$$

$dQ = dA + dU$

$dQ = p\,dV + \dfrac{i}{2}\nu R\,dT = 0$

$\overset{\|}{0}$

$c = 0$ $\quad p\,dV + \dfrac{i}{2}(p\,dV + V\,dp) = 0$

$\dfrac{i+2}{\cancel{2}} p\,dV + \dfrac{i}{\cancel{2}} V\,dp = 0 \Rightarrow \dfrac{i+2}{i}\dfrac{p}{V} = -\dfrac{dp}{dV}$

$$\frac{dp}{dV} = p'_V = \left(p_0\sqrt{r^2 - \frac{V^2}{V_0^2}}\right)' = p_0 \cdot \frac{1}{\cancel{2}\sqrt{r^2 - \frac{V^2}{V_0^2}}} \cdot \left(-\cancel{2}\frac{V}{V_0^2}\right)$$

$$\frac{i+2}{i} \cdot \frac{p}{V} = \frac{\cancel{2}p_0}{\cancel{2}\sqrt{r^2 - \frac{V^2}{V_0^2}}} \cdot \frac{V}{V_0^2} = \frac{p_0 V}{V_0\sqrt{V_0^2 r^2 - V^2}}$$

$\eta = \dfrac{A}{Q_{нач.}} = Q_{13}$

$$\frac{i+2}{i} \cdot \frac{1}{V} \cdot \cancel{p_0}\sqrt{r^2 - \left(\frac{V}{V_0}\right)^2} = \frac{\cancel{p_0} V}{\sqrt{r^2 - \left(\frac{V}{V_0}\right)^2} \cdot V_0^2}$$

$\underline{0,42}$

$$\frac{i+2}{i} \cdot V_0^2\left(r^2 - \left(\frac{V}{V_0}\right)^2\right) = V^2$$

$$\frac{i+2}{i} \cdot (V_0^2 r^2 - V^2) = V^2 \Rightarrow \frac{i+2}{\cancel{i}} V_0^2 r^2 = V^2\left(1 + \frac{i+2}{i}\right) = V^2 \cdot \frac{2i+2}{\cancel{i}}$$

$$V^2 = \frac{i+2}{2i+2} V_0^2 r^2 \Rightarrow V = rV_0\sqrt{\frac{i+2}{2i+2}}$$ $\quad \sin\alpha = \sqrt{\dfrac{3}{8}}$ $\quad 2 \cdot 3 + 2 = 8$

$$\cos\alpha = \frac{V}{V_0 r} = \sqrt{\frac{i+2}{2i+2}} = \sqrt{\frac{5}{8}} = 0{,}79$$

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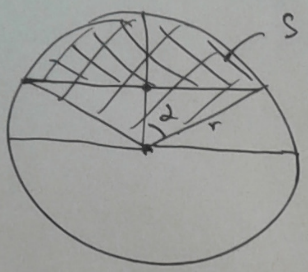
$$A_2 = -\frac{i}{2}\nu R T_2(\sqrt{3}-1) = -\frac{i}{2} p_2 V_2 (\sqrt{3}-1) = -\frac{i}{2} p_0 V_0\, r^2 \cdot \sin 15^\circ \cos 15^\circ (\sqrt{3}-1)$$

$$\cancel{A_2 = \int_{V_1}^{V_2} p\,dV = \int_{V_1}^{V_2} p_0 \sqrt{r^2-\left(\frac{V}{V_0}\right)^2}\,dV}$$



$$S = S_c - S_\Delta = \frac{\pi r^2 \alpha}{180^\circ} - \frac{1}{2} r^2 \sin 2\alpha = r^2 \cdot \left(\frac{\pi \alpha}{180^\circ} - \frac{1}{2}\underbrace{\sin 2\alpha}_{\cos\alpha \sin\alpha}\right)$$

$$S_c = \pi r^2 \cdot \frac{2\alpha}{360^\circ} = \frac{\pi r^2 \alpha}{180^\circ}$$

$$S_\Delta = \frac{1}{2} r^2 \sin 2\alpha$$

$$A_1 = \frac{1}{2}\cdot\left(\frac{\pi r^2 \cdot 60^\circ}{180^\circ} - \cancel{\tfrac{1}{2}}\cdot r^2 \cos 60^\circ \sin 60^\circ\right) - \frac{1}{2}\left(\frac{\pi r^2 \cdot 15^\circ}{180^\circ} - \frac{1}{2} r^2 \cdot \sin 30^\circ\right) =$$

$$= \frac{1}{2} r^2 \left(\left(\frac{4\pi}{12} - \frac{\sqrt{3}}{2}\cdot\frac{1}{2}\right) - \left(\frac{\pi}{12} - \frac{1}{2}\cdot\frac{1}{2}\right)\right) = \frac{1}{2} r^2 \cdot \left(\frac{\pi}{4} - \frac{\sqrt{3}}{4} + \frac{1}{4}\right) = \frac{1}{8} r^2 (\pi - \sqrt{3} + 1)$$

$$\frac{1}{8} r^2 (\pi + 1 - \sqrt{3})\, p_0 V_0$$

$$Q_{13} = A_{13} + \frac{i}{2}\nu R (T_3 - T_1) = \frac{i}{2} p_0 V_0 r^2 \left(\frac{\sqrt{15}}{8} - \frac{\sqrt{3}}{4}\right) + A_{13}$$

$$p_0 r\, \cancel{\sin} \cdot \sqrt{\frac{3}{8}} \cdot V_0 r \cdot \sqrt{\frac{5}{8}} = \nu R T_3 \Rightarrow \nu R T_3 = \frac{p_0 V_0 r^2 \sqrt{15}}{8}$$

$$\nu R T_1 = r^2 \underbrace{\cos 30^\circ}_{\sin 30^\circ} \cdot p_0 V_0 = \frac{p_0 V_0 r^2 \sqrt{3}}{4}$$

$$A_{13} = \cancel{\tfrac{1}{2}} \frac{1}{2} r^2 \left(\left(\frac{\pi \cdot 60^\circ}{180^\circ} - \underbrace{\cancel{\frac{\sqrt{3}}{8}\,\frac{\sqrt{5}}{8}}}_{\frac{\sqrt{3}}{2}\cdot\frac{1}{2}}\right) - \left(\frac{\pi \cdot 30^\circ}{180^\circ} - \cancel{1}\sqrt{\frac{3}{8}}\sqrt{\frac{5}{8}}\right)\right)$$

$$\eta = \frac{A_1 + A_2}{Q_{13}} = \frac{A_1 + A_2}{A_{13} + }$$

Часть 2

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

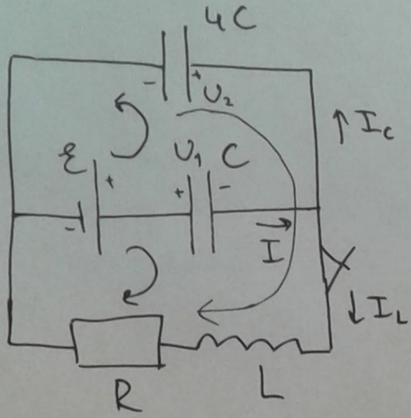
Шифр: **21201208**

ID профиля: **162782**

Вариант 7

Чистовик.

Задача 3.



До замыкания ключа:

$$\left.\begin{array}{l} U_{10}+U_{20}=\mathcal{E} \\ q_1=q_2=q \end{array}\right| \Rightarrow \frac{q}{C}+\frac{q}{4C}=\mathcal{E} \Rightarrow q=\frac{4C\mathcal{E}}{5}$$

$$U_{10}=\frac{q}{C}=\frac{4\mathcal{E}}{5}, \quad U_{20}=\frac{q}{4C}=\frac{\mathcal{E}}{5}$$

1) Сразу после замыкания ключа:

$U_1=U_{10}$, $U_2=U_{20}$

$I_L=0$ (т.к. $\Phi_{до}=\Phi_{после}$, $L=const$)

$$-L\frac{dI_L}{dt}=-U_{20}=-\frac{\mathcal{E}}{5} \Rightarrow \frac{dI_L}{dt}=\frac{\mathcal{E}}{5L}$$

2) В уст. режиме: все токи $=0$ (т.к. есть резистор) $\Rightarrow W_{кат.к}=0$

$W_{кат.н}$ также $=0$

$$\left.\begin{array}{l} \mathcal{E}=U_{1к} \text{ (нижний контур)} \\ \mathcal{E}=U_{1к}+U_{2к} \text{ (верхний контур)} \end{array}\right| \Rightarrow \begin{array}{l} U_{1к}=\mathcal{E} \\ U_{2к}=0 \end{array}$$

ЗСЭ: $$\mathcal{E}\Delta q=\left(\frac{C\mathcal{E}^2}{2}-\left(\frac{C\cdot\left(\frac{4\mathcal{E}}{5}\right)^2}{2}+\frac{4C\cdot\left(\frac{\mathcal{E}}{5}\right)^2}{2}\right)\right)+\cancel{\Delta W_{кат.}}^{\,0}+Q$$

$$\Delta q=q_{1к}-q_{1н}=C\mathcal{E}-C\cdot\frac{4\mathcal{E}}{5}=\frac{C\mathcal{E}}{5}$$

$$\mathcal{E}\cdot\frac{C\mathcal{E}}{5}=\left(\frac{C\mathcal{E}^2}{2}-\frac{\cancel{20}^{\,10\;2}C\mathcal{E}^2}{{}_5\cancel{25\cdot 2}}\right)+Q=\frac{C\mathcal{E}^2}{10}+Q \Rightarrow Q=\frac{C\mathcal{E}^2}{10}$$

3) $$\mathcal{E}=U_1+U_2 \Rightarrow \mathcal{E}=\frac{q_1}{C}+\frac{q_2}{4C}$$

Возьмем производную по времени: $0=\frac{I}{C}+\frac{I_c}{4C}$ ($q_1'=I$, $q_2'=I_c$) $\Rightarrow$

$\Rightarrow I_c=-4I$

$I=I_c+I_L \Rightarrow I_L=5I$

По условию $I=I_0 \Rightarrow I_L=5I_0$ = ток через резистор

Ответ: $\left(\frac{dI_L}{dt}\right)_{нач.}=\frac{\mathcal{E}}{5L}$

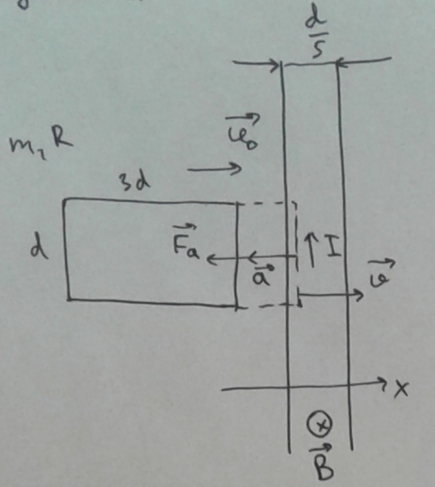
$Q=\frac{C\mathcal{E}^2}{10}$

$I_L=5I_0$

21201208 (U162782 M1269633)

Чистовик.

Задача 4.



Вхождене рамки в поле:

В рамке создается $\mathcal{E}_{инд.}$

$$|\mathcal{E}_{инд.}| = \frac{d\Phi}{dt} = B\cdot\frac{dS}{dt} = B v$$

I в правой стороне направлен вверх (по закону Ленца и правилу правой руки)

F Ампера по правилу левой руки направлена влево

$$F_a = BIl = B\cdot\frac{\mathcal{E}_{инд.}}{R}\cdot d = B\cdot\frac{Bv}{R}d = \frac{B^2vd}{R}$$

2 закон Н.: $\cancel{m\vec{a} = \vec{F_a} = -\frac{B^2\vec{v}d}{R}}$ На левую сторону Fa не действует, на верхнюю и нижнюю – $F_a \perp v \Rightarrow$ нет вклада в ускорение

$$Ox: \; ma = -\frac{B^2vd}{R}$$

1) Сразу после вхождения:

$$v = v_0 \Rightarrow |a_0| = \frac{B^2v_0d}{Rm}, \text{ направлено влево}$$

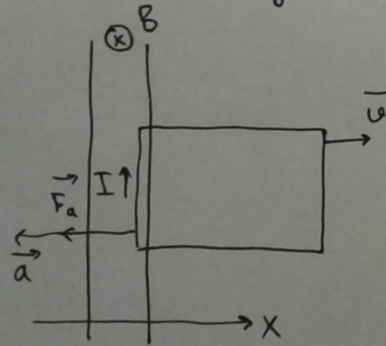
2)

$$ma = -\frac{B^2vd}{R} \Rightarrow m\cdot\frac{dv}{\cancel{dt}} = -\frac{B^2d}{R}\frac{dx}{\cancel{dt}} \Rightarrow m\Delta v = -\frac{B^2d}{R}\Delta x$$

При выходе правой стороны из поля B:

$$m(v_1 - v_0) = -\frac{B^2d}{R}\cdot\frac{d}{5} \Rightarrow v_1 - v_0 = -\frac{B^2d^2}{5mR} \Rightarrow v_1 = v_0 - \frac{B^2d^2}{5mR}$$

3) Выход рамки из поля:



Аналогично вхождению, I направлен вверх, Fa направлена влево. (для левой стороны)

$$\cancel{F_a}\; |\mathcal{E}_{инд.}| = \frac{d\Phi}{dt} = B\cdot\frac{dS}{dt} = Bv$$

$$F_a = BIl = B\cdot\frac{\mathcal{E}_{инд.}}{R}d = B\cdot\frac{Bv}{R}d = \frac{B^2vd}{R}$$

$$ma = -\frac{B^2vd}{R} \Rightarrow m\cdot\frac{dv}{\cancel{dt}} = -\frac{B^2d}{R}\cdot\frac{dx}{\cancel{dt}} \Rightarrow m\Delta v = -\frac{B^2d}{R}\Delta x$$

При выходе левой стороны из B:

$$m(v_2 - v_1) = -\frac{B^2d}{R}\cdot\frac{d}{5} = -\frac{B^2d^2}{5R} \Rightarrow v_2 = v_1 - \frac{B^2d^2}{5mR} = v_0 - \frac{2B^2d^2}{5mR}$$

Ответ: $a_0 = \frac{B^2v_0d}{Rm}$

$v_1 = v_0 - \frac{B^2d^2}{5mR}$

$v_2 = v_0 - \frac{2B^2d^2}{5mR}$

Чистовик.

Задача 5.

Очки расположены вплотную к глазу => оптическая сила очков и глаза складываются как в системе линз

Почти нулевой предел аккомодации => f (расстояние от глаза до сетчатки) и $D_г$ (оптическая сила глаза) $\approx const$

1) Формулы тонкой линзы:

$$\frac{1}{d_{уд.}} + \frac{1}{f} = D_г + D_{уд.}, \quad d_{уд.} \gg f \Rightarrow \frac{1}{f} = D_г + D_{уд.}$$

$$\frac{1}{d_0} + \frac{1}{f} = D_г + D_{чтение}$$

$$\Rightarrow \frac{1}{d_0} = D_{чт.} - D_{уд.}$$

$D_{уд.} > D_{чт.}$, т.к. для удаленных предметов необходимо искажать ход лучей сильнее $\Rightarrow D_{уд.} = 3D_{чт.} \Rightarrow \frac{1}{d_0} = \frac{D_{уд.}}{3} - D_{уд.} \Rightarrow D_{уд.} = -\frac{3}{2} \cdot \frac{1}{d_0} = -\frac{3}{2 \cdot 0{,}25} = -6$ дптр

Без очков:

$$\frac{1}{x} + \frac{1}{f} = D_г \Rightarrow \frac{1}{x} = -D_{уд.} \Rightarrow x = -\frac{1}{D_{уд.}} = \frac{1}{6}\ м \approx 16{,}7\ см$$

2) Для компьютера:

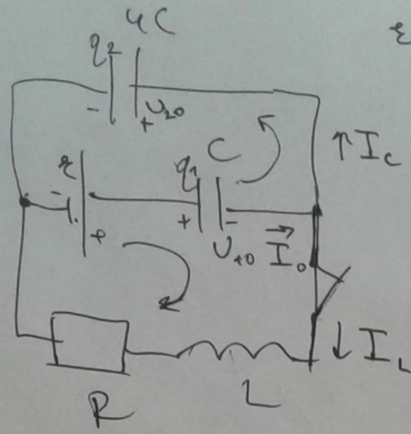
$$\frac{1}{d} + \frac{1}{f} = D_г + D_{ком.} \Rightarrow \frac{1}{d} = D_{ком.} - D_{уд.} \Rightarrow D_{ком.} = \frac{1}{d} + D_{уд.} = \frac{1}{0{,}5} - 6 = -4\ дптр$$

Ответ: $D_{уд.} = -6$ дптр

$x = 16{,}7$ см

$D_{ком.} = -4$ дптр

Черновик.



$$\varepsilon = \frac{q}{4C} + \frac{4q}{4C} = \frac{5q}{4C} \Rightarrow q = \frac{4C\varepsilon}{5}$$

$$U_{20} = \frac{\varepsilon}{5}, \quad U_{10} = \frac{4\varepsilon}{5}$$

$$t=0: \quad \varepsilon - L\frac{dI_L}{dt} = U_{10} = \frac{4\varepsilon}{5} \Rightarrow \frac{dI_L}{dt} = \boxed{\frac{\varepsilon}{5L}}$$

Уст. р.: $I = 0$

$$\varepsilon \Delta q = \frac{25C\varepsilon^2}{50} - \left(\frac{C\cdot\left(\frac{\varepsilon}{5}\right)^2}{2} + \frac{C\cdot\left(\frac{4\varepsilon}{5}\right)^2}{2}\right) + Q$$

$$\frac{C\cdot\frac{17\varepsilon^2}{25}}{2} = \frac{17C\varepsilon^2}{50}$$

$$Q = \varepsilon\Delta q - \frac{8C\varepsilon^2}{50}$$

$$\Delta q = \left(C\varepsilon - C\cdot\frac{4}{5}\varepsilon\right) = \frac{1}{5}C\varepsilon = \frac{5}{25}C\varepsilon$$

$$\frac{2C\varepsilon^2}{25}$$

$$\cancel{\frac{3}{25}C\varepsilon^2}$$

$$\cancel{\varepsilon - L\frac{dI_L}{dt} = I_L R - U_1}$$

$$U_1 = \frac{q_1}{C} \sim I_0$$

$$\varepsilon = U_1 + U_2 = \frac{q_1}{C} + \frac{q_2}{4C} \Rightarrow 0 = \frac{I_1}{C} + \frac{I_C}{4C} \Rightarrow I_C = -4I_1$$

$q_2 \sim I_C$

$\varepsilon =$

$\vec{I}_0$

$$I_0 = I_C + I_L$$

При $I_1 = I_0$: $I_C = -4I_0$

$$I_L = \boxed{5I_0}$$

$$\cancel{-LI_L'' = I_L'R - I_0}$$

$$\omega = \frac{1}{\sqrt{LC}}$$

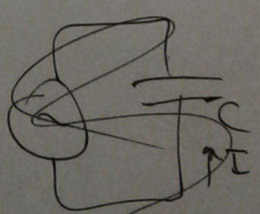
$$X_C = \frac{1}{\sqrt{C}\,C\cdot\frac{1}{\sqrt{LC}}} = \sqrt{\frac{L}{C}}$$

$$\frac{1}{\sqrt{LC}}\cdot L = \sqrt{\frac{L}{C}}$$

$$\frac{1}{10} - \frac{2}{10} = \frac{1}{10}$$

$$U_1 = I_0\sqrt{\frac{L}{C}}$$

$$\cancel{I = I_0\cos\omega t}$$



$$U = U_0\cos\omega t$$

$$U = U_0\cos\omega t = L\frac{dI}{dt}$$

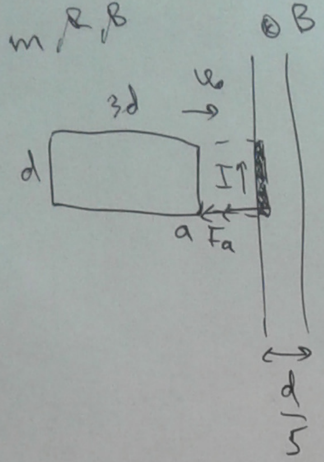
$$q = CU_0\cos\omega t$$

$$I = -CU_0\omega\sin\omega t$$

$$\frac{U_0}{\omega}\sin\omega t = LI$$

$$Z = \frac{1}{C\omega}$$

$$Z = \omega L$$



$$|\varepsilon_i| = B\frac{ds}{dt} = B v_0$$

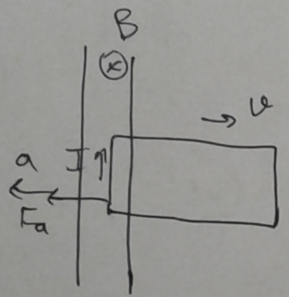
$$ma = F_a = BIl = B\cdot\frac{\varepsilon_i}{R}l = B\cdot\frac{Bv_0}{R}\cdot d$$

$$a = \frac{B^2 v_0 d}{Rm}$$

$$ma = -\frac{B^2 d}{R}v$$

$$m\cdot\frac{dv}{\cancel{dt}} = -\frac{B^2 d}{R}\frac{dx}{\cancel{dt}} \Rightarrow m\Delta v = -\frac{B^2 d}{R}\cdot\frac{d}{5} = \frac{B^2 d^2}{5R}$$

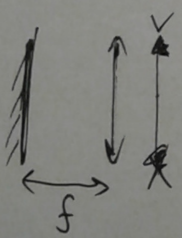
$$v_1 = v_0 - |\Delta v| = v_0 - \frac{B^2 d^2}{5mR} \qquad |\Delta v| = \frac{B^2 d^2}{5mR}$$



$$m\cdot\frac{dv}{\cancel{dt}} = -\frac{B^2 d}{R}\frac{dx}{\cancel{dt}}$$

$$m\Delta v = -\frac{B^2 d}{R}\cdot\frac{d}{5} \Rightarrow |\Delta v| = \frac{B^2 d^2}{5mR}$$

$$v_2 = v_0 - \frac{2B^2 d^2}{5mR}$$



$$\frac{1}{d_1} + \frac{1}{f} = D_r + D_x$$

$$\frac{1}{d_1} + \cancel{D_r} + 3D_2 = \cancel{D_r} + D_x$$

$$D_x = \overset{=2}{\frac{1}{0{,}5}} + 3\cdot\overset{=-6}{(-2)} = \boxed{-4\text{ дптр}}$$

$$\cancel{\frac{1}{d}} + \frac{1}{f} = D_r + D_1$$

$$f = \frac{1}{D_r + D_1}$$

$$\frac{D_1}{D_2} = 3 \qquad D_1 = 3D_2$$

$$\frac{1}{d_0} + \frac{1}{f} = D_r + D_2$$

$$\frac{1}{f} = D_r + 3D_2$$

$$\frac{1}{d_0} + \frac{1}{f} = D_r + D_2$$

$$\frac{1}{d_0} + \cancel{D_r} + 3D_2 = \cancel{D_r} + D_2 \Rightarrow D_2 = -\frac{1}{2d_0} = -\frac{1}{2\cdot 0{,}25} = -2\text{ дптр.}$$

$$D_1 = \boxed{-6\text{ дптр.}}$$

$$\frac{1}{x} + \frac{1}{f} = D_r$$

$$\frac{1}{x} + \cancel{D_r} + 3D_2 = \cancel{D_r} \Rightarrow x = -\frac{1}{3\cdot D_2} = \frac{1}{6}\text{ м} = \boxed{16{,}7\text{ см}}$$