Часть 1

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

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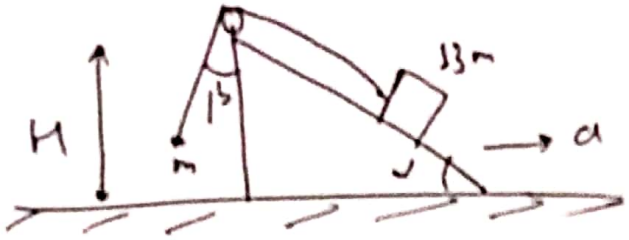
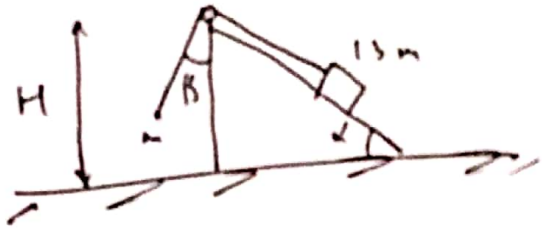
Вариант 5

Листовик

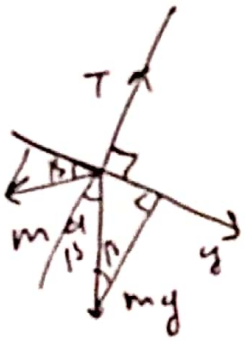
1.



Проанализируем систему отсчёта движущуюся с ускорением a (ускорения клина).



В этой системе на тела действует сила инерции $\vec{F} = -m\vec{a}$.



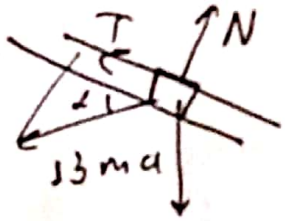
$\beta = const \Rightarrow$ шарик вдоль нити падает.

$a_y = 0$

$mg\sin\beta = ma\cos\beta$

$a = g\,tg\beta = g\sqrt{\frac{1}{\cos^2\beta} - 1} =$

$= g\sqrt{\frac{25}{16} - 1} = \frac{3}{4}g = 7{,}35\ м/с^2$



ускорение бруска направлено вдоль клина.

$T + 13ma\cos\alpha - 13mg\sin\alpha = 13m a_{бруска}$

$mg\cos\beta + ma\sin\beta - T = m a_{шарик}$

$a_{шарик} = a_{бруска}$

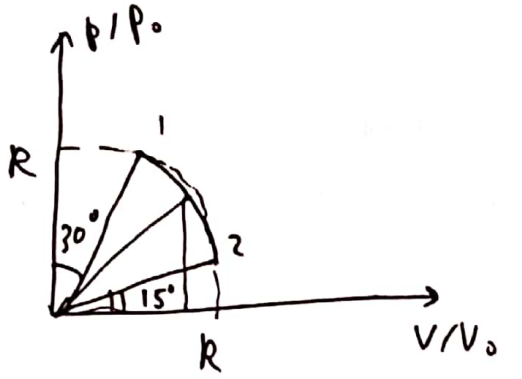
$= m a_{бруска}$

~~$24 + 8ma\cos\alpha - 13mg\sin\alpha - mg\cos\beta - ma\sin\beta = 12ma$~~

$13ma\cos\alpha - 13mg\sin\alpha + mg\cos\beta + ma\sin\beta = 14ma$

Тестовик

2.



$P_1V_1 = \nu R T_1$

$P_2V_2 = \nu R T_2$

$$\frac{T_1}{T_2} = \frac{P_1V_1}{P_2V_2} = \frac{\frac{P_1}{P_0}\cdot\frac{V_1}{V_0}}{\frac{P_2}{P_0}\cdot\frac{V_2}{V_0}} =$$

$$= 2\,\frac{R\cos 30^\circ \cdot R\sin 30^\circ}{2\,R\sin 15^\circ R\cos 15^\circ} = \frac{2\sin 30^\circ\cos 30^\circ}{\sin 30^\circ} = \frac{2\sqrt{3}}{2} \approx 1{,}73$$

$\delta Q = dU + \delta A$ $\qquad C = \frac{\delta Q}{dT} = 0$

$$\delta Q = \frac{3}{2}\nu R\,dT + P\,dV$$

$$\frac{3}{2}\nu R = -P\frac{dV}{dT}$$

$$\frac{3}{2}\nu R\,dT = -P\,dV = \frac{3}{2}(P\,dV + V\,dP)$$

$$\frac{5}{2}P\,dV = -\frac{3}{2}V\,dP$$

$$5\,\frac{P}{P_0}\,d\left(\frac{V}{V_0}\right) = -3\,\frac{V}{V_0}\,d\left(\frac{P}{P_0}\right) \qquad \left(\frac{P}{P_0}\right)^2 + \left(\frac{V}{V_0}\right)^2 = k^2$$

$$\frac{\frac{3V}{V_0}}{\frac{P}{P_0}} = \frac{5\,\frac{P}{P_0}}{\frac{V}{V_0}}$$

$$\int 5\,\frac{d\left(\frac{V}{V_0}\right)}{\frac{V}{V_0}} = \int -3\,\frac{d\left(\frac{P}{P_0}\right)}{\frac{P}{P_0}}$$

$$5\ln\left(\frac{V}{V_0}\right) = -3\ln\left(\frac{P}{P_0}\right)$$

$$\frac{P}{P_0}\,d\left(\frac{P}{P_0}\right) = -\frac{V}{V_0}\,d\left(\frac{V}{V_0}\right)$$

$$\frac{\frac{P}{P_0}}{\frac{V}{V_0}} = \sqrt{\frac{3}{5}} = \operatorname{tg}\alpha$$

$\alpha = 37{,}176^\circ$ (малый угол если между 1 и 2)

(3)

Тимофеев

3.

$$a_\delta = \frac{13g\,tg\beta\cos\alpha - 13g\sin\alpha + g\cos\beta + g\,tg\beta\sin\beta}{14} =$$

$tg\beta = \frac{3}{4}$ $\quad \sin\alpha$ $\quad \cos\beta = \frac{4}{5}$ $\quad \sin\beta = \frac{3}{5}$

$\cos\alpha = \frac{12}{13}$ $\quad tg\alpha = \sqrt{\frac{169}{144} - 1} = \frac{5}{12}$

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

$$= \frac{g}{14}\left(\frac{3}{4}\cdot 13\cdot\frac{12}{13} - 13\cdot\frac{5}{13} + \frac{4}{5} + \left(\frac{3}{4}\cdot\frac{3}{5}\right)\right) = \frac{9}{20}$$

$$= \frac{g}{14}\left(9 - 5 + \frac{9}{20}\right) = \frac{g}{14}\left(4 + \frac{7}{5}\right) = \frac{g\,27}{70} = 3{,}78\ м/с^2$$

$$\frac{a_\delta t^2}{2} = \frac{H}{\cos\beta} = \frac{5H}{4}$$

$$t = \sqrt{\frac{5H}{2a_\delta}} = 0{,}81\sqrt{H}\ с$$

H – в метрах

$$= \frac{g}{14}\left(4 + \frac{4}{5} + \frac{1}{20}\right) = \frac{g(\cdot 105)}{20\cdot 14} = \frac{21g}{56} =$$

$$= 3{,}68\ м/с^2$$

$$\frac{a_\delta t^2}{2} = \frac{H}{\cos\beta} = \frac{5H}{4}$$

$$t = \sqrt{\frac{5H}{2a_\delta}} = 0{,}82\sqrt{H}\ с$$

H – в метрах

Тестовик

2.

$$\frac{A_{1\to2}}{A} = \frac{A_{1\to2}}{A_{1\to2} + A_{2\to1}} =$$

$$Q_{2\to1} = 0 = \Delta U + A_{2\to1} =$$

$$= \frac{3}{2}\nu R(T_1 - T_2) + A_{2\to1}$$

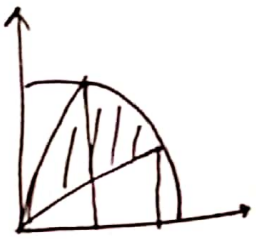
$$A_{2\to1} = -\frac{3}{2}\nu R(T_1 - T_2)$$

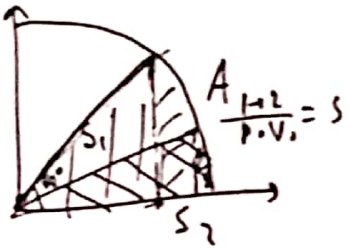
$$= \frac{A_{1\to2}}{A_{1\to2} - \frac{3}{2}\nu R(T_1 - T_2)}$$

$$A = \int P dV =$$

$$= P_0 V_0 \int \frac{P}{P_0} d\left(\frac{V}{V_0}\right)$$

$A_{1\to2} = S \cdot P_0 V_0$





S_1 и S_2 площади сегментов.

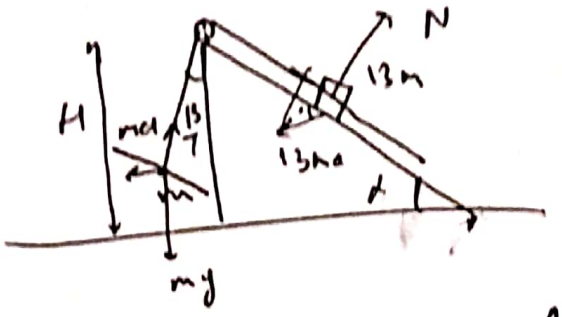
$$S = \frac{60}{90}\frac{\pi k^2}{4} - S_1 - \left(\frac{15}{90}\frac{\pi k^2}{4} - S_2\right) =$$

$$= \frac{\pi k^2}{6} - S_1 + S_2 - \frac{\pi k^2}{24} = \frac{\pi k^2}{8} - S_1 + S_2 =$$

$$= \frac{\pi k^2}{8} - \frac{1}{2} k \sin 60^\circ \cdot k \sin 30^\circ + \frac{1}{2} k^2 \sin 15^\circ \cos 15^\circ =$$

$$= \frac{\pi k^2}{8} - \frac{k^2}{2}\frac{\sqrt{3}}{2}\cdot\frac{1}{2} + \frac{1}{4}k^2 \sin 30^\circ = \frac{\pi k^2}{8} + \frac{k^2}{8} - \frac{k^2\sqrt{3}}{8} =$$

$$= k^2\left(\frac{\pi + 1 - \sqrt{3}}{8}\right)$$



$\cos\alpha = \frac{12}{13}$

$\cos\beta = \frac{4}{5}$

$mg\sin\beta = ma\cos\beta$

$\boxed{a = g\,tg\beta}$

$1 + tg^2\beta = \frac{1}{\cos^2\beta} = \frac{25}{16}$

$\frac{9}{16}$

$tg\beta = \frac{3}{4}$

$a = g\,tg\beta = \frac{10\cdot 3}{4} = 7{,}5\ m/s^2$

~~$13mg\cos\beta - 13mg\sin\alpha = 13m\,a_\delta$~~

$a\cos\alpha$

$-g\sin\alpha$

$g\,tg\beta\cos\alpha = a_\delta$

$a_\delta = g(tg\beta\cos\alpha - \sin\alpha) =$

$= g\cos\alpha(tg\beta - tg\alpha) =$

~~$\cos\alpha =$~~ $tg\alpha = \sqrt{\frac{1}{\cos^2\alpha} - 1} = \sqrt{\frac{169}{144} - 1} = \frac{5}{12}$

$= g\cdot\frac{12}{13}\left(\frac{3}{4} - \frac{5}{12}\right) = \frac{g\cdot 4}{13}$

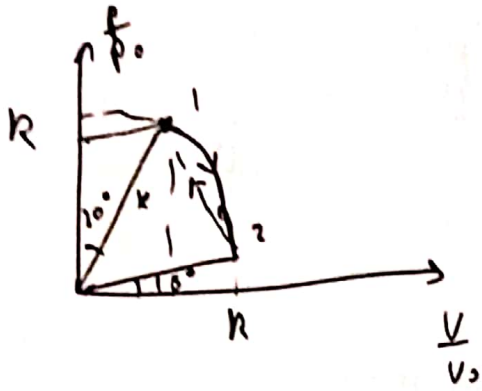
Тестовик

2.

$$\frac{A_{1-2} - \frac{3}{2}(p_1V_1 - p_2V_2)}{A_{1-2}} = 1 - \frac{\frac{3}{2}\left(\frac{p_1}{T_0}\frac{V_1}{V_0} - \frac{p_2}{T_0}\frac{V_2}{V_0}\right)}{S} =$$

$$= 1 - \frac{3\left(R^2 \sin 30° \cos 30° - R^2 \sin 15° \cos 15°\right)}{2R^2\left(\frac{\pi}{4} + 1 - \sqrt{3}\right)} =$$

$$= 1 - \frac{12\left(\frac{\sqrt{3}}{4} - \frac{1}{4}\right)}{\pi + 4 - 4\sqrt{3}} = 1 - \frac{3(\sqrt{3}-1)}{\pi - 4(\sqrt{3}-1)} \approx 0{,}09$$



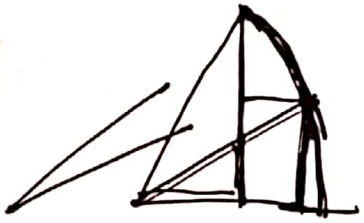
$P_1V_1 = \nu R T_1$

$P_1V_2 = \nu R T_2$

$$\frac{T_1}{T_2} = \frac{P_1V_1}{P_2V_2} = \frac{\frac{P_1}{P_0}\cdot\frac{V_1}{V_0}}{\frac{P_2}{P_0}\cdot\frac{V_2}{V_0}} =$$

$$= \frac{2R\cos 30^\circ \cdot R\sin 30^\circ}{2R\sin 15^\circ \cdot R\cos 15^\circ} = \frac{2\sin 30^\circ \cos 30^\circ}{\sin 30^\circ} = \sqrt{3} \approx 1{,}73$$

$pV^\gamma = const = C$



$$\gamma = \frac{C_p}{C_V} = \frac{5}{3}$$

$$\frac{60}{90}\frac{\pi k^2}{4} =$$

$$= \frac{\pi k^2}{6}$$

$$\frac{15}{90}$$

$$\frac{\pi k^2}{6} - \frac{\pi k^2}{24} = \frac{\pi k^2}{8}$$

$$\frac{\frac{\pi k^2}{8}}{\frac{\pi k^2}{8} - \frac{3}{2}}$$

pdV

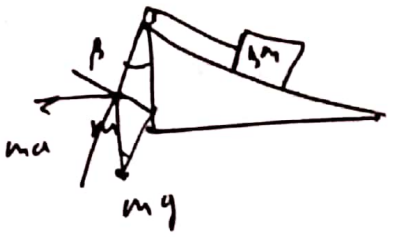
$pV^{\gamma-1} + V^\gamma = 0$

$\frac{pV^\gamma}{V} = 0$

$pV^{\gamma-1}dV + V^\gamma dp = 0$

$\gamma\frac{dV}{V} = -\frac{dp}{p}$

$A = \int pdV = \int \frac{c}{V^\gamma} dV$



$$g\sin\beta = a\cos\beta$$

$$a = g\,tg\beta$$

$$T - \tfrac{13}{5}mg\sin\alpha + \tfrac{12}{5}ma\cos\alpha = \tfrac{13}{5}ma_0$$

$$mg\cos\beta + ma\sin\beta - T = ma_0$$

$$\tfrac{1}{4}ma_0 = mg\cos\beta + ma\sin\beta - \tfrac{13}{5}mg\sin\alpha + \tfrac{13}{5}ma\cos\alpha =$$

$$= mg\cos\beta + mg\,tg\beta\sin\beta - \tfrac{13}{5}mg\sin\alpha + \tfrac{13}{5}mg\,tg\beta\cos\alpha$$

$$tg\beta = \frac{3}{4} \qquad \cos\alpha = \frac{12}{13}$$

$$\cos\beta = \frac{4}{5} \qquad \sin\alpha = \frac{5}{13}$$

$$\sin\beta = \frac{3}{5} \qquad tg\alpha = \frac{5}{12}$$

$$\frac{g}{4}\left(\frac{4}{5} + \frac{3}{4}\cdot\frac{3}{5} - \frac{13\cdot 5}{13} + 13\cdot\frac{3}{4}\cdot\frac{12}{13}\right).$$

$$= \frac{g}{4}\left(4 + \frac{4}{5} + \frac{9}{20}\right)$$

+9G

Часть 2

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

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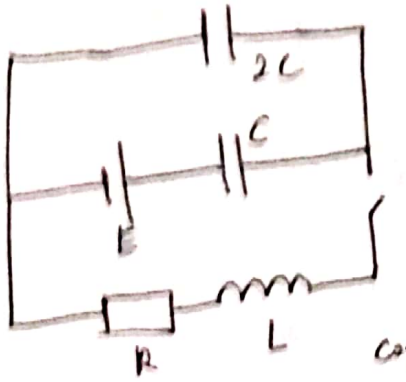
Вариант 5

Тепловик Вариант 11-05

3.



1) Сразу после замыкания ключа ток через катушку и сопротивление равен нулю: $\left|L\frac{dJ}{dt}\right| = \mathcal{E}_i$

$\left(в\ нач.\ м.\ \frac{dJ}{dt} \to \infty\right)$

Заряд у конденсатора C_1 тоже равен нулю.

$$E = L\left(\frac{dJ}{dt}\right)_{t=0}$$

$$\left(\frac{dJ}{dt}\right)_{t=0} = \frac{E}{L}$$

2) $A_{источник} = Q + \Delta W_e$

$q_{2C} = 0$ (поскольку тока в цепи отсутствует)

$W_0 = 0$

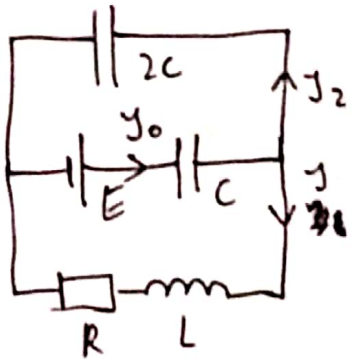
$W_e = \frac{q_C^2}{2C} =$ $\frac{q_C}{C} = E$ $q_C = CE$

$= \frac{CE^2}{2}$

$A_{ист} = q_C E = CE^2$

$$Q = \frac{CE^2}{2}$$

3. 3)



$J_0 = J + J_2$

$L\frac{dJ}{dt} + JR + \frac{q_c}{C} = E$

$\frac{q_c}{C} + \frac{q_{2c}}{2C} = E$

$\frac{\dot{q}_c}{C} + \frac{\dot{q}_{2c}}{2C} = 0$

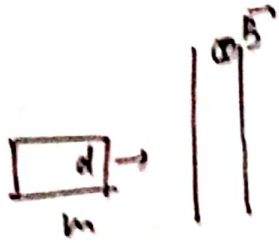
$J_{2C} = -2J_0$

$J_0 = J - 2J_0$

$J = \underline{\underline{3J_0}}$

Тестовик Вариант 11-05

4.



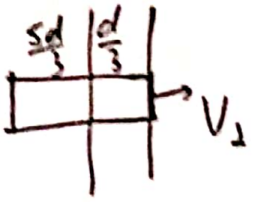
$$\varepsilon = |\mathcal{E}| = \frac{d\Phi}{dt} = BV_0 d$$

$$\rightarrow = \frac{\varepsilon}{R} = \frac{BV_0 d}{R}$$

$$F = JdB = \frac{B^2 d^2 V_0}{R} = ma$$

a

$$a = \frac{B^2 d^2 V_0}{Rm}$$



~~$\frac{B^2 d^2 V_0}{Rm} = -\frac{dV}{dt}$~~

$$\frac{B^2 d^2 V}{Rm} = -\frac{dV}{dt}$$

$$V_1 = V_0 \exp\left(-\frac{B^2 d^2 t_1}{Rm}\right)$$

$$Vdt = dx$$

$$dt = \frac{dx}{V}$$

$$\int_0^{t_1} Vdt = H = \frac{d}{3}$$

$$-\frac{V_0 Rm}{B^2 d^2} e^{-\frac{B^2 d^2}{Rm} t}$$

$$\frac{B^2 d^2 V}{Rm} = -\frac{V dV}{dx}$$

$$V_1 - V_0 = -\frac{B^2 d^2 d}{3Rm}$$

$$V_1 = V_0 - \frac{B^2 d^3}{3Rm}$$

③

Тестовик Вариант 11-05

4. Пока левый конец ещё не дошёл до пола

так в рамке отсутствует ($\frac{d\Phi}{dt}=0$) $\Rightarrow$

$\Rightarrow V_0 = const$ пока левый конец не дошёл.

Когда левый конец доходит до пола начинает течь ток.

$$I = \frac{BVd}{R} \qquad a = \frac{B^2d^2V}{Rm} = -\frac{dV}{dt}$$

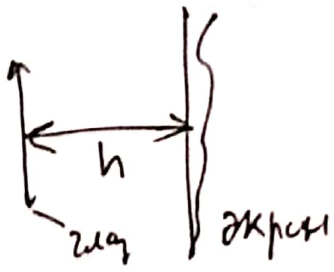
$$-\frac{dV}{dx} = \frac{B^2d^2}{Rm}$$

$$V - V_1 = -\frac{B^2d^3}{3Rm}$$

$$V = V_1 - \frac{B^2d^3}{3Rm} = V_0 - \frac{2B^2d^3}{3Rm}$$

Тестовик вариант 11-05

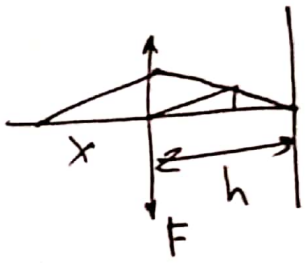
5. Обозначим фокус глаза через F_1, фокус очков F_1 и F_2.



(F_1 – гл. уд. мг., F_2 – 25см.)

$$\frac{1}{F_{уд.}} = \frac{1}{h} = \frac{1}{F_1} + \frac{1}{F}$$

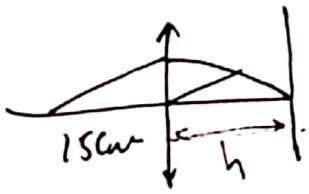
1)



$$\frac{1}{x} + \frac{1}{h} = \frac{1}{F}$$

$$\frac{1}{x} + \frac{1}{F} + \frac{1}{F_1} = \frac{1}{F}$$

$$X = -F_1 \Rightarrow F_1 < 0$$



$$\frac{1}{F_{25см}} = \frac{1}{F_2} + \frac{1}{F}$$

$$\frac{1}{h} + \frac{1}{0{,}25} = \frac{1}{F_2} + \frac{1}{F}$$

$$4 = \frac{1}{F_2} - \frac{1}{F_1}$$

$$\frac{F_1 - F_2}{F_1 F_2} = 4$$

$$F_1 - F_2 = 4F_1F_2$$

$$\frac{F_2}{F_1} = 2$$

$$F_2 = 2F_1$$

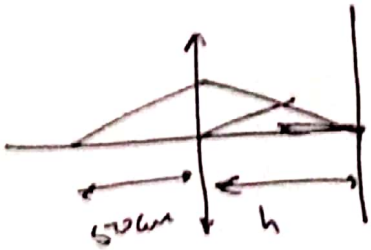
$$-F_1 = 4F_1 \cdot 2F_1 \quad F_1 = -\frac{1}{8}м$$

$$x = \frac{1}{8}м = 12{,}5см$$

(5)

Тестовик вариант 11-05

5. 2)



$$\frac{1}{0,5} + \frac{1}{h} = \frac{1}{F} + \frac{1}{F_3}$$

$$\frac{1}{0,5} + \frac{1}{F_1} + \cancel{\frac{1}{F}} = \cancel{\frac{1}{F}} + \frac{1}{F_3}$$

$$2 - 8 = \frac{1}{F_3}$$

$$F_3 = -\frac{1}{6}\text{м} = \frac{50}{3}\text{см}$$

$$D_3 = \frac{1}{F_3} = -6 \text{ дптр.}$$