Часть 1

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

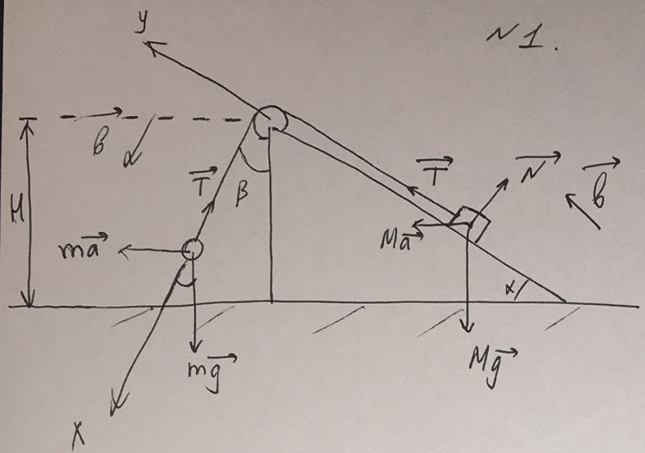
Шифр: **21201885**

ID профиля: **886883**

Вариант 5

Чистовик.

№1.



Пусть M – масса бруска.

1) Пусть b – ускорение шарика и бруска.

Ox: $\cancel{m}b = \cancel{m}a\sin\beta + \cancel{m}g\cos\beta$

Oy: $0 = \cancel{m}g\sin\beta - \cancel{m}a\cos\beta$

$b = a\sin\beta + g\cos\beta$. (1)

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

$$a = \frac{g\sin\beta}{\cos\beta} = g\,tg\beta$$

$$\sin\beta = \sqrt{1-\cos^2\beta} = \sqrt{1-\frac{16}{25}} = \sqrt{\frac{9}{25}} = \frac{3}{5}.$$

$$a = \frac{10\cdot 3}{5}\cdot\frac{5}{4} = 10\cdot 0{,}75 = 7{,}5\ \frac{м}{с^2}$$

2) (1) $b = a\sin\beta + g\cos\beta$ выражение для ускорения бруска относительно клина нашли в первой части.

$$b = 7{,}5\cdot\frac{3}{5} + 10\cdot\frac{4}{5} = 7{,}5\cdot 0{,}6 + 10\cdot 0{,}8 = 4{,}5 + 8 = 12{,}5\ \frac{м}{с^2}$$

3) $$S = \frac{at^2}{2}$$

$$H = \frac{b\cos\beta\cdot t^2}{2}$$

$$b\cos\beta\, t^2 = 2H$$

$$t^2 = \frac{2H}{b\cos\beta}$$

$$t = \sqrt{\frac{2H}{b\cos\beta}}$$

$$t = \sqrt{\frac{2H}{12{,}5\cdot\frac{4}{5}}} = \sqrt{\frac{2H}{10}} = \sqrt{0{,}2H}\ с$$

1

Ответ: 1) $a = 7{,}5\ \frac{м}{с^2}$; 2) $b = 12{,}5\ \frac{м}{с^2}$; 3) $t = \sqrt{0{,}2H}\ с$

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3) $0 = A_{21} + \frac{3}{2}\nu R(T_1 - T_2)$

$$A_{21} = -\frac{3}{2}\nu R\left(\frac{p_1V_1}{\nu R} - \frac{p_2V_2}{\nu R}\right) = -\frac{3}{2}\cancel{\nu R}\cdot\frac{1}{\cancel{\nu R}}(p_1V_1 - p_2V_2) =$$

$$= -\frac{3}{2}\left(p_0\cos 30°\cdot R\cdot V_0\cdot\sin 30°\cdot R - p_0\sin 15°\cdot R\cdot V_0\cos 15°\cdot R\right) =$$

$$= -\frac{3}{2}p_0V_0R^2\left(\sin 30°\cdot\cos 30° - \sin 15°\cdot\cos 15°\right) = -\frac{3}{4}p_0V_0R^2\left(\sin 60° - \sin 30°\right) =$$

$$= -\frac{3}{4}p_0V_0R^2\left(\frac{\sqrt{3}}{2} - \frac{1}{2}\right)$$

$$A_{12} = \int_{V_1}^{V_2} p\,dV = \int_{V_0\sin 30°\cdot R}^{V_0\cos 15°\cdot R} p\,dV = \int_{V_0\sin 30°\cdot R}^{V_0\cos 15°\cdot R} p_0\sqrt{R^2 - \frac{V^2}{V_0^2}}\,dV = p_0V_0R^2\cdot\frac{\pi+1-\sqrt{3}}{8}$$

$$A_{цикл} = A_{12} + A_{21} = p_0V_0\cdot R^2\,\frac{\pi+1-\sqrt{3}}{8} - \frac{3}{4}p_0V_0R^2\left(\frac{\sqrt{3}}{2} - \frac{1}{2}\right) =$$

$$= p_0V_0R^2\left(\frac{\pi+1-\sqrt{3}-3\sqrt{3}+3}{8}\right) = p_0V_0R^2\left(\frac{\pi+4-4\sqrt{3}}{8}\right)$$

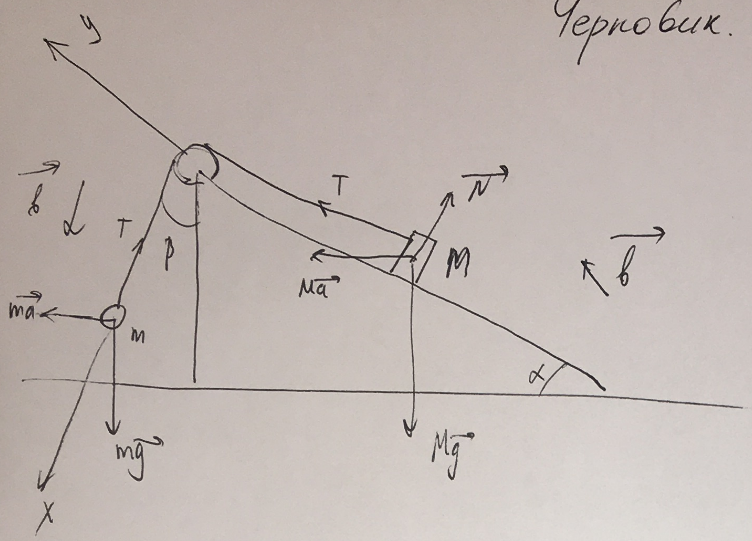
$$\frac{A_{цикл}}{A_{12}} = \frac{\cancel{p_0V_0R^2}\left(\frac{\pi+4-4\sqrt{3}}{8}\right)}{\cancel{p_0V_0R^2}\left(\frac{\pi+1-\sqrt{3}}{8}\right)} = \frac{\pi+4-4\sqrt{3}}{8}\cdot\frac{8}{\pi+1-\sqrt{3}} =$$

$$= \frac{\pi+4-4\sqrt{3}}{\pi+1-\sqrt{3}}$$

Ответ: 1) $\frac{T_1}{T_2} = \sqrt{3}$; 2) $\varphi \approx 37{,}7°$; 3) $\frac{A_{цикл}}{A_{12}} = \frac{\pi+4-4\sqrt{3}}{\pi+1-\sqrt{3}}$

3

Черновик.



1) $Ox: m b = m a \sin\beta + m g \cos\beta$

$Oy: \ 0 = m g \sin\beta - m a \cos\beta$

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

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

$a = \dfrac{g\sin\beta}{\cos\beta} = g\,tg\beta$

$\sin\beta = \sqrt{1 - \frac{16}{25}} = \sqrt{\frac{9}{25}} = \frac{3}{5}.$

$\underline{a} = \dfrac{10 \cdot 3}{5} \cdot \dfrac{5}{4} = 10 \cdot 0{,}75 = \underline{7{,}5.}$

2) $\underline{b} = a\sin\beta + g\cos\beta = 7{,}5 \cdot \frac{3}{5} + 10 \cdot 0{,}8 = 4{,}5 + 8 = \underline{12{,}5.}$

3) $S = \dfrac{a t^2}{2}$

$b\cos\beta$ – ускорение шарика (проектированное).

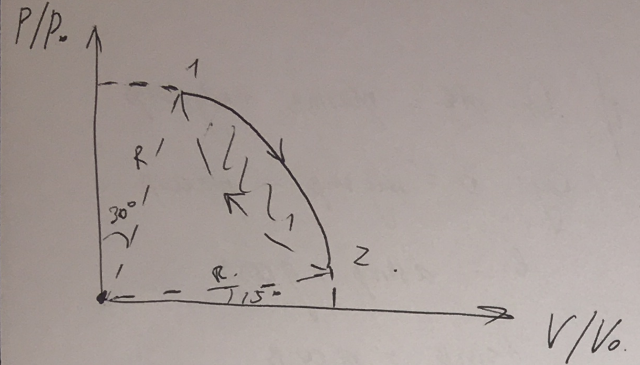
$H = \dfrac{b\cos\beta \cdot t^2}{2}$

$b\cos\beta \cdot t^2 = 2H$

$t^2 = \dfrac{2H}{b\cos\beta}$

$\underline{t} = \sqrt{\dfrac{2H}{b\cos\beta}} = \dfrac{2H}{12{,}5 \cdot \frac{4}{5}} = \sqrt{\dfrac{2H}{10}} = \underline{\sqrt{0{,}2H}\ c.}$

№2. Черновик.

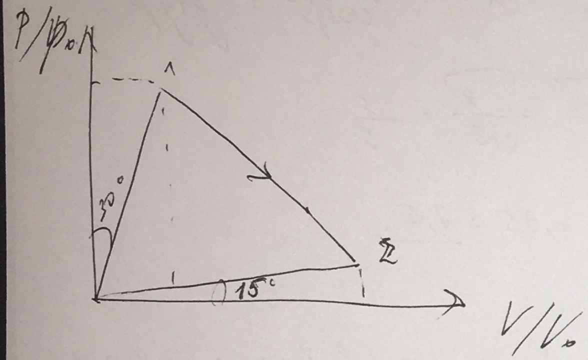


$$C = \frac{Q}{\Delta t} = 0.$$

1-2.

$$p_1V_1 = p_2V_2.$$

$$pV = \vartheta R \Delta T$$



$$Q = A + \Delta U.$$

$$pV = \vartheta RT.$$

$$\Delta U = \frac{3}{2}\vartheta R \Delta T = 0$$

$$C = \frac{Q}{\Delta t} = \frac{Q}{\vartheta R \Delta T}$$

$$C = \frac{Q}{\Delta t} = \frac{\vartheta R \Delta T}{\Delta T} = \vartheta R$$

$$\cos\alpha = \frac{p_1}{R}$$

$$p_1 = R\cos 30°$$

$$\sin 15 = \frac{x}{R} \qquad \frac{dp}{dV} = -\frac{5}{3}\frac{p}{V}$$

$$\cos 15 =$$

$$\frac{\pi + 1 - \sqrt{3}}{8}$$

$$p_0V_0 k^2 \left(\frac{\pi + 1 - \sqrt{3}}{8} - \frac{3\sqrt{3}+3}{8}\right.$$

$$= \frac{3}{4} p_0V_0 k^2 \left(\frac{\sqrt{3}-1}{2}\right)$$

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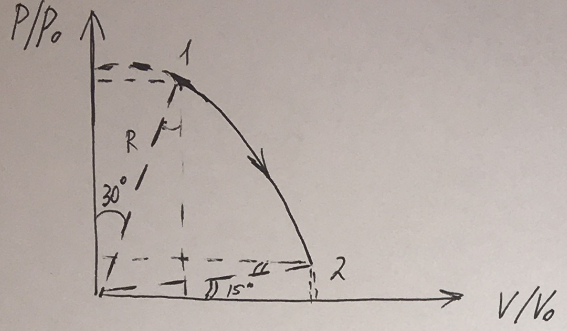
Чистовик.

№2.



1) $P_1 = p_0 \cos 30° \cdot R$

$V_1 = V_0 \sin 30° \cdot R$

~~$P_2 = p_0 \cdot \cos 15° \cdot R$~~

~~$V_2 = V_0 \cdot \sin 15° \cdot R$~~

$P_2 = p_0 \cdot \sin 15° \cdot R$

$V_2 = V_0 \cdot \cos 15° \cdot R$

$$\frac{T_1}{T_2} = \frac{P_1 V_1}{P_2 V_2} = \frac{\cancel{p_0} \cos 30° \cdot \cancel{R} \cdot \cancel{V_0} \cdot \sin 30° \cdot \cancel{R}}{\cancel{p_0} \cdot \sin 15° \cdot \cancel{R} \cdot \cancel{V_0} \cdot \cos 15° \cdot \cancel{R}} = \frac{\cos 30° \cdot \sin 30°}{\sin 15° \cdot \cos 15°} =$$

$$= \frac{2 \cdot \sin 30° \cdot \cos 30°}{2 \cdot \sin 15° \cdot \cos 15°} = \frac{\sin 60°}{\sin 30°} = \frac{\frac{\sqrt{3}}{2}}{\frac{1}{2}} = \frac{\sqrt{3}}{\cancel{2}} \cdot \frac{\cancel{2}}{1} = \sqrt{3}$$

2) $\delta Q = p dV + \frac{3}{2} \nu R dT$; $C = \frac{\delta Q}{\nu dT} = \frac{p dV}{\nu dT} + \frac{3}{2} R = 0$;

$$\frac{dV}{dT} = -\frac{3R \cdot \nu}{2p} \Rightarrow \frac{dT}{dV} = -\frac{2p}{3\nu R} \Rightarrow \frac{V dp + p dV}{\cancel{\nu R} dV} = -\frac{2p}{3\cancel{\nu R}}$$

$$\underline{\frac{dp}{dV} = -\frac{5}{3} \frac{p}{V}}$$

$$\left(\frac{p}{p_0}\right)^2 + \left(\frac{V}{V_0}\right)^2 = R^2 \Rightarrow 2 \frac{p}{p_0} \frac{dp}{p_0} + 2 \frac{V}{V_0} \frac{dV}{V_0} = 0 \Rightarrow$$

$$\Rightarrow \underline{\frac{dp}{dV} = -\frac{V}{p} \cdot \frac{p_0^2}{V_0^2}}$$

Приравниваем: $\frac{5}{3} \frac{p}{V} = \frac{V}{p} \frac{p_0^2}{V_0^2}$

$$\frac{5}{3} \frac{V_0^2}{p_0^2} = \frac{V^2}{p^2} \Rightarrow$$

$$\Rightarrow tg\,\varphi = \sqrt{\frac{3}{5}} = \sqrt{0,6} = 0,774$$

$$\varphi = arctg\ 0,774 = 37,73° \approx 37,7°$$

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Часть 2

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

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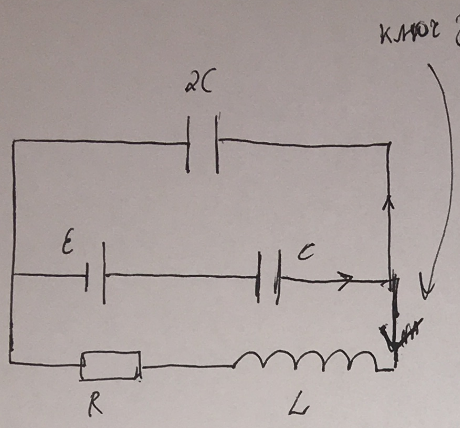
Вариант 5

№3. Чистовик.



$$\begin{cases} \mathcal{E} = \dfrac{q_1(t)}{C} + L\cdot I'(t) + I(t)R \\ 0 = -\dfrac{q_2(t)}{2C} + L\cdot I'(t) + I(t)R \\ \dot{q}_1(t) = I(t) + \dot{q}_2(t) \end{cases}$$

$$\begin{cases} \dot{q}_1 = -LC\ddot{I} - \dot{I}R \\ \dot{q}_2 = 2LC\ddot{I} + \dot{I}R \\ -LC\ddot{I} - \dot{I}R = I + \dot{I}R + 2LC\ddot{I} \end{cases}$$

$$I(t) = I_0 e^{-\frac{Rt}{3CL}} \cdot \sin wt, \text{ где } w = \sqrt{\frac{R^2 - 3LC}{3LC}}$$

$$3LC\ddot{I} + 2\dot{I}R + I = 0.$$

$$q_2(t) = 2CL \cdot \dot{I}(t) + I(t)R$$

1) $I(0) = 0\,A$.

$$\begin{cases} \mathcal{E} = \dfrac{q_1(0)}{C} + LI'(0) \\ 0 = -\dfrac{q_2(0)}{2C} + L\cdot I'(0) \\ q_1'(0) = q_2'(0) \Rightarrow \Delta q_1 = \Delta q_2 \end{cases}$$

1

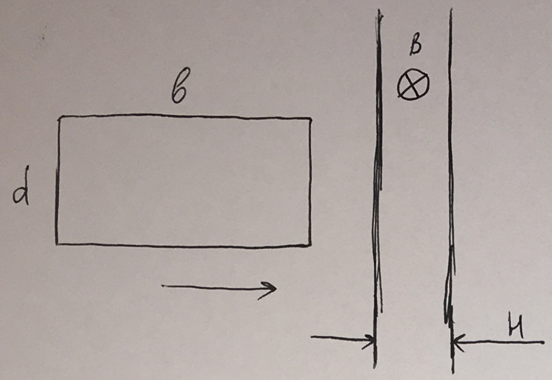
$$\frac{\mathcal{E}}{2} = \frac{3LI'(0)}{2} \Rightarrow \underline{I'(0) = \frac{\mathcal{E}}{3L}}$$

2) $\underline{Q} = A_{ст} - \dfrac{C\mathcal{E}^2}{2} = C\mathcal{E}^2 - \dfrac{C\mathcal{E}^2}{2} = \underline{\dfrac{C\mathcal{E}^2}{2}}$

Ответ: 1) $I'(0) = \dfrac{\mathcal{E}}{3L}$; 2) $Q = \dfrac{C\mathcal{E}^2}{2}$.

Чистовик.

№4.



1) $\mathcal{E}_i = v_0 \cdot d \cdot B$

$I_i = \frac{\mathcal{E}_i}{R} = \frac{v_0 \cdot d \cdot B}{R}$

$F_A = I_i \cdot B \cdot d = \frac{v_0 d B}{R} \cdot B \cdot d =$

$= \frac{v_0 \cdot B^2 \cdot d^2}{R}$

$F_A = ma$

$a = \frac{F_A}{m} = \frac{v_0 \cdot B^2 \cdot d^2}{mR}$

2) $m\dot{v}(t) = -\frac{v(t) B^2 d^2}{R}$

$v(t) = v_0 \exp\left(-\frac{B^2 d^2}{m \cdot R} \cdot t\right)$

$\frac{d}{3} = \int_0^{\tau} v(t)\,dt = v_0\left(-\frac{mR}{B^2 d^2}\right) \cdot \left(e^{-\frac{B^2 d^2 \cdot \tau}{mR}} - 1\right) \Rightarrow$

$\Rightarrow v(\tau) = v_0 e^{-\frac{B^2 d^2 \tau}{mR}} = -\frac{B^2 d^3}{3mR} + v_0 = v_0 - \frac{B^2 d^3}{3mR}$

3) $V_2 = v_0 - \frac{2B^2 d^3}{3mR}$

Чтобы получить скорость при вылете из поля заменим в предыдущем выражении $\frac{d}{3}$ на $\frac{2d}{3}$.

2

Ответ: 1) $a = \frac{v_0 B^2 d^2}{mR}$; 2) $V_1 = v_0 - \frac{B^2 d^3}{3mR}$; 3) $V_2 = v_0 - \frac{2B^2 d^3}{3mR}$.

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Черновик.

~~$F_{Л} = B\vartheta_0 q \sin\alpha$~~

$\mathcal{E}_i = \vartheta_0 B l = \vartheta_0 B d$

$F_A = BIl\sin\alpha$

$q = CU$

$W_{нач} = \frac{q^2}{2C} = \frac{CU^2}{2}$

$q_1 + q_2 = q_1' + q_2'$

$\frac{C^2U^2}{2C} = \frac{CU^2}{2}$

$\mathcal{E} = I(R + r) = \mathcal{E} = IR$

а рассеив. линза и мнимое изобр.

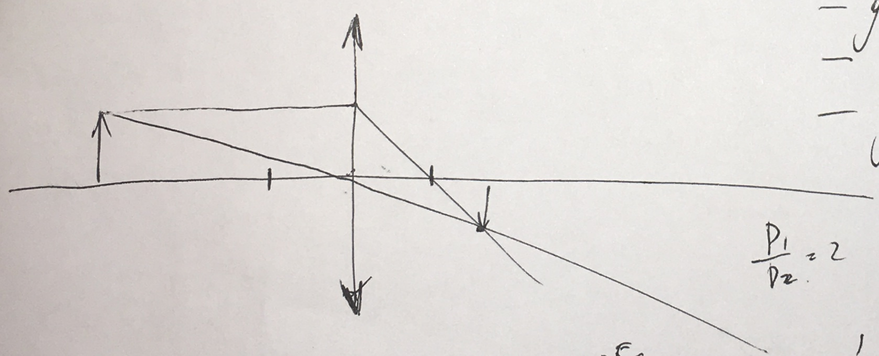
$-\frac{1}{F} = \frac{1}{d} - \frac{1}{f}$

собир. линза и действ. изобр.

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

$\Gamma = \frac{f}{d} = \frac{H}{h}$

К №5.



— действ,
— прямое,
— ~~увелич. прямое~~ прямое

$\frac{D_1}{D_2} = 2 \quad \frac{F_2}{F_1} = 2. \quad d_2 = 25.$

$F_2 = 2F_1 = 2 \cdot 6{,}25 = 12{,}5$

$\frac{1}{F_1} =$

$F_2 = 2F_1$

$\frac{1}{2F_1} = \frac{1}{d} + \frac{1}{2F_2} = \frac{1}{d} + \frac{1}{4F_1}$

$\frac{1}{2F_1} - \frac{1}{4F_1} = \frac{1}{d}$

$D_2 = \frac{1}{12{,}5}$

$D_1 = \frac{4}{25} = 0{,}16$ дптр.

$\frac{2-1}{4F_1} = \frac{1}{d}$

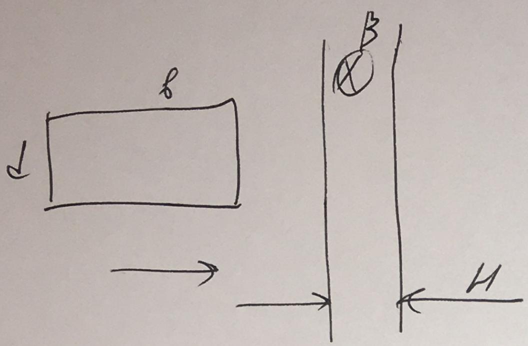
$\frac{1}{4F_1} = \frac{1}{d}$

$4F_1 = d \quad F_1 = \frac{d}{4} = \frac{25}{4} = 6{,}25$

$4{,}00 : 25 = 0{,}16$; $25 \cdot 4 = 100$; $6{,}25 \cdot 2 = 12{,}50$; $25 \cdot 0{,}4 = 10{,}0$

Черновик.

№4.



$$\mathcal{E}_i = v_0 d B. \Rightarrow$$

$$\Rightarrow \mathcal{E}_i = I_i R.$$

$$I_i = \frac{\mathcal{E}_i}{R} = \frac{v_0 d B}{R}.$$

$$F_A = ma = I_i B d = \frac{v_0 B d}{R} \cdot B d$$

$$ma = \frac{v_0 B^2 d^2}{R}.$$

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

$$m\dot{v}(t) = -ma = -m \cdot \frac{v(t) B^2 d^2}{Rm} = -\frac{v(t) B^2 d^2}{R}.$$

$$v(t) = v_0 \exp\left(-\frac{B^2 d^2}{mR} \cdot t\right).$$

$$\frac{d}{3} = \int_0^{\tau} v(t)\,dt = v_0 \left(-\frac{mR}{B^2 d^2}\right)\left(e^{-\frac{B^2 d^2 \tau}{mR}} - 1\right) \Rightarrow$$

$$\Rightarrow v(\tau) = v_0 e^{-\frac{B^2 d^2 \tau}{mR}} = -\frac{B^2 d^3}{3mR} + v_0 = V_0 - \frac{B^2 d^3}{3mR} = V_1$$

$$V_2 = V_0 - \frac{2B^2 d^3}{3mR}.$$

Черновик.

$F_{уб} = 6{,}25$ $F_{25} = 12{,}5$ $F_3 = 25$

$D_3 - ?$

к №5.

$d = 50$ см.

$F_x =$

$$\frac{1}{F_3} = \frac{1}{d} + \frac{1}{2F_3}$$

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

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

$$\frac{1}{2F_3} = \frac{1}{d}$$

$$2F_3 = d$$

$$F_3 = \frac{d}{2} = \frac{50}{2} = 25 \text{ см}$$

$$D_3 = \frac{1}{25} = 0{,}04 \text{ дптр.}$$

$$\begin{array}{r} 25 \\ \times\ 0{,}4 \\ \hline 10{,}0 \end{array}$$

$$\begin{array}{r} 25 \\ \times\ 0{,}04 \\ \hline 1{,}00 \end{array}$$

$$\frac{1}{F_x} = \frac{1}{x} + \frac{1}{2F_x}$$

$$\frac{1}{F_x} - \frac{1}{2F_x} = \frac{1}{x}$$

$$\frac{1}{2F_x} = \frac{1}{x}$$

$$2F_x = x < 25.$$

$$-\frac{1}{2F_1} = \frac{1}{d} - \frac{1}{4F_1}$$

$$\frac{1}{4F_1} - \frac{1}{2F_1} = \frac{1}{d}$$

$$\frac{1-2}{4F_1} = \frac{1}{d}$$

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

$$4F_1 = -d$$

$$F_1 = -\frac{d}{4} = -\frac{25}{4}$$

$$W_{нач} = \frac{2C\varepsilon^2}{2\cdot 4} + \frac{C\varepsilon^2}{2} =$$

$$= \frac{2C\varepsilon^2}{8} + \frac{C\varepsilon^2}{2} = \frac{2C\varepsilon^2 + 4C\varepsilon^2}{8} = \frac{6C\varepsilon^2}{8} =$$

$$= \frac{3C\varepsilon^2}{4}$$

$$W_{нач} + A_{поля} = W_{кон} - Q.$$

$W_{кон} =$

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