Часть 1

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

Шифр: **21202447**

ID профиля: **330585**

Вариант 5

Чистовик

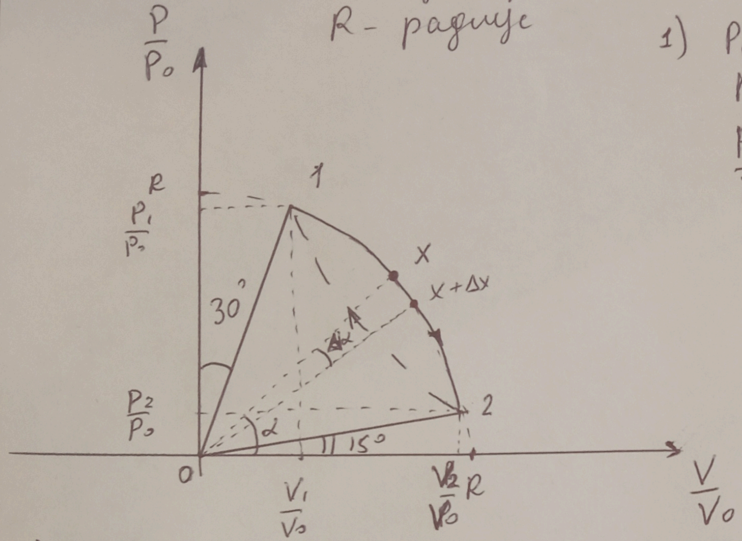
№ 2

$i = 3$

$2 \to 1: \ \Delta Q \approx 0$

R_0 - универс газ пост

R - радиус



1) $P_1 V_1 = \nu R_0 T_1$

$P_2 V_2 = \nu R_0 T_2$

$\frac{P_1}{P_0} = R \cdot \cos 30^\circ \quad \frac{V_1}{V_0} = R \cdot \sin 30^\circ$

$\frac{V_2}{V_0} = R \cdot \cos 15^\circ \quad \frac{P_2}{P_0} = R \cdot \sin 15^\circ$

$$\frac{T_1}{T_2} = \frac{\nu R_0 T_1}{\nu R_0 T_2} = \frac{P_1 V_1}{P_2 V_2} =$$

$$= \frac{\cancel{P_0} \cancel{R} \cdot \cos 30^\circ \cdot \cancel{V_0} \cancel{R} \cdot \sin 30^\circ}{\cancel{P_0} R \cdot \sin 15^\circ \cdot \cancel{V_0} R \cdot \cos 15^\circ} =$$

$$= \frac{2 \cdot \sin 30^\circ \cdot \cos 30^\circ}{2 \cdot \sin 15^\circ \cdot \cos 15^\circ} = \frac{\sin 60^\circ}{\sin 30^\circ} = \sqrt{3}$$

2) $C = 0$: , $C = \frac{\Delta Q}{\Delta t} = 0$, (1) $\frac{P_x + \Delta P}{P_0} = R \cdot \sin(\alpha - \Delta\alpha)$,

(6) $\Delta Q = \Delta U + \Delta A = 0$, (2) $\frac{V_x + \Delta V}{V_0} = R \cdot \cos(\alpha - \Delta\alpha)$,

$\Delta U = \frac{3}{2} \nu R_0 \Delta T$,

(1') $\Delta P = P_0 R \cdot \sin(\alpha - \Delta\alpha) - P_x$

(2') $\Delta V = V_0 R \cdot \cos(\alpha - \Delta\alpha) - V_x$

(3) $\frac{P_x}{P_0} = R \cdot \sin\alpha$,

$P_x V_x = \nu R_0 T_x$,

(4) $\frac{V_x}{V_0} = R \cdot \cos\alpha$,

(5) $P_x \Delta V + \Delta P V_x = \nu R_0 \Delta T$,

(6) $\frac{3}{2} \nu R_0 \Delta T = - P_x \Delta V$

(1'), (2'), (3), (4) $\to$ (5): $P_0 R \cdot \sin\alpha \cdot (V_0 R \cdot \cos(\alpha - \Delta\alpha) - V_0 R \cdot \cos\alpha) +$

$+ (P_0 R \cdot \sin(\alpha - \Delta\alpha) - P_0 R \cdot \sin\alpha) \cdot V_0 R \cdot \cos\alpha = \nu R_0 \Delta T$

$P_0 R^2 \cdot V_0 \cancel{4} (\sin\alpha \, (\cos(\alpha - \Delta\alpha) - \cos\alpha) + \cos\alpha \, (\sin(\alpha - \Delta\alpha) - \sin\alpha)) = \nu R \Delta T$

$P_0 V_0 R^2 (\sin\alpha \, (\cos\alpha \cdot \underbrace{\cancel{\cos \Delta\alpha}}_{1} + \sin\alpha \cdot \underbrace{\cancel{\sin\Delta\alpha}}_{\Delta\alpha} - \cos\alpha) + \cos\alpha \, (\sin\alpha \cdot \underbrace{\cancel{\cos\Delta\alpha}}_{1} -$

$- \cos\alpha \cdot \underbrace{\cancel{\sin \Delta\alpha}}_{\Delta\alpha} - \sin\alpha)) = \nu R_0 \Delta T$, $\Delta\alpha \to 0$, ~~...~~

$\sin \Delta\alpha \to \Delta\alpha$

$\cos\Delta\alpha \to 1$

$P_0 V_0 R^2 (\sin\alpha \, (\cancel{\cos\alpha} + \sin\alpha \cdot \Delta\alpha - \cancel{\cos\alpha}) + \cos\alpha \, (\cancel{\sin\alpha} - \cos\alpha \, \Delta\alpha - \cancel{\sin\alpha})) =$

$= P_0 V_0 R^2 (\sin^2\alpha \, \Delta\alpha - \cos^2\alpha \cdot \Delta\alpha) = \nu R_0 \Delta T$ (7)

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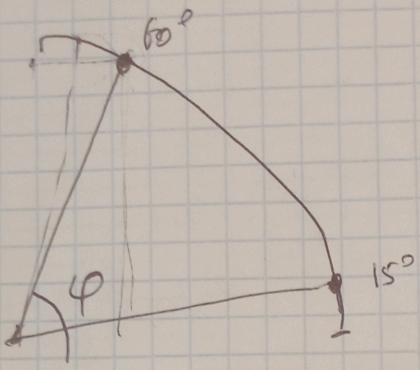


$$\frac{P_\varphi}{P_0} = R\cdot\sin\varphi$$

$$\frac{V}{V_0} = R\cdot\cos\varphi$$

$$V = V_0 R\cdot\cos\varphi$$

$$dV = -V_0 R\cdot\sin\varphi\, d\varphi$$

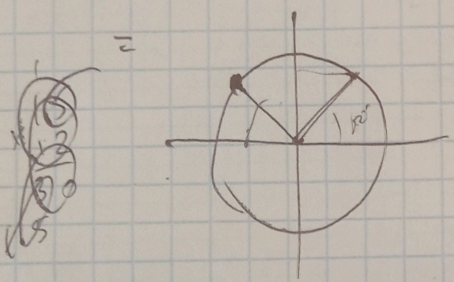
$$\cos 2\alpha = \cos^2\alpha - \sin^2\alpha = 1 - 2\cdot\sin^2\alpha$$

$$\sin^2\alpha = \frac{1-\cos 2\alpha}{2}$$

$$A = -P_0 R\cdot\sin\varphi\, V_0 R\cdot\sin\varphi\, d\varphi = -P_0 V_0 R^2\cdot\sin^2\varphi\, d\varphi =$$

$$= \int -\frac{P_0V_0R^2}{2}\cdot\left(1-\cos 2\varphi\right)d\varphi =$$

$$=$$



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$$\underbrace{P_0R}\sin\alpha\cdot\underbrace{V_0R}(\cos(\alpha-\Delta\alpha)-\cos\alpha)+\underbrace{P_0R}(\sin(\alpha-\Delta\alpha)-\sin\alpha)\underbrace{V_0}R\cdot\cos\alpha=$$

$$=\nu R\Delta T$$

$$\nu R\Delta T=-\frac{2}{3}P_0R\sin\alpha\cdot V_0R(\cos(\alpha-\Delta\alpha)-\cos\alpha)$$

$$\frac{3}{2}\cancel{P_0V_0R^2}(\sin\alpha(\cos(\alpha-\Delta\alpha)-\cos\alpha)+\cos\alpha(\sin(\alpha-\Delta\alpha)-\sin\alpha))\cdot\cancel{P_0V_0R^2}=$$

$$=-\frac{2}{3}\cancel{P_0V_0R^2}\cdot\sin\alpha(\cos(\alpha-\Delta\alpha)-\cos\alpha)$$

$$5\sin\alpha(\cos(\alpha-\Delta\alpha)-\cos\alpha)+3\cos\alpha(\sin(\alpha-\Delta\alpha)-\sin\alpha)=0$$

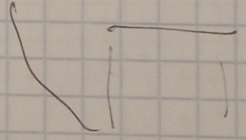
$$\cos\alpha(60°-30°)=\frac{\sqrt3}{2}$$

$$5\cdot\sin\alpha(\cos\alpha\cdot\cos\Delta\alpha+\sin\alpha\cdot\sin\Delta\alpha-\cos\alpha)+3\cos\alpha(\sin\alpha\cdot\cos\Delta\alpha-$$
$$-\cos\alpha\cdot\sin\Delta\alpha-\sin\alpha)=0$$

$$5\sin\alpha(\sin\alpha\cdot\Delta\alpha)-3\cdot\cos\alpha\cdot(\cos\alpha\cdot\Delta\alpha)=0$$

$$5\cdot\sin^2\alpha\cdot\cancel{\Delta\alpha}=3\cdot\cos^2\alpha\,\cancel{\Delta\alpha}$$

$$\operatorname{tg}^2\alpha=\frac{3}{5},\quad \operatorname{tg}\alpha=\frac{\sqrt3}{\sqrt5}=\frac{\sqrt{15}}{5}$$



$$\frac{A_{газа}}{A_{расш}}=$$

$$=\frac{A_{расш}+A_{сж}}{A_{расш}}=$$

$$=1+\frac{A_{сж}}{A_{расш}}$$

$\Delta Q_{сж}\approx0$ => адиабата

$$PV^\gamma=\nu RT,\quad \gamma=\frac{C_p}{C_v}=\frac{\frac{5}{2}R}{\frac{3}{2}R}=\frac{5}{3}$$

$$\Delta U+A=0$$

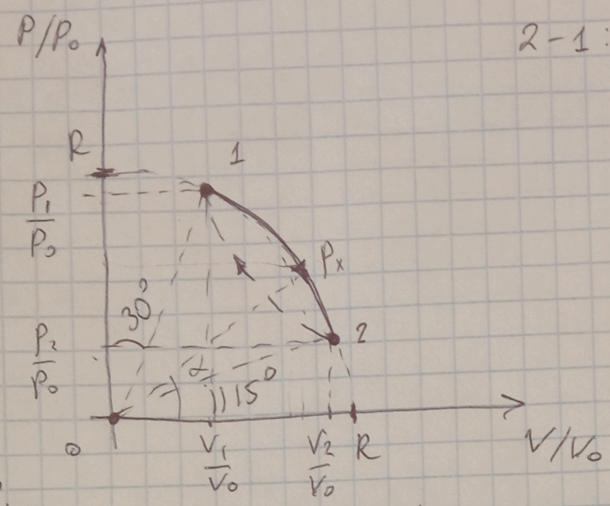
$$\frac{3}{2}\nu R\Delta T=-A$$

$A_{расш}=$

$$\left(\frac{P_\alpha}{P_0}\right)^2+\left(\frac{V_\alpha}{V_0}\right)^2=R^2$$

$P\,dV$,

$i = 3$



$2-1: \quad \Delta Q \approx 0$

$P_1 V_1 = \nu R T_1$

$P_2 V_2 = \nu R T_2$

$\cancel{\left(\frac{P_1}{P_0}\right)^2 + \left(\frac{V_1}{V_0}\right)^2 = R^2}$

$\cancel{\left(\frac{P_2}{P_0}\right)^2 + \left(\frac{V_2}{V_0}\right)^2 = R^2}$

$\frac{P_1}{P_0} = R \cdot \cos 30^\circ \qquad \frac{V_2}{V_0} = R \cdot \cos 15^\circ$

$\frac{V_1}{V_0} = R \cdot \sin 30^\circ \qquad \frac{P_2}{P_0} = R \sin 15^\circ$

$\frac{P_x}{P_0} = R \cdot \sin\alpha$

$\frac{V_x}{V_0} = R \cdot \cos\alpha$

1) $\frac{T_1}{T_2} = \frac{P_1 V_1}{P_2 V_2} = \frac{\cancel{P_0} \cancel{R} \cdot \cos 30^\circ \cdot \cancel{V_0} \cdot \cancel{R} \cdot \sin 30^\circ}{\cancel{P_0} \cdot \cancel{R} \cdot \sin 15^\circ \cdot \cancel{V_0} \cdot \cancel{R} \cdot \cos 15^\circ} = \frac{2 \cdot \cos 30^\circ \cdot \sin 30^\circ}{2 \cdot \sin 15^\circ \cdot \cos 15^\circ} =$

$= \frac{\sin 60^\circ}{\sin 30^\circ} = \frac{\sqrt{3}}{2 \cdot 1/2} = \sqrt{3}$

2) $C = 0$, $C = \frac{\Delta Q}{\Delta T} = 0 \Rightarrow \Delta Q = 0 = ?$

$\Delta Q = \frac{3}{2} \nu R \Delta T_x + P \Delta V_x = 0$

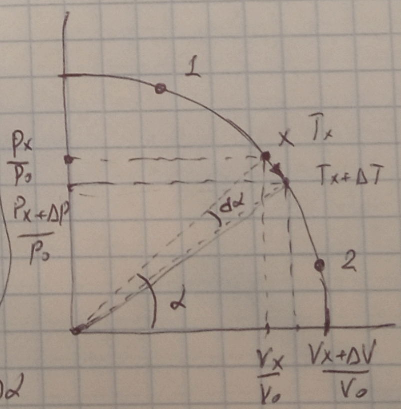
$\cancel{\frac{3}{2} \nu R \Delta T_x = - P_x \Delta V_x}$

$$\begin{cases} P_x \cdot V_x = \nu R T_x \\ P_x \, \Delta V_x + \Delta P_x \cdot V_x = \nu R \Delta T_x \\ \Delta U + P_x \Delta V = 0 \end{cases}$$

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

$\frac{P_x + \Delta P}{P_0} = R \sin(\alpha - \Delta\alpha)$

$\frac{V_x + \Delta V}{V_0} = R \cos(\alpha - \Delta\alpha)$



$\Delta P = P_0 R \sin(\alpha - \Delta\alpha) - P_0 R \cdot \sin\alpha$

$\Delta V = V_0 R \cdot \cos(\alpha - \Delta\alpha) - V_0 R \cdot \cos\alpha$

$\cancel{P_0 R \cdot \sin\alpha (V_0 R \cdot \cos(\alpha - \Delta\alpha) - V_x) + P_0 R \cdot \sin(\alpha + \Delta\alpha) - P_x}$

$\Delta P = P_0 R (\sin(\alpha - \Delta\alpha) - \sin\alpha)$

$\Delta V = V_0 R (\cos(\alpha - \Delta\alpha) - \cos\alpha)$

1) $a = ?$

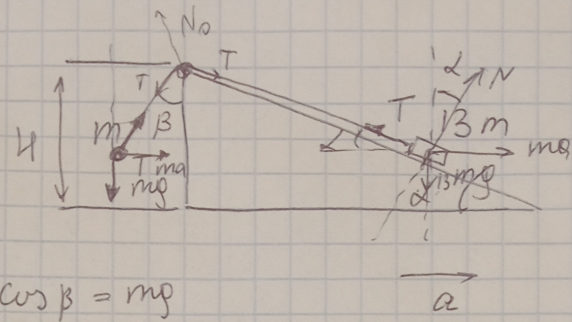
2) $a_{отн} = ?$

3) $t_{шест} = ?$

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

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

шарик дост. стола раньше, чем брусок доедет до блока



$$\begin{cases} T\cdot\cos\beta = mg \\ T\cdot\sin\beta = ma \end{cases}$$

$$\boxed{\operatorname{tg}\beta = \frac{a}{g}}$$

$N\sin\alpha - T\cdot\cos\alpha = 13ma$

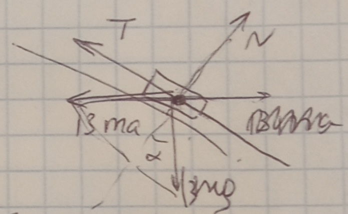
$N\cdot\cos\alpha + T\cdot\sin\alpha = 13mg$

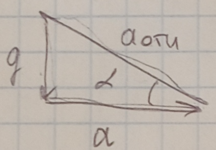
~~$N\sin\alpha + T\cos\alpha = 13ma$~~

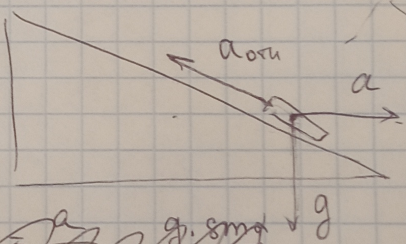
$N = \frac{13mg - T\cdot\sin\alpha}{\cos\alpha}$

$\left(\frac{13mg - T\cdot\sin\alpha}{\cos\alpha}\right)\cdot\sin\alpha - T\cdot\cos\alpha = 13ma$

$(13mg - T\cdot\sin\alpha)\operatorname{tg}\alpha - T\cdot\cos\alpha = 13ma$







$a_{отн}\cdot\cos\alpha = a$

$a_{отн}\cdot\sin\alpha = g$

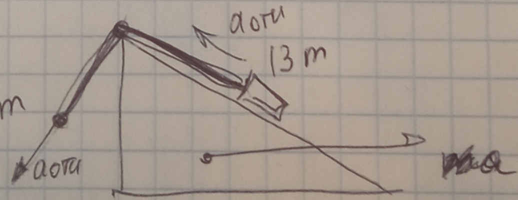
~~$a_{отн} = \frac{a}{\cos\alpha} = \frac{g\cdot\sin\alpha}{\cos^2\alpha}$~~

$\frac{35}{52}\cdot\frac{35}{50} = 0,7$

$13mg\cos\alpha + 13ma\sin\alpha = N$

$T + 13ma\cos\alpha$

$$\begin{array}{r|l} 350 & 52 \\ \underline{312} & 0,67 \\ 380 & \\ \underline{364} & \\ 160 & \end{array}$$



$$\begin{array}{r} 169 \\ -\,144 \\ \hline 25 \end{array}$$

$$\begin{array}{r} 65 \\ -\,16 \\ \hline 49 \end{array}$$

Чистовик

№ 1

$\cos\alpha = \frac{12}{13}$, $\sin\alpha = \frac{\sqrt{13^2-12^2}}{13} = \frac{5}{13}$

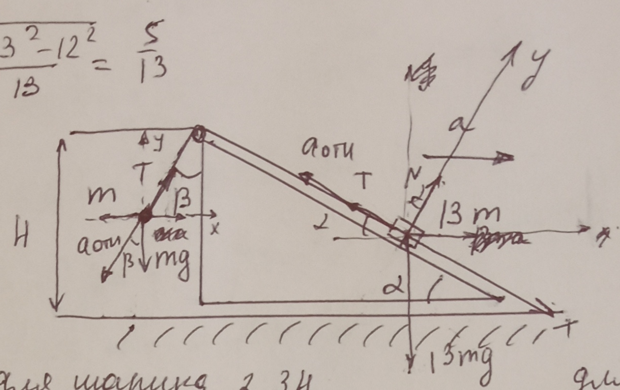
$\cos\beta = \frac{4}{5}$, $\sin\beta = \frac{3}{5}$

1) $a = ?$

2) $a_{отн\ бр} = ?$

3) $t_{ст} = ?$

нить нерастяж ⇒ ускорение шарика и бруска равны



для шарика 2 З.Н. — для бруска 2 З.Н.

1)

~~Ox: ...~~
~~Oy: ...~~

Ox: $-T\cdot\sin\beta + ma = m a_{отн}\sin\beta$

Oy: $mg - T\cdot\cos\beta = m a_{отн}\cdot\cos\beta$

Для бруска:

Ox: $T + 13ma\cos\alpha - 13mg\cdot\sin\alpha = 13m a_{отн}$

Oy: $N = 13mg\cos\alpha + ma\sin\alpha$

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

$a_{отн} = \frac{ma - T\cdot\sin\beta}{m\cdot\sin\beta} = \frac{a}{\sin\beta} - \frac{T}{m}$

$mg - T\cdot\cos\beta = \cancel{m}\cdot\frac{ma - T\cdot\sin\beta}{\cancel{m}\cdot\sin\beta}\cdot\cos\beta = (ma - T\cdot\sin\beta)\,ctg\,\beta$

$mg - \cancel{T\cdot\cos\beta} = ma\,ctg\,\beta - \cancel{T\cos\beta}$

$\cancel{m}g = \cancel{m}a\,ctg\,\beta$, $\boxed{a = g\,tg\,\beta = 10\cdot\frac{3}{4} = 7{,}5\ м/с^2}$

2) $T = 13m a_{отн} + 13mg\cdot\sin\alpha - 13m\cdot\cos\alpha\cdot g\,tg\,\beta$

$a_{отн} = \frac{g\,tg\,\beta}{\sin\beta} - \frac{13\cancel{m}(a_{отн} + g\sin\alpha - \cos\alpha\cdot g\,tg\,\beta)}{\cancel{m}}$

$a_{отн}\cdot\sin\beta = g\,tg\,\beta - 13a_{отн}\cdot\sin\beta + g\sin\alpha\cdot\sin\beta - \cos\alpha\, g\,tg\,\beta\cdot\sin\beta$

$14a_{отн}\cdot\sin\beta = g\,tg\,\beta + g\cdot\sin\alpha\cdot\sin\beta - \cos\alpha\cdot g\cdot tg\,\beta\cdot\sin\beta$

$a_{отн} = \frac{g\cdot\frac{\cancel{\sin\beta}}{\cos\beta}}{14\cdot\cancel{\sin\beta}} + \frac{g\cdot\sin\alpha\cdot\cancel{\sin\beta}}{14\cdot\cancel{\sin\beta}} - \frac{\cos\alpha\cdot g\cdot tg\,\beta\cdot\cancel{\sin\beta}}{14\,\cancel{\sin\beta}} =$

$= g\left(\frac{1}{14\cos\beta} + \frac{\sin\alpha}{14} - \frac{\cos\alpha\cdot tg\,\beta}{14}\right) = 10\cdot\left(\frac{5}{14\cdot 4} + \frac{5}{13\cdot 14} - \frac{\cancel{12}^{3}\cdot 3}{13\cdot 14\cdot\cancel{4}}\right) =$

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Чистовик

№ 1 (2)

$$a_{отн} = \frac{\cancel{10}^{5}}{\cancel{14}_{7}}\left(\frac{5}{4}+\frac{5}{13}-\frac{9}{13}\right) = \frac{5}{7}\left(\frac{5}{4}-\frac{4}{13}\right) = \frac{5}{7}\left(\frac{65-16}{4\cdot 13}\right) = \frac{5\cdot \cancel{49}^{7}}{\cancel{7}\cdot 4\cdot 13} =$$

$$= \frac{35}{52}\ м/с^2$$

3)

$$H = \frac{a_{отн}\cdot\cos\beta\, t^2}{2}$$

$$t = \sqrt{\frac{2H}{a_{отн}\cdot\cos\beta}} = \sqrt{\frac{2H}{\frac{\cancel{4}}{\cancel{5}}\cdot\frac{\cancel{35}^{7}}{\cancel{52}_{13}}}} = \sqrt{\frac{13\cdot 2H}{7}} = \sqrt{\frac{26H}{7}}\ с$$

Ответ: $a = g\,tg\beta = 7{,}5\ м/с^2$

$a_{отн} = \frac{35}{52}\ м/с^2$

$t = \sqrt{\frac{26H}{7}}\ с$

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~~(3)~~ №2 (2) чистовик

(6): $\frac{3}{2}\nu R_0\Delta T = -P_0R\cdot\sin\alpha\left(V_0R\cdot\cos(\alpha-\Delta\alpha) - V_0R\cdot\cos\alpha\right) =$

$= -P_0R^2V_0\cdot\sin\alpha\left(\cancel{\cos\alpha}\cdot\overset{1}{\cos\Delta\alpha} + \sin\alpha\cdot\overset{\Delta\alpha}{\sin\Delta\alpha} - \cancel{\cos\alpha}\right) =$

$\cdot P_0V_0R^2$

$= -P_0V_0R^2\cdot\sin^2\alpha\,\Delta\alpha$, $\quad \nu R_0\Delta T = -\frac{2}{3}\sin^2\alpha\,\Delta\alpha$ (8)

(8) → (7): $\cancel{P_0V_0R^2}(\sin^2\alpha - \cos^2\alpha)\cancel{\Delta\alpha} = -\frac{2}{3}\sin^2\alpha\,\cancel{\Delta\alpha}\cdot\cancel{P_0V_0R^2}$

$$3\sin^2\alpha - 3\cos^2\alpha = -2\sin^2\alpha$$

$$5\sin^2\alpha = 3\cos^2\alpha$$

$$tg^2\alpha = \frac{3}{5}, \quad tg\,\alpha = \frac{\sqrt{15}}{5}$$

3) $D = \frac{A_{газа}}{A_{расш}} = ?$ $\quad A_{газа} = A_{расш} + A_{сж}.$

$$\Delta Q_{21} = \Delta U_{21} + A_{21} \approx 0$$

$$A_{21} = -\Delta U_{21} = -\frac{3}{2}\nu R_0(T_1 - T_2) = \frac{3}{2}\nu R_0(T_2 - T_1) =$$

$$= \frac{3}{2}\left(P_0R\cdot\sin 15°\cdot V_0R\cdot\cos 15° - P_0R\cdot\cos 30°\cdot V_0R\cdot\sin 30°\right) =$$

$$= \frac{3}{2}P_0V_0R^2\left(\frac{\sin 30°}{2} - \frac{\sin 60°}{2}\right)$$

$D = 1 + \frac{A_{сж}}{A_{расш}}$; $\quad A_{расш} = \int_{V_1}^{V_2} P\,dV$

$P = P_0\cdot R\cdot\sin\varphi$

$V = V_0\cdot R\cdot\cos\varphi$, $dV = -\sin\varphi\, d\varphi\cdot V_0R$

$A_{расш} = \int_{15°}^{60°} -P_0R\cdot\sin\varphi^2\cdot V_0R\,d\varphi = -P_0V_0R^2\int_{15°}^{60°}\frac{1-\cos 2\varphi}{2}d\varphi =$

$= -P_0V_0R^2\left(\frac{1}{2}\varphi\Big|_{15°}^{60°} - \int_{15°}^{60°}\frac{\cos 2\varphi}{2}\frac{d2\varphi}{2}\right) = -P_0V_0R^2\left(\frac{1}{2}\varphi\Big|_{15°}^{60°} -\right.$

$\left. - \frac{\sin 2\varphi}{4}\Big|_{15°}^{60°}\right) = -P_0V_0R^2\left(\frac{1}{2}\left(\frac{4\pi}{12} - \frac{\pi}{12}\right) - \frac{\sin 120°}{4} + \frac{\sin 30°}{4}\right) =$

$= -P_0V_0R^2\left(\frac{\pi}{8} - \frac{\sqrt{3}}{8} + \frac{1}{8}\right)$

$$D = 1 - \frac{\frac{3}{\cancel{2}}\cancel{P_0V_0R^2}(\sin 30° - \sin 60°)}{\cancel{P_0V_0R^2}\left(\frac{\pi}{8} - \frac{\sqrt{3}}{8} + \frac{1}{8}\right)} = 1 - \frac{3}{\cancel{4}}\cdot\frac{\left(\frac{1}{\cancel{2}} - \frac{\sqrt{3}}{\cancel{2}}\right)}{(\pi - \sqrt{3} + 1)}\cdot\cancel{8}^{2} = 1 - \frac{3(1-\sqrt{3})}{(\pi - \sqrt{3} + 1)}$$

Ответ: $\sqrt{3}$; $\frac{\sqrt{15}}{5}$; $1 - \frac{3(1-\sqrt{3})}{(\pi - \sqrt{3} + 1)}$

Чистовик

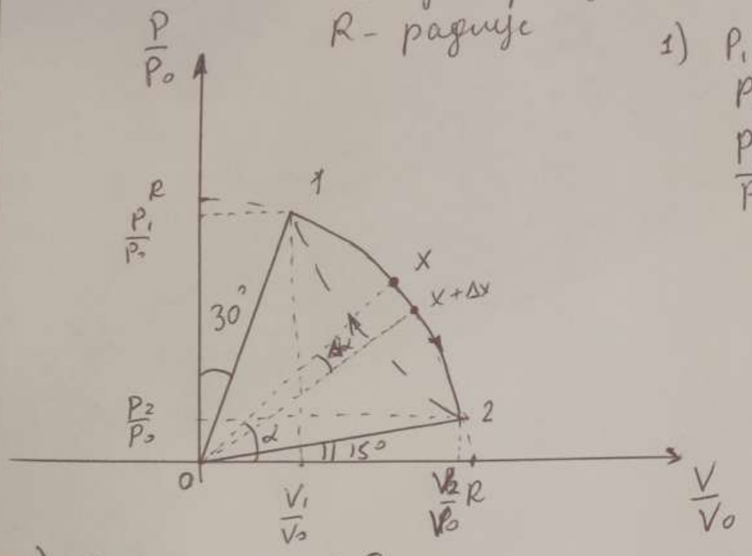
№ 2

$i=3$

$2\to 1:\ \Delta Q \approx 0$

R_0 - универс газ пост

R - радиус



1) $P_1V_1 = \nu R_0 T_1$

$P_2 V_2 = \nu R_0 T_2$

$\frac{P_1}{P_0} = R\cdot\cos 30^\circ \quad \frac{V_1}{V_0} = R\cdot\sin 30^\circ$

$\frac{V_2}{V_0} = R\cdot\cos 15^\circ \quad \frac{P_2}{P_0} = R\cdot \sin 15^\circ$

$$\frac{T_1}{T_2} = \frac{\nu R_0 T_1}{\nu R_0 T_2} = \frac{P_1V_1}{P_2V_2} = \frac{\cancel{P_0}\cancel{R}\cdot\cos 30^\circ\cdot \cancel{V_0}\cancel{R}\cdot \sin 30^\circ}{\cancel{P_0}\cancel{R}\cdot\sin 15^\circ\cdot\cancel{V_0}\cancel{R}\cdot\cos 15^\circ} = \frac{2\cdot\sin 30^\circ\cdot\cos 30^\circ}{2\cdot \sin 15^\circ\cdot\cos 15^\circ} = \frac{\sin 60^\circ}{\sin 30^\circ} = \sqrt{3}$$

2) $Q=0$: , $C = \frac{\Delta Q}{\Delta T} = 0$, (1) $\frac{P_x+\Delta P}{P_0} = R\cdot\sin(\alpha-\Delta\alpha)$, (2) $\frac{V_x+\Delta V}{V_0} = R\cdot\cos(\alpha-\Delta\alpha)$,

(6) $\Delta Q = \Delta U + \Delta A = 0$

$\Delta U = \frac{3}{2}\nu R_0\Delta T$,

(3) $\frac{P_x}{P_0} = R\cdot\sin\alpha$,

(4) $\frac{V_x}{V_0} = R\cdot\cos\alpha$,

$P_xV_x = \nu R_0 T_x$,

(5) $P_x\Delta V + \Delta P V_x = \nu R_0\Delta T$,

(6) $\frac{3}{2}\nu R_0\Delta T = -P_x\Delta V$

(1') $\Delta P = P_0R\cdot\sin(\alpha-\Delta\alpha) - P_x$

(2') $\Delta V = V_0R\cdot\cos(\alpha-\Delta\alpha) - V_x$

(1'), (2'), (3), (4) → (5): $P_0R\cdot\sin\alpha\cdot(V_0R\cdot\cos(\alpha-\Delta\alpha) - V_0R\cdot\cos\alpha)$ +

$+ (P_0R\cdot\sin(\alpha-\Delta\alpha) - P_0R\cdot\sin\alpha)\cdot V_0R\cdot\cos\alpha = \nu R_0\Delta T$

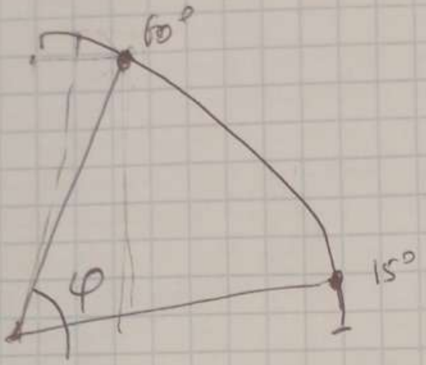
$P_0R^2\cdot V_0\cancel{2}(\sin\alpha\ (\cos(\alpha-\Delta\alpha)-\cos\alpha) + \cos\alpha\ (\sin(\alpha-\Delta\alpha)-\sin\alpha)) = \nu R\Delta T$

$P_0V_0R^2(\sin\alpha\ (\cos\alpha\cdot\overset{1}{\cancel{\cos\Delta\alpha}} + \sin\alpha\cdot\overset{\Delta\alpha}{\cancel{\sin\Delta\alpha}} - \cos\alpha) + \cos\alpha\ (\sin\alpha\cdot\overset{1}{\cancel{\cos\Delta\alpha}} -$

$- \cos\alpha\cdot\overset{\Delta\alpha}{\cancel{\sin\Delta\alpha}} - \sin\alpha)) = \nu R_0\Delta T$, $\Delta\alpha\to 0$, ~~[illegible]~~ $\sin\Delta\alpha\to\Delta\alpha$, $\cos\Delta\alpha\to 1$

$P_0V_0R^2(\sin\alpha\ (\cancel{\cos\alpha} + \sin\alpha\cdot\Delta\alpha - \cancel{\cos\alpha}) + \cos\alpha\ (\cancel{\sin\alpha} - \cos\alpha\Delta\alpha - \cancel{\sin\alpha})) =$

$= P_0V_0R^2(\sin^2\alpha\,\Delta\alpha - \cos^2\alpha\cdot\Delta\alpha) = \nu R_0\Delta T$ (7)



$$\frac{P_\varphi}{P_0} = R \cdot \sin\varphi$$

$$\frac{V}{V_0} = R \cdot \cos\varphi$$

$$V = V_0 R \cdot \cos\varphi$$

$$dV = -V_0 R \cdot \sin\varphi \, d\varphi$$

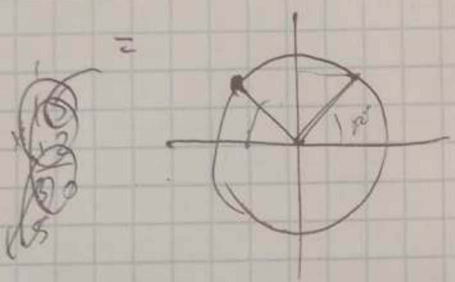
$$\cos 2\alpha = \cos^2\alpha - \sin^2\alpha = 1 - 2 \cdot \sin^2\alpha$$

$$\sin^2\alpha = \frac{1 - \cos 2\alpha}{2}$$

$$A = -P_0 R \cdot \sin\varphi \, V_0 R \cdot \sin\varphi \, d\varphi = -P_0 V_0 R^2 \cdot \sin^2\varphi \, d\varphi =$$

$$= \int -\frac{P_0 V_0 R^2}{2} \cdot \left(1 - \cos 2\varphi\right) d\varphi =$$

$=$



$\underbrace{P_0 R}\sin\alpha\cdot\underbrace{V_0 R}(\cos(\alpha-\Delta\alpha)-\cos\alpha)+\underbrace{P_0 R}(\sin(\alpha-\Delta\alpha)-\sin\alpha)\underbrace{V_0 R}\cdot\cos\alpha=$

$=\nu R\Delta T$

$\nu R\Delta T=-\frac{2}{3}P_0 R\sin\alpha\cdot V_0 R(\cos(\alpha-\Delta\alpha)-\cos\alpha)$

$\frac{3}{2}(\ldots)(\sin\alpha(\cos(\alpha-\Delta\alpha)-\cos\alpha)+\cos\alpha(\sin(\alpha-\Delta\alpha)-\sin\alpha))\cdot\ldots=$

$=-\frac{2}{3}\ldots\sin\alpha(\cos(\alpha-\Delta\alpha)-\cos\alpha)$

$5\sin\alpha(\cos(\alpha-\Delta\alpha)-\cos\alpha)+3\cos\alpha(\sin(\alpha-\Delta\alpha)-\sin\alpha)=0$

$=\nu\Delta\alpha\ldots$

$5\cdot\sin\alpha(\cos\alpha\cdot\overset{1}{\cos\Delta\alpha}+\sin\alpha\cdot\overset{\Delta\alpha}{\sin\Delta\alpha}-\cos\alpha)+3\cos\alpha(\sin\alpha\cdot\overset{1}{\cos\Delta\alpha}-$

$-\cos\alpha\cdot\overset{\Delta\alpha}{\sin\Delta\alpha}-\sin\alpha)=0$

$5\sin\alpha(\sin\alpha\cdot\Delta\alpha)-3\cdot\cos\alpha\cdot(\cos\alpha\cdot\Delta\alpha)=0$

$5\cdot\sin^2\alpha\cdot\cancel{\Delta\alpha}=3\cdot\cos^2\alpha\,\cancel{\Delta\alpha}$

$\tg^2\alpha=\frac{3}{5}$, $\tg\alpha=\frac{\sqrt3}{\sqrt5}=\frac{\sqrt{15}}{5}$

$\frac{A_{газа}}{A_{расш.}}=$

$=\frac{A_{расш}+A_{ст}}{A_{расш}}=$

$=1+\frac{A_{ст}}{A_{расш}}$

$\left(\frac{P_x}{P_0}\right)^2+\left(\frac{V_x}{V_0}\right)^2=R^2$

$P\,dV$,

$\Delta Q_{ст}\approx0\Rightarrow$ адиабата

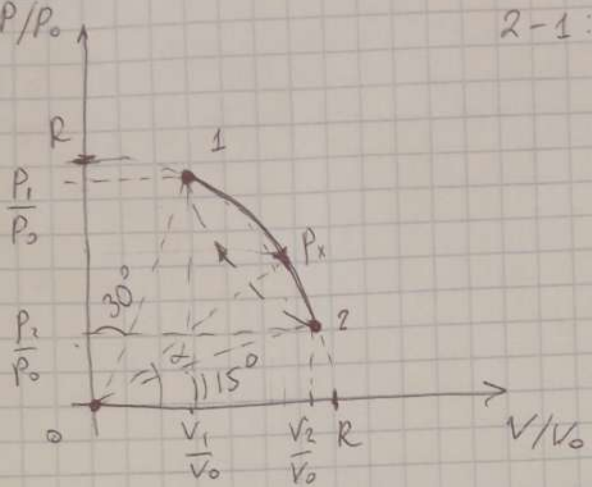
$PV^\gamma=\nu RT$, $\gamma=\frac{C_p}{C_v}=\frac{\frac{5}{2}R}{\frac{3}{2}R}=\frac{5}{3}$

$\Delta U+A=0$

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

$A_{расш.}=$

$i = 3$



2-1: $\Delta Q \approx 0$

$p_1 V_1 = \nu R T_1$

$P_2 V_2 = \nu R T_2$

$\cancel{\left(\frac{P_1}{P_0}\right)^2 + \left(\frac{V_1}{V_0}\right)^2 = R^2}$

$\cancel{\left(\frac{P_2}{P_0}\right)^2 + \left(\frac{V_2}{V_0}\right)^2} = R^2$

$\frac{P_1}{P_0} = R \cdot \cos 30°$ $\qquad \frac{V_2}{V_0} = R \cdot \cos 15°$

$\frac{V_1}{V_0} = R \cdot \sin 30°$ $\qquad \frac{P_2}{P_0} = R \sin 15°$

$\frac{P_x}{P_0} = R \cdot \sin\alpha$

$\frac{V_x}{V_0} = R \cdot \cos\alpha$

1) $\frac{T_1}{T_2} = \frac{P_1 V_1}{P_2 V_2} = \frac{\cancel{P_0} \cancel{R} \cdot \cos 30° \cdot V_0 \cdot R \cdot \sin 30°}{\cancel{P_0} \cdot R \cdot \sin 15° \cdot \cancel{V_0} \cdot \cancel{R} \cdot \cos 15°} = \frac{2 \cdot \cos 30° \cdot \sin 30°}{2 \cdot \sin 15° \cdot \cos 15°} =$

$= \frac{\sin 60°}{\sin 30°} = \frac{\sqrt{3}}{2 \cdot 1/2} = \sqrt{3}$

2) $C = 0$, $C = \frac{\Delta Q}{\Delta T} = 0 \Rightarrow \Delta Q = 0 = ?$

$\Delta Q = \frac{3}{2}\nu R \Delta T_x + P_x \Delta V_x = 0$

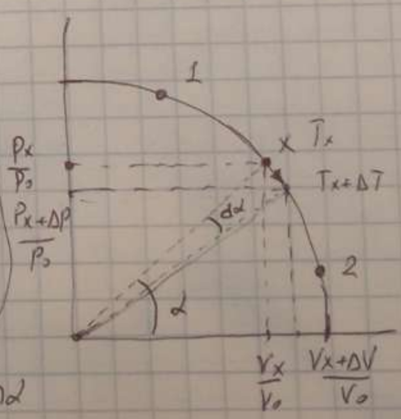
$\cancel{\frac{3}{2}\nu R \Delta T_x = -P_x \Delta V_x}$

$$\begin{cases} P_x \cdot V_x = \nu R T_x \\ P_x \Delta V_x + \Delta P_x \cdot V_x = \nu R \Delta T_x \\ \Delta U + P_x \Delta V = 0 \end{cases}$$

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

$\frac{P_x + \Delta P}{P_0} = R \sin(\alpha - \Delta\alpha)$

$\frac{V_x + \Delta V}{V_0} = R \cos(\alpha - \Delta\alpha)$



$\Delta P = P_0 R \sin(\alpha - \Delta\alpha) - P_0 R \cdot \sin\alpha$

$\Delta V = V_0 R \cdot \cos(\alpha - \Delta\alpha) - V_0 R \cdot \cos\alpha$

$\cancel{P_0 R \sin\alpha (V_0 R \cos(\alpha - \Delta\alpha) - V_x) + P_0 R \sin\alpha + \Delta\alpha - P_x}$

$\Delta P = P_0 R (\sin(\alpha - \Delta\alpha) - \sin\alpha)$

$\Delta V = V_0 R (\cos(\alpha - \Delta\alpha) - \cos\alpha)$

N

$$P_0R\sin\alpha\cdot V_0R(\cos(\alpha-\Delta\alpha)-\cos\alpha)+P_0R(\sin(\alpha-\Delta\alpha)-\sin\alpha)V_0R\cdot\cos\alpha=$$
$$=\nu R\Delta T$$

$$\nu R\Delta T=-\frac{2}{3}P_0R\sin\alpha\cdot V_0R(\cos(\alpha-\Delta\alpha)-\cos\alpha)$$

$$\frac{3}{2}\left(\sin\alpha(\cos(\alpha-\Delta\alpha)-\cos\alpha)+\cos\alpha(\sin(\alpha-\Delta\alpha)-\sin\alpha)\right)=$$
$$=-\frac{2}{3}\sin\alpha(\cos(\alpha-\Delta\alpha)-\cos\alpha)$$

$$5\sin\alpha(\cos(\alpha-\Delta\alpha)-\cos\alpha)+3\cos\alpha(\sin(\alpha-\Delta\alpha)-\sin\alpha)=0$$

$$5\cdot\sin\alpha(\cos\alpha\cos\Delta\alpha+\sin\alpha\cdot\sin\Delta\alpha-\cos\alpha)+3\cos\alpha(\sin\alpha\cdot\cos\Delta\alpha-$$
$$-\cos\alpha\cdot\sin\Delta\alpha-\sin\alpha)=0$$

$$5\sin\alpha(\sin\alpha\cdot\Delta\alpha)-3\cdot\cos\alpha\cdot(\cos\alpha\cdot\Delta\alpha)=0$$

$$5\cdot\sin^2\alpha\cdot\Delta\alpha=3\cdot\cos^2\alpha\,\Delta\alpha$$

$$\operatorname{tg}^2\alpha=\frac{3}{5},\quad \operatorname{tg}\alpha=\frac{\sqrt3}{\sqrt5}=\frac{\sqrt{15}}{5}$$

$$\frac{A_{газа}}{A_{расш.}}=$$

$$=\frac{A_{расш}+A_{ст}}{A_{расш}}=1+\frac{A_{ст}}{A_{расш}}$$

$$\left(\frac{P}{P_0}\right)^2+\left(\frac{V}{V_0}\right)^2=R^2$$

$P\,dV$,

$\Delta Q_{ст}\approx0\Rightarrow$ адиабата

$$PV^\gamma=\nu RT,\quad \gamma=\frac{C_p}{C_v}=\frac{\frac{5}{2}R}{\frac{3}{2}R}=\frac{5}{3}$$

$$\Delta U+A=0$$

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

$A_{расш.}=$

1) $a = ?$

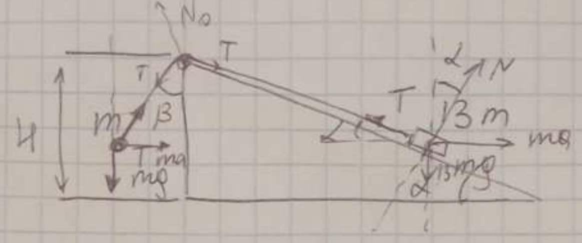
2) $a_{отн} = ?$

3) $t_{шест} = ?$

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

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

шарик дост. стола раньше, чем брусок доедет до блока



$\vec{a}$

$$\begin{cases} T\cdot\cos\beta = mg \\ T\cdot\sin\beta = ma \end{cases}$$

$$\boxed{\operatorname{tg}\beta = \frac{a}{g}}$$

$N\sin\alpha - T\cdot\cos\alpha = 13ma$

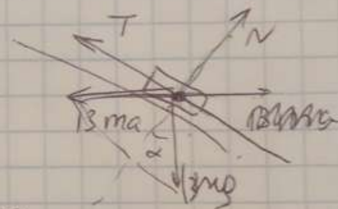
$N\cdot\cos\alpha + T\cdot\sin\alpha = 13mg$

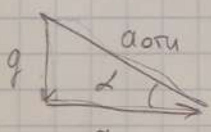
~~$N\sin\alpha + T\cos\alpha = 13ma$~~

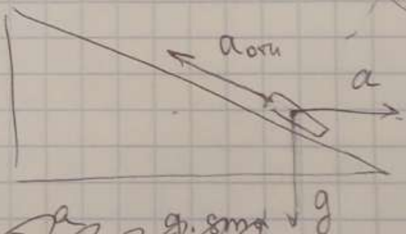
$N = \dfrac{13mg - T\cdot\sin\alpha}{\cos\alpha}$

$\left(\dfrac{13mg - T\cdot\sin\alpha}{\cos\alpha}\right)\cdot\sin\alpha - T\cdot\cos\alpha = 13ma$

$(13mg - T\cdot\sin\alpha)\operatorname{tg}\alpha - T\cdot\cos\alpha = 13ma$







$a_{отн}\cdot\cos\alpha = a$

$a_{отн}\cdot\sin\alpha = g$

$\frac{35}{52} \cdot \frac{35}{50} = 0{,}7$

~~$a_{отн} = \frac{a}{\cos\alpha}$ $\frac{g\cdot\sin\alpha}{\cos\alpha}$~~

$13mg\cos\alpha + 13ma\sin\alpha = N$

$T + 13ma\cos\alpha$

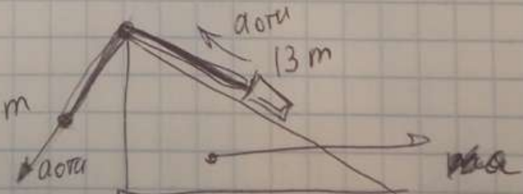
$350 : 52 = 0{,}67$

312

380

364

160



$169 - 144 = 25$

$65 - 16 = 49$

~~(8)~~ №2 (2) чистовик

№ (6): $\frac{3}{2}\nu R_0\Delta T = -P_0R\cdot\sin\alpha\left(V_0R\cdot\cos(\alpha-\Delta\alpha) - V_0R\cdot\cos\alpha\right) =$

$= -P_0R^2V_0\cdot\sin\alpha\left(\cancel{\cos\alpha}\cdot\cos\Delta\alpha + \sin\alpha\cdot\sin\Delta\alpha - \cancel{\cos\alpha}\right) =$

$= -P_0V_0R^2\cdot\sin^2\alpha\,\Delta\alpha\,,\quad \nu R_0\Delta T = -\frac{2}{3}\sin^2\alpha\,\Delta\alpha\cdot P_0V_0R^2 \;(8)$

(8) → (7): $\cancel{P_0V_0R^2}(\sin^2\alpha-\cos^2\alpha)\cancel{\Delta\alpha} = -\frac{2}{3}\sin^2\alpha\,\cancel{\Delta\alpha\cdot P_0V_0R^2}$

$3\sin^2\alpha - 3\cos^2\alpha = -2\sin^2\alpha$

$5\sin^2\alpha = 3\cos^2\alpha$

$\operatorname{tg}^2\alpha = \frac{3}{5}\,,\quad \operatorname{tg}\alpha = \frac{\sqrt{15}}{5}$

3) $D = \frac{A_{газа}}{A_{расш}} = ?\qquad A_{газа} = A_{расш} + A_{сж}.$

$\Delta Q_{21} = \Delta U_{21} + A_{21} \approx 0$

$A_{21} = -\Delta U_{21} = -\frac{3}{2}\nu R_0(T_1-T_2) = \frac{3}{2}\nu R_0(T_2-T_1) =$

$= \frac{3}{2}\left(P_0R\cdot\sin 15^\circ\cdot V_0R\cdot\cos 15^\circ - P_0R\cdot\cos 30^\circ\cdot V_0R\cdot\sin 30^\circ\right) =$

$= \frac{3}{2}P_0V_0R^2\left(\frac{\sin 30^\circ}{2} - \frac{\sin 60^\circ}{2}\right)$

$D = 1 + \frac{A_{сж}}{A_{расш}}\;;\quad A_{расш} = \int_{V_1}^{V_2} P\,\Delta V$

$P = P_0\cdot R\cdot\sin\varphi$

$V = V_0\cdot R\cdot\cos\varphi\,,\; dV = -\sin\varphi\, d\varphi\cdot V_0R$

$A_{расш} = \int_{15^\circ}^{60^\circ} -P_0R\cdot\sin\varphi^2\cdot V_0R\,d\varphi = -P_0V_0R^2\int_{15^\circ}^{60^\circ}\frac{1-\cos 2\varphi}{2}\,d\varphi =$

$= -P_0V_0R^2\left(\frac{1}{2}\varphi\Big|_{15^\circ}^{60^\circ} - \int_{15^\circ}^{60^\circ}\frac{\cos 2\varphi}{2}\frac{d2\varphi}{2}\right) = -P_0V_0R^2\left(\frac{1}{2}\varphi\Big|_{15^\circ}^{60^\circ} -\right.$

$\left. -\frac{\sin 2\varphi}{4}\Big|_{15^\circ}^{60^\circ}\right) = -P_0V_0R^2\left(\frac{1}{2}\left(\frac{4\pi}{12}-\frac{\pi}{12}\right) - \frac{\sin 120^\circ}{4} + \frac{\sin 30^\circ}{4}\right) =$

$= -P_0V_0R^2\left(\frac{\pi}{8} - \frac{\sqrt{3}}{8} + \frac{1}{8}\right)$

$D = 1 - \frac{\frac{3}{4}\cancel{P_0V_0R^2}\left(\sin 30^\circ - \sin 60^\circ\right)}{\cancel{P_0V_0R^2}\left(\frac{\pi}{8}-\frac{\sqrt{3}}{8}+\frac{1}{8}\right)} = 1 - \frac{3}{\cancel{4}}\cdot\frac{\left(\frac{1}{\cancel{2}}-\frac{\sqrt{3}}{\cancel{2}}\right)}{(\pi-\sqrt{3}+1)}\cdot\cancel{8}^{2} = 1 - \frac{3(1-\sqrt{3})}{(\pi-\sqrt{3}+1)}$

Ответ: $\sqrt{3}\;;\;\frac{\sqrt{15}}{5}\;;\;1 - \frac{3(1-\sqrt{3})}{(\pi-\sqrt{3}+1)}$

Чистовик

№ 1

нить нерастяж => ускорение шарика и бруска равны

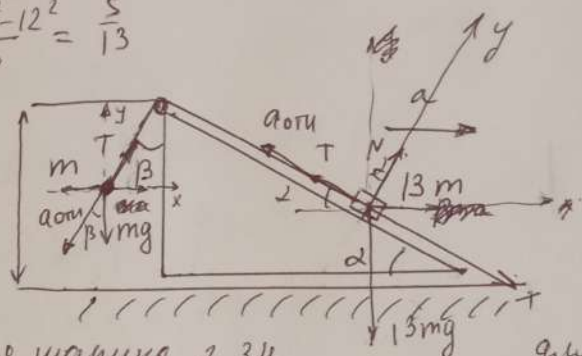
$\cos\alpha = \frac{12}{13}$, $\sin\alpha = \frac{\sqrt{13^2-12^2}}{13} = \frac{5}{13}$

$\cos\beta = \frac{4}{5}$, $\sin\beta = \frac{3}{5}$

1) $a = ?$

2) $a_{\text{отн бр}} = ?$

3) $t_{\text{ст}} = ?$



для шарика 2 з.н.

1)

$Ox: -T\cdot\sin\beta + ma = m a_{\text{отн}} \sin\beta$

$Oy: \quad mg - T\cdot\cos\beta = m a_{\text{отн}}\cdot\cos\beta$

для бруска 2з.н.

$Ox: T + 13mg\cos\alpha - 13mg\cdot\sin\alpha = 13 m a_{\text{отн}}$

$Oy: N = 13mg\cos\alpha + ma\sin\alpha$

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

$a_{\text{отн}} = \frac{ma - T\cdot\sin\beta}{m\cdot\sin\beta} = \frac{a}{\sin\beta} - \frac{T}{m}$

$mg - T\cdot\cos\beta = \cancel{m}\cdot\frac{ma - T\cdot\sin\beta}{\cancel{m}\cdot\sin\beta}\cdot\cos\beta = (ma - T\cdot\sin\beta)\,\mathrm{ctg}\,\beta$

$mg - T\cdot\cos\beta = ma\,\mathrm{ctg}\,\beta - T\cos\beta$

$\cancel{m}g = \cancel{m}a\,\mathrm{ctg}\,\beta$, $\boxed{a = g\,\mathrm{tg}\,\beta = 10\cdot\frac{3}{4} = 7{,}5 \text{ м/с}^2}$

2) $T = 13 m a_{\text{отн}} + 13mg\cdot\sin\alpha - 13m\cdot\cos\alpha\cdot g\,\mathrm{tg}\,\beta$

$a_{\text{отн}} = \frac{g\,\mathrm{tg}\,\beta}{\sin\beta} - \frac{13\cancel{m}(a_{\text{отн}} + g\sin\alpha - \cos\alpha\cdot g\,\mathrm{tg}\,\beta)}{\cancel{m}}$

$a_{\text{отн}}\cdot\sin\beta = g\,\mathrm{tg}\,\beta - 13 a_{\text{отн}}\cdot\sin\beta + g\sin\alpha\cdot\sin\beta - \cos\alpha\, g\,\mathrm{tg}\,\beta\cdot\sin\beta$

$14 a_{\text{отн}}\cdot\sin\beta = g\,\mathrm{tg}\,\beta + g\cdot\sin\alpha\cdot\sin\beta - \cos\alpha\cdot g\cdot\mathrm{tg}\,\beta\cdot\sin\beta$

$a_{\text{отн}} = \frac{g\cdot\frac{\sin\beta}{\cos\beta}}{14\cdot\cancel{\sin\beta}} + g\,\frac{\sin\alpha\cdot\cancel{\sin\beta}}{14\cdot\cancel{\sin\beta}} - \frac{\cos\alpha\cdot g\cdot\mathrm{tg}\,\beta\cdot\cancel{\sin\beta}}{14\,\cancel{\sin\beta}} =$

$= g\left(\frac{1}{14\cos\beta} + \frac{\sin\alpha}{14} - \frac{\cos\alpha\cdot\mathrm{tg}\,\beta}{14}\right) = 10\cdot\left(\frac{5}{14\cdot 4} + \frac{5}{13\cdot 14} - \frac{\overset{3}{\cancel{12}}\cdot 3}{13\cdot 14\cdot\cancel{4}}\right) =$

$=$

чистовик

№ 1 (2)

$$a_{отн} = \frac{\cancel{10}^{5}}{\cancel{14}_{7}}\left(\frac{5}{4}+\frac{5}{13}-\frac{9}{13}\right) = \frac{5}{7}\left(\frac{5}{4}-\frac{4}{13}\right) = \frac{5}{7}\left(\frac{65-16}{4\cdot 13}\right) = \frac{5\cdot \cancel{49}^{7}}{\cancel{7}\cdot 4\cdot 13} = \frac{35}{52}\ м/с^2$$

3)

$$H = \frac{a_{отн}\cdot\cos\beta\, t^2}{2}$$

$$t = \sqrt{\frac{2H}{a_{отн}\cdot\cos\beta}} = \sqrt{\frac{2H}{\frac{\cancel{4}}{5}\cdot\frac{35^{7}}{\cancel{52}_{13}}}} = \sqrt{\frac{13\cdot 2H}{7}} = \sqrt{\frac{26H}{7}}\ с$$

Ответ: $a = g\,tg\beta = 7{,}5\ м/с^2$

$a_{отн} = \frac{35}{52}\ м/с^2$

$t = \sqrt{\frac{26H}{7}}\ с$

Часть 2

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

Шифр: **21202447**

ID профиля: **330585**

Вариант 5

3) $\frac{mV_0^2}{2} = \frac{mV_1^2}{2} + A_A$, чистовик A_A - работа силы Ампера

когда передняя сторона уже вышла из поля, а задняя еще не вошла, F_A действует $\perp$ напр. движ $\Rightarrow$ $\Rightarrow A_A = 0$.

~~[illegible]~~

работа силы Ампера по передв. передней ~~рамки~~ стороны =

= работе по передв. задней, ~~[illegible]~~

~~[illegible]~~

$$\frac{mV_0^2}{2} = \frac{mV_2^2}{2} + 2A_A = \frac{mV_2^2}{2} + 2\frac{mV_0^2}{2} - 2\frac{mV_1^2}{2}$$

$$2mV_1^2 - mV_2^2 = mV_0^2$$

$$2V_1^2 - V_2^2 = V_0^2$$

$$V_2^2 = 2V_1^2 - V_0^2 = 2\left(\frac{RmV_0 - d^3B^2}{3Rm}\right)^2 - V_0^2$$

5

Ответ: $a = (Bd)^2 \frac{V_0}{mR}$

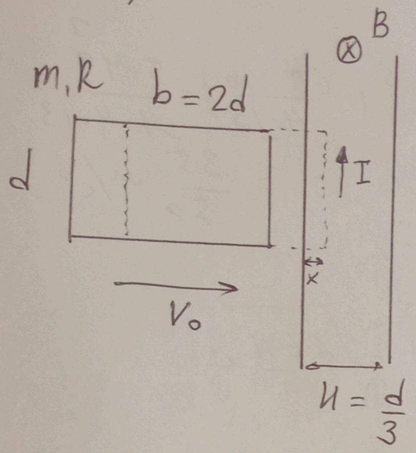
$$V_1 = \frac{3RmV_0 - d^3B^2}{3Rm}$$

$$V_2 = 2\left(\frac{RmV_0 - d^3B^2}{3Rm}\right)^2 - V_0^2$$

21202447 (U330585 M1269027)

Чистовик

№ 4



1) $\varepsilon_i = -\frac{d\Phi}{dt} = -B\frac{dS}{dt} = \cancel{B}$

$= -B \cdot d \cdot \frac{dx}{dt} = -BdV_0$,

т.к. в начальный момент скорость рамки еще не изменилась,

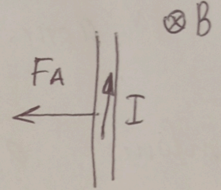
1) $a = ?$
2) $V_1 = ?$
3) $V_2 = ?$

$|\varepsilon_i| = IR$, $-BdV_0 = IR$, $I = \frac{-BdV_0}{R}$

$F_A = ma = BId \cdot \sin 90° = BId$

$a = \frac{Bd}{m} \cdot \frac{BdV_0}{R}$

$a = (Bd)^2 \cdot \frac{V_0}{mR}$



2) $\varepsilon_i = -BdV = IR$, $I = -\frac{BdV}{R}$

$F_A = m\frac{dV}{dt} = BId = -\frac{(Bd)^2 V}{R}$

$\int \frac{dV}{V} = \int -\frac{(Bd)^2}{Rm} dt$, $\ln V = -\frac{(Bd)^2 t}{Rm} + const$

$t = 0$: $V = V_0$, $\ln V_0 = const$.

$\ln \frac{V}{V_0} = -\frac{(Bd)^2 t}{Rm}$,

$V = V_0 \cdot e^{-(Bd)^2 t / Rm}$

$\int_0^{\tau} V dt = \int_0^{d/3} dx$

$\int_0^{\tau} V_0 \cdot e^{-(Bd)^2 t / Rm} dt = RV_0 m \left. \frac{e^{-(Bd)^2 t/Rm}}{-(Bd)^2} \right|_0^{\tau} = \frac{d}{3}$

$\frac{RmV_0}{-(Bd)^2}\left(e^{-(Bd)^2\tau/Rm} - 1\right) = \frac{d}{3}$

$\frac{RmV_0}{(Bd)^2}\left(1 - e^{-(Bd)^2\tau/Rm}\right) = \frac{d}{3}$, $e^{-(Bd)^2\tau/Rm} = 1 - \frac{d}{3}\cdot\frac{(Bd)^2}{RmV_0}$

$V_1 = V(\tau) = V_0 \cdot e^{-(Bd)^2\tau/Rm} = \cancel{V_0} \cdot \frac{3RmV_0 - d^3B^2}{3Rm\cancel{V_0}} = \frac{3RmV_0 - d^3B^2}{3Rm}$

4

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3 №5(2) чистовик

$$\begin{cases} \frac{1}{x} + \frac{1}{f} = \frac{1}{F_0} \\ \frac{1}{d} + \frac{1}{f} = \frac{1}{F_{10}} \\ \frac{1}{F_{10}} = \frac{1}{F_0} + \frac{1}{F_1} \\ \frac{1}{F_{20}} = \frac{1}{F_2} + \frac{1}{F_0} \\ f = F_{20} \\ \frac{1}{F_2} = \frac{2}{F_1} \end{cases}
\qquad
\begin{cases} \frac{1}{x} + \frac{1}{f} = \frac{1}{F_0} \\ \frac{1}{d} + \frac{1}{f} = \frac{1}{F_0} + \frac{1}{F_1} \\ \frac{1}{f} = \frac{1}{F_2} + \frac{1}{F_0} \\ F_1 = F_2 \cdot 2 \end{cases}
\qquad
\begin{cases} \frac{1}{x} + \frac{1}{f} = \frac{1}{F_0} \\ \frac{1}{d} + \frac{1}{f} = \frac{1}{F_0} + \frac{1}{F_2 \cdot 2} \\ \frac{1}{f} = \frac{1}{F_2} + \frac{1}{F_0} \end{cases}$$

$$\cancel{\frac{1}{f} = \frac{1}{F_0} - \frac{1}{x} = \frac{1}{F_2} + \frac{1}{F_2} \quad x = -F_2}$$

$$\cancel{\frac{1}{d} + \frac{1}{F_0} - \frac{1}{x} = \frac{1}{F_0} + \frac{2}{F_2}}$$

$$\cancel{\frac{1}{d} + \frac{1}{F_2} = \frac{2}{F_2} \quad \frac{1}{d} = \frac{1}{F_2} \quad F_2 = d}$$

$$\cancel{D_2 = \frac{1}{F_2} = \frac{1}{d} = \frac{1}{0{,}25} = 4 \text{ дптр}}$$

$$\frac{1}{f} = \frac{1}{F_0} - \frac{1}{x} = \frac{1}{F_2} + \frac{1}{F_0} = \frac{1}{F_0} + \frac{1}{2F_2} - \frac{1}{d}$$

$$\frac{1}{d} + \frac{1}{f} = \frac{1}{F_0} + \frac{1}{2F_2}$$

$$-\frac{1}{x} = \frac{1}{F_2} = \frac{1}{2F_2} - \frac{1}{d}$$

$$-x = F_2 \qquad \frac{1}{d} = \frac{1}{2F_2} - \frac{2}{2F_2} = -\frac{1}{2F_2}, \qquad 2F_2 = -d$$

$$F_2 = -\frac{d}{2} = -12{,}5 \text{ см}$$

$$x = -F_2 = \frac{d}{2} = \frac{25 \text{ см}}{2} = 12{,}5 \text{ см}.$$

$$D_2 = \frac{1}{F_2} = -\frac{2}{d} = -\frac{2}{0{,}25} = -8 \text{ дптр},$$

2) $D_3 = ? = \frac{1}{F_3} = ?$ $h = 50$ см

$$\begin{cases} \frac{1}{h} + \frac{1}{f} = \frac{1}{F_{30}} = \frac{1}{F_0} + \frac{1}{F_3} \\ \frac{1}{f} = \frac{1}{F_2} + \frac{1}{F_0} \end{cases},$$

$$\frac{1}{f} - \frac{1}{F_0} = \frac{1}{F_3} - \frac{1}{h} = \frac{1}{F_2}$$

$$D_3 = \frac{1}{F_3} = \frac{1}{h} + \frac{1}{F_2} = \left(\frac{1}{50} - \frac{2}{25}\right) \cdot 10^2 =$$

$$= \left(\frac{1}{50} - \frac{4}{50}\right) \cdot 10^2 = -\frac{3}{50} \cdot 10^2 =$$

$$= -0{,}06 \cdot 10^2 = -6 \text{ дптр}.$$

Ответ: $x = 12{,}5$ см,

$D_2 = -8$ дптр.

$D_3 = -6$ дптр.

3

Чистовик

№5

$d = 25$ см

$D_1 / D_2 = 1/2$

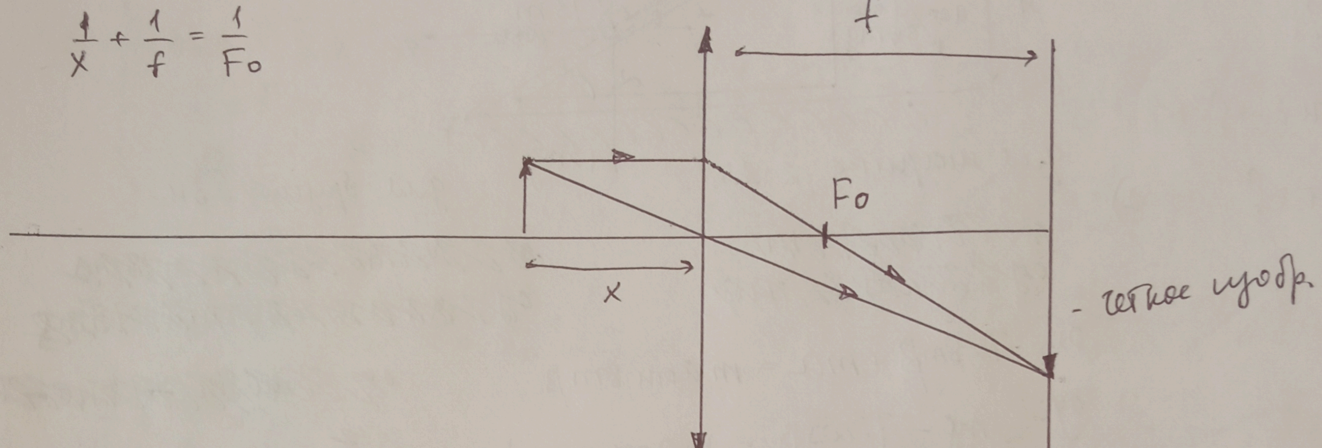
очки расположены вплотную к глазу => => оптическая сила очков + глаза = $D_{очков} + D_{глаз}$.

$\frac{1}{F_1}$ – опт. сила первых очков

$\frac{1}{F_2}$ – опт. сила вторых очков

1) глаз без очков:

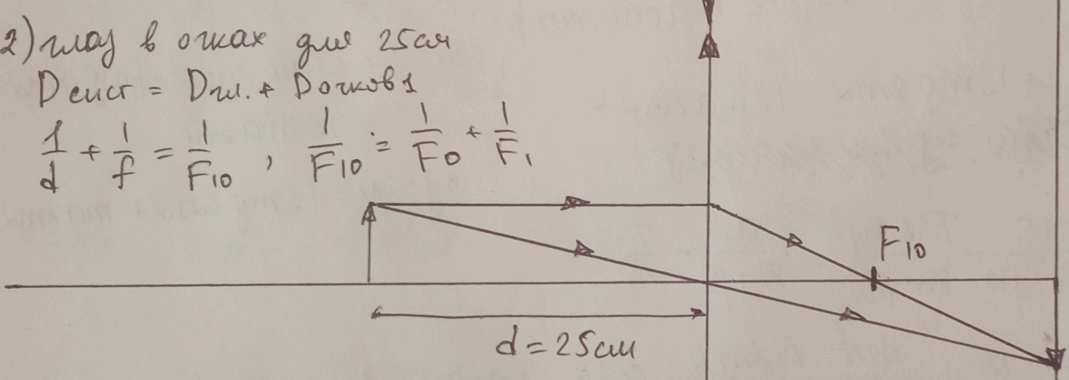
$$\frac{1}{x} + \frac{1}{f} = \frac{1}{F_0}$$



2) глаз в очках для 25см

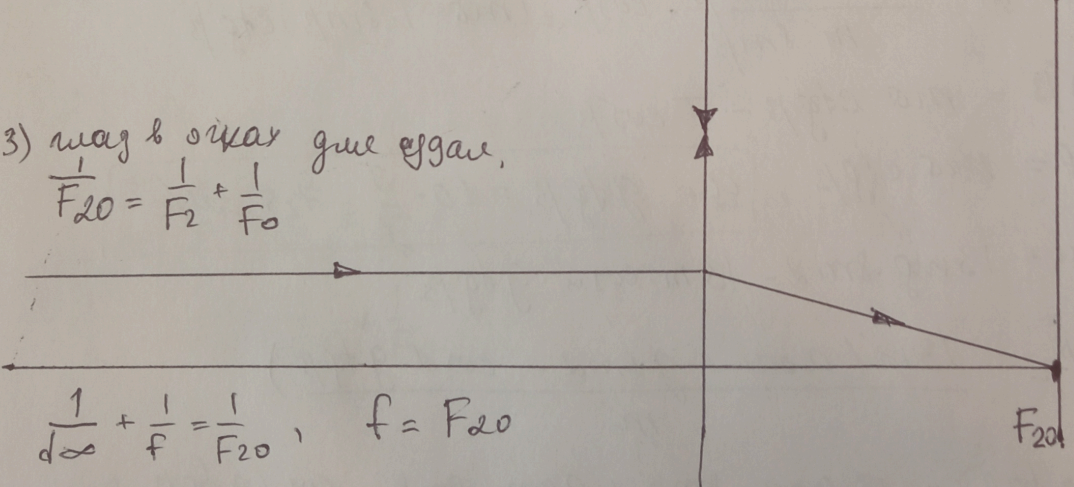
$D_{сист} = D_{гл.} + D_{очков 1}$

$$\frac{1}{d} + \frac{1}{f} = \frac{1}{F_{10}}, \quad \frac{1}{F_{10}} = \frac{1}{F_0} + \frac{1}{F_1}$$



3) глаз в очках для удал.

$$\frac{1}{F_{20}} = \frac{1}{F_2} + \frac{1}{F_0}$$



$$\frac{1}{d\infty} + \frac{1}{f} = \frac{1}{F_{20}}, \quad f = F_{20}$$

$F_{20} > F_{10}$

$$\frac{1}{F_{20}} < \frac{1}{F_{10}}, \quad \cancel{\frac{1}{F_0}} + \frac{1}{F_2} < \cancel{\frac{1}{F_0}} + \frac{1}{F_1}$$

$D_2 > D_1 \Rightarrow D_2 = D_1 \cdot 2$

2

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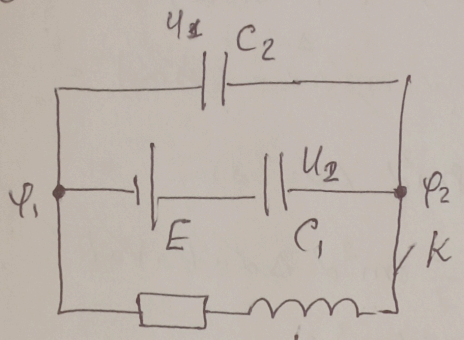
Чистовик.

№3

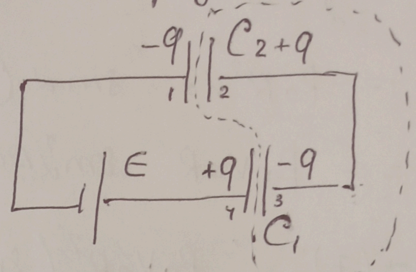


$C_1 = C$

$2C = C_2$

$q_{1,2}(0) = 0$

ключ разомкнут:



т.к обкладки 2 и 3 изолир.,

$q_2 + q_3 = 0,$

$q_2 = -q_3 = q$

$E = U_1 + U_2 = \frac{q_2}{C_2} + \frac{q_4}{C_1} = \frac{q}{2C} + \frac{q}{C} = \frac{3q}{2C}, \quad q = \frac{2CE}{3}$

$U_1 = \frac{q}{2C} = \frac{E}{3}, \quad U_2 = \frac{2E}{3}$

1) ток ч/з катушку не меняется скачком, значит т.к до замык. $I_L = 0$, в ~~…~~ момент сразу после замык ток ч/з резистор и катушку не идет =>

$U_L = L\frac{dI}{dt} = E - U_2 = E - \frac{2E}{3} = \frac{E}{3},$

$\frac{dI}{dt} = \frac{E}{3L}$

2) до замык: $W_0 = \frac{2CU_1^2}{2} + \frac{CU_2^2}{2} = \frac{2C \cdot E^2}{9 \cdot 2} + \frac{C}{2} \cdot \frac{4E^2}{9} = \frac{3CE^2}{9} = \frac{CE^2}{3}$

в установ. режиме (t_K) после замык ключа ток не идет. => $\varphi_1 = \varphi_2$

$U_2(t_K) = E, \quad W = \frac{CE^2}{2},$ q_K – заряд на C_1 ~~…~~ при $t = t_K$

q – начальный заряд

$q_K = CE$

$\Delta q = q_K - q = CE - \frac{2CE}{3} = \frac{CE}{3}$

$W_0 + A_{ист} = W + Q$

$\frac{CE^2}{3} + E\Delta q = \frac{CE^2}{2} + Q, \quad Q = \frac{CE^2}{3} + \frac{CE^2}{3} - \frac{CE^2}{2} = \frac{2CE^2}{3} - \frac{CE^2}{2} = \frac{CE^2}{6}$

Ответ: $\frac{E}{3L}$; $\frac{CE^2}{6}$

1

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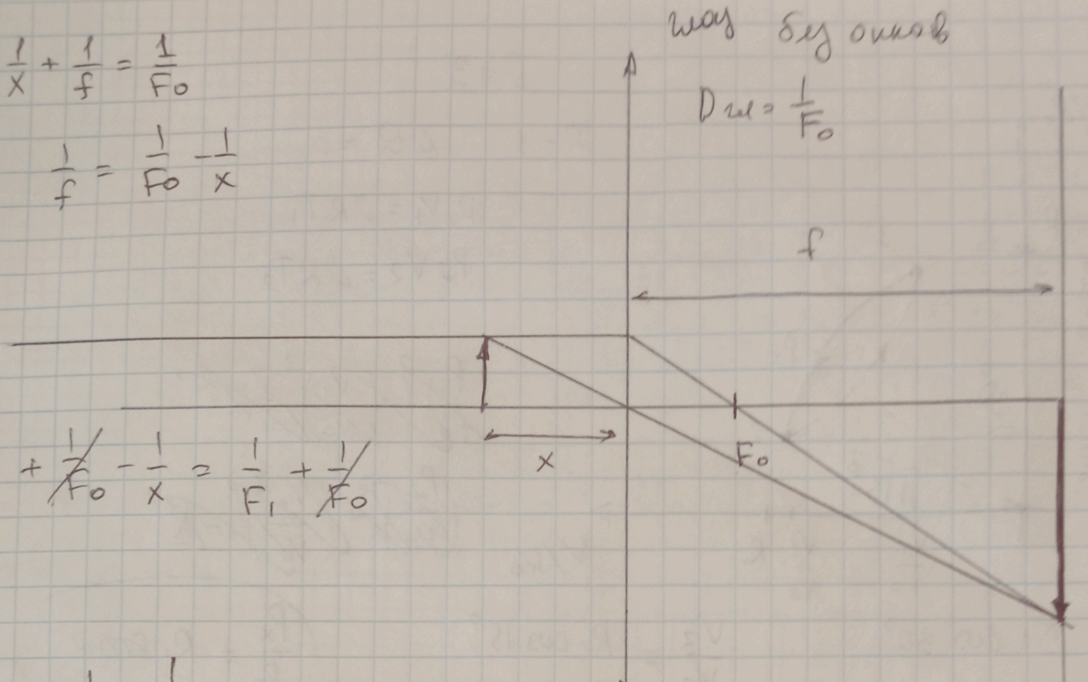
$$\frac{1}{x} + \frac{1}{f} = \frac{1}{F_0}$$

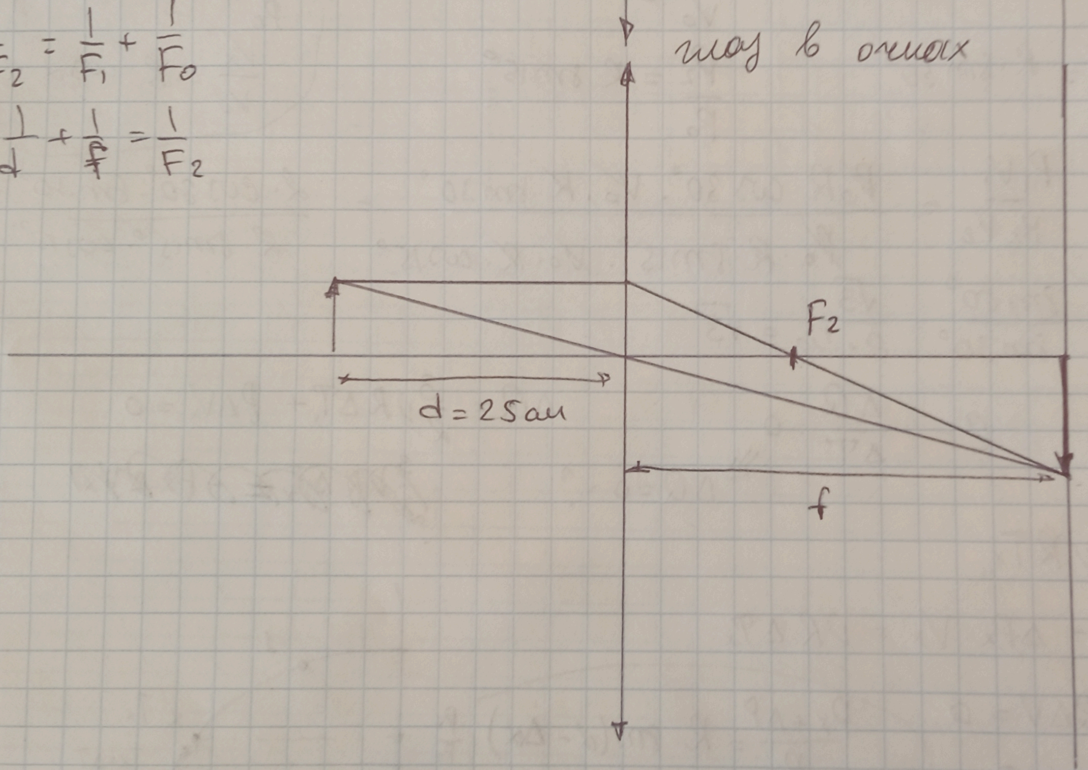
$$\frac{1}{f} = \frac{1}{F_0} - \frac{1}{x}$$

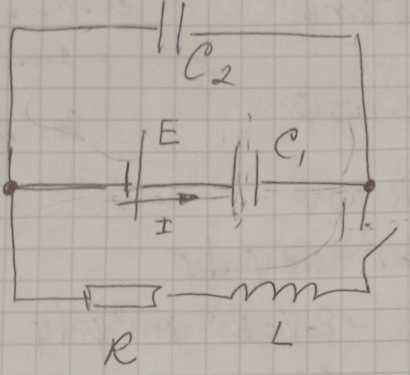


$$\frac{1}{d} + \cancel{\frac{1}{F_0}} - \frac{1}{x} = \frac{1}{F_1} + \cancel{\frac{1}{F_0}}$$

$$\frac{1}{F_2} = \frac{1}{F_1} + \frac{1}{F_0}$$

$$\frac{1}{d} + \frac{1}{f} = \frac{1}{F_2}$$

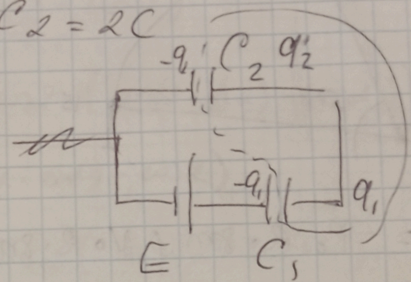




$C_1 = C$

$C_2 = 2C$

1)



$q_1 + q_2 = 0$, $q_1 = -q_2$

$E = U_2 + U_1 = \frac{q_1}{C} + \cancel{\frac{q_2}{2C}}$

$q_1 = CU_1 = q_2$

$q_2 = 2CU_2$

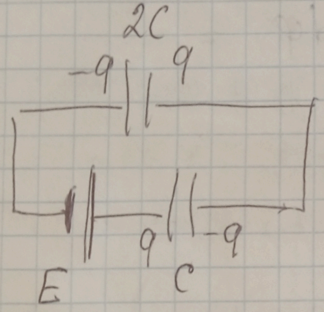
$CU_1 = 2CU_2$

$U_1 = 2U_2$

$t = 0$:

$E = 3U_2$

$E = 3 \cdot \frac{U_1}{2} = \frac{3}{2} U_1$



1) $\frac{dI}{dt} = ?$ ток из-за катушки не меняется мгновенно =>

$I(0) = 0$, $U_L = U_2 = \frac{E}{3}$

2) $W_0 = \frac{2CU_2^2}{2} + \frac{CU_1^2}{2} = \frac{2C \cdot \left(\frac{E}{3}\right)^2}{2} + \frac{C}{2} \cdot \left(\frac{2}{3}E\right)^2 =$

$= \frac{CE^2}{9} + \frac{C}{2} \cdot \frac{4}{9}E^2 = \frac{3}{9}CE^2 = \frac{CE^2}{3}$

$W_0 + E\Delta q = Q + \ldots +$

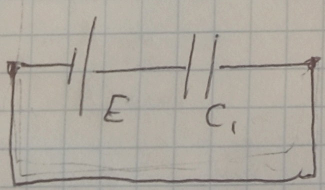
режим установ. => $I_R = 0$, $I_{C_2} = 0$

при $U_{C_1} = E$

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

CE

$\Delta q = C \cdot \frac{2}{3} E = \frac{C}{3} E$

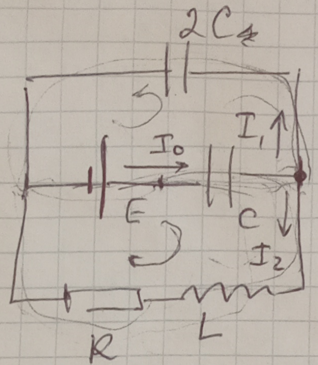


$\frac{CE^2}{3} + \frac{CE^2}{3} = Q + \frac{CE^2}{2}$

$\frac{4CE^2}{6} - \frac{3CE^2}{6} = Q = \frac{CE^2}{6}$

3)

3) $I_L = ?$ $\quad C_1 = I_0$



$$I_0 = I_1 + I_2$$

$$E = U_{C_1} + U_L + I_2 R, \qquad U_L = L\frac{dI_2}{dt}$$

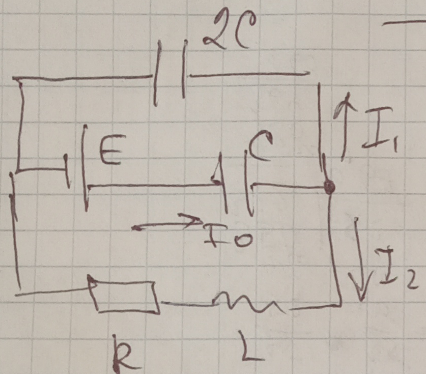
$$E = U_{C_1} \pm U_{C_2}$$

$$C_1 \frac{dU_1}{dt} = I_0$$

$$C_2 \frac{dU_2}{dt} = I_1$$

$$C_1 \frac{dU_1}{dt} = C_2 \frac{dU_2}{dt} + I_2$$

$$C \frac{dU_1}{dt} = 2C \frac{d(E-U_1)}{dt} + I_2$$



$$C\frac{dU_1}{dt} = I_0$$

$$C\frac{dU_2}{dt} = I_1$$

$$L\frac{dI_2}{dt} = U_L$$

$$\begin{cases} E = U_1 + L\frac{dI_2}{dt} + I_2 R \\ E = U_1 + U_2, \quad U_2 = E - U_1 \\ C\frac{dU_1}{dt} = C\frac{dU_2}{dt} + I_2 \end{cases}$$

$$E = U_1 + L\frac{dI_2}{dt} + I_2 R$$

$$C\frac{dU_1}{dt} = C\frac{d(E-U_1)}{dt} + I_2$$

$\frac{mv_0^2}{2} - \frac{mv_1^2}{2} = 2A_{FA}$

$\frac{mv_0^2}{2} - \frac{mv_2^2}{2} = 2A_{FA} = 2\frac{mv_0^2}{2} - 2\frac{mv_1^2}{2}$

$\frac{2\cancel{m}v_1^2}{\cancel{2}} = \frac{\cancel{m}v_0^2}{\cancel{2}} + \frac{\cancel{m}v_2^2}{\cancel{2}}$

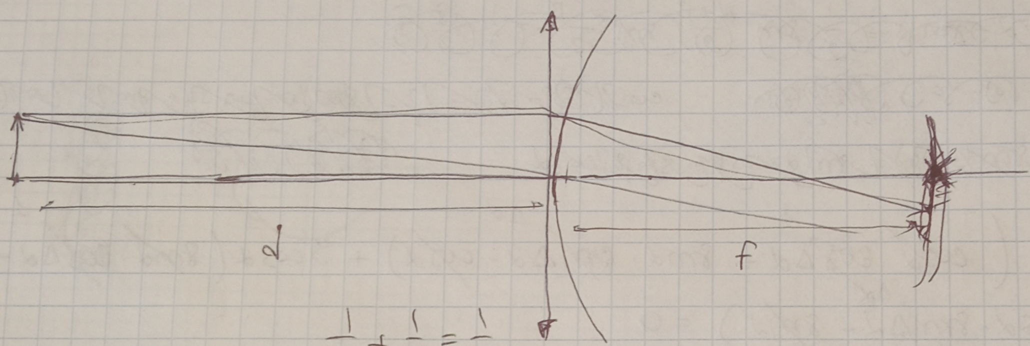
$2v_1^2 = v_0^2 + v_2^2$

2\. $v_2^2 = 2v_1^2 - v_0^2$

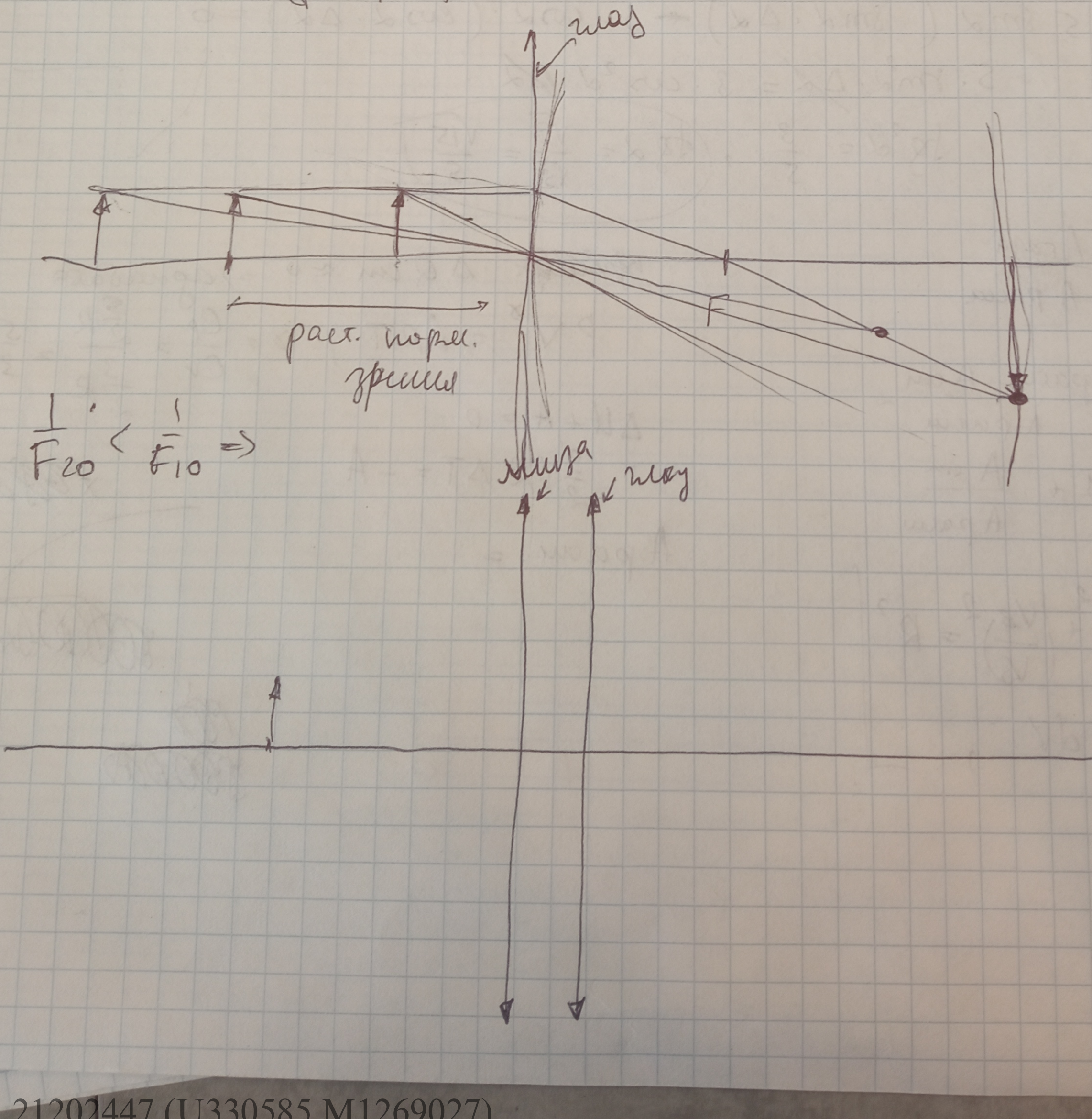
удал. нр. f очки для 25 см

$h_1 = 25$ см

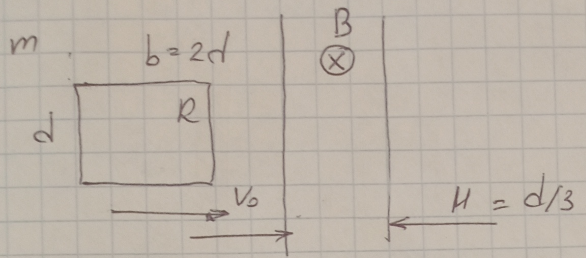
$D_1 / D_2 = 2$

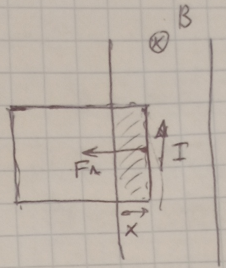


$\frac{1}{d} + \frac{1}{f} = \frac{1}{F}$



$\frac{1}{F_{20}} < \frac{1}{F_{10}} \Rightarrow$



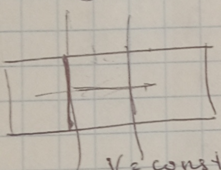


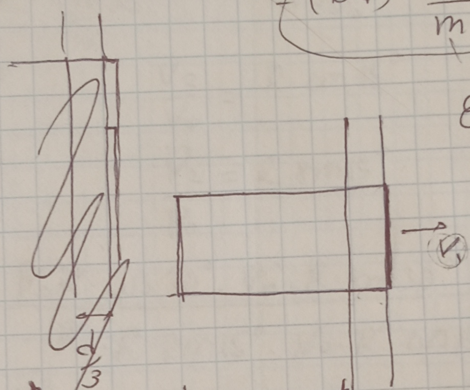
$$\mathcal{E}_i = \frac{d\Phi}{dt} = B\frac{dS}{dt} = B \cdot d \frac{dx}{dt} = B \cdot d \cdot \dot{x} = I \cdot R = B \cdot d V_0 = I \cdot R,$$

$$F_A = BIL \cdot \sin 90° = BId$$

$$F_A = ma, \quad a = \frac{F_A}{m} = \frac{BId}{m} = \frac{Bd}{m} \cdot \frac{BdV_0}{R} = \frac{(Bd)^2 V_0}{mR} \qquad I = \frac{BdV_0}{R}$$

$$\frac{mV_0^2}{2} = \frac{mV_1^2}{2} + A_A$$





V = const, т.к. $F_A = 0$ напр. $A_A = 0$

$$\mathcal{E}_i = \frac{d\Phi}{dt} = B \cdot d \cdot \frac{dx}{dt} = I \cdot R$$

$$F = \frac{BId}{3} = \frac{Bd \cdot Bd \cdot \frac{dx}{dt}}{R} = \frac{(Bd)^2}{R} \cdot \frac{dx}{dt}$$

$$\frac{dV}{dt} = \frac{(Bd)^2}{R \cdot m} V$$

$$\frac{dV}{V} = \frac{(Bd)^2}{Rm} dt$$

$$\ln V = -\frac{(Bd)^2}{Rm} t + C$$

$$\ln V_0 = C$$

$$\frac{V}{V_0} = e^{-\frac{(Bd)^2 t}{Rm}}$$

$$V = V_0 e^{-\frac{(Bd)^2 t}{Rm}}$$

$$\int V dt = S$$

$$\int V_0 e^{-(Bd)^2 t/Rm} dt = V_0 \cdot \frac{e^{-(Bd)^2 t/Rm}}{-(Bd)^2/Rm}\Bigg|^t = S$$

$$t = 0: \quad \frac{V_0 Rm}{-(Bd)^2} = 0 + C$$

$$S = \frac{V_0 Rm}{(Bd)^2}\left(1 - e^{-(Bd)^2 t/Rm}\right) = \frac{d}{3}$$

$$e^{-(Bd)^2 t/Rm} = 1 - \frac{d}{3} \cdot \frac{(Bd)^2}{V_0 Rm}$$

$$e^{-\frac{(Bd)^2 t}{Rm}} = \left(\frac{3V_0Rm - B^2d^3}{3V_0Rm}\right)$$

$$V = V_0 \cdot \frac{3V_0Rm - B^2d^3}{3V_0Rm} = \frac{3V_0Rm - B^2d^3}{3Rm}$$