Часть 1

Олимпиада: **Физика, 10 класс (1 часть)**

Шифр: **21206013**

ID профиля: **861973**

Вариант 4

Чистовик

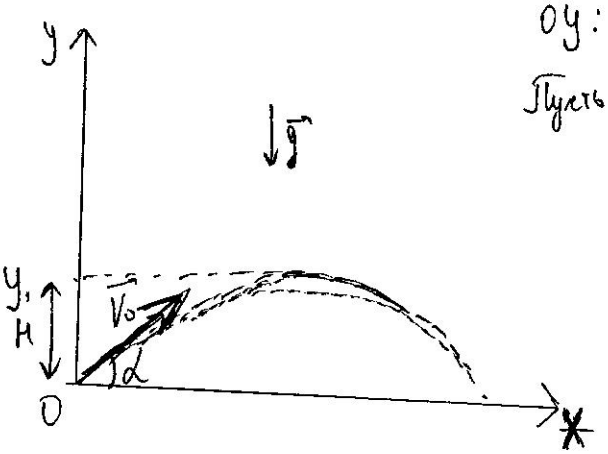
№1

Дано:
$\alpha = 45°$
$H = 10\text{м}$
$g = 10 \frac{\text{м}}{\text{с}^2}$
$2F = mg$

1) V_0 – ?
2) V – ?

для камня:

1)



ОУ: $H = V_0 \sin\alpha \, t_1 - \frac{g t_1^2}{2}$

Пусть $H_1 = 0 \rightarrow t_0 \left(V_0 \sin\alpha - \frac{g t_0}{2} \right) = 0$

$t_0 = \frac{2 V_0 \sin\alpha}{g}$, где t_0 – время всего полёта камня

$t_0 = 2t_1 \rightarrow t_1 = \frac{V_0 \sin\alpha}{g}$

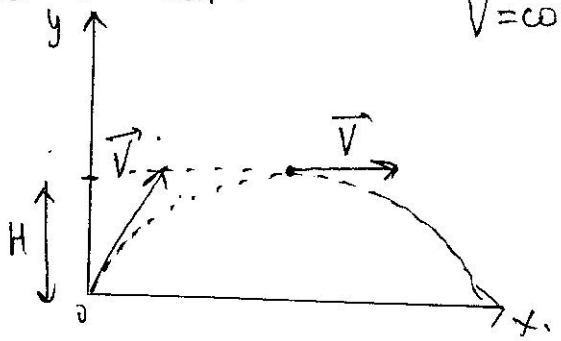
$H = \frac{V_0 \sin\alpha \cdot V_0 \sin\alpha}{g} - \frac{g V_0^2 \sin^2\alpha}{2g^2} =$

$= \frac{V_0^2 \sin^2\alpha}{2g}$

$V_0 = \sqrt{\frac{2gH}{\sin^2\alpha}} = \frac{1}{\sin\alpha} \sqrt{2gH}$

1) $V_0 = \frac{1}{\sin 45°} \sqrt{2 \cdot 10 \frac{\text{м}}{\text{с}^2} \cdot 10\text{м}} = 20 \frac{\text{м}}{\text{с}}$.

для самолёта:



$V = \text{const}$.

Напишем Закон изменения импульса (ЗиИ):

$\left. \begin{array}{l} \sum \vec{F} \cdot t = m\vec{V} \\ F = \frac{mg}{2} \text{ (из усл.)} \end{array} \right\} \Rightarrow V = \frac{gt}{2}$, где

t – время полёта самолёта на высоту H

$t = \frac{t_2}{2}$, t_2 – время всего полёта.

ОУ: $H = V \sin\alpha \cdot t_2 \rightarrow t = \frac{H}{V \sin\alpha} \rightarrow V = \frac{g}{2} \frac{H}{V \sin\alpha} \rightarrow V = \sqrt{\frac{gH}{2\sin\alpha}}$

$V = \sqrt{\frac{10 \frac{\text{м}}{\text{с}^2} \cdot 10\text{м}}{2 \cdot \sin 45°}} \approx 9{,}2 \frac{\text{м}}{\text{с}}$

Ответ: 1) $20 \frac{\text{м}}{\text{с}}$; 2) $\approx 9{,}2 \frac{\text{м}}{\text{с}}$

Участок

№2

Дано:

$\cos\alpha = \frac{24}{25}$

$h = 1{,}4$ м

$\mu_1 = 0{,}5$

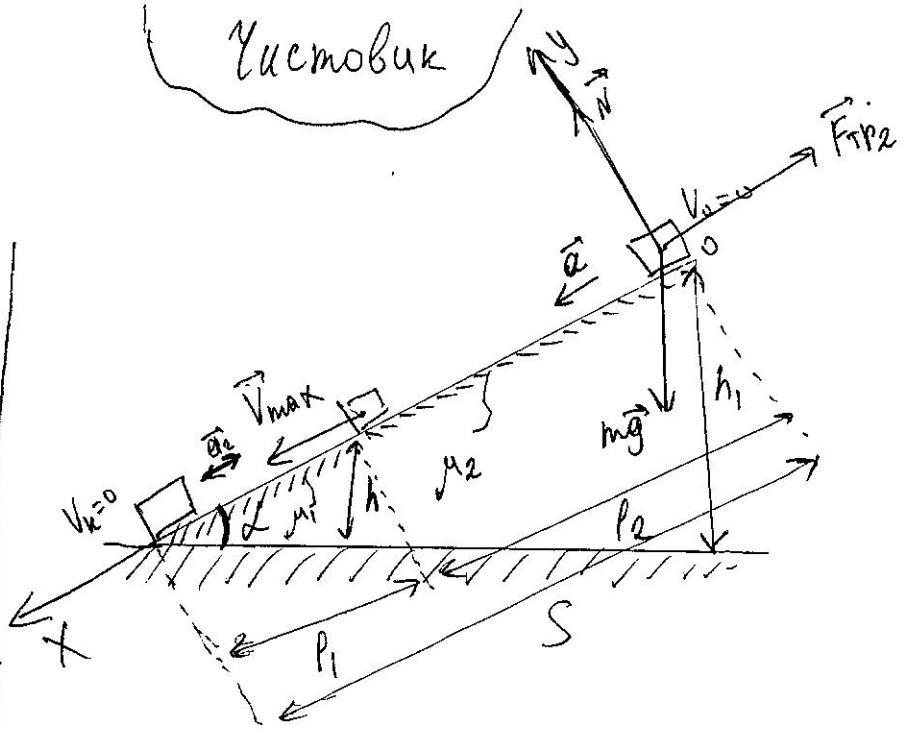
$\mu_2 = 0{,}06$

$V_0 = 0$

$V_k = 0$

1) V_{max} — ?

2) S — ?



$\cos\alpha = \frac{24}{25}$

$\cos^2\alpha + \sin^2\alpha = 1.$

$\sin\alpha = \frac{7}{25}$

2) Начнём со 2-го вопроса:

ЗСЭ: $mgh_1 = A_{F_{тр1}} + A_{F_{тр2}} \longrightarrow mgS\sin\alpha = F_{тр1}l_1 + F_{тр2}l_2$

$h = l_1\sin\alpha$

$mgS\sin\alpha = \mu_1 mg\cos\alpha\, l_1 + \mu_2 mg\cos\alpha\, l_2 \rightarrow S\sin\alpha = \mu_1\cos\alpha\, l_1 + \mu_2\cos\alpha\, l_2$

$S\sin\alpha = \mu_1\cos\alpha\cdot\frac{h}{\sin\alpha} + \mu_2\cos\alpha\left(S - \frac{h}{\sin\alpha}\right) \rightarrow S(\sin\alpha - \mu_2\cos\alpha) = \frac{h}{\sin\alpha}\cos\alpha$

$S = \frac{h\cos\alpha(\mu_1+\mu_2)}{\sin\alpha(\sin\alpha - \mu_2\cos\alpha)}$ $\quad S = \frac{1{,}4\text{ м}\cdot 24\cdot 25}{7\quad 25}\cdot\frac{(0{,}5-0{,}06)}{\left(\frac{7}{25} - 0{,}06\cdot\frac{24}{25}\right)} \approx 9{,}5\text{ м}.$

1) Ox: $ma = mg\sin\alpha - F_{тр2}$

$F_{тр2} = \mu_2 N$

Oy: $N = mg\cos\alpha$

$\Rightarrow ma = mg\sin\alpha - \mu_2 mg\cos\alpha$

$a = g(\sin\alpha - \mu_2\cos\alpha).$

Ox: $l_2 = \frac{V_{max}^2}{2a} \rightarrow l_2 = \frac{V_{max}^2}{2g(\sin\alpha - \mu_2\cos\alpha)}$

$l_2 = S - \frac{h}{\sin\alpha}.$

$\rightarrow V_{max} = \sqrt{2g(\sin\alpha - \mu_2\cos\alpha)\ldots}$

$V_{max} = \sqrt{\left(S - \frac{h}{\sin\alpha}\right)(2g(\sin\alpha - \mu_2\cos\ldots}$

$V_{max} = \sqrt{\left(9{,}5\text{ м} - \frac{1{,}4}{\frac{7}{25}}\right)\left(2\cdot 10\,\frac{\text{м}}{\text{с}^2}\left(\frac{7}{25} - 0{,}06\cdot\frac{24}{25}\right)\right)} \approx 4{,}5\,\frac{\text{м}}{\text{с}}$

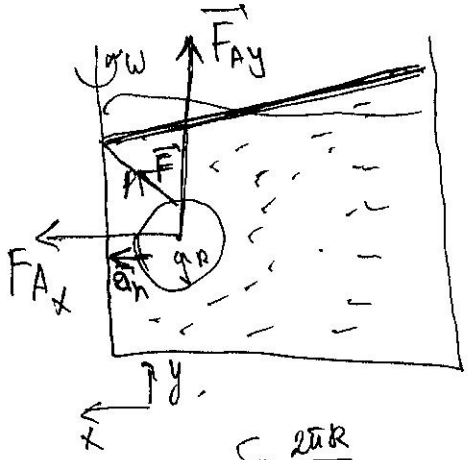
Ответ: 1) $V_{max} = 4{,}5\,\frac{\text{м}}{\text{с}}$ 2) $\approx 9{,}5$ м

Чистовик

№3

Дано:
$R = 8\,см$
$\rho = 8\,см$
$m = 5{,}2\,кг$
$\alpha = 60°$
$g = 10\,\frac{м}{с^2}$

1) $F - ?$
2) $T - ?$



Ox: $ma_n = F_{Ax} + F\sin\alpha$

Oy: $F_{Ay} + F\cos\alpha = mg$

$F_{Ax} = \rho_в a_n V$
$F_{Ay} = \rho_в g V$
} где $\rho_в$ – плотность воды $= 10^3\,\frac{кг}{м^3}$

$\delta = \frac{2\pi R}{T}$

$a_n = \frac{v^2}{R} = \frac{4\pi^2 R}{T^2}$, $V = \frac{4}{3}\pi R^3$

$m\frac{4\pi^2 R}{T^2} = \rho_в \frac{4\pi^2 R}{T^2} V + F\sin\alpha$.

$\rho_в g V + F\cos\alpha = mg \rightarrow F = \frac{mg - \rho_в g V}{\cos\alpha} = \frac{g(m - \rho_в V)}{\cos\alpha}$

$\frac{\sin\alpha}{\cos\alpha} = \operatorname{tg}\alpha$

$F = \frac{10\,\frac{м}{с^2}}{\cos 60°}\left(5{,}2\,кг - 10^3\,\frac{кг}{м^3} \cdot \frac{4}{3}\pi (0{,}08\,м)^3\right) \approx 90\,Н$.

$\frac{4\pi^2 R}{T^2}(m - \rho_в V) = \frac{g \cdot \sin\alpha}{\cos\alpha}(m - \rho_в V) \rightarrow \frac{4\pi^2 R}{T^2} = g\operatorname{tg}\alpha$

$T = \sqrt{\frac{4\pi^2 R}{g\operatorname{tg}\alpha}} = 2\pi\sqrt{\frac{R}{g\operatorname{tg}\alpha}}$, $T = 2\pi\sqrt{\frac{0{,}08\,м}{10\,\frac{м}{с^2} \cdot \operatorname{tg}60°}} \approx 0{,}4\,с$

Ответ: 1) $F \approx 90\,Н$; 2) $T \approx 0{,}4\,с$

Черновик.

$14 \cdot \frac{24}{7}$

$\frac{0,2 \cdot 24 \cdot (0,44) \cdot 25}{7 - 24,006}$

5186.

(1)

$\alpha = 45^\circ$

$H = 10\,м$

1) $V_0 - ?$

$g = 10\ \frac{м}{с^2}$

$2F = mg$

2) $V - ?$

1) $H = \frac{v_0^2 \sin^2\alpha}{2g}$

$H = v_0 \sin\alpha \cdot t - \frac{gt^2}{2}$

$t_1 (v_0 \sin\alpha - \frac{gt}{2}) = 0$

Т.к. $H = 0$. $\rightarrow$ $t_1 = \frac{2v_0 \sin\alpha}{g}$

$t_2 = 2t$.

$H = \frac{v_0 \sin\alpha \cdot 2v_0 \sin\alpha}{g} - \frac{g v_0^2 \sin^2\alpha}{g \cdot 2} =$

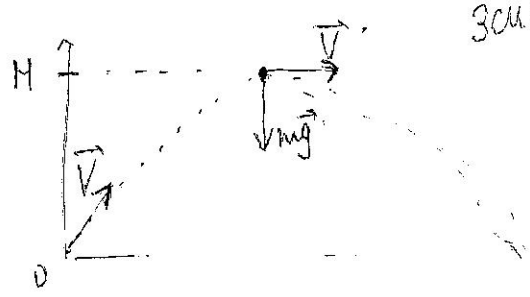
$H = \frac{v_0^2 \sin^2\alpha}{2g}$.

$v_0 = \sqrt{\frac{2gH}{\sin^2\alpha}} = \frac{1}{\sin\alpha}\sqrt{2gH}$.

$v_0 = \frac{1}{\sin 45^\circ}\sqrt{2 \cdot 10\frac{м}{с^2} \cdot 10м} =$

$= \frac{2}{\sqrt{2}} 10\sqrt{2} = \sqrt{2} \cdot 10 \cdot \sqrt{2} = 20\ \frac{м}{с}$.

2).



ЗСИ: $\vec{F} \cdot t = m\vec{v}$ (II з. Н.)

ОХ: $Ft = mV$.

$\frac{mg}{2} t = mV \rightarrow V = \frac{gt_0}{2}$.

$t = \frac{t_2}{2}$, где t_2 - время всего полёта самолёта

$V = \frac{gt_2}{4}$.

$H = V\sin\alpha \cdot t_0$. $\rightarrow$ $t_0 = \frac{H}{V\sin\alpha}$.

$V = \frac{gH}{2V\sin\alpha} \rightarrow V^2 = \frac{gH}{2\sin\alpha}$

$V = \sqrt{\frac{gH}{2\sin\alpha}}$ $V = \sqrt{\frac{10\frac{м}{с^2} \cdot 10м}{2 \cdot \frac{\sqrt{2}}{2}}} =$

$= 10\sqrt{\frac{1}{\sqrt{2}}} \approx 9,2\ \frac{м}{с}$.

(2)

$\cos\alpha = \frac{24}{25}$

$h = 1,4м$

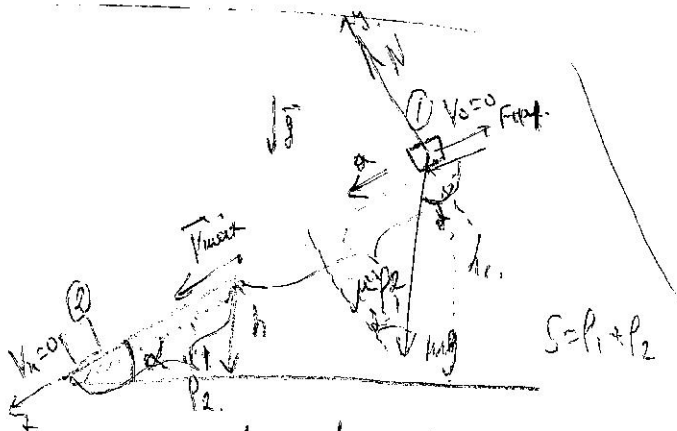
$\mu_1 = 0,5$

$\mu_2 = 0,06$

$V_0 = 0$, $V_к = 0$

1) $V_{max} - ?$

2) $S - ?$



$S = l_1 + l_2$

2) ЗСЭ: $mgh = A_{Fтр_1} + A_{Fтр_2}$

$mgS\sin\alpha = F_{тр_1} l_1 + F_{тр_2} l_2$ $\rightarrow$ $mgS\sin\alpha = \mu_2 mg\cos\alpha + \mu_1 mg\cos\alpha$

$S\sin\alpha = \mu_2\cos\alpha + \mu_1\cos\alpha$.

$S = \frac{(\mu_2 + \mu_1)\cos\alpha}{\sin\alpha} = (\mu_2 + \mu_1)\operatorname{ctg}\alpha$.

$\cos\alpha = \frac{24}{25}$

$\cos^2\alpha + \sin^2\alpha = 1$ $\Rightarrow$ $\sin\alpha = \sqrt{1 - \frac{576}{625}} =$

$= \sqrt{\frac{49}{625}} = \frac{7}{25}$.

$\cos\alpha = \frac{24}{25}$

$\sin\alpha = \frac{7}{25}$

$\frac{\cos\alpha}{\sin\alpha} = \operatorname{ctg}\alpha$

$\operatorname{ctg}\alpha = \frac{24}{25} \cdot \frac{25}{7} = \frac{24}{7}$

$S = (0,5 + 0,06) \cdot \frac{24}{7} = \frac{0,56 \cdot 24}{7} =$

$= 1,92м$

Черновик

4) ~~$l_2 = \frac{h}{\sin\alpha}$~~

$h = \sin\alpha \cdot l_2 \to l_2 = \frac{h}{\sin\alpha}$

$l_1 = S - l_2$.

ox: $ma = mg\sin\alpha - F_{тр2}$

$F_{тр2} = \mu_2 N$

oy: $N = mg\cos\alpha$.

$ma = mg\sin\alpha - \mu_2 mg\cos\alpha$

$a = g(\sin\alpha - \mu_2\cos\alpha)$

(=)

$2g(\sin\alpha - \mu_2\cos\alpha)/\left(\frac{\mu_2\cos\alpha + \mu_1\cos\alpha - h}{\sin\alpha}\right) =$

$= 2g/\left(\mu_2\cos\alpha + \mu_1\cos\alpha - h - \frac{\mu_1\cos\alpha(\mu_1\cos\alpha + \mu_2\cos\alpha - h)}{\sin\alpha}\right)$

$V_{max} = \sqrt{2g(\sin\alpha - \mu_2\cos\alpha)/\left(\frac{(\mu_2+\mu_1)\cos\alpha - h}{\sin\alpha}\right)}$

$V_{max} = \sqrt{2\cdot 10\left(\frac{4}{25} - 0{,}06\cdot\frac{24}{25}\right)/\left(\frac{(0{,}06+0{,}5)\cdot\frac{24}{25} - 0{,}4}{\frac{7}{25}}\right)} =$

$= 20(0{,}2175)/($

$V_{max} \approx 2\ \frac{м}{с}$.

$0{,}0552$

$F_{трmax}$

ox: $l_1 = \frac{\delta_{max}^2 - \delta_0^2}{2a}$, но $\delta_0 = 0$ (по усл.)

$l_1 = \frac{\delta_{max}^2}{2a} \to \delta_{max}^2 = 2al_1$

$\delta_{max}^2 = 2g(\sin\alpha - \mu_2\cos\alpha)(S - \frac{h}{\sin\alpha}) =$

$= 2g(\sin\alpha - \mu_2\cos\alpha)/\left(S - \frac{h}{\sin\alpha}\right) =$

$= 2g(\sin\alpha - \mu_2\cos\alpha)/\left(\frac{(\mu_2+\mu_1)\cos\alpha}{\sin\alpha} - \frac{h}{\sin\alpha}\right)$ (=)

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(3) $g = 10\frac{м}{с^2}$

$R = 8$ см

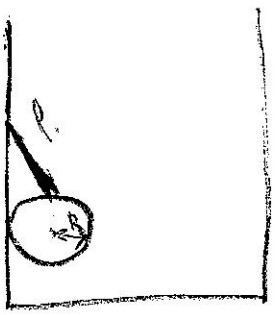
$l = 8$ см

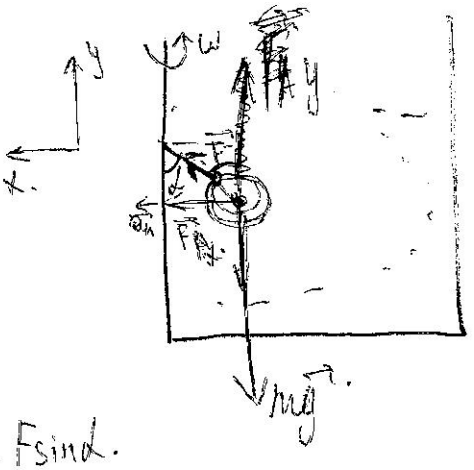
$m = 512$ кг

$\alpha = 60°$

1) $F - ?$

2) $T - ?$





ox: $ma_n = F_{Ax} + F_{sin}$

oy: $F_{Ay} + F\cos\alpha = mg$

$F_{Ax} = \rho_в a_n V$

$F_{Ay} = \rho_в g V$ (где $\rho_в$ плотность воды, $\rho_в = 10$)

$a_n = \frac{\delta^2}{R} = \left(\frac{2\pi R}{T}\right)^2\frac{1}{R} = \frac{4\pi^2 R}{T^2}$

$m\frac{4\pi^2 R}{T^2} = \rho_в\frac{4\pi^2 R}{T^2}V + F\sin\alpha$.

$\rho_в g V + F\cos\alpha = mg \to F = \frac{mg - \rho_в gV}{\cos\alpha} = \frac{g}{\cos\alpha}(m - \rho_в V)$, $V = \frac{4}{3}\pi R^3$

$\frac{4\pi^2 R}{T^2}(m - \rho_в V) = \frac{g\cdot\sin\alpha}{\cos\alpha}(m - \rho_в V) \to \frac{4\pi^2 R}{T^2} = g\,\mathrm{tg}\,\alpha \to T = \sqrt{\frac{4\pi^2 R}{g\,\mathrm{tg}\,\alpha}}$

$= 2\pi\sqrt{\frac{R}{g\,\mathrm{tg}\,\alpha}}$

1) $F = \frac{10}{\cos 60°}\left(512 - 10^3\frac{кг}{м^3}\cdot\frac{4}{3}\pi(0{,}08)^3\right) \approx 90$ Н.

$0{,}08$ м

$0{,}000512$

$0{,}6\pm 8\ 2656666\ldots$

$T = 2\cdot 3{,}14\sqrt{\frac{0{,}08}{10\sqrt{3}}} =$

$6{,}28\sqrt{\frac{0{,}002}{\sqrt{3}}} = \frac{0{,}0}{\sqrt{1}}$

$\approx 0{,}4$ с.

$0{,}4\ 26\ldots$

Часть 2

Олимпиада: **Физика, 10 класс (2 часть)**

Шифр: **21206013**

ID профиля: **861973**

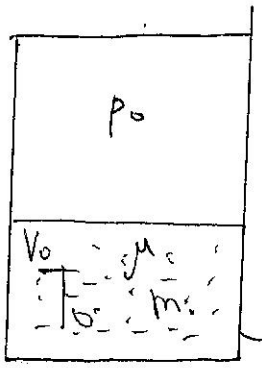
Вариант 4

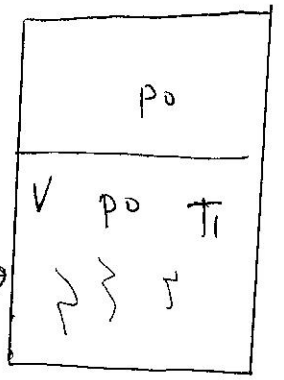
Вар. 10-04. Чистовик Часть 2 Физика

№4

Дано:
$m = 0{,}01$ кг
$t_0 = 20°C$ ~~$= 293$ K~~. $T_0 = 293$ K
$P_0 = 10^5$ Па.
$Q = 33 \cdot 10^3$ Дж

1) Q_1 – ?
2) V – ?





ц-да равновесия поршня. $p_0 = p_0$.

$Q_1 = Cm(t - t_0)$, где $t = 100°C$

$Q_1 = 4180 \frac{Дж}{кг \cdot К} \cdot 0{,}01 кг (100°C - 20°C) = 3344$ Дж.

$$\left.\begin{array}{l} Q_3 = Q - Q_1 - Q_2 = m \cdot c_p \cdot (t_1 - t) \\ Q_2 = m \cdot r \end{array}\right\} \Rightarrow t_1 = \frac{Q - Q_1 - mr}{c_p \cdot m} + t.$$

$T_1 = t_1 + 273.$

$\frac{V}{T} = const$

$\frac{V_0}{T_0} = \frac{V}{T_1}$.

$p_0 V_0 = \frac{m}{\mu(H_2O)} R T_0$

$V_0 = \frac{m R T_0}{\mu(H_2O)\, p_0}$

$$V = \frac{V_0 T_1}{T_0} = \frac{m R T_0}{\mu p_0 T_0} \cdot \left(\frac{Q - Q_1 - mr}{c_p \cdot m} + t + 273. \right)$$

$$V = \frac{0{,}01 кг \cdot 8{,}31 \cdot}{18 \cdot 10^{-3} \frac{кг}{моль} \cdot 10^5 Па} \cdot \left(\frac{33000 Дж - 3344 Дж - 0{,}01 \cdot 2{,}26 \cdot 10^6 \frac{Дж}{кг}}{2200 \frac{Дж}{кг \cdot К} \cdot 0{,}01 кг} \right.$$

$\left. + 100°C + 273 \right) \approx 32$ л

Ответ: 1) 3344 Дж 2) 32 л

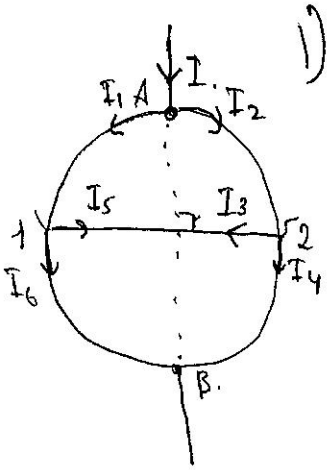
Чистовик 2 часть Физика. вар 10-04

№5

Дано:
$R = 72$ Ом
$U = 24$ В

1) P – ? ($\alpha = 90°$)
2) β – ? ($I' = 0{,}5$ А)
3) P_2 – ?

1)



1) $\left.\begin{matrix} I = I_1 + I_2 \\ I_1 = I_2 \end{matrix}\right\} \Rightarrow I = 2I_1$

$\left.\begin{matrix} I_{53} = I_5 + I_3. \\ I_5 = I_3 = \end{matrix}\right\} \quad I_{53} = 2I_5$

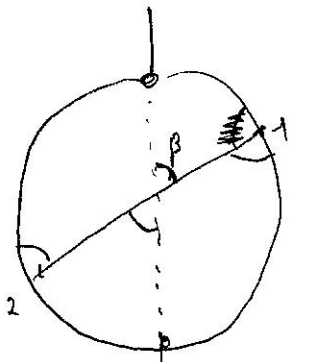
$I_5 = \frac{1}{2} I_1$

$I_{53} = 2 \cdot \frac{1}{2} I_1 = \frac{I}{2}$.

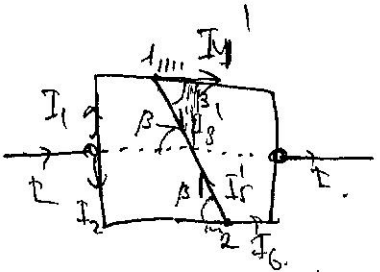
$P_1 = U I_{53}. \rightarrow P = U \frac{I}{2}, I =$

$P = \frac{24\text{В} \cdot 24\text{В}}{2 \quad 72\text{ Ом}} = 4$ Ом.

2)



$\rightarrow$



$I = 2I_1$

$I_1 = I_3' + I_4'$

$I_2 = I_5 + I_6.$

$I_3' = I_3 + I_3 \operatorname{tg}\beta$ $\quad I_4' = I_4 - I_4 \operatorname{tg}\beta.$

$I_3' = I_3 (1 + \operatorname{tg}\beta)$ $\quad I_4' = I_4 (1 - \operatorname{tg}$

$I_3' + I_5' = I_3 + I_3 \operatorname{tg}\beta + I_5 - I_5 \cos\beta =$

$= I_3 + I_5 + \operatorname{tg}\beta (I_3 - I_5).$

$= \frac{U}{2R} + \operatorname{tg}^2\beta$

$\operatorname{tg}\beta = \sqrt{I' - \frac{U}{2R}}$. $\quad I_5' = I_4' = I_5 (1 - \operatorname{tg}\beta).$

$\operatorname{tg}\beta = \sqrt{0{,}5 - \frac{24}{72 \cdot 2}} = \sqrt{\frac{3-1}{6}} =$

$= \frac{1}{\sqrt{3}} \rightarrow \beta =$

3) $P_2 = U \cdot I' \rightarrow P_2 = 24\text{ В} \cdot 0{,}5\text{ А} = 12$ Вт.

Ответ: 1) 4 Вт, 2) 30° 3) 12 Вт.

Часть 2 Физика

Черновик.

№4

Дано:

$m = 0{,}01\,кг$

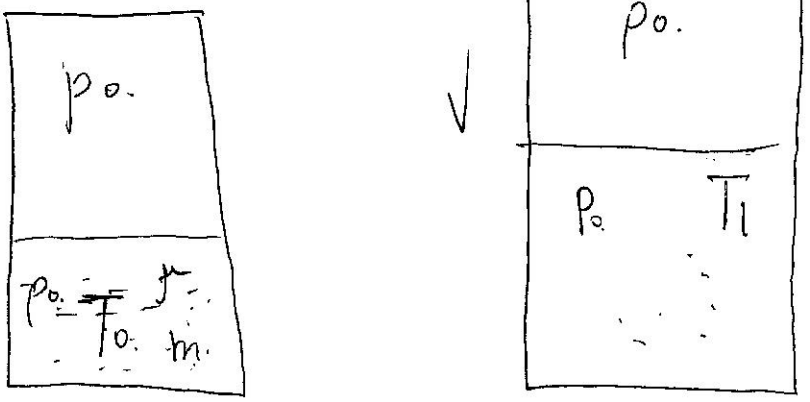
$t_0 = 20°C = 293\,K$

$p_0 = 10^5\,Па$

$Q = 33 \cdot 10^3\,Дж$

1) $Q_1 - ?$

2) $V - ?$



$Q_1 = cm(t - t_0)$, где $t = 100°C$.

$Q_1 = 4180 \frac{Дж}{кг \cdot К} \cdot 0{,}01\,кг \cdot (373\,K - 293\,K) = 3344\,Дж$.

$Q_3 + Q_2 = Q - Q_1$. $Q_2 = 33000 - 3344 = 29656$

$Q_2 = m \cdot r$.

$Q_2 = 0{,}01 \cdot 2{,}26 \cdot 10^6$ 22600.

$Q_3 = Q - Q_1 - mr$

$Q_3 = \Delta T \cdot c_p \cdot m = (t_1 - t) \cdot c_p \cdot m$

$t_1 = \frac{Q - cm(t - t_0) - mr}{c_p \cdot m} + t$

$T_1 = t_1 + 273\,(K)$.

$p_0 V_0 = \frac{m}{\mu} R T_0$.

$V_0 = \frac{m R T_0}{\mu p_0}$.

$p_0 = p$.

$\frac{V_0}{T_0} = \frac{V_1}{T_1}$ → $V_1 = \frac{V_0 T_1}{T_0} = V_0 \left(\frac{Q - cm(t - t_0) - mr}{c_p \cdot m} + t \right)$

$V = \frac{mRT_0}{\mu p_0 T_0} \left(\frac{33 \cdot 10^3 - 3344 - 0{,}01 \cdot 2{,}26 \cdot 10^6}{2200 \cdot 0{,}01} + 3 \right)$

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$V = 0{,}3\,м^3$.

Термовик

(4)

$m = 10\,г$

$t_0 = 20°C$

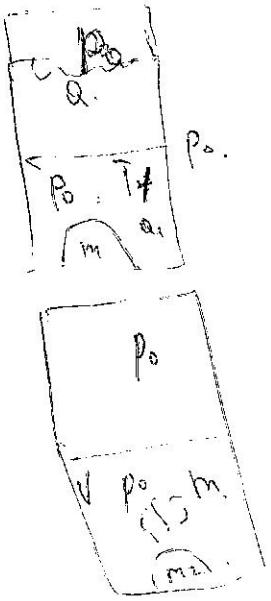
$P_0 = 10^5\,Па$

$Q = 33\,кДж$

1) $Q_1 - ?$

2) $V - ?$

$T_0 = 273 + t_0 = 293\,K.$



$P_0 = P_0.$

$pV = \frac{m}{\mu} RT$

$Q_1 = mc(t - t_0)$, где $t = 100°C$.

$Q_1 = mc_в(t_0 - t_0)$.

$Q_1 = 0{,}01\,кг \cdot 4200 \cdot 80° =$

$= 3360\,Дж = 3{,}36\,кДж$

$p_0 V_1 = \frac{m - m_2}{\mu} RT. \rightarrow m_2$

$p_0(V - V_1) = \frac{m_1}{\mu_1} RT$

$p_0(V - V_1) = Q.$

$V_1 = \frac{Q}{p_0}$

$V_2 = \frac{Q_1}{p_0} = \frac{3{,}36\,кДж}{10^5\,Па} = 0{,}0336\,м^3 = 33{,}6\,л$

$V = V_1 + \frac{Q_1}{p_0}$

$V = \frac{Q_1 + Q_2}{p_0} = \frac{3360 + 33000}{10^5} = \frac{36360}{10^5}$

Схема.

(5)

$R = 72\,Ом$

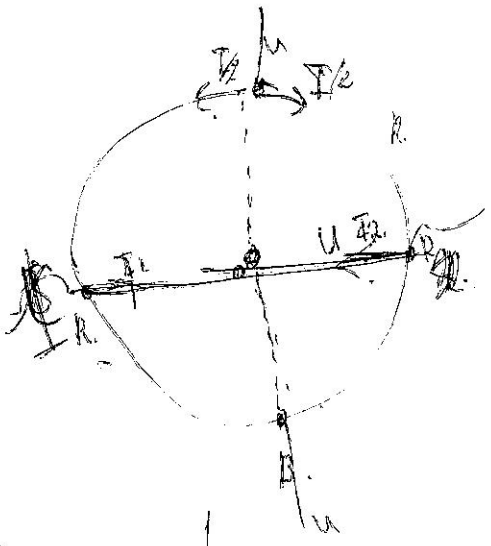
$U = 24\,В$

1) $P - ?$

2) $\beta - ?$

$I = 0{,}5\,А$

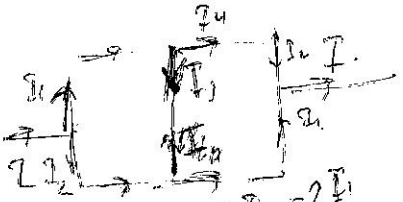
3) $P_2 - ?$



$P = UI.$

$I = I_1 + I_2.$

$R_0 = \frac{R_1 R_2}{R_1 + R_2}$



$I_3 = I_4 = I_1 + I_2$

$I_2 = I_3 + I_4.$

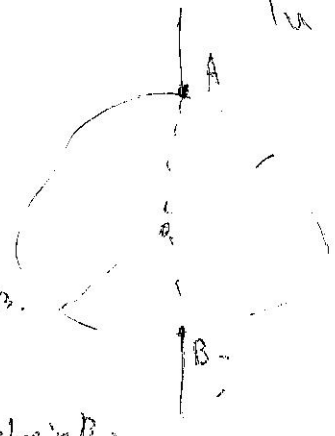
$I = I_1 + I_2 = 2I_1$

$I = \frac{U}{R_0}$

$I_1 = \frac{U}{2R_0}$

$P_2 = \frac{U^2}{2R_0} = 2\,Вт.$

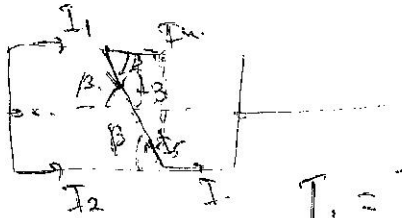
2)



$I_3 \sin\beta = I_2 \sin\beta.$

$I = I_3' \sin\beta + I_3'' \sin(180° - \beta)$

$I_3' = I_3''$



$I_1 = I_3 + I_4$

$I = I_3 + I_5$