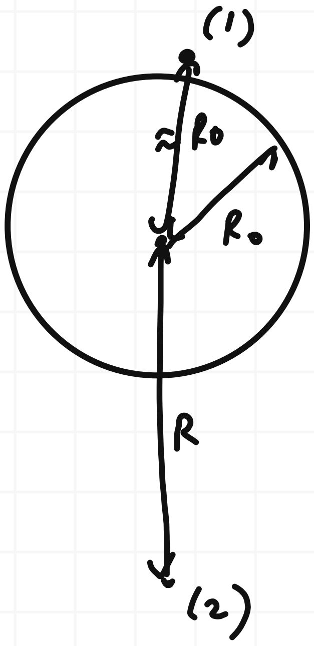
Неделя 4.

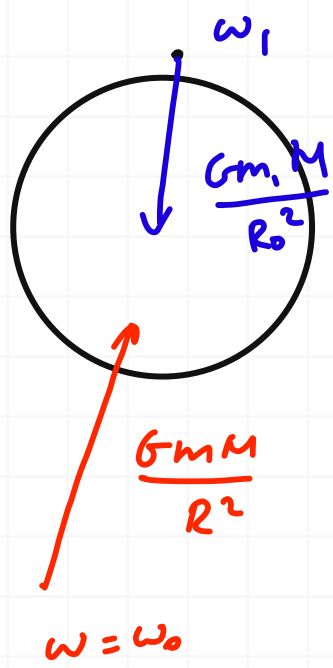
08

$\frac{R}{R_0}$ – ?

$T_0 = 17T_1$

$\omega = \omega_0$





$T_0 = 17T_1$

$\frac{\cancel{2\pi}}{\omega_0} = 17\frac{\cancel{2\pi}}{\omega_1}$

$\omega_1 = 17\omega_0$

II з.Н.

$\cancel{m_1}\omega_1^2 R_0 = \frac{G\cancel{m_1}M}{R_0^2}$; $R_0^3 = \frac{GM}{\omega_1^2} = \frac{GM}{289\,\omega_0^2}$

$\cancel{m}\omega^2 R = \frac{G\cancel{m}M}{R^2}$; $R^3 = \frac{GM}{\omega^2} = \frac{GM}{\omega_0^2}$

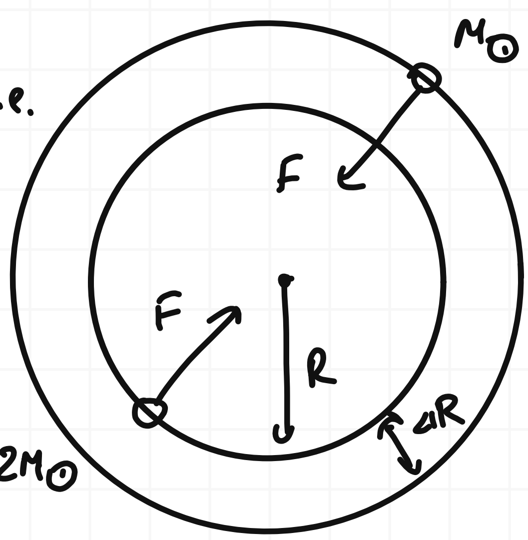
$$\frac{R}{R_0} = \sqrt[3]{\frac{\cancel{GM}}{\cancel{\omega_0^2}}\cdot\frac{289\,\cancel{\omega_0^2}}{\cancel{GM}}} = \sqrt[3]{289} = \underline{6,61}$$

09

$L = 0,5$ а.е.

$M_\odot, 2M_\odot$

T – ?



$e = 0 \iff$ окружности

центр масс неподвижен, т.к. на систему из двух тел не действуют внешних сил

$R\cdot 2\cancel{M_\odot} = (R+\Delta R)\cancel{M_\odot}$

$\cancel{2}R = \cancel{R}+\Delta R$; $R = \Delta R$

$$F = \frac{2GM_\odot^2}{(2R+\Delta R)^2} = [\omega_1 = \omega_2 = \omega] = 2M_\odot\omega^2 R$$

$$\frac{\cancel{2}GM_\odot^{\cancel{2}}}{9R^2} = \cancel{2}\cancel{M_\odot}\omega^2 R \;;\; \frac{GM_\odot}{9R^3} = \omega^2 = \frac{4\pi^2}{T^2} \;;\; T^2 = \frac{4\pi^2\cdot 9R^3}{GM_\odot} = \frac{4\pi^2 L^3}{3GM_\odot}$$

$L = 3R$

$r = 1$ а.е. – ρ(Земля, Солнце)

З $\downarrow$ $\dfrac{GM_З M_\odot}{r^2}$ $\qquad$ $\dfrac{G\cancel{M_З}M_\odot}{r^2} = \cancel{M_З}\,\omega^2 r$

• С $\qquad$ $r^3 = \dfrac{GM_\odot}{\omega^2} = \dfrac{GM_\odot}{4\pi^2}T_0^2$ $\qquad$ $T_0 = 1$ год

$$T = 2\pi\sqrt{\frac{L^3 \text{a.e}^3}{3GM_\odot}} = \cancel{2\pi}\sqrt{\frac{L^3\cdot \cancel{GM_\odot}T_0^2}{\cancel{4\pi^2}\cdot 3\cancel{GM_\odot}}} = \sqrt{\frac{(0{,}5)^3}{3}}\,T_0 =$$

$= 0{,}204$ года $=$ $\underline{2{,}45 \text{ месяца}}$

<u>7.1</u>

$v_1 = 3000$ м/с

$v_2 = 1500$ м/с

$\Delta v = 10$ м/с

$T = 300°C =$
$= 573K$

$$F(v) = 4\pi v^2\left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}}\exp\left(-\frac{mv^2}{2kT}\right)$$

$$dP(v) = 4\pi v^2\left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}}\exp\left(-\frac{mv^2}{2kT}\right)dv$$

$n_1 = dN_1 = N\,dP(v_1)$

$n_2 = dN_2 = N\,dP(v_2)$

$$\underline{\frac{n_1}{n_2}} = \frac{dP(v_1)}{dP(v_2)} = \frac{v_1^2\exp\left(-\frac{mv_1^2}{2kT}\right)}{v_2^2\exp\left(-\frac{mv_2^2}{2kT}\right)} = \frac{v_1^2}{v_2^2}\exp\left(\frac{mv_2^2}{2kT} - \frac{mv_1^2}{2kT}\right) =$$

$$= \frac{v_1^2}{v_2^2}\exp\left(\frac{m}{2kT}(v_2^2 - v_1^2)\right) =$$

// $m = \nu\mu = \dfrac{1}{N_A}\mu = \dfrac{\mu}{N_A}$

$\dfrac{m}{k} = \dfrac{\mu}{k\cdot N_A} = \dfrac{\mu}{R}$ $\qquad$ //

$$= \frac{v_1^2}{v_2^2}\exp\left(\frac{\mu}{2RT}(v_2^2 - v_1^2)\right) =$$

$$= \left(\frac{3000}{1500}\right)^2\exp\left(\frac{2\cdot 10^{-3}}{2\cdot 8{,}314\cdot 573}(1500^2 - 3000^2)\right) = \underline{0{,}97}$$

4.41

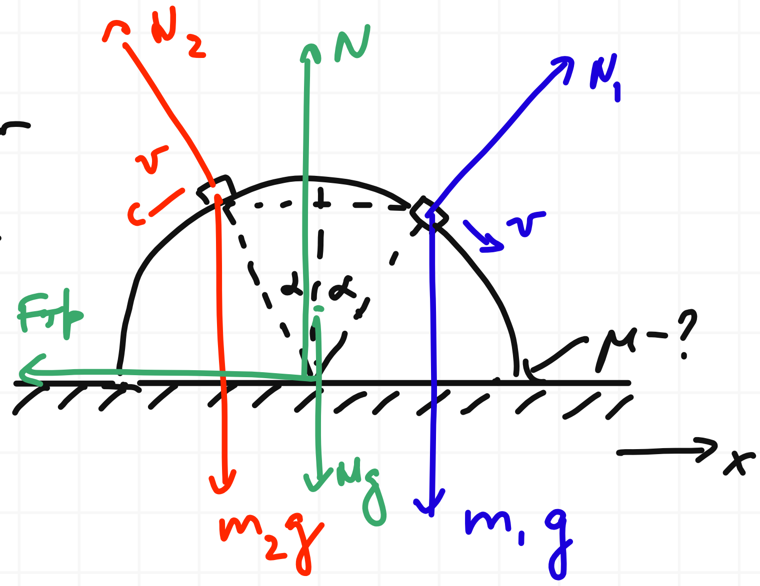
$M = 200г = 0{,}200кг$

$m_1 = 20г = 0{,}020кг$

$m_2 = 15г = 0{,}015кг$

$\alpha = 10^\circ$

$\mu - ?$



$$\frac{\cancel{m_i} v_i^2}{2} = \cancel{m_i} g R(1-\cos\alpha); \quad v_i = \sqrt{2gR(1-\cos\alpha)} = v$$

$$\frac{m_i v_i^2}{R} = m_i g\cos\alpha - N_i; \quad m_i \cdot 2g(1-\cos\alpha) = m_i g\cos\alpha - N_i$$

$$N_i = m_i g(\cos\alpha - 2 + 2\cos\alpha) = m_i g(3\cos\alpha - 2)$$

$$N = (M+m_1+m_2)g - (N_1+N_2)\cos\alpha = (M+m_1+m_2)g - (m_1+m_2)g(3\cos\alpha-2)\cos\alpha =$$

$$F_{тр} = (N_1 - N_2)\sin\alpha$$

$$\underline{\mu} = \frac{F_{тр}}{N} = \frac{(m_1-m_2)\cancel{g}(3\cos\alpha-2)\sin\alpha}{(M+m_1+m_2)\cancel{g} - (m_1+m_2)\cancel{g}(3\cos\alpha-2)\cos\alpha} \approx \frac{m_1-m_2}{M}\alpha =$$

$$= \frac{20-15}{200}\cdot\alpha_{рад} = \underline{4{,}3\cdot 10^{-3}}$$

4.76

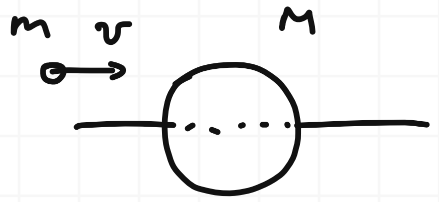
m, v

$v/2$

$F = \alpha v m$

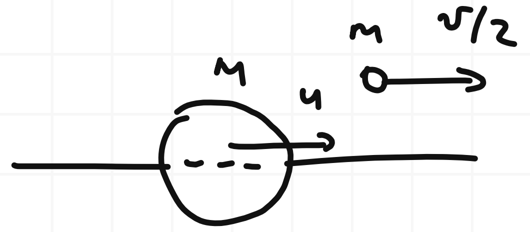
$l - ?$

(1)



за мгновение до пробоя

(2)



сразу после вылета пули

где (1) и (2) уместно записать ЗСИ, т.к. $\Delta t \to 0$

$$mv = \frac{1}{2}mv + Mu \qquad \frac{1}{2}mv = Mu; \quad u = \frac{m}{2M}v$$

Р-м движение шара после вылета пули.

$u(t=0)=u$

$M\frac{du}{dt} = -\alpha u$; $M\,du = -\alpha u\,dt = -\alpha\,dx$

$M\int\limits_u^0 du = -\alpha\int\limits_0^L dx$; $M(0-u) = -\alpha(0-L)$; $\underline{L} = \frac{Mu}{\alpha} = \underline{\frac{mv}{2\alpha}}$

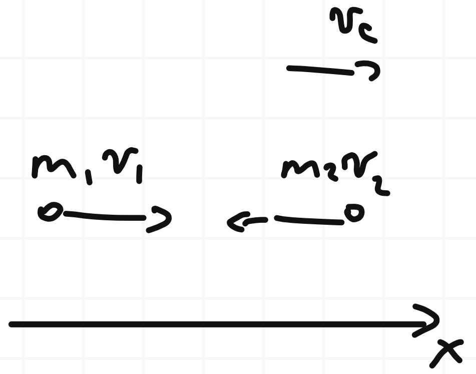
<u>4.90</u>

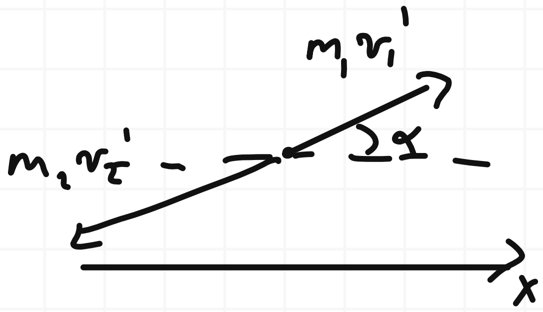
m_1, m_2

$(m_1 > m_2)$

$\alpha = 30^\circ$

$\beta = 60^\circ$

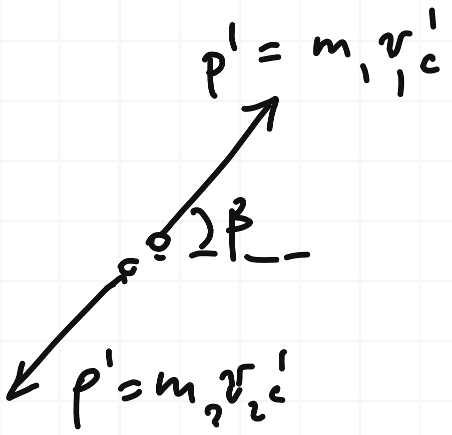




$\vec{v}_c = \frac{m_1\vec{v}_1 - m_2\vec{v}_2}{m_1+m_2}$

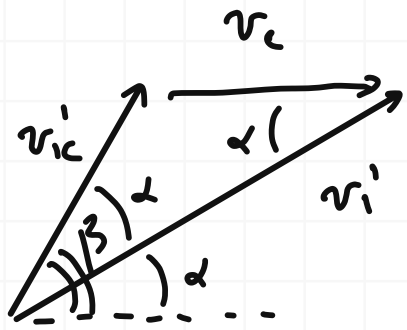
$\vec{v}_{1c} = \vec{v}_1 - \vec{v}_c = \frac{m_2(\vec{v}_1 - \vec{v}_2)}{m_1+m_2}$

$\vec{v}_{2c} = \frac{m_1(\vec{v}_2 - \vec{v}_1)}{m_1+m_2}$



$p_{1c} = p_{2c} = p$

$p_{1c}' = p_{2c}' = p'$



$v_{1c}' = v_c$

$v_1' = 2v_c\cos\alpha = \sqrt{3}\,v_c$

$\frac{p^2}{\cancel{2}m_1} + \frac{p^2}{\cancel{2}m_2} = \frac{p'^2}{\cancel{2}m_1} + \frac{p'^2}{\cancel{2}m_2}$ $\qquad \frac{1}{\mu} = \frac{1}{m_1} + \frac{1}{m_2}$

$p^2 = p'^2$

$|m_1 v_{1c}| = |m_1 v_{1c}'|$; $|v_{1c}| = |v_{1c}'|$

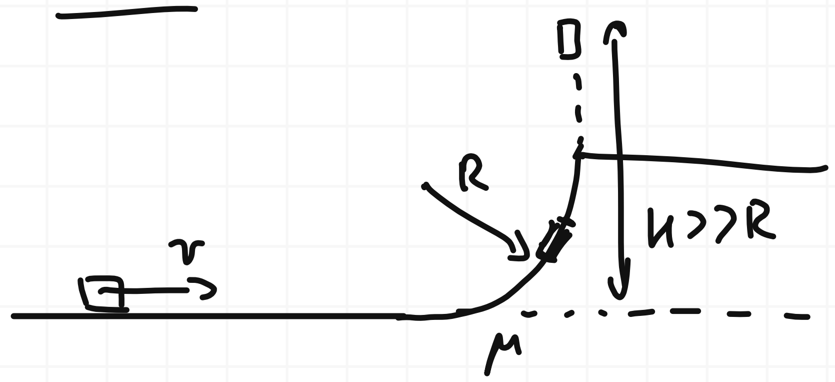
$\frac{m_1\vec{v}_1 + m_2\vec{v}_2}{\cancel{m_1+m_2}} = \frac{m_2\vec{v}_1 - m_2\vec{v}_2}{\cancel{m_1+m_2}} \quad \Big| : m_2$; $\frac{m_1}{m_2}$

$\frac{m_1}{m_2}\vec{v}_1 + \vec{v}_2 = \vec{v}_1 - \vec{v}_2$ $\qquad \vec{v}_1 \uparrow\downarrow \vec{v}_2$

$\left(1 - \frac{m_1}{m_2}\right)\vec{v}_1 = 2\vec{v}_2$

$\left(\frac{m_1}{m_2} - 1\right)v_1 = 2v_2$; $\underline{\frac{m_1}{m_2}} = 1 + 2\frac{v_2}{v_1} = [v_1 = v_2] = \underline{3}$

4.125

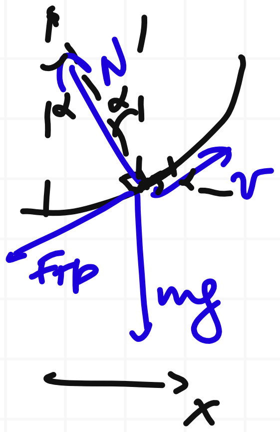


1) без трения

$$\frac{mv^2}{2} = mgH ; \quad H = \frac{v^2}{2g}$$

2) с трением

$$mgH - \frac{mv^2}{2} = A_{F_{тр}}$$



$$\frac{mv^2}{R} = N - mg\cos\alpha ; \quad N = \frac{mv^2}{R} + mg\cos\alpha$$

$$A_{F_{тр}} = \int \mu N\,dl = \mu\frac{m}{R}\int v^2\,dl + \mu mg\int \underbrace{\cos\alpha\,dl}_{dx} =$$

// $dl = v\,dt ; \int v^2\,dl = \int v^3\,dt$ //

$$m\frac{dv}{dt} = -\cancel{m}g\sin\alpha - \mu N \overset{:m}{=} -\cancel{m}g\sin\alpha - \mu\cancel{m}\frac{v^2}{R} - \mu\cancel{m}g\cos\alpha =$$

$$= -\left(\cancel{m}g(\sin\alpha + \mu\cos\alpha) + \frac{\mu\cancel{m}}{R}v^2\right)$$

$$-\frac{dv}{dt} = g(\sin\alpha + \mu\cos\alpha) + \frac{\mu}{R}v^2 \quad \Big| \cdot \frac{R}{\mu}$$

$$-\frac{R}{\mu}\cdot\frac{dv}{dt} = \underbrace{\frac{gR}{\mu}(\sin\alpha + \mu\cos\alpha)}_{\text{этим слаг. можно пренебречь}} + v^2$$

$R \ll \frac{v^2}{2g}$; $g < 2g \ll \frac{v^2}{R}$

$v^2 \gg gR$

$$-\frac{R}{\mu}\frac{dv}{v} = v\,dt = dl$$

$$-\frac{\cancel{R}}{\mu}\ln\left(\frac{v_{out}}{v}\right) = \frac{\pi}{2}\cancel{R} ;$$

из условия что 12%:

$$\frac{v_{out}^2}{2g} = 0,88\cdot\frac{v^2}{2g} ; \quad \frac{v_{out}^2}{v^2} = 0,88$$

$$\underline{\mu} = -\frac{2}{\pi}\ln\left(\sqrt{0,88}\right) = -\frac{\ln(0,88)}{\pi} = \underline{0,04}$$

4.100

${}^4He + {}^7Li \longrightarrow {}^{10}B + n$ $\qquad Q = 2{,}85 \cdot 10^6$ эВ

$\exists\, m(n) = m$; $\quad m(He) = 4m$, $m(Li) = 7m$, $m(B) = 10m$

$$K_\alpha = \underbrace{k'}_{\min} + Q$$

(ЗСИ) $\quad p_\alpha = p_B + p_n$; $p_n = p_\alpha - p_B$

(ЗСЭ) $$\frac{p_\alpha^2}{8m}^{\backslash 5} = Q + \frac{p_B^2}{20m}^{\backslash 2} + \frac{p_\alpha^2 - 2p_\alpha p_B + p_B^2}{2m}^{\backslash 20}$$

$$5p_\alpha^2 = 40mQ + \underbrace{2p_B^2 + 20p_\alpha^2 - 40p_\alpha p_B + 20p_B^2}_{f\ \sim k'} \qquad \Big|: p_B;\ \frac{p_\alpha}{p_B} = x$$

$f = 22p_B^2 + 20p_\alpha^2 - 40p_\alpha p_B$; $\quad p_\alpha = const$

$$\frac{\partial f}{\partial p_B} = 44p_B - 40p_\alpha = 0; \quad \frac{p_B}{p_\alpha} = \frac{40}{44} = \frac{10}{11}; \qquad \exists\, p_\alpha = p,\ p_B = \frac{10}{11}p$$

$$\frac{40mQ}{p^2} = \cancel{5} - 22\cdot\frac{10^2}{11^2} - \overset{-15}{\cancel{20}} + 40\frac{10}{11} = \frac{35}{11}$$

$$\underline{K_\alpha} = \frac{p^2}{8m} = 5Q\cdot\frac{p^2}{40mQ} = \frac{5\cdot 2{,}85\ \text{МэВ}}{35/11} = \underline{4{,}48\ \text{МэВ}}$$

7.1

$W_1 = -\frac{GmM}{R^2} \qquad W_2 = 0$

$M = 1{,}1\cdot 10^{16}$ кг

$R = 11{,}1$ км

$$\frac{\cancel{m}v^2}{2} = \frac{G\cancel{m}M}{R}; \quad v^? = \sqrt{\frac{2GM}{R}} =$$

$$= \frac{2\cdot 6{,}67\cdot 10^{-11}\cdot 1{,}1\cdot 10^{16}}{11{,}1\cdot 10^3} = 11{,}5\ \text{м/с} \ - \text{too much}$$

Ответ: нет.