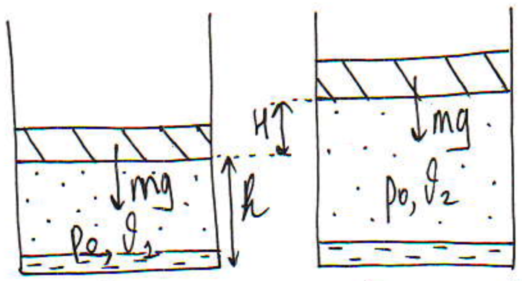
1



давление поршня $\frac{mg}{S} = Const$

$\Downarrow$

$$p = Const = p_0 = \frac{mg}{S}$$

$$p_0 S = mg$$

$$p_0 h S = \nu_1 R T_1 \qquad p_0 (h+H) S = \nu_2 R T_2$$

$$\nu_1 = \frac{p_0 h S}{R T_1} \qquad \nu_2 = \frac{p_0 \cancel{h} S (h+H)}{R T_2}$$

При увеличении T жидкость испаряется, оставляя насыщенный пар, и поднимает поршень

Рассмотрим $\Delta T \to 0$, поэтому $p_{нп} = Const$

$$\Delta \nu = \nu_2 - \nu_1 = \frac{p_0 \cancel{h} S (H+h)}{R T_2} - \frac{p_0 S h}{R T_1} = \frac{p_0 S}{R} \left(\frac{H T_1 + h T_1 - h T_2}{T_1 T_2} \right) = \frac{mg}{R} \left(\frac{h(T_1 - T_2) + H T_1}{T_1 T_2} \right)$$

$\Delta T \to 0 \Rightarrow T_1 - T_2 \to 0$

$T_1 \approx T_2 \approx T$

$$\Delta \nu = \frac{mg}{R} \frac{HT}{T^2} = \frac{mgH}{RT}$$

$$A_п = mgH$$

$$A_з = A_p + Q$$

$Q = \Delta \nu \mu L$ – на испарение

$A_p = S p_0 H = mgH$ – на поднятие поршня

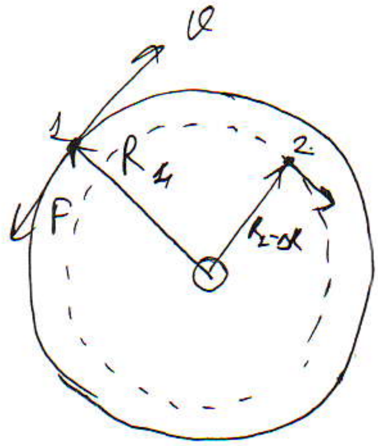
$$A_з = mgH + \frac{mgH}{RT} \mu L$$

$$\eta = \frac{A_п}{A_з} = \frac{mgH}{mgH + \frac{mgH}{RT} \mu L} = \frac{1}{1 + \frac{\mu L}{RT}}$$

② $\vartheta = \sqrt{\frac{GM}{R}}$

$\Delta p = F\Delta t = \Delta m \vartheta$ $\quad \Delta R \to 0 \Rightarrow \Delta \vartheta \to 0$

$F = kn\vartheta$



$kn = \frac{\Delta m}{\Delta t}$

$kn_1 = \frac{\Delta m_1}{\Delta t}$

$kn_2 = \frac{\Delta m_2}{\Delta t}$

$E = \frac{m\vartheta^2}{2} - \frac{GmM}{R}$

$\vartheta^2 = \frac{GM}{R}$

$E = -G\frac{mM}{2R}$

$E_1 = E_2 + A$

$A = FS = kn\vartheta\, \vartheta\Delta t$ $\quad F = const$ и $\vartheta = const$, т.к. $\Delta R << R$

$-\frac{GmM}{2R} = -\frac{GmM}{2(R-\Delta R)} + kn\frac{GM}{R}\Delta t$

$\frac{m}{\cancel{m}2}\left(\frac{R-(R-\Delta R)}{\cancel{R}(R-\Delta R)}\right) = \frac{\Delta m\, \cancel{\Delta t}}{\cancel{\Delta t}\, \cancel{R}}$

$\frac{m\Delta R}{2(R-\Delta R)} = \Delta m$

$\Delta m_1 = \frac{m\Delta R_1}{2(R_1-\Delta R_1)}$

$\Delta m_2 = \frac{m\Delta R_2}{2(R_2-\Delta R_2)}$

$\frac{\Delta m_1}{\Delta m_2} = \frac{\Delta R_1(R_2-\Delta R_2)}{\Delta R_2(R_1-\Delta R_1)}$

$\Delta R_2\Delta m_1(R_1-\Delta R_1) = \Delta m_2\Delta R_1 R_2 - \Delta R_2\Delta m_2\Delta R_1$

$\Delta R_2 = \frac{\Delta m_2\Delta R_1 R_2}{\Delta m_1(R_1-\Delta R_1) + \Delta m_2\Delta R_1}$

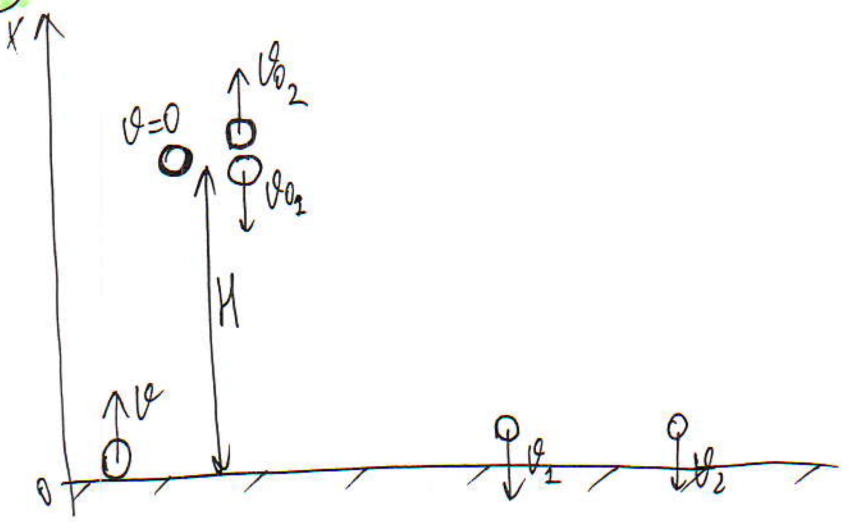
$\Delta R_1 << R_1$

$\Delta R_2 = \frac{\Delta m_2\Delta R_1 R_2}{\Delta m_1 R_1 + \Delta m_2\Delta R_1}$

$\Delta R_2 = \frac{2{,}8\cdot 1\cdot 5000}{0{,}5\cdot 10000 + 2{,}8\cdot 1}\text{км} = \frac{14000}{5002{,}8}\text{км} = 2{,}798\text{ км}$

Ответ: $\Delta R_2 \approx 2{,}8$ км

3



$$H=\frac{\vartheta^2}{2g}$$

$$2gH=\vartheta^2$$

По з-ну сохр. имп. ox: $0=\vartheta_{0_2}m_2-\vartheta_{0_1}m_1$
в момент разрыва

$$\frac{\vartheta_{0_2}}{\vartheta_{0_1}}=\frac{m_1}{m_2}=n$$

$$\vartheta_{0_2}=n\vartheta_{0_1}$$

Для 1 осколка по ЗСЭ $\frac{m_1\vartheta_{0_1}^2}{2}+m_1gH=\frac{m_1\vartheta_1^2}{2}$

$$\vartheta_{0_1}^2+2gH=\vartheta_1^2 \qquad \vartheta_{0_1}^2+\vartheta^2=\vartheta_1^2$$

Для 2 осколка по ЗСЭ $\frac{m_2\vartheta_{0_2}^2}{2}+m_2gH=\frac{m_2\vartheta_2^2}{2}$

$$\vartheta_{0_2}^2+2gH=\vartheta_2^2 \qquad \vartheta_{0_2}^2+\vartheta^2=\vartheta_2^2$$

$$\cancel{\vartheta_{0_1}^2-\vartheta_{0_2}^2=\vartheta_1^2-\vartheta_2^2}$$

$$n^2\vartheta_{0_1}^2+\vartheta^2=\vartheta_2^2$$

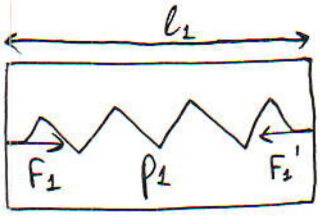
$$\vartheta_{0_1}^2=\frac{\vartheta_2^2-\vartheta^2}{n^2}$$

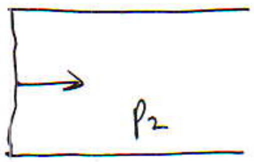
$$\frac{\vartheta_2^2-\vartheta^2}{n^2}+\vartheta^2=\vartheta_1^2$$

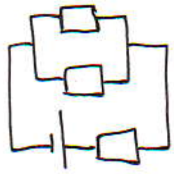
$$\vartheta_2^2-\vartheta^2=n^2(\vartheta_1^2-\vartheta^2)$$

$$n=\sqrt{\frac{\vartheta_2^2-\vartheta^2}{\vartheta_1^2-\vartheta^2}}$$

4

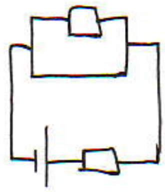






$$P_1 = \frac{U^2}{R_{o_1}} = \frac{U^2}{1{,}5R}$$

$$\frac{P_2}{P_1} = \frac{U^2}{R} \cdot \frac{1{,}5R}{U^2} = 1{,}5$$



$$P_2 = \frac{U^2}{R_{o_2}} = \frac{U^2}{R}$$

При достижении равновесия

$$P = P_{\text{теплот}} = \alpha T^4 (2S + 2\pi R l)$$

$$S \to 0$$

$$P = \beta T^4 l$$

$$\frac{P_2}{P_1} = \frac{T_2^4 l_2}{T_1^4 l_1}$$

$$pS = F = kl$$

$$p = \frac{\nu RT}{lS}$$

$$\frac{\nu RT \cancel{S}}{l \cancel{S}} = kl$$

$$\nu RT = kl^2$$

$$\nu RT_1 = kl_1^2$$

$$\nu RT_2 = kl_2^2$$

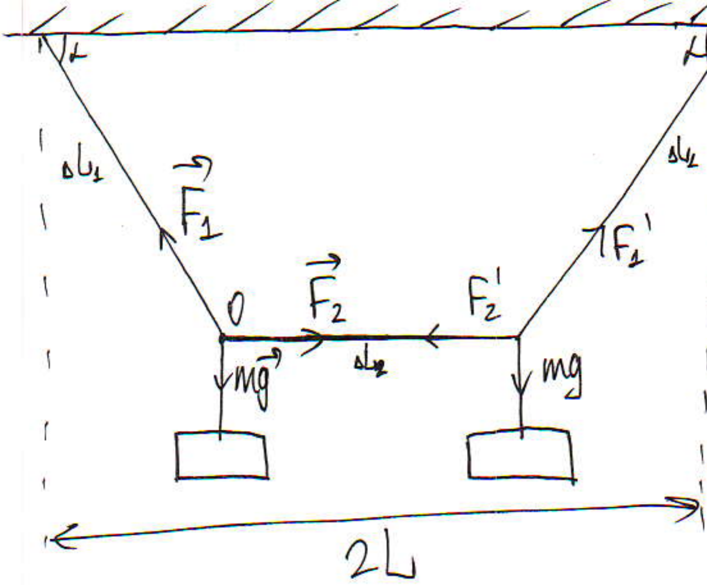
$$\frac{T_1}{T_2} = \frac{l_1^2}{l_2^2}$$

$$\frac{P_2}{P_1} = \left(\frac{l_2^2}{l_1^2}\right)^4 \frac{l_2}{l_1} = \left(\frac{l_2}{l_1}\right)^9$$

$$\frac{V_2}{V_1} = \frac{\pi R^2 l_2}{\pi R^2 l_1} = \frac{l_2}{l_1} = \sqrt[9]{\frac{P_2}{P_1}} \approx 1{,}046$$

Ответ: $\approx 1{,}046$

5



Система симметрична

$\Downarrow$

удлинения боковых нитей равны

$F_1 = F_1' = k\Delta L_1$

$F_2 = F_2' = k\Delta L_2$

$$2L = 2(L+\Delta L_1)\cos\alpha + (L+\Delta L_2)$$

$$L = 2L\cos\alpha + 2\Delta L_1\cos\alpha + \Delta L_2$$

Для O:

$$\vec{F_1} + \vec{F_2} + m\vec{g} = 0$$

$$F_1\cos\alpha = F_2 \qquad F_1\sin\alpha = mg$$

$$k\Delta L_1\cos\alpha = k\Delta L_2 \qquad \Delta L_1 k\sin\alpha = mg$$

$$\Delta L_1\cos\alpha = \Delta L_2$$

$$L = 2L\cos\alpha + 2\Delta L_1\cos\alpha + \Delta L_1\cos\alpha \qquad k = \frac{mg}{\Delta L_1\sin\alpha}$$

$$3\Delta L_1\cos\alpha = L(1-2\cos\alpha)$$

$$\Delta L_1 = L\,\frac{1-2\cos\alpha}{3\cos\alpha}$$

$$k = \frac{mg\cdot 3\cos\alpha}{L(1-2\cos\alpha)\sin\alpha} = \frac{3\,\mathrm{ctg}\,\alpha\, mg}{L(1-2\cos\alpha)}$$

$$H = (L+\Delta L_1)\sin\alpha = L\sin\alpha\left(\frac{3\cos\alpha + 1 - 2\cos\alpha}{3\cos\alpha}\right) = L\,\frac{\mathrm{tg}\,\alpha\,(1+\cos\alpha)}{3}$$

Ответ: $k = \dfrac{3\,\mathrm{ctg}\,\alpha\, mg}{L(1-2\cos\alpha)}$

$H = L\,\dfrac{\mathrm{tg}\,\alpha\,(1+\cos\alpha)}{3}$