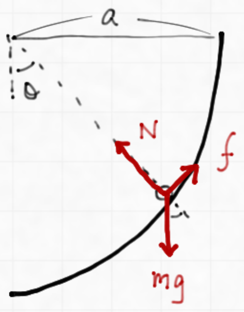
2016 大阪医大(後)

1 (1)



$$\begin{cases} N = mg\cos\theta \\ f = mg\sin\theta \leqq \mu N \end{cases}$$

$$\cancel{mg}\sin\theta \leqq \mu \cancel{mg}\cos\theta$$

等号成立は $\tan\theta = \mu$ のとき.

このとき最下点からの高さ(hとする)は

$$h = a - a\cos\theta = a(1-\cos\theta) = a\left(1-\sqrt{\frac{1}{\tan^2\theta+1}}\right) = a\left(1-\sqrt{\frac{1}{1+\mu^2}}\right)$$

(2) $f = \dfrac{V}{\lambda}$　気温が低いと音速が遅くなり、fも小さくなる. **(c)**

弦の張力が増加すると、弦を伝わる波が速くなり、fは大きくなる **(a)**

(3) 目安となるような数値は覚えておく、

原子の大きさは $0.1\,\mathrm{nm} = 10^{-10}\,\mathrm{m}$ 程度　光の速度は $3\times10^{8}\,\mathrm{m/s}$

コロイド粒子は $1\sim100\,\mathrm{nm} = 10^{-9}\sim10^{-7}\,\mathrm{m}$ 程度.　音速は $340\,\mathrm{m/s}$ 程度

可視光線の振動数は $400\sim800\,[\mathrm{THz}] = 4\times10^{14}\sim8\times10^{14}\,[\mathrm{Hz}]$

可聴音 $20\sim20\,\mathrm{kHz}$

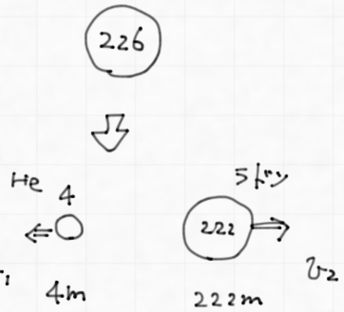
これらの値を参考にしながら考える

①原子の大きさ 10^{-10} **D**　②原子核の大きさ 10^{-14} **E**

③可視光線の波長 $3\times10^{8}\div10^{15}$ ぐらい… 10^{-7} **C**

④空気中での音の速さ $340\div100$ ぐらい… 1m **A**

(4) α線は $^{4}_{2}He$ だから質量数は4減る.　$226-4=$ **222**



$$4m v_1 = 222 m v_2$$

$$\frac{1}{2}\cdot 222 m v_2^2 = \frac{222}{2}\cdot m\cdot\left(\frac{4}{222}v_1\right)^2$$

$$= \left(\frac{1}{2}4mv_1^2\right)\times\cancel{\frac{16}{222}}\ \frac{8}{111}\times\frac{1}{4}$$

$$= \frac{2}{111}\times4.8\ (\mathrm{MeV})$$

$$= \mathbf{8.6\times10^{-2}}\ (\mathrm{MeV})$$

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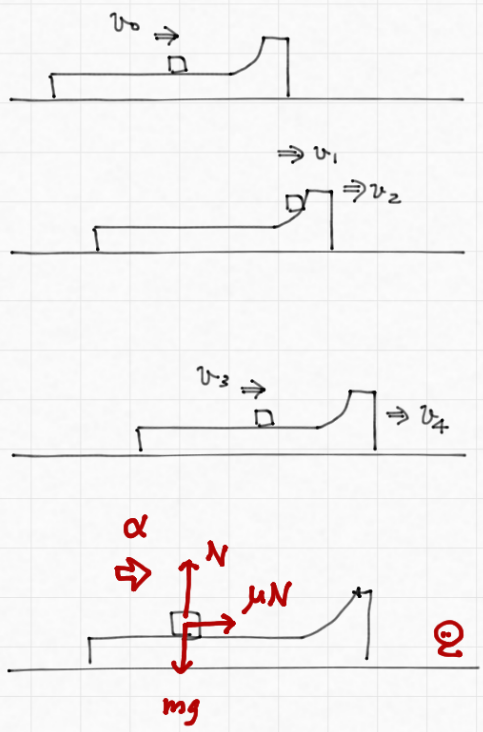

(1) 最高点に達したとき、台から見た小物体の速度は 0 となっている。($v_1 = v_2$) このことを考慮して運動量保存の式を立てると

$$m v_0 = m v_1 + M v_2 \quad (= (m+M) v_1)$$

$$v_1 = v_2 = \frac{m}{m+M} v_0$$

(2) エネルギーおよび運動量が保存する

$$\begin{cases} \frac{1}{2} m v_0^2 = \frac{1}{2} m v_3^2 + \frac{1}{2} M v_4^2 \\ m v_0 = m v_3 + M v_4 \end{cases}$$

$v_4 = \dfrac{m(v_0 - v_3)}{M}$ を代入

$$\cancel{\frac{1}{2}}\cancel{m} v_0^2 = \cancel{\frac{1}{2}}\cancel{m} v_3^2 + \cancel{\frac{1}{2}}\cancel{M} \frac{m^{\cancel{2}}(v_0^2 - 2 v_0 v_3 + v_3^2)}{M^{\cancel{2}}}$$

$$M v_0^2 = M v_3^2 + m v_0^2 - 2 m v_0 v_3 + m v_3^2$$

$$(m+M) v_3^2 - 2 m v_0 v_3 - M v_0^2 + m v_0^2 = 0$$

$$(v_3 - v_0)\{(m+M) v_3 + (m-M) v_0\} = 0$$

$$v_3 = \frac{m-M}{m+M} v_0 \qquad v_4 = \frac{2m}{m+M} v_0$$

(3) 小物体が台上で静止するまで、運動量は保存し続けている

$$m v_0 = m v_5 + M v_5 \qquad \therefore\ v_5 = \frac{m}{m+M} v_0$$

(4) $W = \dfrac{1}{2} m v_0^2 - \dfrac{1}{2}(m+M) v_5^2 = \dfrac{mM}{2(m+M)} v_0^2$

(5) $W = \mu N \times \overline{PB} = \mu m g \overline{PB}$ $\qquad \overline{PB} = \dfrac{1}{\mu \cancel{m} g} \times \dfrac{\cancel{m} M}{2(m+M)} v_0^2 = \dfrac{M v_0^2}{2\mu(m+M)g}$

(6) $\begin{cases} m\alpha = \mu N \\ N = mg \end{cases} \qquad \alpha = \mu g$

$v = \dfrac{m-M}{m+M} v_0 + \mu g t = \dfrac{m}{m+M} v_0 \ (= v_5)$ より $t = \dfrac{M}{\mu g(m+M)} v_0$ 秒後に静止する。

小物体の移動距離は

$$v_3 t + \frac{1}{2}\alpha t^2 = \frac{m-M}{m+M} \times \frac{M v_0}{\mu g(m+M)} + \frac{1}{2}\cancel{\mu g}\frac{M^2 v_0^2}{\mu^{\cancel{2}} g^{\cancel{2}}(m+M)^2}$$

$$= \frac{2mM - 2M^2 + M^2}{2\mu g(m+M)^2} v_0^2 = \frac{M(2m - M) v_0^2}{2\mu g(m+M)^2}$$

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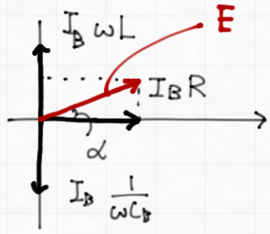
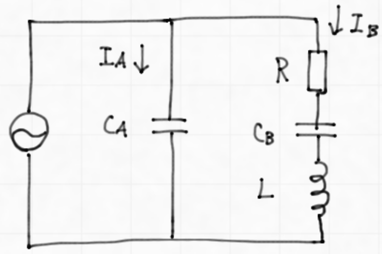
III





(1) $E = \dfrac{1}{\omega C_A} I_A$

$I_A = \omega C_A E$

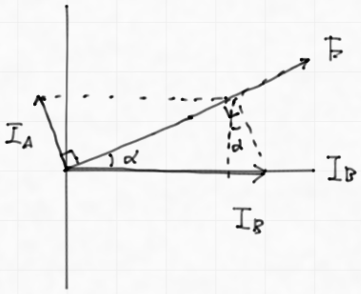
$$E = \sqrt{\left(I_B \omega L - I_B \frac{1}{\omega C_B}\right)^2 + (I_B R)^2}$$

$$= I_B \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C_B}\right)^2}$$

$$I_B = \frac{E}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C_B}\right)^2}}$$

(2) $\dfrac{\pi}{2}$ 進んでいる

(3)



$$\sin\alpha = \frac{I_B \omega L - I_B \frac{1}{\omega C_B}}{E} = \frac{I_A}{I_B}$$

$$\frac{E^{\cancel{2}}}{R^2 + \left(\omega L - \frac{1}{\omega C_B}\right)^2} \times \left(\omega L - \frac{1}{\omega C_B}\right) \times \cancel{\frac{1}{E}} = \omega C_A \cancel{E}$$

$$C_A = \frac{\omega L - \frac{1}{\omega C_B}}{\omega \left\{R^2 + \left(\omega L - \frac{1}{\omega C_B}\right)^2\right\}}$$

(4) $I_E = I_B \cos\alpha$

$$= I_B \left(\frac{I_B R}{E}\right) = \frac{R}{E} I_B^2 = \frac{R}{\cancel{E}} \times \frac{E^{\cancel{2}}}{R^2 + \left(\omega L - \frac{1}{\omega C_B}\right)^2} = \frac{RE}{R^2 + \left(\omega L - \frac{1}{\omega C_B}\right)^2}$$

(5) $I_E Z_E = E$

$$Z_E = \frac{R^2 + \left(\omega L - \frac{1}{\omega C_B}\right)^2}{R}$$

(6) $\overline{P_E} = R I_B^2 = \dfrac{RE^2}{R^2 + \left(\omega L - \frac{1}{\omega C_B}\right)^2}$

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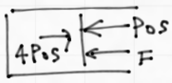
IV

① $N = \dfrac{P_0 S l}{R T_0} = \dfrac{Sl}{R} \cdot \dfrac{P_0}{T_0}$



② $P_0 S l = 4 P_0 V_1 \qquad V_1 = \dfrac{1}{4} S l$

③ $F = (4P_0 - P_0) S = 3S P_0$

④ $\dfrac{P_2 V_1}{4 P_0 V_1} = \dfrac{N R \alpha T_0}{N R T_0} \Leftrightarrow P_2 = 4\alpha P_0$

⑤ $\Delta U = \dfrac{5}{2} R (\alpha - 1) N T_0$

⑥ $\dfrac{P_3 \beta \cancel{V_1}}{P_2 \cancel{V_1}} = \dfrac{N R \alpha T_0}{N R \alpha T_0}$

$P_3 = \dfrac{1}{\beta} P_2 = \dfrac{4}{\beta} \alpha P_0$

⑦ $1000 V_1 < m < 1000 \beta V_1$

⑧
⑨ $\dfrac{\cancel{4}}{\beta} \alpha \cancel{P_0} (\beta V_1)^{\frac{7}{5}} = \cancel{4 P_0} V_4^{\frac{7}{5}}$

$V_4 = \beta V_1 \left(\dfrac{\alpha}{\beta}\right)^{\frac{5}{7}} \qquad T_4 = \dfrac{4 P_0}{N R} \beta V_1 \left(\dfrac{\alpha}{\beta}\right)^{\frac{5}{7}}$

$W_A = -\dfrac{5}{2} N R (T_4 - \alpha T_0) = -\dfrac{5}{2} \cdot 4 P_0 \beta V_1 \left(\dfrac{\alpha}{\beta}\right)^{\frac{5}{7}} + \dfrac{5}{2} N R \alpha T_0$

$= \dfrac{5}{2} \alpha\, N R T_0 \left(1 - \dfrac{4 P_0 \beta}{N R T_0} \dfrac{1}{\alpha} V_1 \left(\dfrac{\alpha}{\beta}\right)^{\frac{5}{7}}\right) = \dfrac{5}{2} \alpha\, N R T_0 \left(1 - \left(\dfrac{\alpha}{\beta}\right)^{-\frac{2}{7}}\right)$

⑩ $W_B = 4 P_0 (V_1 - V_4) = 4 P_0 V_1 - 4 P_0 \beta V_1 \left(\dfrac{\alpha}{\beta}\right)^{\frac{5}{7}}$

$= N R T_0 - \beta N R T_0 \left(\dfrac{\alpha}{\beta}\right)^{\frac{5}{7}} = N R T_0 \times \left\{1 - \alpha \left(\dfrac{\alpha}{\beta}\right)^{-\frac{2}{7}}\right\}$

⑪ $W_A + W_B = 5 N R T_0 \left(1 - \left(\dfrac{2}{\beta}\right)^{-\frac{2}{7}}\right) + N R T_0 \left(1 - 2\left(\dfrac{2}{\beta}\right)^{-\frac{2}{7}}\right)$

$= N R T_0 \left(6 - 7\left(\dfrac{2}{\beta}\right)^{-\frac{2}{7}}\right) > 0$

$6 > 7\left(\dfrac{2}{\beta}\right)^{-\frac{2}{7}} \Leftrightarrow \left(\dfrac{2}{\beta}\right)^{-\frac{2}{7}} < \dfrac{6}{7} \Leftrightarrow \left(\dfrac{2}{\beta}\right)^{-\frac{2}{7} \times \left(-\frac{7}{2}\right)} < \left(\dfrac{6}{7}\right)^{-\frac{7}{2}} = \dfrac{12}{7}$

$\dfrac{2}{\beta} < \dfrac{12}{7} \Leftrightarrow \beta > \dfrac{7}{6}$

$0 : \; P_0 S l = N R T_0$

等温 $\downarrow \quad Q_{01} = W_{01} + 0$

$1 : \; 4 P_0 V_1 = N R T_0$

定積 $\downarrow \quad Q_{12} = 0 + \dfrac{5}{2} N R (\alpha T_0 - T_0)$

$2 : \; P_2 V_1 = N R \cdot \alpha T_0$

等温 $\downarrow \quad Q_{23} = W_{23} + 0$

$3 : \; P_3 \beta V_1 = N R \alpha T_0$

断熱 $\downarrow \quad 0 = W_A + \dfrac{5}{2} N R (T_4 - \alpha T_0)$

$P_3 (\beta V_1)^{\frac{7}{5}} = (4 P_0) V_4^{\frac{7}{5}}$

$4 : \; 4 P_0 \cdot V_4 = N R T_4$

定圧 $\downarrow \quad Q_{41} = W_B + \dfrac{5}{2} N R (T_0 - T_4)$

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