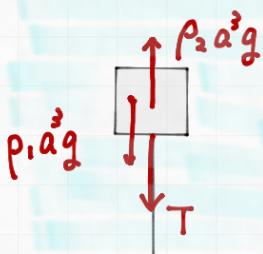


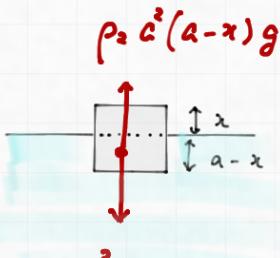
1
(1)

①

力のつもりあい

$$\rho_2 a^2 g = \rho_1 a^3 g + T$$

$$\text{よし } T = (\rho_2 - \rho_1) a^3 g$$



②

力のつもりあい

$$\rho_2 a^2 (a-x)g = \rho_1 a^3 g$$

$$\rho_2 a - \rho_1 a = \rho_1 a$$

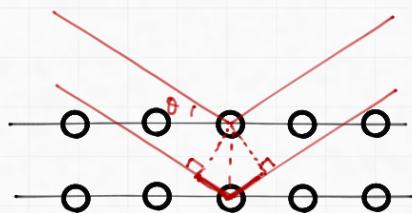
$$\lambda = \frac{\rho_2 - \rho_1}{\rho_2} a$$

$$(2) \text{ ① エネルギー保存より } eV = \frac{1}{2} m v^2 \quad m v = \sqrt{2eV}$$

$$\text{トーラスの波長は } \lambda = \frac{\hbar}{mv} = \frac{\hbar}{\sqrt{2meV}}$$

$$\text{② 数値を代入 } \lambda = \frac{6.6 \times 10^{-34}}{\sqrt{2 \cdot 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 3.1 \times 10^3}} = 2.2 \times 10^{-11}$$

③



左図太線部が経路差だから

$$2d \sin \theta = \lambda$$

$$\sin \theta = \frac{\lambda}{2d} = \frac{10^{-12}}{2 \times 10^{-10}} = 0.005$$

$$\theta = 0.005 \text{ (rad)} \hat{=} 0.005 \times \frac{180}{\pi} < 1 \quad \therefore d$$

$$(3) \text{ ① 公式 磁場 } B = \mu_0 \times \frac{N}{l} I = \frac{\mu_0 N I}{l}$$

② ノレノイドに生じる誘導起電力は、磁束を重として

$$V = -N \frac{\Delta \Phi}{\Delta t} = -N \frac{\Delta BS}{\Delta t} = -\frac{\mu_0 N S}{l} \cdot \frac{\Delta I}{\Delta t} \quad \therefore \text{自己インダクタンス } L = \frac{\mu_0 N^2 S}{l}$$

$$\text{③ 薄くされたエネルギーと } U = \frac{1}{2} L I^2$$

$$\text{体積 } Sl \text{ で } \frac{U}{Sl} = \frac{LI^2}{2Sl} = \frac{I^2}{2S} \times \frac{\mu_0 N^2 S}{l} = \frac{\mu_0 N^2 I^2}{2l^2}$$

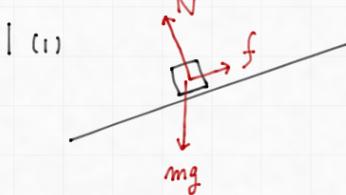
$$\text{④ } \frac{\mu_0 N^2 I^2}{2l^2} = \frac{1}{2\mu_0} \left(\frac{\mu_0 N I}{l} \right)^2 = \frac{1}{2\mu_0} B^2$$

(4) ① Heは原子番号2 質量数4 Alは原子番号13 質量数27 Pは原子番号15 質量数30



$$\text{③ } 1.0 \times 10^{23} \times \left(\frac{1}{2} \right)^{\frac{30}{15}} = 2.5 \times 10^{22} \quad \therefore 1.0 \times 10^{23} - 2.5 \times 10^{22} = 7.5 \times 10^{22}$$

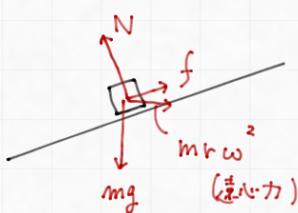
2

力のつりあい $N = mg \cos \theta$

$$mg \sin \theta = f \leq \mu N$$

$$f = \mu N \text{ のとき } \theta = \theta_0 \text{ たゞが } mg \sin \theta_0 = \mu mg \cos \theta_0 \quad \mu = \tan \theta_0$$

II (2)



円運動している視点から考え方(非慣性系)

$$\begin{cases} \text{力のつりあい} \\ N = mg \cos \theta + mr\omega^2 \sin \theta \\ mg \sin \theta = mr\omega^2 \cos \theta + f \end{cases}$$

$$f = mg \sin \theta - mr\omega^2 \cos \theta$$

$$(3) f = 0 \text{ となるとき. } mg \sin \theta - mr\omega^2 \cos \theta = 0 \quad \omega = \sqrt{\frac{g}{r} \tan \theta}$$

III (4) $f \geq -\mu N$

$$mg \sin \theta - \mu r\omega^2 \cos \theta \geq -\mu(mg \cos \theta + \mu r\omega^2 \sin \theta)$$

$$r\omega^2 \cos \theta - \mu r\omega^2 \sin \theta \leq g \sin \theta + \mu g \cos \theta$$

$$\omega \leq \sqrt{\frac{g}{r} \times \frac{\sin \theta + \mu \cos \theta}{\cos \theta - \mu \sin \theta}}$$

$$\left. \begin{aligned} \cos \theta - \mu \sin \theta &= \cos \theta (1 - \mu \tan \theta) \\ &\geq \cos \theta (1 - \mu \cdot \frac{1}{\mu}) = 0 \end{aligned} \right.$$

(5) $f \leq \mu N$

$$mg \sin \theta - \mu r\omega^2 \cos \theta \leq \mu(mg \cos \theta + \mu r\omega^2 \sin \theta)$$

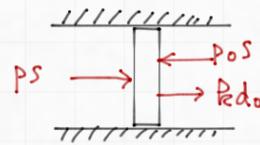
$$r\omega^2 \cos \theta + \mu r\omega^2 \sin \theta \leq g \sin \theta - \mu g \cos \theta$$

$$\omega \leq \sqrt{\frac{g}{r} \times \frac{\sin \theta - \mu \cos \theta}{\cos \theta + \mu \sin \theta}}$$

$$\left. \begin{aligned} \sin \theta - \mu \cos \theta &= \sin \theta (\tan \theta - \mu) \\ &> 0 \end{aligned} \right.$$

$\therefore \theta_0 < \theta$

- 3 I (1) 気体の圧力をとる。状態方程式より $p_{\text{S}}l_0 = nRT_0$
ピストンにかかる力のつりあい $p_{\text{S}} + p_{\text{d},0} = p_{\text{o}}S$



$$n = \frac{p_{\text{S}}l_0}{RT_0} = \frac{S l_0}{RT_0} \left(p_{\text{o}} - \frac{p_{\text{d},0}}{S} \right)$$

- II (2) 終始温度を T_1 とする。状態方程式より $p_{\text{S}}l_1 = nRT_1$

$$\frac{l_0}{l_1} = \frac{T_0}{T_1} \quad \therefore T_1 = \frac{l_1}{l_0} T_0$$

$$(3) \Delta U = \frac{3}{2}nR(T_1 - T_0) = \frac{3}{2} \frac{S l_0}{RT_0} \times \frac{S p_{\text{o}} - p_{\text{d},0}}{S} \times R \left(\frac{l_1}{l_0} - 1 \right) T_0 = \frac{3}{2} (S p_{\text{o}} - p_{\text{d},0})(l_1 - l_0)$$

$$(4) Q = p_{\text{S}}(l_1 - l_0) + \Delta U = \frac{3}{2} (S p_{\text{o}} - p_{\text{d},0})(l_1 - l_0)$$

- III (5) 断熱変化なので 気体のした仕事を 内部エネルギーの減少量。

また、気体のした仕事を = 大気のした仕事を + 間内のエネルギーの増加量だから

$$p_{\text{o}}S(l_2 - l_0) + \frac{1}{2}R(2d)^2 - \frac{1}{2}Rd_0^2 = \frac{3}{2}nR(T_0 - T_2) \dots \textcircled{1}$$

ピストンにかかる力のつりあい $p_2S + p_2d_0 = p_{\text{o}}S \dots \textcircled{2}$

状態方程式 $p_2 \cdot S l_2 = nRT_2 \dots \textcircled{3}$

$$\textcircled{2} \textcircled{3} \text{ より } (p_{\text{o}}S - 2p_2d_0)l_2 = nRT_2 \quad l_2 = \frac{nRT_2}{p_{\text{o}}S - 2p_2d_0}$$

$$\textcircled{1} \text{ より } T_0 - T_2 = \frac{2}{3nR} \left(p_{\text{o}}Sl_2 - p_{\text{o}}Sl_0 + \frac{3}{2}Rd_0^2 \right)$$

$$T_0 - T_2 = \frac{2}{3nR} p_{\text{o}}S \cdot \frac{\cancel{R}T_2}{p_{\text{o}}S - 2p_2d_0} - \frac{2}{3nR} \frac{\cancel{R}T_0}{l_0(p_{\text{o}}S - 2p_2d_0)} \left(p_{\text{o}}Sl_0 - \frac{3}{2}Rd_0^2 \right)$$

$$\frac{2}{3} \times \frac{p_{\text{o}}S}{p_{\text{o}}S - 2p_2d_0} T_2 + T_2 = T_0 + \frac{2}{3} \frac{p_{\text{o}}Sl_0 - \frac{3}{2}Rd_0^2}{l_0(p_{\text{o}}S - 2p_2d_0)} T_0$$

$$T_2 = \frac{\frac{2}{3} \cdot \frac{p_{\text{o}}Sl_0 - \frac{3}{2}Rd_0^2}{l_0(p_{\text{o}}S - 2p_2d_0)} + 1}{\frac{2}{3} \cdot \frac{p_{\text{o}}S}{p_{\text{o}}S - 2p_2d_0} + 1} T_0$$

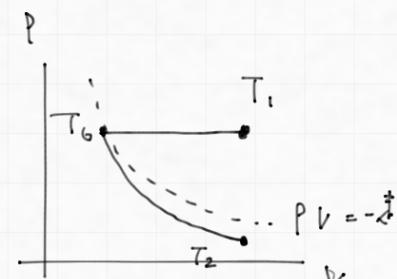
$\textcircled{1} \text{ で } T_0 \text{ を消す}.$ $T_2 = \frac{p_{\text{o}}S - 2p_2d_0}{nR} \times l_2 = \frac{l_2(p_{\text{o}}S - 2p_2d_0)}{R} \times \frac{\cancel{R}T_0}{l_0(S p_{\text{o}} - p_{\text{d},0})}$

$$= \frac{l_2}{l_0} \times \frac{S p_{\text{o}} - 2p_2d_0}{S p_{\text{o}} - p_{\text{d},0}} T_0$$

- (6) ① $T_1 > T_0 > T_2$

- ② 定圧で取引させるとには加熱が必要なので $T_1 > T_0$

- 断熱膨張では温度が下がるので $T_0 > T_2$



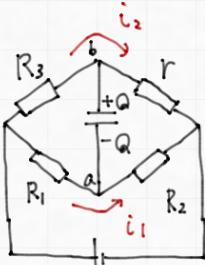
4 1

1. 点aと点bの電位が等しいので ホイントンブリッジ回路と同様 可変抵抗値をRとして

$$R_1 R = R_2 R_3 \quad \therefore R = \frac{R_2 R_3}{R_1}$$

$$2. \frac{V}{R_3 + R} = \frac{V}{R_3 + \frac{R_2 R_3}{R_1}} = \frac{R_2 V}{R_2 (R_1 + R)}$$

II



$$3. \left\{ \begin{array}{l} V = i_1 (R_1 + R_2) = i_2 (R_3 + r) \\ V_{ba} = \frac{Q}{C} = i_1 R_2 - i_2 r \end{array} \right.$$

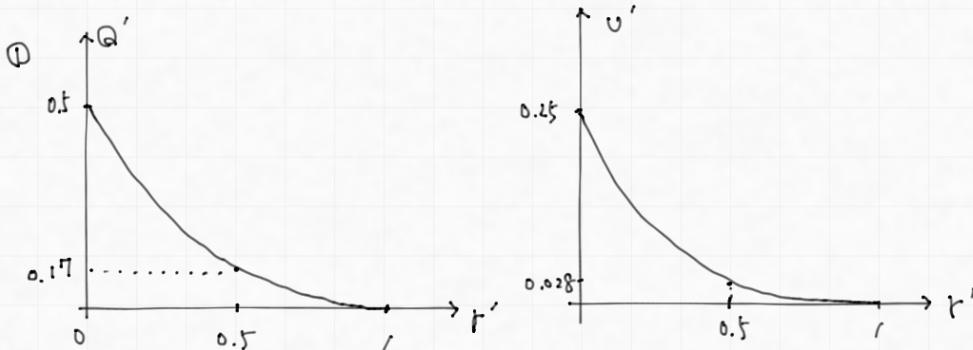
$$V_{ba} = \frac{R_2}{R_1 + R_2} V - \frac{r}{R_3 + r} V = \frac{(R_2 R_3 - r R_1) V}{(R_1 + R_2)(r + R_3)}$$

$$4. r \rightarrow 0 \text{ と } C \quad Q = C \frac{R_2 R_3 V}{(R_1 + R_2) R_3} = \frac{R_2 C V}{R_1 + R_2}$$

III

$$5. Q = \frac{(RR' - rR)Vc}{(R+r)(r+R)} = \frac{R-r}{2(R+r)} CV \quad Q' = \frac{R-r}{2(R+r)} = \frac{1 - \frac{r}{R}}{2(1 + \frac{r}{R})} = \frac{1-r'}{2(1+r')}$$

$$U = \frac{Q^2}{2C} = \frac{1}{2C} \times \frac{(1-r')^2}{4(1+r)^2} (CV)^2 = \frac{(1-r')^2}{4(1+r')^2} \times \frac{1}{2} CV^2 \quad U' = \frac{(1-r')^2}{4(1+r')^2}$$



5

1. 電波望遠鏡を右のように折り返した位置（図中X）を考えると距離差は図中の赤太線部に対応するので

$$2hs \sin\theta$$

$$2. 2hs \sin\theta \times \frac{1}{\lambda} \times 2\pi + \pi = 2\pi \left(\frac{2hs \sin\theta}{\lambda} + \frac{1}{2} \right)$$

$$3. 2\pi \left(\frac{2hs \sin\theta}{\lambda} + \frac{1}{2} \right) = (m+1) \times 2\pi$$

$$\frac{2hs \sin\theta}{\lambda} = m + \frac{1}{2} \quad \sin\theta = \frac{\lambda}{2h} \left(m + \frac{1}{2} \right)$$

$$4. \theta \doteq \frac{\frac{3 \times 10^8}{50 \times 10^3}}{2,200} \left(0 + \frac{1}{2} \right) = \frac{3 \times 10^2}{8,800 \times 10^3} = \frac{3}{400} = 7.5 \times 10^{-3} \text{ [rad]}$$

$$5. \lambda' = \frac{c - \frac{1}{20}c}{c} \lambda = \frac{19}{20} \lambda \text{ だから } \theta' = \theta \times \frac{19}{20} = 0.95\theta$$

