2017大阪医大(後)

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(1)
$$\begin{cases} x = v_0\cos 45^\circ t, & v_x = v_0\cos 45^\circ = \dfrac{v_0}{\sqrt{2}} \\ y = v_0 \sin 45^\circ t - \dfrac{1}{2}gt^2 \\ v_y = v_0\sin 45^\circ - gt \end{cases}$$

$$v_x : v_y = \sqrt{3} : -1$$

$$v_y = -\frac{1}{\sqrt{3}} \times \frac{v_0}{\sqrt{2}} = -\frac{v_0}{\sqrt{6}}$$

(2)
$$-\frac{v_0}{\sqrt{6}} = \frac{v_0}{\sqrt{2}} - gt$$

$$gt = \left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{6}}\right)v_0 \qquad t = \frac{3\sqrt{2}+\sqrt{6}}{6}\frac{v_0}{g}$$

(3) 衝突後のx方向の速度は $-\dfrac{v_0}{\sqrt{6}}$ だから
$$e = \frac{\frac{1}{\sqrt{6}}v_0}{\frac{1}{\sqrt{2}}v_0} = \frac{1}{\sqrt{3}}$$

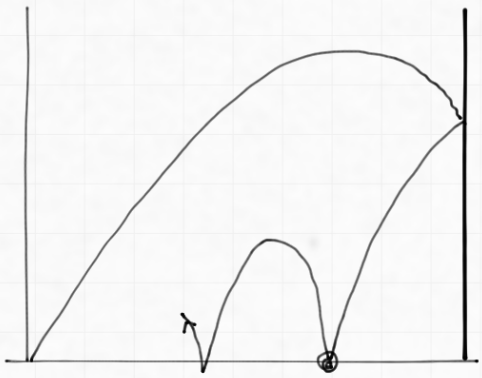
(4)
$$L = \frac{v_0}{\sqrt{2}} \times \frac{3\sqrt{2}+\sqrt{6}}{6} \times \frac{v_0}{g} = \frac{3+\sqrt{3}}{6}\cdot\frac{v_0^2}{g}$$

$$h_1 = \frac{v_0}{\sqrt{2}}\cdot\frac{3\sqrt{2}+\sqrt{6}}{6} \times \frac{v_0}{g} - \frac{1}{2}g\left(\frac{3\sqrt{2}+\sqrt{6}}{6}\right)^2\left(\frac{v_0}{g}\right)^2 = \frac{v_0^2}{6g}$$

(5) $y=0$となる時 $t = \dfrac{1}{g}\cdot\dfrac{v_0}{\sqrt{2}} \times 2$

$$\therefore t_1 = \sqrt{2}\frac{v_0}{g} - \frac{3\sqrt{2}+\sqrt{6}}{6}\cdot\frac{v_0}{g} = \frac{3\sqrt{2}-\sqrt{6}}{6}\cdot\frac{v_0^2}{g}$$

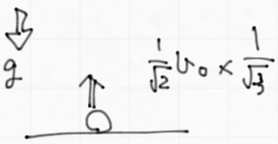
$$L_1 = \frac{1}{\sqrt{6}}v_0 \times t_1 = \frac{\sqrt{3}-1}{6}\frac{v_0^2}{g}$$



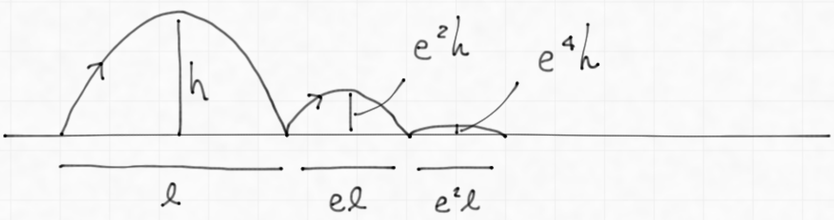
(6)
$$\frac{1}{\sqrt{2}}v_0 \times \frac{1}{\sqrt{3}} \times \frac{1}{g} = \frac{v_0}{\sqrt{6}g} = t_2$$

$$h_2 = \frac{1}{\sqrt{6}}v_0\cdot t_2 - \frac{1}{2}gt_2^2 = \frac{v_0^2}{12g}$$

$$L_2 = \frac{1}{\sqrt{6}}v_0 \times (t_2 \times 2) = \frac{1}{\sqrt{6}} \times \frac{v_0}{\sqrt{6}g} \times v_0 \times 2 = \frac{v_0^2}{3g}$$



(7) 下図より $\dfrac{1}{\sqrt{3}}$ 倍



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(1) $P_0V_0 = nRT_0$ より $T_0 = \frac{P_0V_0}{nR}$

(2) $P_0 aV_0 = nRT_B$ より

$T_B = \frac{aP_0V_0}{nR} = aT_0$

(3) 気体がされた仕事 $= -(P_0aV_0 - P_0V_0)$

$= (1-a)P_0V_0 = (1-a)nRT_0$

吸収した熱量 $= Q_{AB}$

$= -(1-a)nRT_0 + nC_v(T_B - T_0)$

$= -(1-a)n(R+C_v)T_0$

(4) $Q_{BC} = 0 + nC_v(T_C - T_B) = nC_v \cdot abT_0 - nC_v \cdot aT_0$

$= a(b-1)nC_vT_0$

(5) $bP_0(aV_0)^\gamma = P_D V_0^\gamma$ より $P_D = a^\gamma b P_0$

$T_D = \frac{V_0}{nR} a^\gamma b P_0 = a^\gamma b T_0 = a^{\frac{C_v+R}{C_v}} b P_0$

(6) $-nC_v(T_D - T_C) = -nC_v a^\gamma b T_0 + nC_v abT_0 = -(a^{\frac{C_v+R}{C_v}} - a)bnC_vT_0$

(7) B→C イ

(8) $\gamma = \frac{C_v+R}{C_v} = \frac{5}{3}$

AB での仕事 $= W_{AB} = P_0(\frac{1}{2}-1)V_0 = -\frac{1}{2}P_0V_0$

CD 〃 $= W_{CD} = -nC_v(T_D - T_C) = -(a^{\frac{5}{3}} - a)bnC_vT_0 = -\frac{1}{2}(2^{-\frac{2}{3}} - 1) \times 4 \times \frac{3}{2}nRT_0$

$= -\frac{3}{2}(2^{\frac{1}{3}} - 2)P_0V_0 = \frac{3}{2} \times (2 - 1.26)P_0V_0 = 1.11 P_0V_0$

$Q_{BC} = \frac{1}{2}(4-1) \cdot \frac{3}{2}P_0V_0 = \frac{9}{4}P_0V_0$

$e = \frac{W_{AB} + W_{CD}}{Q_{BC}} = \frac{-\frac{1}{2}P_0V_0 + 1.12P_0V_0}{\frac{9}{4}P_0V_0} = \frac{-2+4.48}{9} = \frac{2.48}{9} = 0.275\cdots = 0.28$

$2^{-\frac{2}{3}} = 2^{\frac{1}{3}-1} = 2^{\frac{1}{3}} \times \frac{1}{2}$

Ⓐ $P_0V_0 = nRT_0$

定圧 ↓ $Q_{AB} = P_0(a-1)V_0 + nC_v(T_B - T_0) = n(C_v+R)(T_B-T_0)$

Ⓑ $P_0 aV_0 = nRT_B$

定積 ↓ $Q_{BC} = 0 + nC_v(T_C - T_B)$

Ⓒ $bP_0aV_0 = nRT_C$

断熱膨張 ↓ $0 = W_{CD} + nC_v(T_D - T_C)$

$bP_0(aV_0)^\gamma = P_D V_0^\gamma$

Ⓓ $P_DV_0 = nRT_D$

定積 ↓ $Q_{DA} = 0 + nC_v(T_0 - T_D)$

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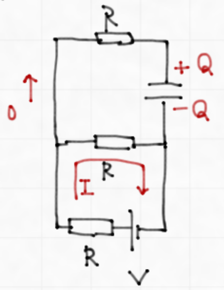
III (1)



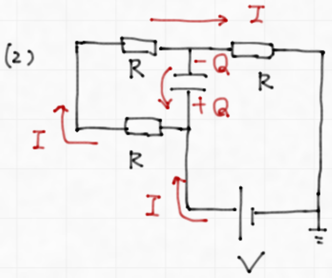
十分な時間が経ったとき、コンデンサーに流れこむ電流は 0 となる。

$-IR-IR+\frac{Q}{C}=0$

$$\begin{cases} V = IR + IR \\ V = IR + \frac{Q}{C} \end{cases}$$

$I = \frac{V}{2R}$　　$\frac{Q}{C} = \frac{1}{2}V$　　$\therefore Q = \mathbf{\frac{1}{2}CV}$

(2)



$$\begin{cases} V = IR + IR + IR \\ V = \frac{Q}{C} + IR \end{cases}$$

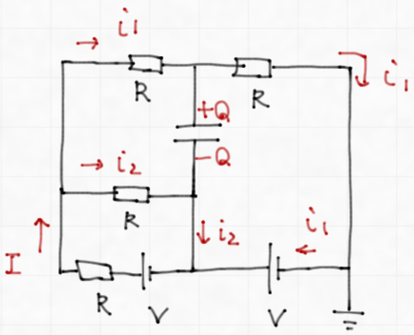
$I = \frac{V}{3R}$　　$Q = \frac{2}{3}CV$

このときコンデンサーが蓄えている静電エネルギー U は

$$U = \frac{Q^2}{2C} = \frac{1}{2C}\left(\frac{2}{3}CV\right)^2 = \frac{2}{9}CV^2$$

スイッチ S_2 を開くと、左側部分に電流が流れ、このエネルギーが左部分で失われる　　$\therefore \mathbf{\frac{2}{9}CV^2}$

(3)



$$\begin{cases} V = IR + i_2R & \cdots ① \\ V = IR + i_1R + \frac{Q}{C} & \cdots ② \\ V = -\frac{Q}{C} + i_1R & \cdots ③ \\ I = i_1 + i_2 & \cdots ④ \end{cases}$$

④より $i_2 = I - i_1$ を①に代入　　$V = IR + IR - i_1R = 2IR - i_1R$ …⑤

②＋③　　$2V = IR + 2i_1R$ …⑥

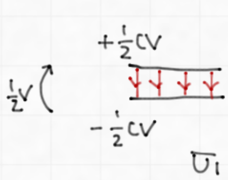
⑤×2＋⑥　　$4V = 5IR$　　$I = \frac{4V}{5R}$ …⑦

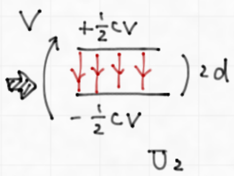
⑦を⑤に代入　　$V = \frac{8}{5}V - i_1R$　　$i_1 = \frac{3V}{5R}$ …⑧

④に⑦⑧を代入　　$i_2 = \frac{4V}{5R} - \frac{3V}{5R} = \frac{V}{5R}$ …⑨

③に⑧を代入　　$\frac{Q}{C} = \frac{3}{5}V - V$　　$Q = -\frac{2}{5}CV$　　$\therefore \mathbf{-\frac{2}{5}CV}$

(4)　(1)より $\frac{1}{2}CV$ の電荷がたまった状態にある。

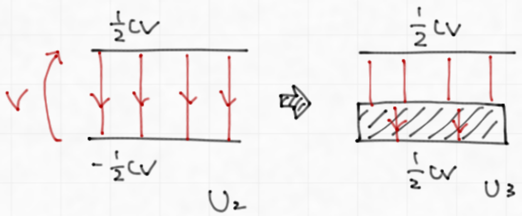




$$\Delta U = U_2 - U_1$$
$$= \frac{1}{2}\cdot\left(\frac{1}{2}CV\right)\cdot V - \frac{1}{2}\left(\frac{1}{2}CV\right)\left(\frac{1}{2}V\right) = \frac{1}{8}CV^2 = F\times d$$

$$F = \mathbf{\frac{CV^2}{8d}}$$

(5)　比誘電率 $\varepsilon_r = 2$.



合成容量 C' は　$\frac{1}{C} + \frac{1}{2C} = \frac{1}{C'}$ より $C' = \frac{2}{3}C$

$$U_3 = \frac{\left(\frac{1}{2}CV\right)^2}{2\cdot\frac{2}{3}C} = \frac{3}{16}CV^2$$

このエネルギーが失われ、ジュール熱となる　　$\mathbf{\frac{3}{16}CV^2}$

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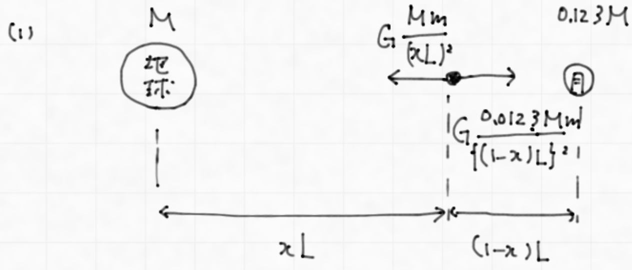
IV

(1)



$$\cancel{G}\frac{\cancel{M}m}{(x\cancel{L})^2} = \cancel{G}\frac{0.0123\cancel{M}\cancel{m}}{\{(1-x)\cancel{L}\}^2}$$

$$0.0123x^2 = (1-x)^2$$

$$\pm 0.0123^{\frac{1}{2}}x = 1-x$$

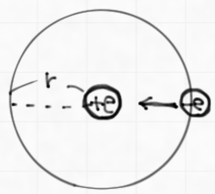
$$x = \frac{1}{1+0.0123^{\frac{1}{2}}} \quad (\because x<1)$$

$$= (1+0.0123^{\frac{1}{2}})^{-1} \fallingdotseq 1-0.0123^{\frac{1}{2}}$$

$$= 1-0.11 = 0.89 \fallingdotseq \mathbf{0.9}$$

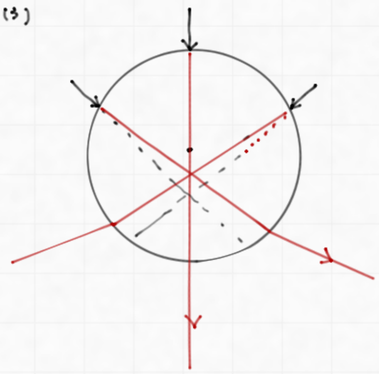
$x \ll 1$ $\quad \frac{1}{1+x} = (1+x)^{-1} \fallingdotseq 1-x$

(2)



$$m\frac{v^2}{r} = k\frac{e^2}{r^2} \qquad \therefore v = e\sqrt{\frac{k}{mr}}$$

(3)



光は下方向に力を及ぼす

屈折の方向を考えると光は下方向の運動量を減らしている。これは上向きの力積を受けていることを示しており、球は、その反作用を受けることから下向きの力積を受けていることが分かる。