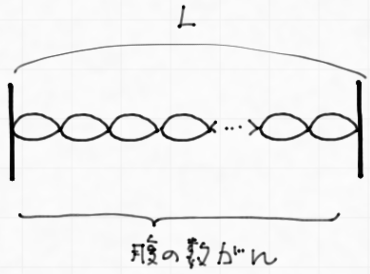
大阪府立大中期2022



1 (1a) $\lambda = \dfrac{2L}{n}$ (右図)　　(1b) $\nu = \dfrac{c}{\lambda} = \dfrac{nc}{2L}$

(2) $\lambda' = \dfrac{2L+2\Delta L}{n}$　　$\nu' = \dfrac{c}{\lambda'} = \dfrac{nc}{2L+2\Delta L}$

$$\Delta\nu = \nu - \nu' = \frac{nc}{2L} - \frac{nc}{2L+2\Delta L} = \frac{nc}{2L}\left(1 - \left(1+\frac{\Delta L}{L}\right)^{-1}\right)$$

$$\fallingdotseq \frac{nc}{2L}\left(1-1+\frac{\Delta L}{L}\right) = \frac{nc}{2L^2}\Delta L = \frac{\nu}{L}\Delta L$$

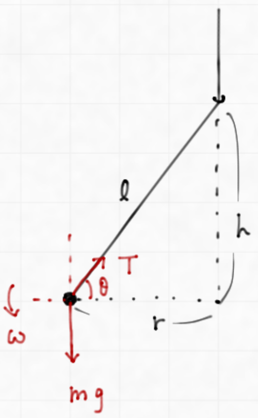
(3) 往復に要する時間は $\dfrac{2L}{c}$　1秒間の衝突回数は $\dfrac{c}{2L}$ だから $\dfrac{ct}{2L}$

(4) 運動量の向きが反転するので p から $-p$ へと変化し、光子の受ける力積は $-p-p=-2p$ だと分かる。したがって M_2の受ける力積は $2p$

(5) $\bar{F} \times t = \cancel{2}p \times \dfrac{ct}{\cancel{2}L}$ より $\bar{F} = \dfrac{pc}{L}$

M_2の行う仕事は $\bar{F} \times \Delta L \times (-1) = -pc\dfrac{\Delta L}{L}$

M_2が仕事をした分だけ光子のエネルギーは変化する $\Delta E = -\bar{F}\Delta L = -pc\dfrac{\Delta L}{L}$



(6a) $\begin{cases} T\cos\theta = mr\omega^2 \\ T\sin\theta = mg \end{cases}$, $\cos\theta = \dfrac{r}{l}$, $\sin\theta = \dfrac{h}{l}$

$$T = \frac{mg}{\sin\theta} = \frac{mgl}{h}$$

(6b) $\omega = \sqrt{\dfrac{T\cos\theta}{mr}} = \sqrt{\dfrac{\cancel{m}gl \times \cancel{r}}{\cancel{m}\cancel{r}h\cancel{l}}} = \sqrt{\dfrac{g}{h}}$

(7) $E = \dfrac{1}{2}m(r\omega)^2 = \dfrac{1}{2}mr^2\cdot\dfrac{g}{h} = \dfrac{mgr^2}{2h} = \dfrac{mg}{2h}(l^2-h^2)$

(8) $-T\Delta l = \Delta E - mg\Delta h$

(9a)
(9b) $\Delta E = \dfrac{mg}{2}\left(\dfrac{(l+\Delta l)^2}{h+\Delta h} - (h+\Delta h)\right) - \dfrac{mg}{2}\left(\dfrac{l^2}{h} - h\right) = \dfrac{mg}{2}\left\{\dfrac{l^2}{h} \times \dfrac{\left(1+\frac{\Delta l}{l}\right)^2}{1+\frac{\Delta h}{h}} - h - \Delta h\right\} - \dfrac{mg}{2}\left(\dfrac{l^2}{h} - h\right)$

$$= \frac{mg}{2}\left[\frac{l^2}{h}\left\{\left(1+\frac{\Delta l}{l}\right)^2\left(1+\frac{\Delta h}{h}\right)^{-1} - 1\right\} - \Delta h\right] \fallingdotseq \frac{mg}{2}\left[\frac{l^2}{h}\left(2\frac{\Delta l}{l} - \frac{\Delta h}{h}\right) - \Delta h\right] = -\frac{mg}{2}\left(\frac{l^2}{h^2}+1\right)\Delta h + \frac{mgl}{h}\Delta l$$

(10) $\Delta E = -\dfrac{mg}{2}\left(\dfrac{l^2}{h^2}+1\right)\Delta h + \dfrac{\cancel{mgl}}{\cancel{h}}\left(\dfrac{\Delta E - mg\Delta h}{-\frac{\cancel{mgl}}{\cancel{h}}\ -1}\right)$

$$2\Delta E = \left(-\frac{mgl^2}{2h^2} - \frac{mg}{2} + mg\right)\Delta h = \frac{1}{2}mg\left(1 - \frac{l^2}{h^2}\right)\Delta h = \frac{mg}{2h}(h^2 - l^2)\frac{1}{h}\Delta h = -\frac{E}{h}\Delta h$$

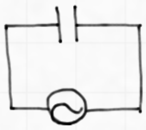
(11) $\omega + \Delta\omega = \sqrt{\dfrac{g}{h+\Delta h}} = \sqrt{\dfrac{g}{h}}\left(1+\dfrac{\Delta h}{h}\right)^{-\frac{1}{2}} \fallingdotseq \sqrt{\dfrac{h}{g}}\left(1 - \dfrac{\Delta h}{2h}\right)$　∴ $\Delta\omega = -\dfrac{\omega}{2h}\Delta h$

(12a)
(12b) $\Delta E = -\dfrac{E}{2h}\Delta h = \dfrac{E}{\omega}\Delta\omega = \dfrac{E}{\omega}2\pi\Delta\nu$　　$\dfrac{E+\Delta E}{\nu+\Delta\nu} = \dfrac{E\left(1+\frac{1}{\nu}\Delta\nu\right)}{\nu+\Delta\nu} = \dfrac{E}{\nu}$

$\dfrac{E-\Delta E}{\nu-\Delta\nu} = \dfrac{E - pc\frac{\Delta L}{L}}{\nu - \frac{\nu}{L}\Delta L} = \dfrac{E}{\nu}$ より $\cancel{E} - pc\dfrac{\Delta L}{L} = \cancel{E} - E\dfrac{1}{L}\Delta L$

$$\therefore p = \frac{E}{\cancel{L}}\cancel{\Delta L} \times \frac{\cancel{L}}{c\cancel{\Delta L}} = \frac{E}{c}$$

2

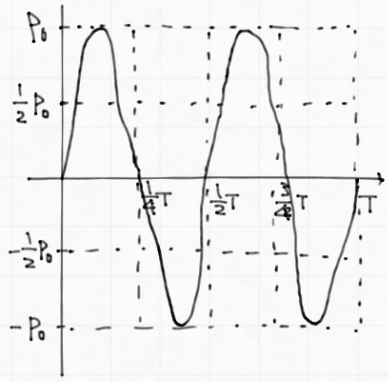


(1) $Q = CV = \mathbf{CV_0 \sin 2\pi f t}$

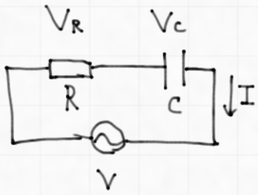
(2) $I = \dfrac{Q(t+\Delta t) - Q(t)}{\Delta t} = \mathbf{2\pi f CV_0 \cos 2\pi f t}$

(3) $P = IV = 2\pi f C^2 V_0^2 \cos 2\pi f t \sin 2\pi f t$

$= \pi f C^2 V_0^2 \sin 4\pi f t$

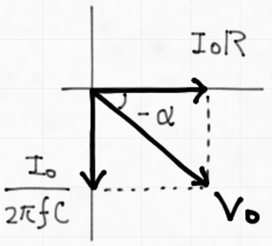


$\dfrac{1}{2\pi f C}$ (Ω)



(4) コンデンサーの平均消費電力は 0

抵抗のみを考える.



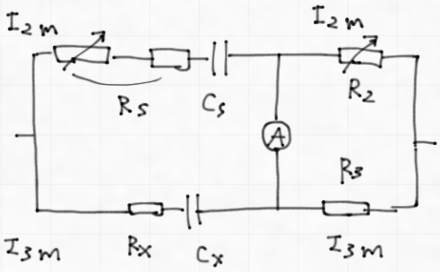
$$P = \underbrace{\frac{I_0}{\sqrt{2}}} \times \underbrace{\frac{V_0 \cos(-\alpha)}{\sqrt{2}}} = \mathbf{\frac{1}{2} V_0 I_0 \cos\alpha}$$

実効値

(5) $V_{R0} = \mathbf{I_0 R}$

(6) $V_0 = \sqrt{(I_0 R)^2 + \left(\dfrac{I_0}{2\pi f C}\right)^2} = \mathbf{I_0 \sqrt{R^2 + \dfrac{1}{4\pi^2 f^2 C^2}}}$

(7) $\tan\alpha = \mathbf{-\dfrac{1}{2\pi f C R}}$



(8)
$$\begin{cases} I_{2m} R_2 = I_{3m} R_3 \\ (I_{2m} R_S)^2 + \left(I_{2m} \dfrac{1}{2\pi f C_S}\right)^2 = (I_{3m} R_X)^2 + \left(I_{3m} \dfrac{1}{2\pi f C_X}\right)^2 \\ \dfrac{1}{2\pi f C_S R_S} = \dfrac{1}{2\pi f C_X R_X} \end{cases}$$

$I_{2m} R_S = I_{3m} R_X$

$I_{2m} = \mathbf{\dfrac{R_3}{R_2} I_{3m}}$

(9) $C_X = \mathbf{\dfrac{R_S}{R_X} C_S}$

(10) $\dfrac{\sqrt{R_S^2 + \left(\dfrac{1}{2\pi f C_S}\right)^2}}{\sqrt{R_X^2 + \left(\dfrac{1}{2\pi f C_X}\right)^2}} = \dfrac{I_{3m}}{I_{2m}} = \mathbf{\dfrac{R_S}{R_X}}$

(11) $\dfrac{I_{3m}}{I_{2m}} = \dfrac{R_S}{R_X} = \dfrac{R_2}{R_3}$ $R_X = \mathbf{\dfrac{R_3}{R_2} R_S}$

(12) $R_X = \dfrac{3.5 \times \cancel{10^2}}{7.5 \times \cancel{10^2}} \times 3.0 = \dfrac{21}{15} = \dfrac{7}{5}$

$C_X = \dfrac{3}{\frac{7}{5}} \times 2.2 \times 10^{-6} = \dfrac{33}{7} \times 10^{-6} = \mathbf{4.7 \times 10^{-6}}$ (F)