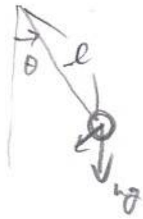
R2

1.

(1) ml^2

(2) $mgl\sin\theta$



(3) $ml^2\ddot{\theta} = -mgl\sin\theta$

$\approx -mgl\cdot\theta$

(4) $\ddot{\theta} = -\frac{mgl}{ml^2}\cdot\theta = -\frac{g}{l}\theta$

$\therefore T = 2\pi\sqrt{\frac{l}{g}}$

$\int_0^{2\pi}\int_0^R \frac{M}{\pi R^2}\cdot r^2\cdot r\,dr\,d\theta$

$= 2\pi\cdot\frac{M}{\pi R^2}\cdot\left[\frac{r^4}{4}\right]_0^R = \frac{1}{2}MR^2$

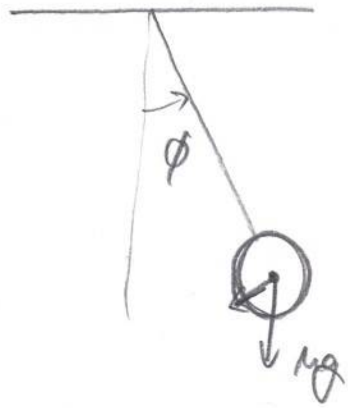
(7), (8)

Cまわりの慣性モーメントIcは

$I_C = \frac{1}{2}MR^2$

よって、Pまわりの慣性モーメントIは

$I = I_C + ML^2 = \frac{1}{2}MR^2 + ML^2$



(5) $I\ddot{\phi} = -MgL\sin\phi \approx -MgL\cdot\phi$

(6) $\ddot{\phi} = -\frac{MgL}{I}\cdot\phi$

$\therefore T = 2\pi\sqrt{\frac{I}{MgL}} = 2\pi\sqrt{\frac{\frac{1}{2}MR^2 + ML^2}{MgL}} = 2\pi\sqrt{\frac{\frac{R^2}{2}+L^2}{gL}}$

(9) $2\pi\sqrt{\frac{\frac{R^2}{2}+L^2}{gL}} = 2\pi\sqrt{\frac{l}{g}}$

$\therefore l = \frac{R^2}{2L} + L$

3.

(1) $W_{AB} = \int_{A\to B} p\,dV = \int_{V_A}^{V_B} \frac{RT_H}{V}\,dV = RT_H \ln\frac{V_B}{V_A}$

(2) $PV^{\gamma} = PV^{\frac{C_V+R}{C_V}} = PV^{1+\frac{R}{C_V}} = \text{const.}$

(3) $\begin{cases} T_H V_A^{\gamma-1} = T_L V_D^{\gamma-1} \\ T_H V_B^{\gamma-1} = T_L V_C^{\gamma-1} \end{cases}$

$\Delta U = Q - p\,dV$

$\therefore \frac{V_B}{V_A} = \frac{V_C}{V_D}$

(4) $W_{BC} = -\Delta U_{BC}$

$= -C_V(T_L - T_H)$

$= C_V(T_H - T_L)$

$W_{DA} = -\Delta U_{DA}$

$= -C_V(T_H - T_L)$

$\therefore W_{BC} + W_{DA} = 0$

(5)

$C\to D$ で行う仕事 W_{CD} は

$W_{CD} = \int_{C\to D} p\,dV = \int_{V_C}^{V_D} \frac{RT_L}{V}\,dV = RT_L \ln\frac{V_D}{V_C} = -RT_L \ln\frac{V_C}{V_D}$

$= -RT_L \ln\frac{V_B}{V_A}$

また，$A\to B$ について等温変化より $\Delta U_{AB} = 0$.

$\therefore Q_H = W_{AB}$

したがって，

$\frac{W_{ex}}{Q_H} = \frac{W_{AB} + W_{BC} + W_{CD} + W_{DA}}{W_{AB}}$

$= 1 + \frac{W_{CD}}{W_{AB}}$

$= 1 - \frac{T_L}{T_H}$