P.2

① $(m_t + m_p)\ddot{x} + m_p l \ddot{\theta}_B = u - b\dot{x}$

② $m_p l \ddot{x} + (I + m_p l^2)\ddot{\theta}_B = -m_p l g \theta_B$

$\mathcal{L}\downarrow$

① $(m_t + m_p)s^2 X(s) + m_p l s^2 \Theta(s) = U(s) - bsX(s)$

② $m_p l s^2 X(s) + (I + m_p l^2)s^2 \Theta(s) = -m_p l g \Theta(s)$

① $\left[(m_t + m_p)s^2 + bs\right] X(s) + m_p l s^2 \Theta(s) = U(s)$

② $m_p l s^2 X(s) = -\left[(I + m_p l^2)s^2 + m_p l g\right]\Theta(s)$

$$\Rightarrow X(s) = -\left[\frac{I s^2}{m_p l s^2} + \frac{m_p l^2 s^2}{m_p l s^2} + \frac{m_p l g}{m_p l s^2}\right]\Theta(s)$$

$$\Rightarrow X(s) = -\left[\frac{I}{m_p l} + l + \frac{g}{s^2}\right]\Theta(s)$$

② $\xrightarrow{X(s)}$ ①

$$-\left[m_t s^2 + m_p s^2 + bs\right]\left[\frac{I}{m_p l} + l + \frac{g}{s^2}\right]\Theta(s) + m_p l s^2 \Theta(s) = U(s)$$

$$\Rightarrow -\left\{\frac{m_t I}{m_p l}s^2 - m_t l s^2 - m_t g \frac{s^2}{s^2} - \frac{m_p I}{m_p l}s^2 - m_p l s^2 - m_p g \frac{s^2}{s^2}\right.$$

$$\left. - \frac{bI}{m_p l}s - bls - bg\frac{s}{s^2}\right]\Theta(s) + m_p l s^2 \Theta(s) = U(s)$$

③ $\Rightarrow \left(\left[m_p l - \frac{m_t I}{m_p l} - m_t l - \frac{I}{l} - m_p l\right]s^2 - \left[\frac{bI}{m_p l} + bl\right]s - \left[m_t g + m_p g\right]\right.$

$$\left. - bg\frac{1}{s}\right)\Theta(s) = U(s)$$

$s \cdot$ ③ $\left(-\left[\frac{m_t I + m_t m_p l I + m_p I}{m_p l}\right]s^3 - \left[\frac{bI}{m_p l} + bl\right]s^2 - \left[(m_t g + m_p g)\right]s - bg\right)\Theta(s) = U(s)s$

$$\boxed{\frac{\Theta_B(s)}{U(s)} = \frac{-s}{\underbrace{\left(\frac{m_t I + m_t m_p l I + m_p I}{m_p l}\right)}_{a}s^3 + \underbrace{\left(\frac{bI + m_p bl}{m_p l}\right)}_{b}s^2 + \underbrace{(m_t + m_p)g}_{c}s + \underbrace{bg}_{d}}}$$