

$$f_0 = \frac{1}{2\pi} \sqrt{\frac{k_L - m_P \cdot g \cdot \frac{m_L \frac{L_L}{2} + m_P L_P}{m_S} - m_L \cdot g \cdot \frac{m_L \frac{L_L}{2} + m_P L_P}{m_S}}{\frac{1}{3} \cdot m_L \cdot L_L^2 + m_P \cdot L_P^2 + m_S \cdot \left(\frac{m_L \frac{L_L}{2} + m_P L_P}{m_S}\right)^2}}$$

$$\begin{aligned} \omega_0 = 2\pi f_0 &= \sqrt{\frac{k_L}{m_S}} = \sqrt{k_L \cdot \left(\frac{1}{m_L} + \frac{1}{m_P}\right)} = \sqrt{\frac{F_L}{\Delta L} \cdot \left(\frac{1}{m_L} + \frac{1}{m_P}\right)} \\ &= \sqrt{\frac{m_S \cdot \ddot{x}}{\frac{1}{2} \ddot{x} t^2 + \dot{x}_0 t + x_0} \cdot \frac{m_L + m_P}{m_L \cdot m_P}} \end{aligned}$$