$$m_h l_v \ddot{\theta} = (m_h + m_v) g \theta_v - \tau \; ; \; m_h \ddot{x} = \tau - m_v g \theta_v$$

$$x_1 = \theta \quad \dot{x}_1 = \dot{\theta} = x_2$$

$$\ddot{x}_1 = \ddot{\theta} = \dot{x}_2$$

$$x_3 = x$$

$$\dot{x}_3 = \dot{x} = x_4$$

$$\ddot{x}_3 = \ddot{x} = \dot{x}_4$$

$$m_h \dot{x}_4 = \tau - m g x_1$$

$$\dot{x}_4 = \frac{\tau}{m_h} - \frac{m_v g \theta_v}{m_h} \qquad \dot{x}_2 = \frac{(m_h + m_v) g}{m_h l_v} x_1 - \frac{\tau}{m_h l_v}$$

State Space equation

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \\ \dot{x}_4 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ \frac{(m_h+m_v)g}{m_h l_v} & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ -\frac{m_v}{m_h} g & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} + \begin{bmatrix} 0 \\ -\frac{1}{m_h l_v} \\ 0 \\ \frac{1}{m_h} \end{bmatrix} [\tau]$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} + [0][\tau] \qquad \begin{matrix} y_1 = \theta \\ y_2 = x \end{matrix}$$