

### The System:

The system is not a conventional inverted pendulum, but it is such that it steers a horizontal balancing rod in the presence of gravity to control the vertical pendulum rod. The overall system contains both the right half plane poles (unstable) and zeroes (non-minimum phase). The friction effects have been neglected and the overall model can be shown as follows:

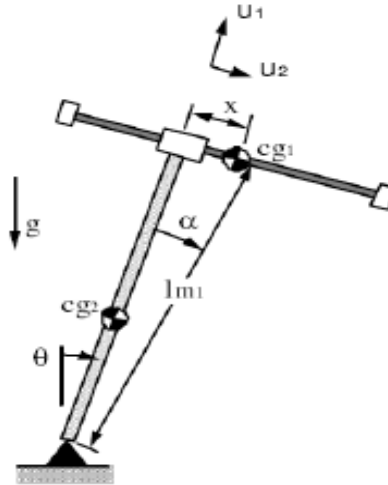


Fig: Model of the Plant

### Linearized Model:

The linearized model of the plant can be written in the form of state-space equations as:

$$m_1 \ddot{x}(t) + m_1 l_0 \ddot{\theta}(t) - m_1 g \theta(t) = F(t)$$

$$m_1 l_0 \ddot{x}(t) + J_0 \ddot{\theta}(t) - (m_1 l_0 + m_2 l_c) g \theta(t) - m_1 g x(t) = 0$$

Here  $F(t)$  is the input signal and we have two outputs  $\theta$  and  $x$ .

### System Parameters:

The values for the parameters are given in the table below:

$m_1$	0.213 kg
$m_2$	1.785 kg
$l_0$	0.330 m
$J_0$	0.0246 kg-m <sup>2</sup>
$l_c$	0.071 m