

1(a). FBD of Mass in FlightAssumptions

- Spring and damper are massless.
- Ideal Spring

FBD of mass in Stance ( $\dot{y} < 0$  stage)Flight Dynamics

$$\cdot \sum F = m\ddot{y} \rightarrow -Mg = m\ddot{y} \rightarrow \ddot{y} = -g$$

Stance Dynamics

$$\cdot \sum F = m\ddot{y} \rightarrow u(t) + F_s + F_d - Mg = m\ddot{y}$$

• Expanding we get,

$$u(t) - k(y - l_0) - c\dot{y} - Mg = m\ddot{y}$$

• Substituting  $x$ , and solving for  $\ddot{y}$  gives,

$$\ddot{y} = \frac{u(t) - k(x_1 - l_0) - cx_2 - Mg}{m}$$

$$\therefore \ddot{y} = \left\{ \begin{array}{l} -g, \text{ if } y > l_0 \\ \frac{u(t) - k(x_1 - l_0) - cx_2 - Mg}{m}, \text{ if } y \leq l_0 \end{array} \right\}$$

$$\text{where } x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} y \\ \dot{y} \end{bmatrix}$$