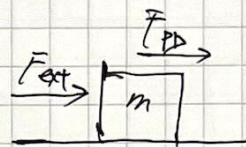


F : control force, F_{ext} : external force

$$m\ddot{x} = F + F_{ext}$$

$$F = k_p(x_d - x) - k_d\dot{x}$$

$$m\ddot{x} + k_d\dot{x} = k_p(x_d - x) - k_d\dot{x} = F_d = F$$



$$m\ddot{x} = F + F_{ext}$$

$$F_{ext} = m\ddot{x} - F = m\ddot{x} - F_d = m\ddot{x} - [k_p(x_d - x) - k_d\dot{x}]$$

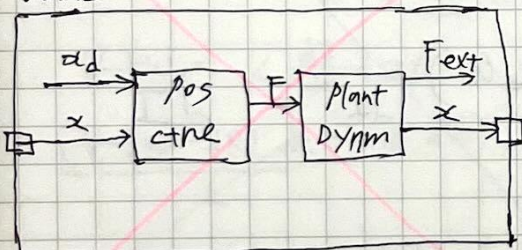
$$= m\ddot{x} + k_d\dot{x} + k_p(x - x_d)$$

$$= M_d(\ddot{x}_d - \ddot{x}_0) + B_d(\dot{x}_d - \dot{x}_0) + K_d(x - x_0)$$

while



while



$$Z(s) = \frac{F(s)}{V(s)} = \frac{Ms^2 + Cs + \frac{K}{s}}{s} = Ms + C + \frac{K}{s}$$

Inertial $\Leftrightarrow |Z(0)| = 0$

Resistive $\Leftrightarrow |Z(0)| = C$

Capacitive $\Leftrightarrow |Z(0)| = \infty$

contact motion \rightarrow soft motion control
free " \rightarrow stiff motion control