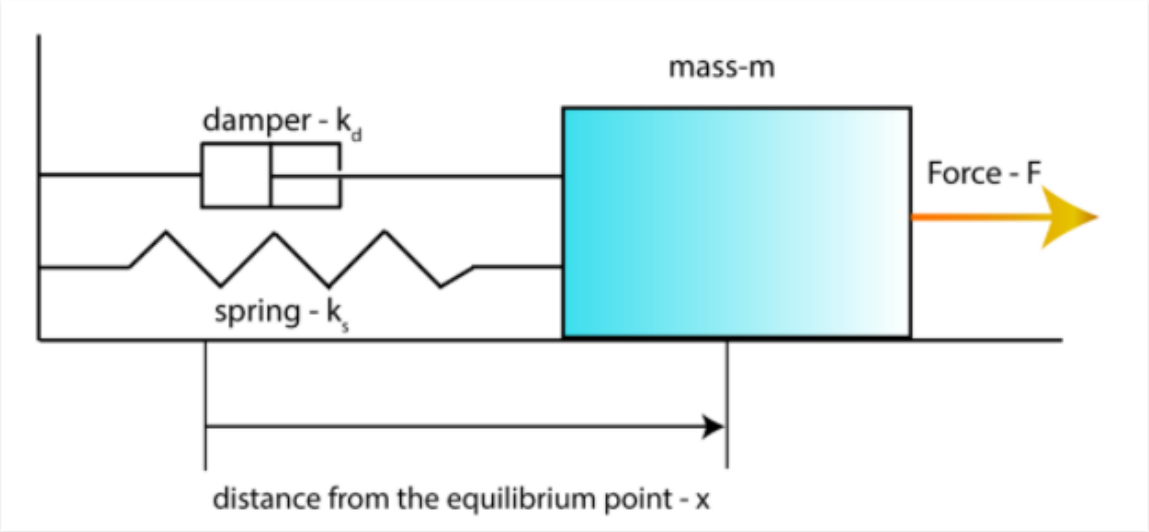
A mass-spring-damper system:

- *Source:* Introduction to MATLAB Control System Toolbox – Defining Models and Computing Responses | Aleksandar Haber



The differential equation:

$$m\ddot{x} + k_d\dot{x} + k_s x = F$$

Laplace equation:

$$ms^2X(s) + k_d sX(s) + k_s X(s) = F(s)$$

Transfer Function:

$$W(s) = \frac{X(s)}{F(s)} = \frac{1}{ms^2 + k_d s + k_s}$$

State-space representation:

$$x_1 = x$$
$$x_2 = \dot{x}$$

$$\underbrace{\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}}_{\dot{\mathbf{x}}} = \underbrace{\begin{bmatrix}0 & 1\\ -\frac{k_s}{m} & -\frac{k_d}{m}\end{bmatrix}}_{A}\underbrace{\begin{bmatrix}x_1\\ x_2\end{bmatrix}}_{x} + \underbrace{\begin{bmatrix}0\\ \frac{1}{m}\end{bmatrix}}_{B}\underbrace{F}_{u}$$

$$y = \underbrace{\begin{bmatrix}1 & 0\end{bmatrix}}_{C}\underbrace{\begin{bmatrix}x_1\\ x_2\end{bmatrix}}_{\mathbf{x}} + \underbrace{0}_{D}\cdot\underbrace{F}_{u}$$