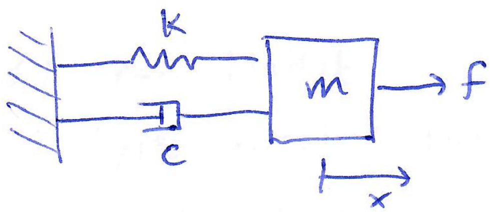
ME 4555 - Lecture 9 - Intro to Simulink

Simulink is an application built in to Matlab that can simulate a dynamical system. To do this, we must represent the dynamics using a block diagram. We will illustrate using a standard spring-mass-damper system.



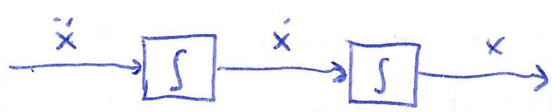
$$m\ddot{x} + c\dot{x} + kx = f$$

Step 1: isolate highest-order derivative ($\ddot{x}$)

$$\ddot{x} = \frac{1}{m}\left(f - c\dot{x} - kx\right)$$

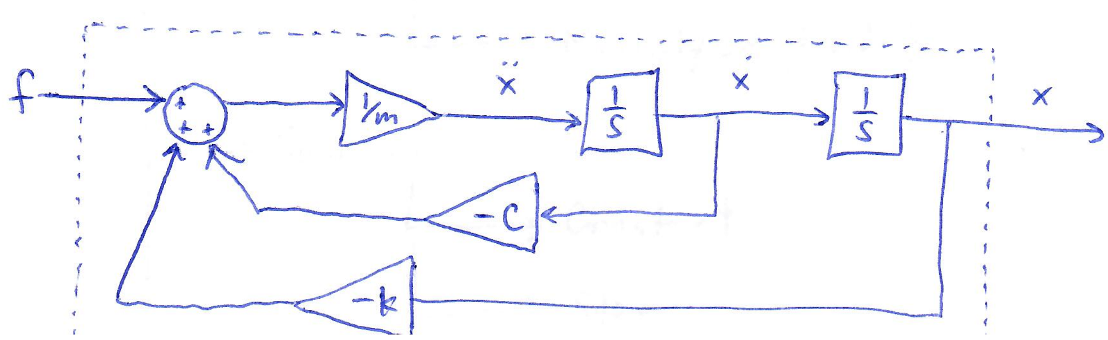
it takes two integrators to reduce $\left\{\ddot{x} \xrightarrow{\int} \dot{x} \xrightarrow{\int} x\right\}$ to x.

Step 2 create chain starting from $\ddot{x}$ and ending at x:



integrators in Simulink are denoted " $\boxed{\frac{1}{s}}$ ". we'll see why later!

Step 3 use gain blocks -▷- and summing junctions -⊕- to re-create the EOM:



Basic steps

1) open Matlab
2) type simulink [ENTER] or find simulink button in "Home" toolbar
3) create blank model.
4) click "Library Browser" button to access blocks.
5) most useful blocks (in Library browser) for right now:

- → Simulink
  - → Continuous
    - → integrator
    - → derivative
  - → Math Operations
    - → Add (or Sum)
    - → Gain
    - → Multiply (or divide)
  - → Sources
    - → Constant
    - → Step
    - → Sine wave
  - → Sinks
    - → Scope

Useful commands and procedures

★ Connecting blocks:

- click source then click destination (click the ports)
- click source block then control-click destination

★ Creating/placing blocks:

- drag block from Library Browser
- double-click empty space and start typing block name

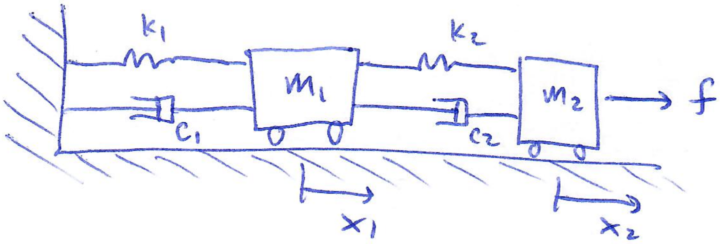
★ Duplicating

- select items, control-C, control-V (copy-paste)
- Control-click + drag selection to make copy.

Other useful things

- Add names to signals (click the signal arrow + type name)
- Rotate a block (control-R)
- Change block parameters (double-click block)
- define constants in Matlab workspace, use symbols in Simulink!
- Add legend to Scope (view menu → legend)
- Increase resolution/smoothness: "Modeling tab" → Model Settings (or Control-E) Solver → Max. step size. **or** Data Import/Export → Additional Parameters,

Ex. EOM for two masses



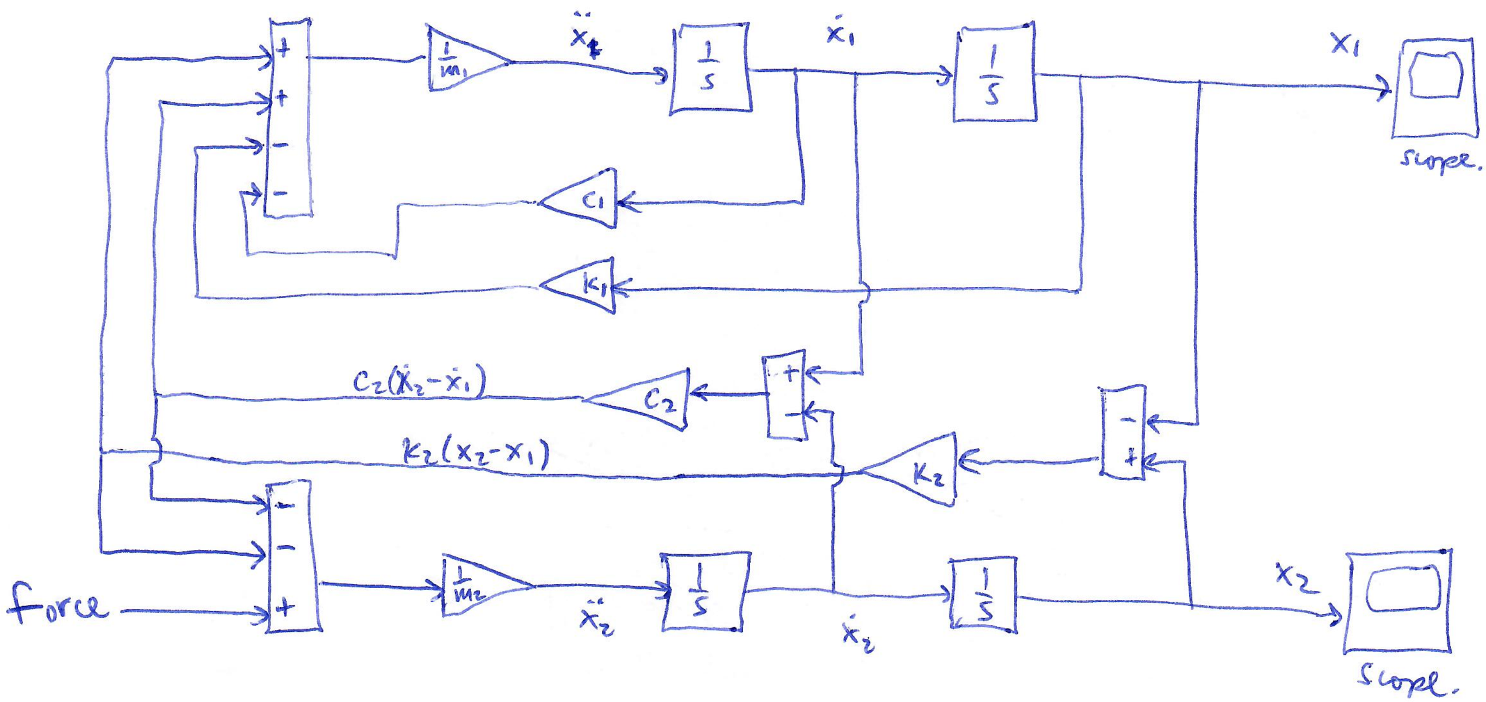
$$\begin{cases} m_1\ddot{x}_1 + c_1\dot{x}_1 + k_1x_1 = k_2(x_2-x_1) + c_2(\dot{x}_2-\dot{x}_1) \\ m_2\ddot{x}_2 + c_2(\dot{x}_2-\dot{x}_1) + k_2(x_2-x_1) = f \end{cases}$$

1) Re-arrange:

$$\ddot{x}_1 = \frac{1}{m_1}\left(-c_1\dot{x}_1 - k_1x_1 + c_2(\dot{x}_2-\dot{x}_1) + k_2(x_2-x_1)\right)$$

$$\ddot{x}_2 = \frac{1}{m_2}\left(f - c_2(\dot{x}_2-\dot{x}_1) - k_2(x_2-x_1)\right)$$

2) draw!



Ex : DC motor dynamics.

$$\begin{cases} L\dfrac{di}{dt} + Ri + V_b = V_{in} \\ T = K_t i \\ J\dot{\omega} = T - b\omega - T_L \\ V_b = K_b \omega \end{cases} \Rightarrow \begin{cases} \dfrac{di}{dt} = \dfrac{1}{L}\left(V_{in} - V_b - Ri\right) \\ T = K_t i \\ \dot{\omega} = \dfrac{1}{J}\left(T - b\omega\right) \\ V_b = K_b \omega \end{cases}$$