Lab1: Simulink

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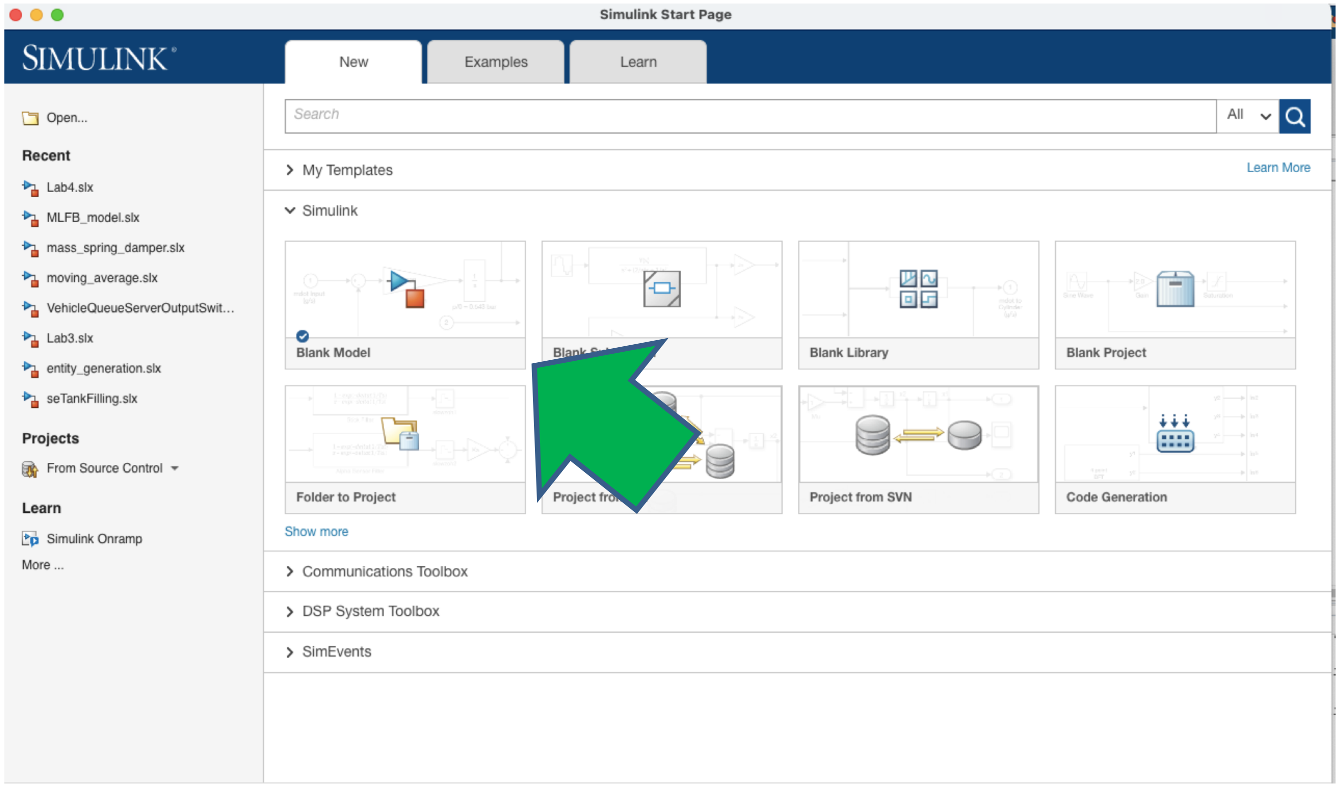
Matlab Simulink

- To open Simulink, do one of the following things
  - from Matlab prompt type "`simulink`"
  - click on the Simulink icon in the Home Toolbar (if present)
  - open an already existing Simulink model (with extension .slx) by
    - double-clicking on its name on the "Current Folder" window
    - by typing open_system(model_name) at Matlab prompt

Matlab Simulink

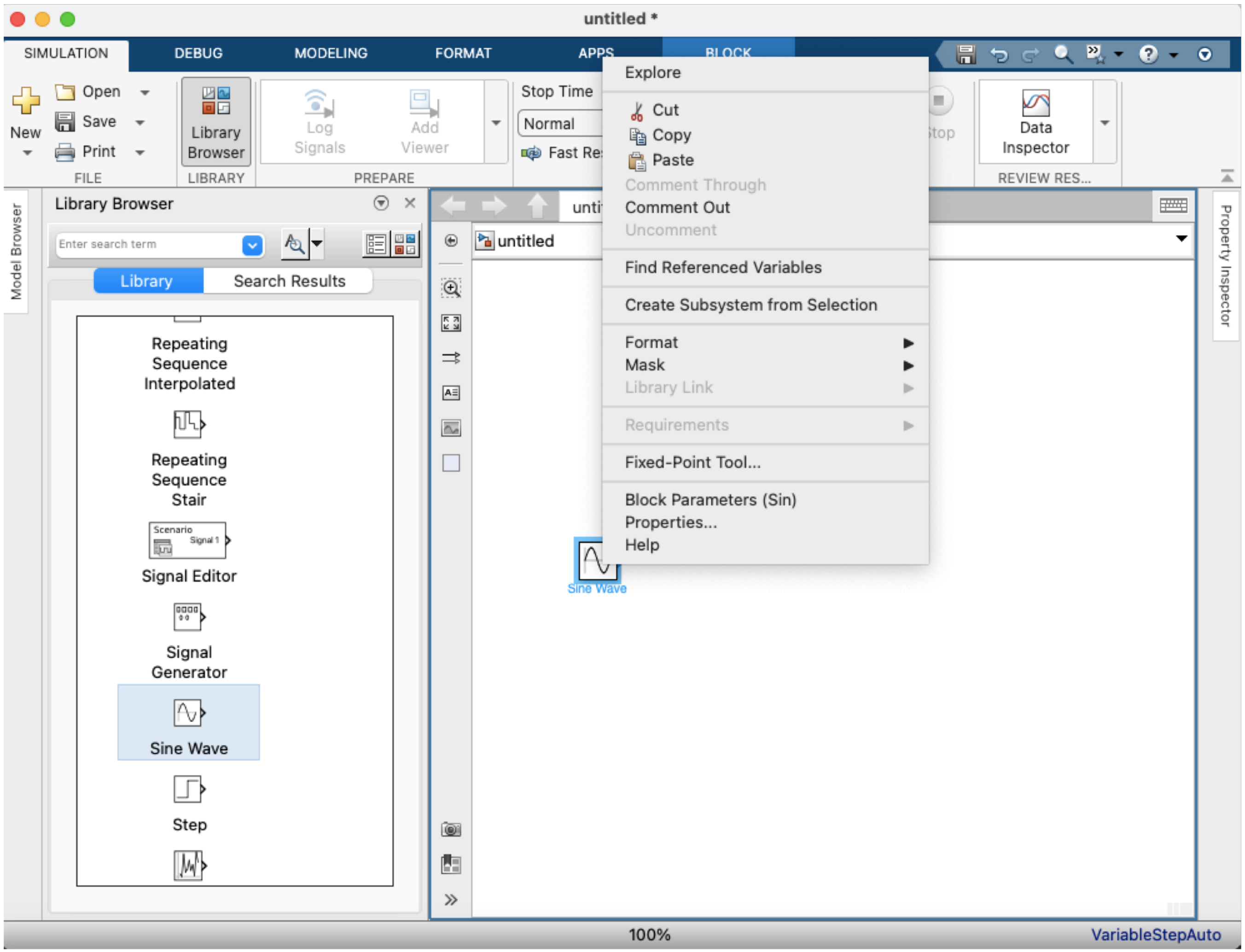
– Create a blank model from Simulink Start Page
– The Simulink canvas is ready for work!



Matlab Simulink

- Open the Library Browser
- Blocks can be added to your model:
  - by dragging them from the Library Browser
  - by double-clicking in the canvas area and typing the block name
- Each block is characterized by parameters, which can be set by right-clicking on the block and selecting the “Block Parameters” option from the pop-up window

Matlab Simulink



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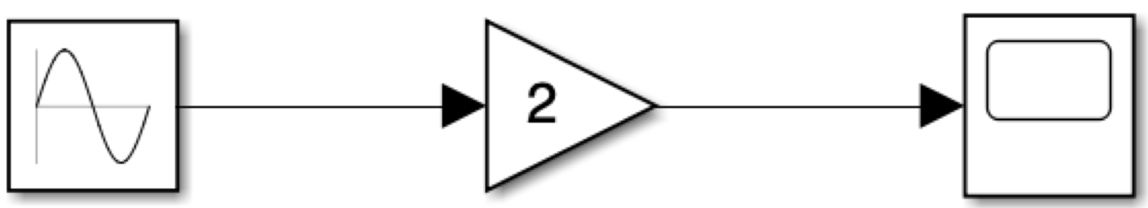
Matlab Simulink

- Blocks can be easily connected by arrows
- In the figure, a ”Sine Wave” block outputs a sinusoid, which is first multiplied by two and then sent to a “Scope” block to see the signal



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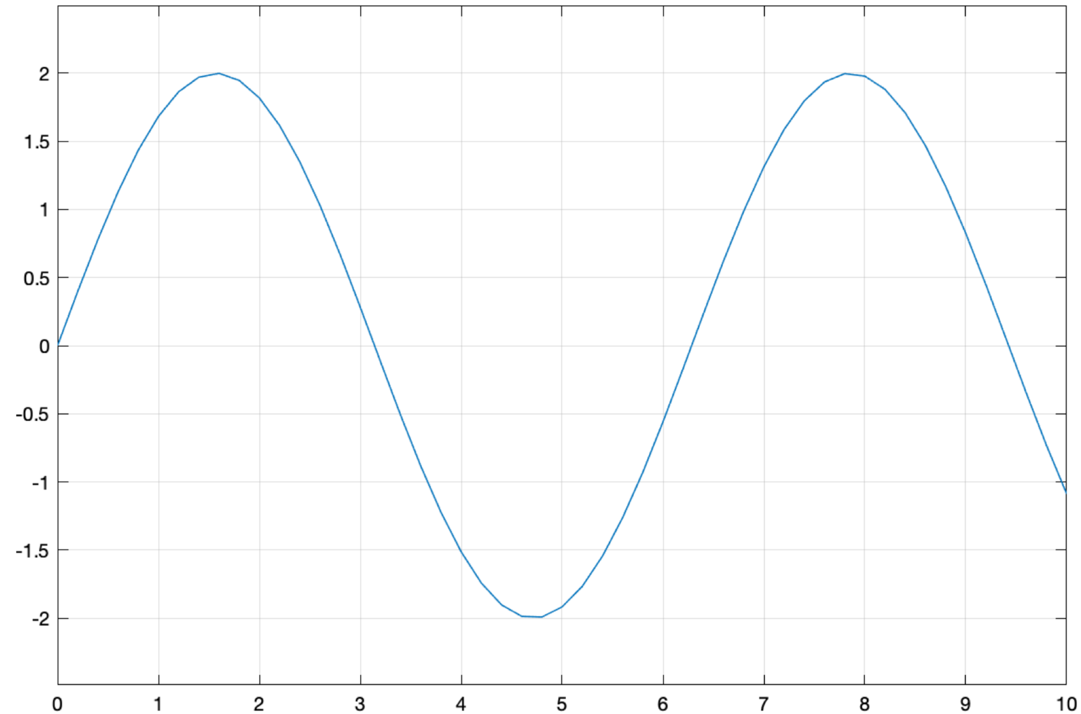
Click the Run button in the Simulation toolbar and double-click the Scope block



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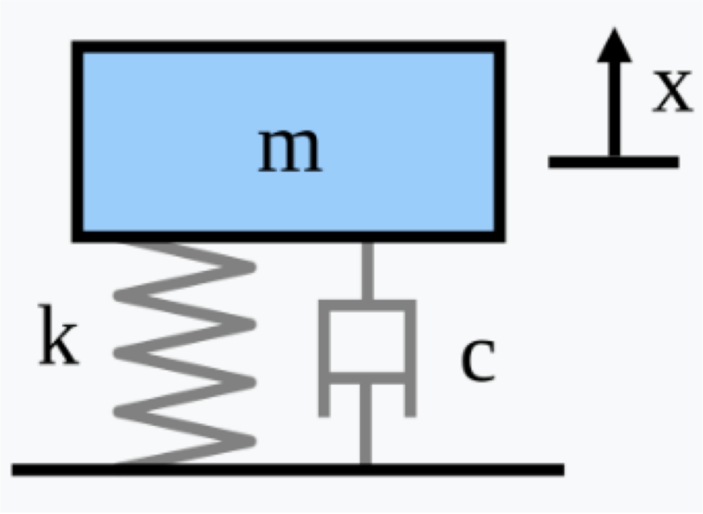
Exercise 1: continuous-time model

- Mass-spring-damper model

$$m\ddot{x} = F_{\text{ext}} - kx - c\dot{x}$$



F_{ext}: external applied force

Exercise 1: continuous-time model

1. Implement the model in Simulink, first without external forces ($F_{\mathrm{ext}} = 0$)
   - Set $k = 1$, $c = 1$, $m = 1$
   - Useful Simulink blocks: Integrator, Add, Gain, Scope
   - Set the initial conditions ($t = 0$) for position and velocity in the integrators
     - $x(0) = 1$, $v(0) = 0$
   - Watch the evolution of position $x(t)$ from $t = 0$ to $t = 10$

Exercise 1: continuous-time model

– Let $\omega_n = \sqrt{\frac{k}{m}}$ and $\zeta = \frac{c}{2m\omega_n}$

– The analytical solution with $F_{\text{ext}} = 0$ is

$$x(t) = K_1 \mathrm{e}^{-\omega_n t\left(\zeta - \sqrt{\zeta^2 - 1}\right)} + K_2 \mathrm{e}^{-\omega_n t\left(\zeta + \sqrt{\zeta^2 - 1}\right)}$$

with K_1 and K_2 depending on the initial conditions

2. Verify through Matlab or Simulink that the simulated model agrees with the formula if

$$K_1 = \frac{1}{2} - \frac{j}{2\sqrt{3}} \qquad K_2 = \frac{1}{2} + \frac{j}{2\sqrt{3}}$$

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Exercise 1: continuous-time model

3. Simulate the model with $F_{\mathrm{ext}} = \sin(2\pi f_0 t)$
   - Set f_0 = 1 Hz
   - Useful Simulink block: Sine Wave
   - Watch the evolution of position $x(t)$ from $t = 0$ to $t = 10$
   - Try to change the values of the parameters and of the initial conditions to see the effect on $x(t)$

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Exercise 2: discrete-time model

- Moving-average system

$$y[n] = y[n-1] + \frac{1}{M}\left(x[n] - x[n-M]\right)$$

  - Implement the model in Simulink with M = 5 and $x[t] = \sin(2\pi n T_s)$ with a sample time T_s = 0.1 s
  - Useful block: Delay
  - Watch the evolution of $y[n]$ from t = 0 to t = 10

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