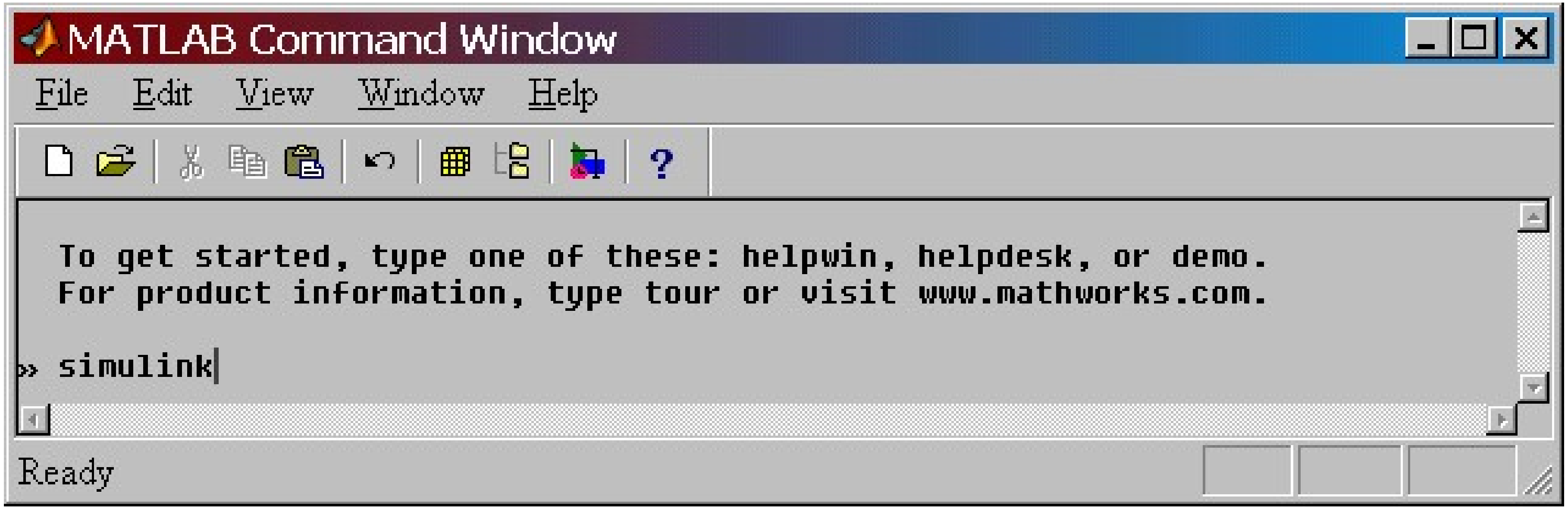
Getting started with Simulink

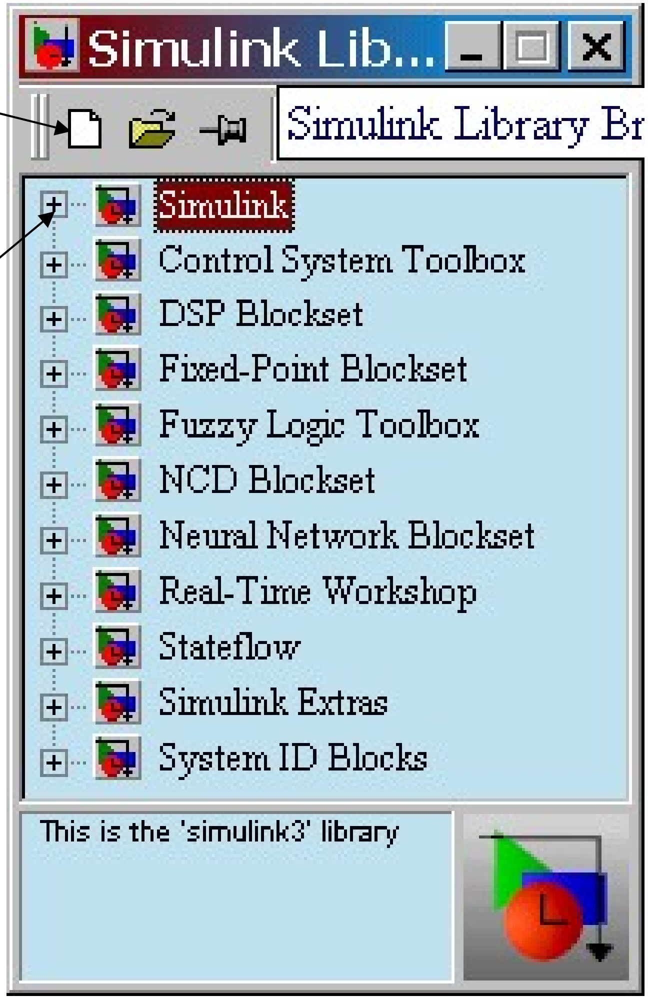
Launch Simulink

In the MATLAB command window,
at the >> prompt, type **`simulink`**
and press ↵ Enter



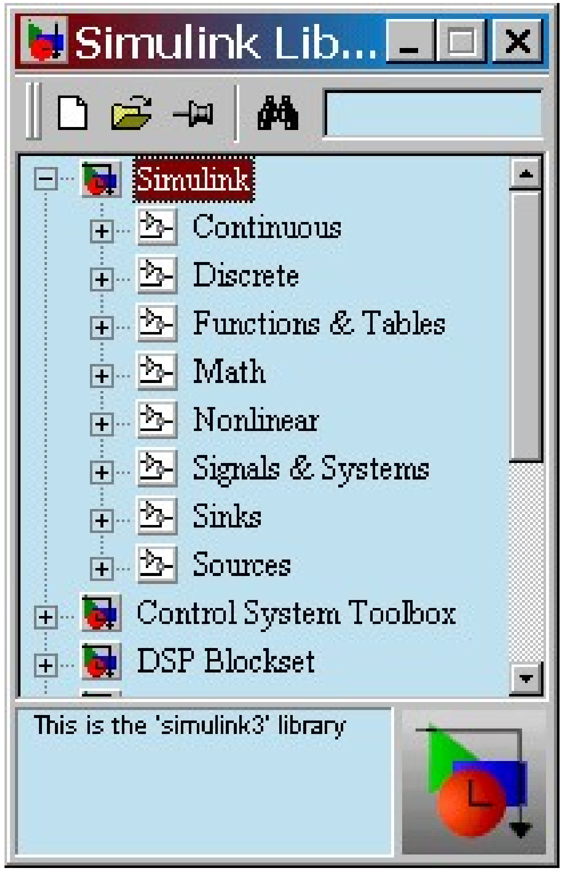
Create a new model

- Click the new-model icon in the upper left corner to start a new Simulink file
- Select the Simulink icon to obtain elements of the model

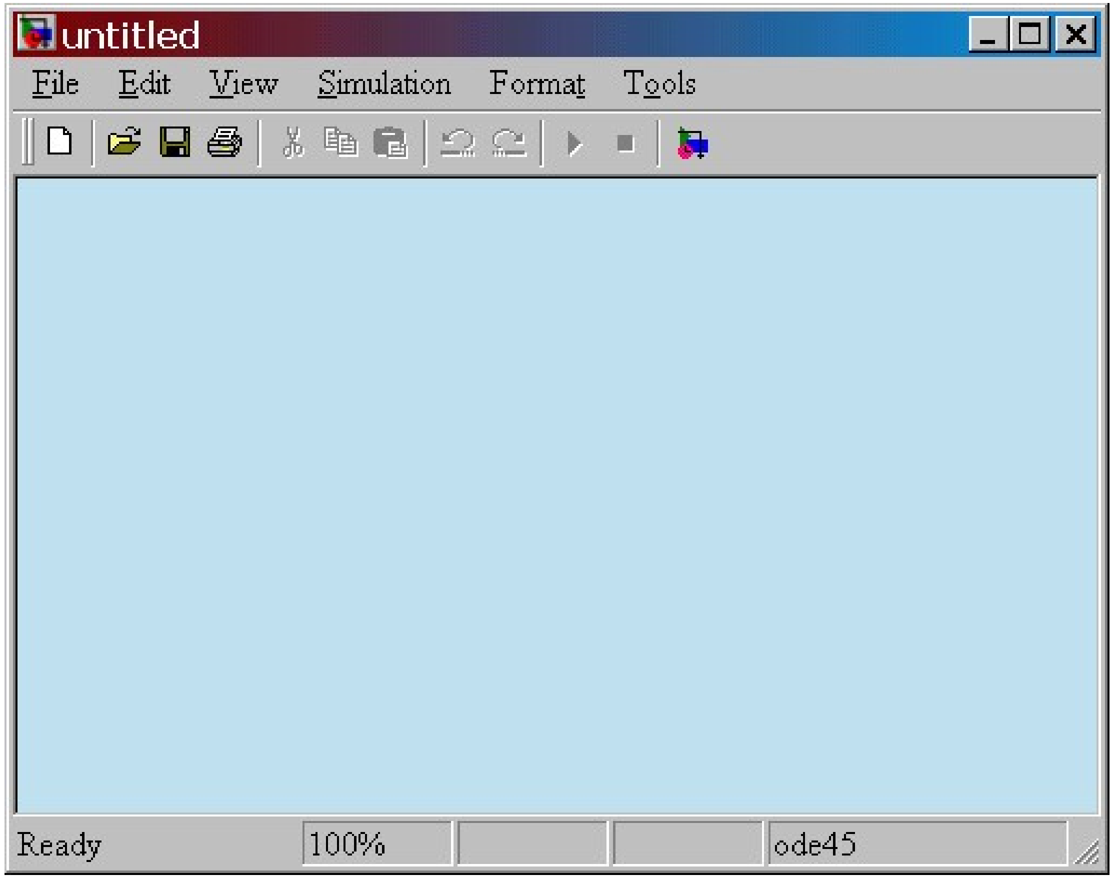


Your workspace

Library of elements

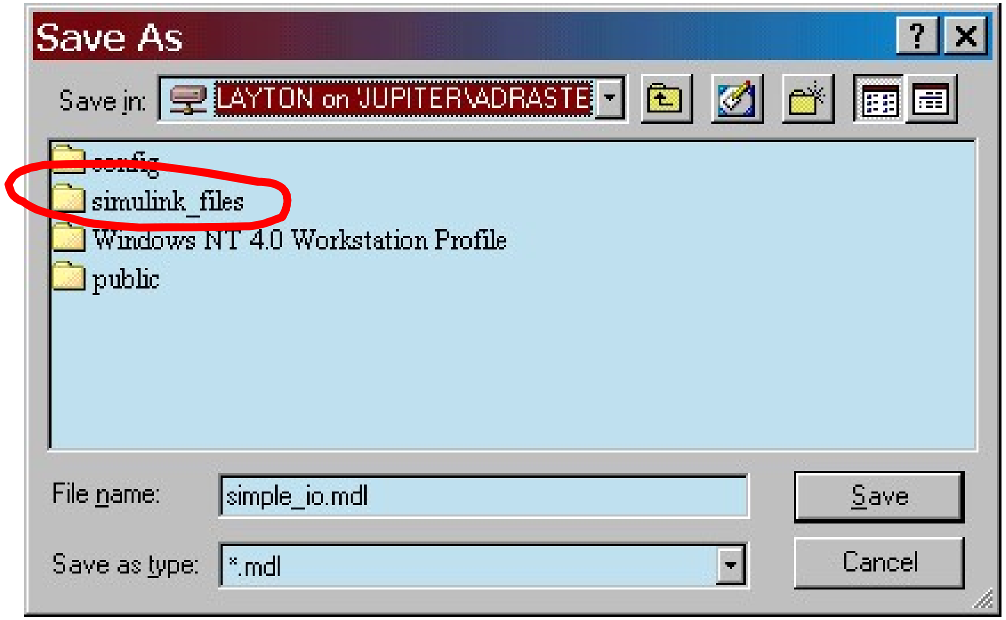


Model is created in this window



Save your model

- You might create a new folder, like the one shown below, called *simulink_files*
- Use the .mdl suffix when saving



Example 1: a simple model

- Build a Simulink model that solves the differential equation

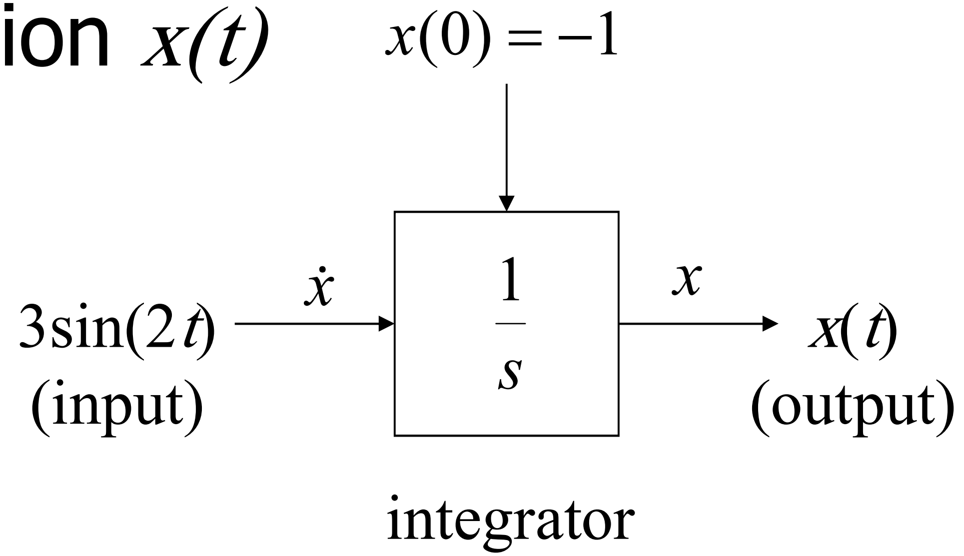
$$\dot{x} = 3\sin(2t)$$

- Initial condition $x(0) = -1$.
- First, sketch a simulation diagram of this mathematical model (equation)

(3 min.)

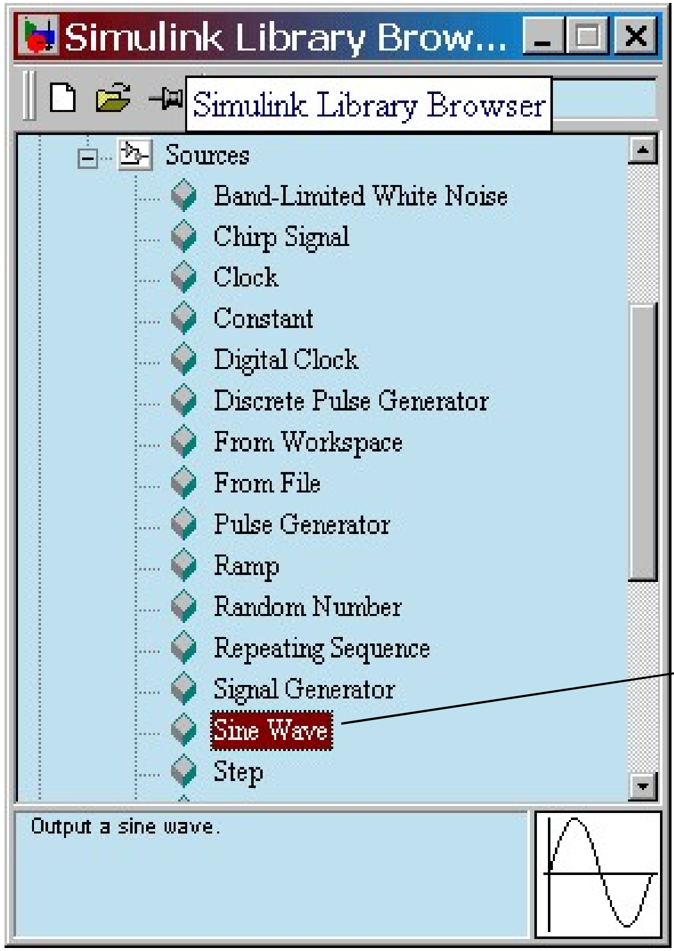
Simulation diagram

- Input is the forcing function $3\sin(2t)$
- Output is the solution of the differential equation *x(t)*

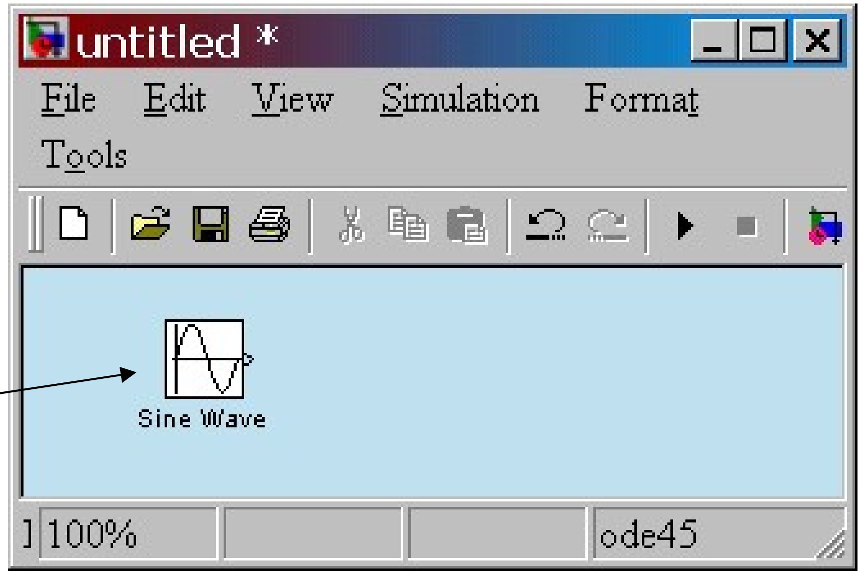


- Now build this model in Simulink

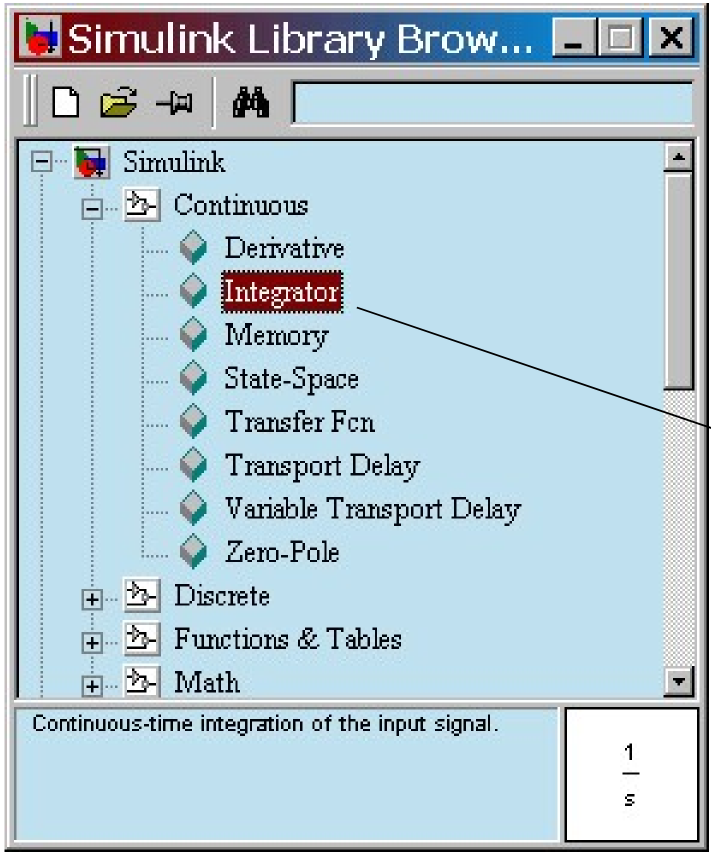
Select an input block



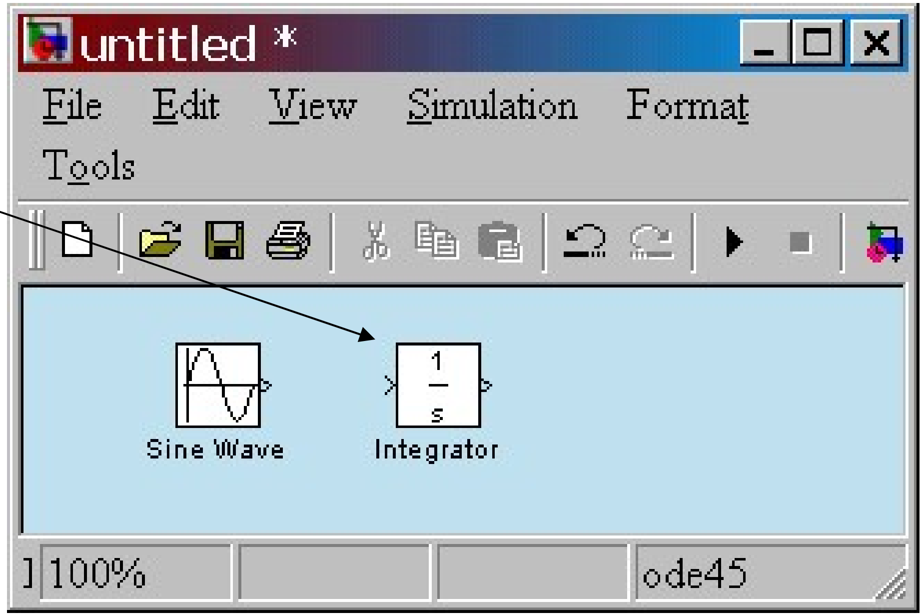
Drag a *Sine Wave* block from the *Sources* library to the model window



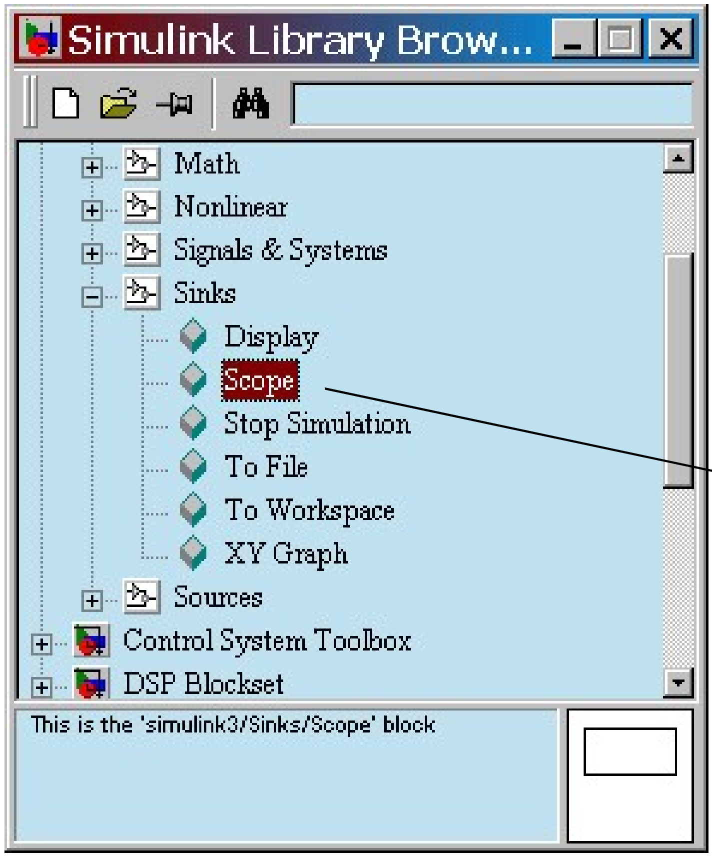
Select an operator block



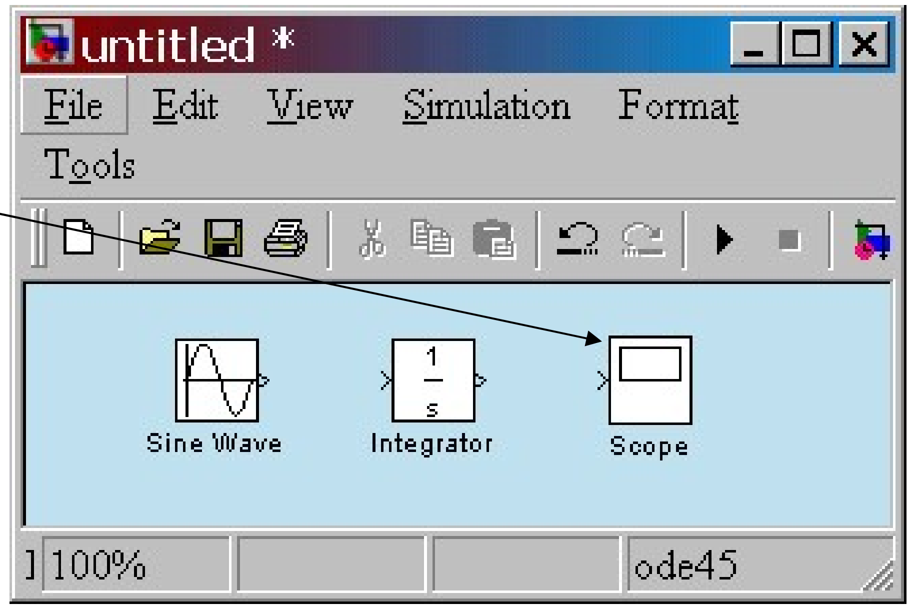
Drag an *Integrator* block from the *Continuous* library to the model window



Select an output block

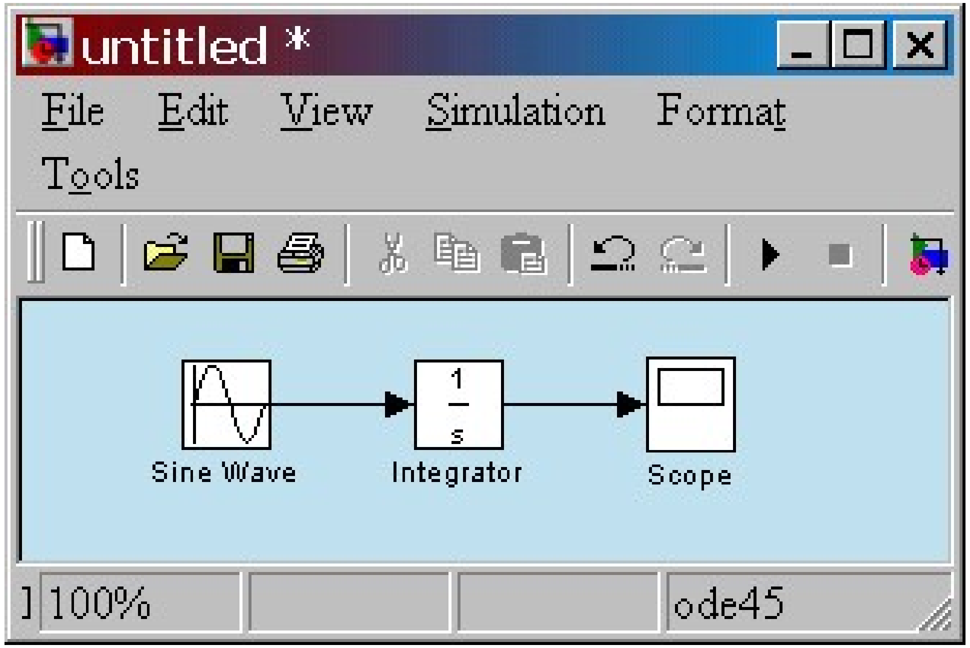


Drag a *Scope* block from the *Sinks* library to the model window



Connect blocks with signals

- Place your cursor on the output port (>) of the *Sine Wave* block
- Drag from the *Sine Wave* **output** to the *Integrator* **input**
- Drag from the *Integrator* **output** to the *Scope* **input**

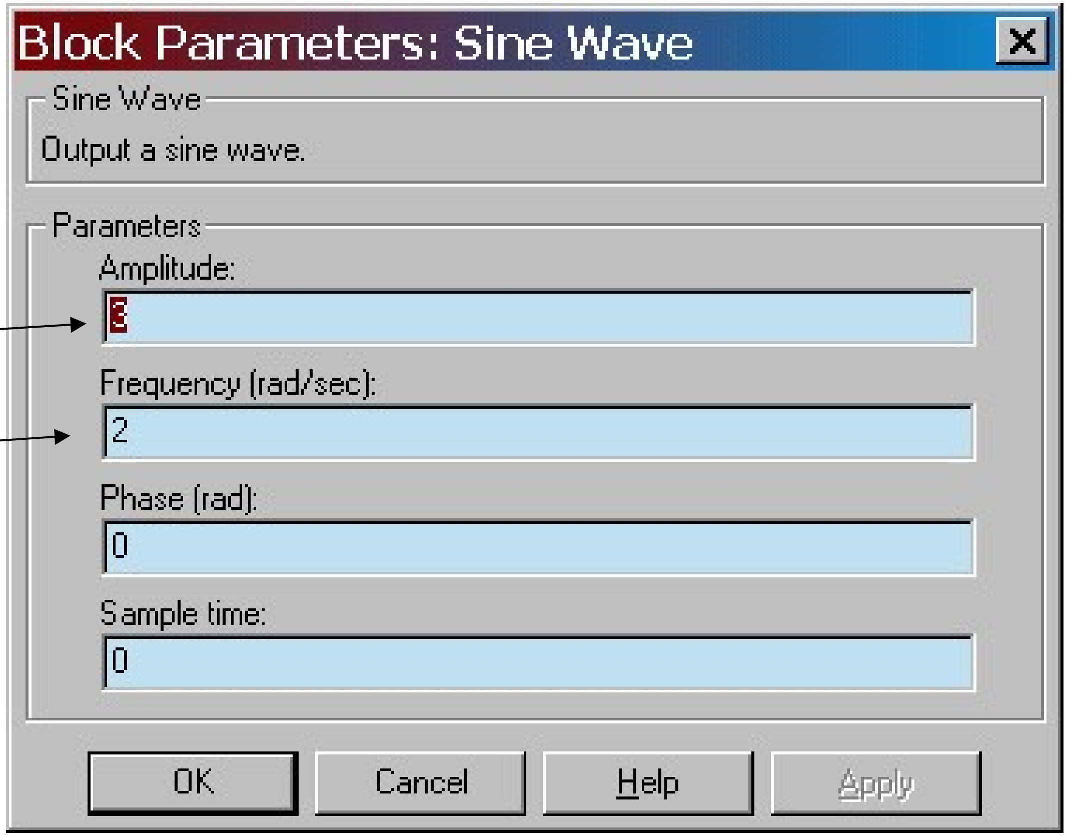


Arrows indicate the direction of the signal flow.

Select simulation parameters

Double-click on the *Sine Wave* block to set amplitude = 3 and freq = 2.

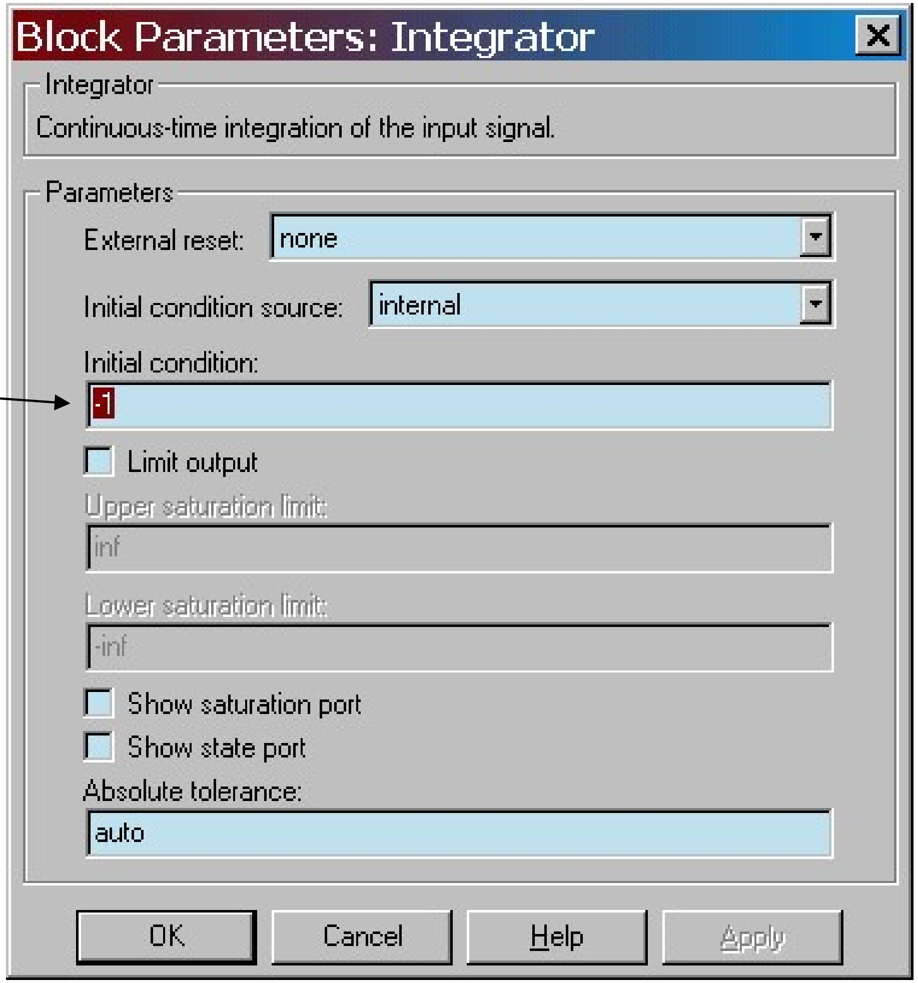
This produces the desired input of $3\sin(2t)$



Select simulation parameters

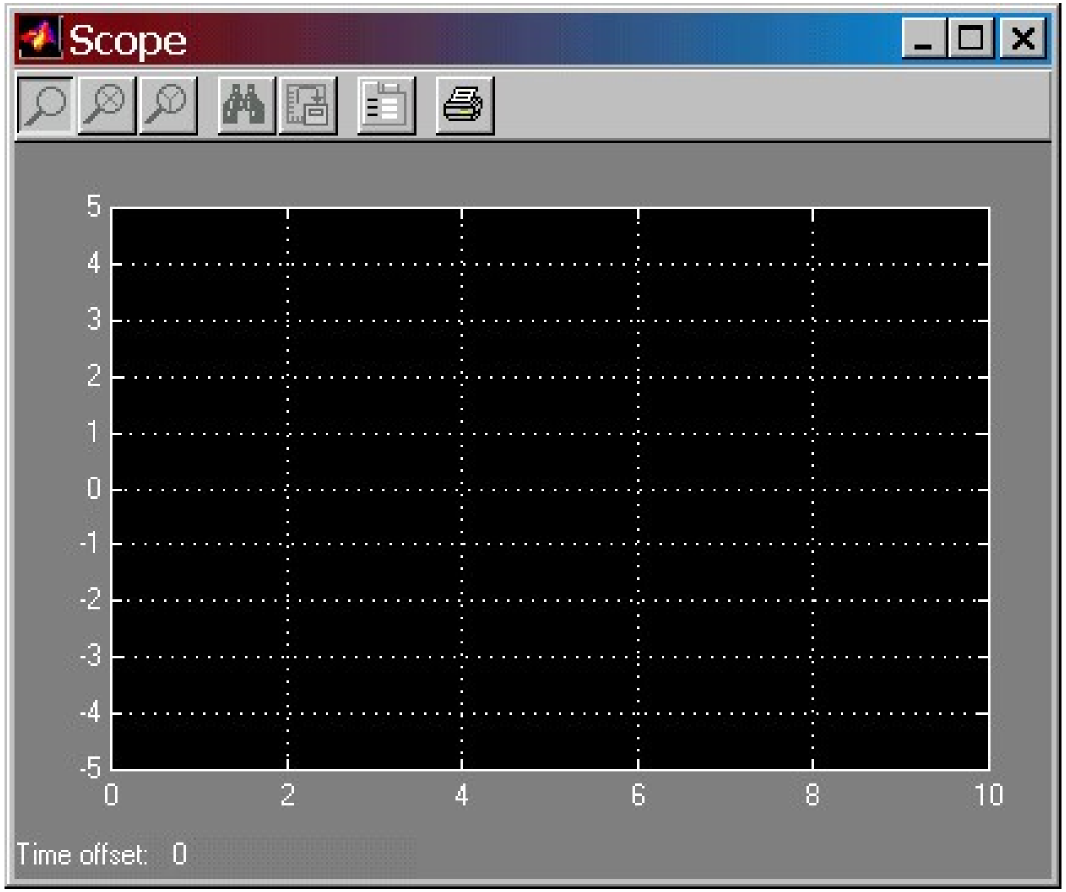
Double-click on the *Integrator* block to set initial condition = -1.

This sets our IC $x(0) = -1$.



Select simulation parameters

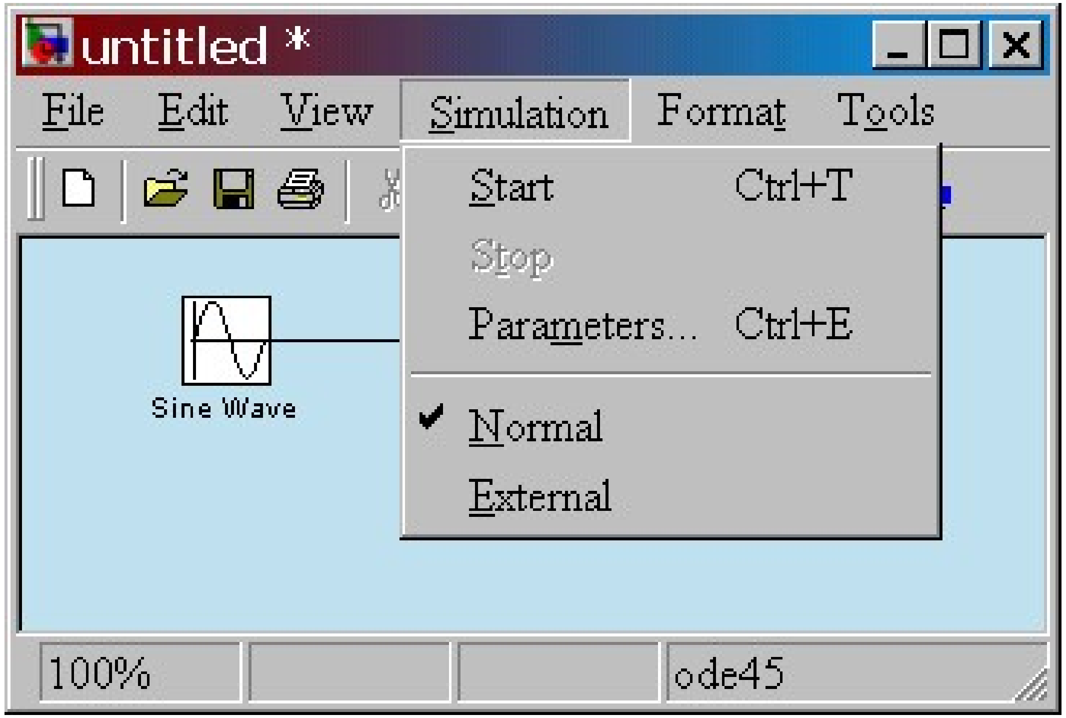
Double-click on the *Scope* to view the simulation results



Run the simulation

In the model window, from the *Simulation* pull-down menu, select *Start*

View the output $x(t)$ in the *Scope* window.



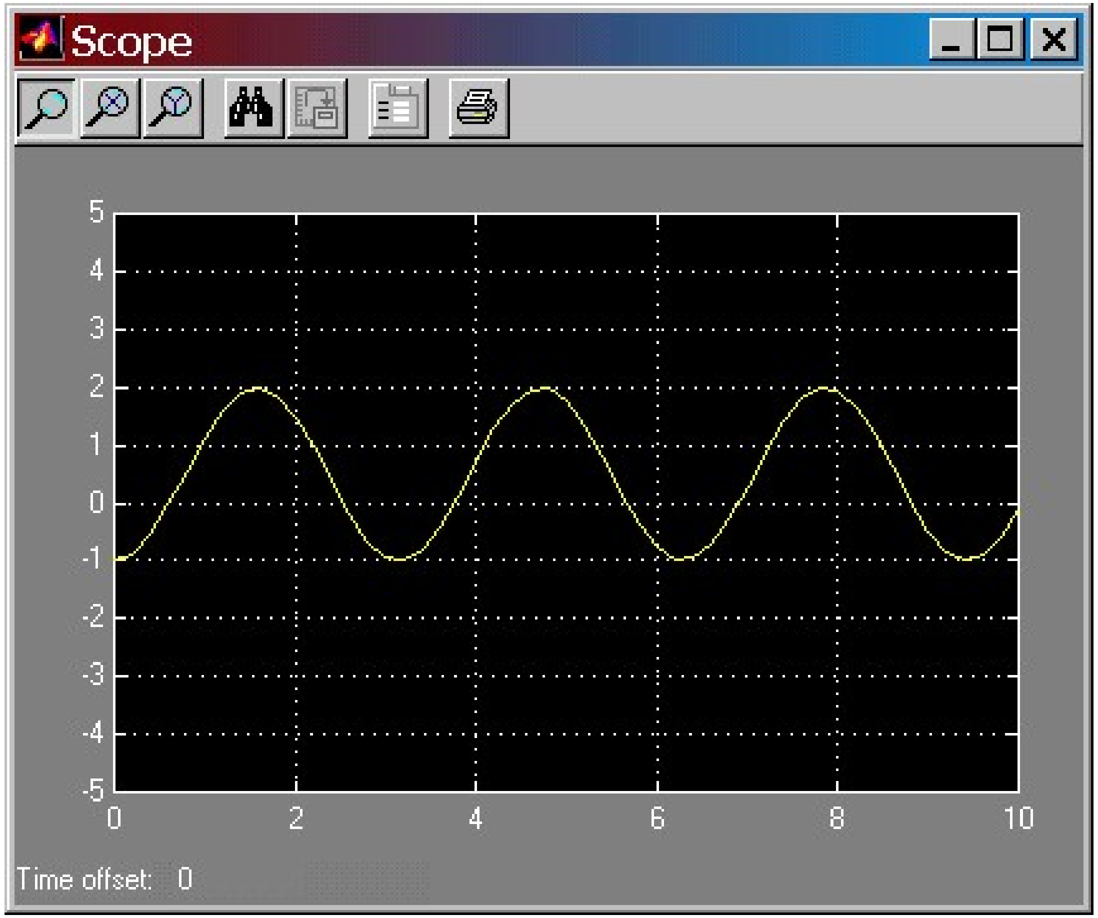
Simulation results

To verify that this plot represents the solution to the problem, solve the equation analytically.

The analytical result,

$$x(t) = \tfrac{1}{2} - \tfrac{3}{2}\cos(2t)$$

matches the plot (the simulation result) exactly.



Example 2

- Build a Simulink model that solves the following differential equation
  - 2nd-order mass-spring-damper system
  - zero ICs
  - input $f(t)$ is a step with magnitude 3
  - parameters: $m = 0.25,\ c = 0.5,\ k = 1$

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

Create the simulation diagram

- On the following slides:
  - The simulation diagram for solving the ODE is created step by step.
  - After each step, elements are added to the Simulink model.
- Optional exercise: first, sketch the complete diagram (5 min.)

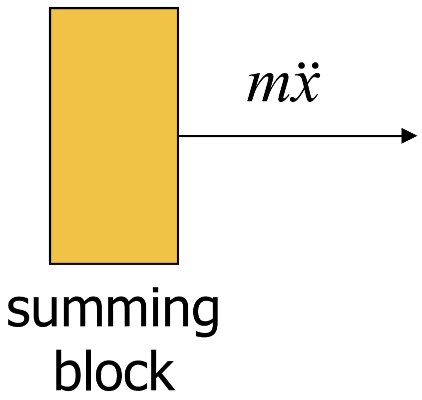
$$m\ddot{x} + c\dot{x} + kx = f(t)$$

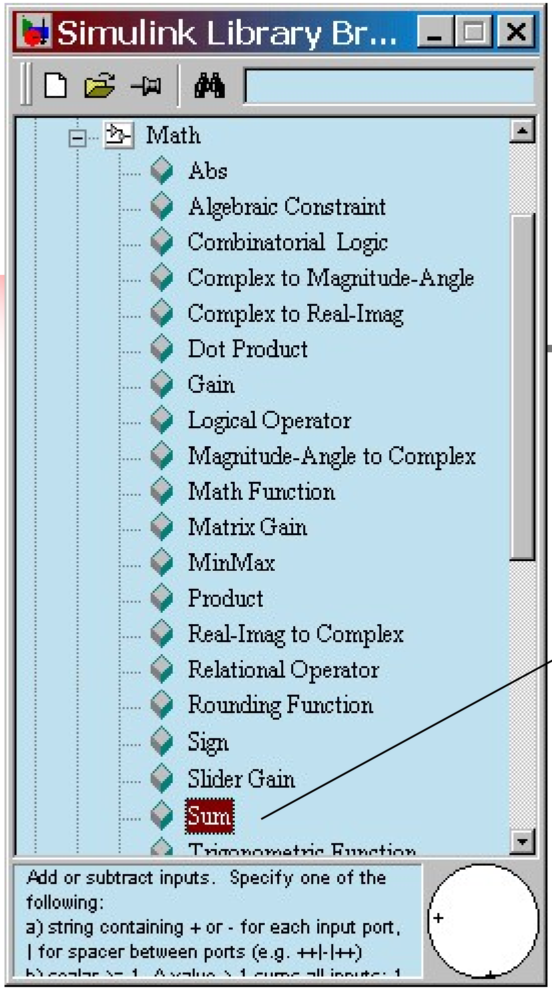
(continue)

- First, solve for the term with highest-order derivative

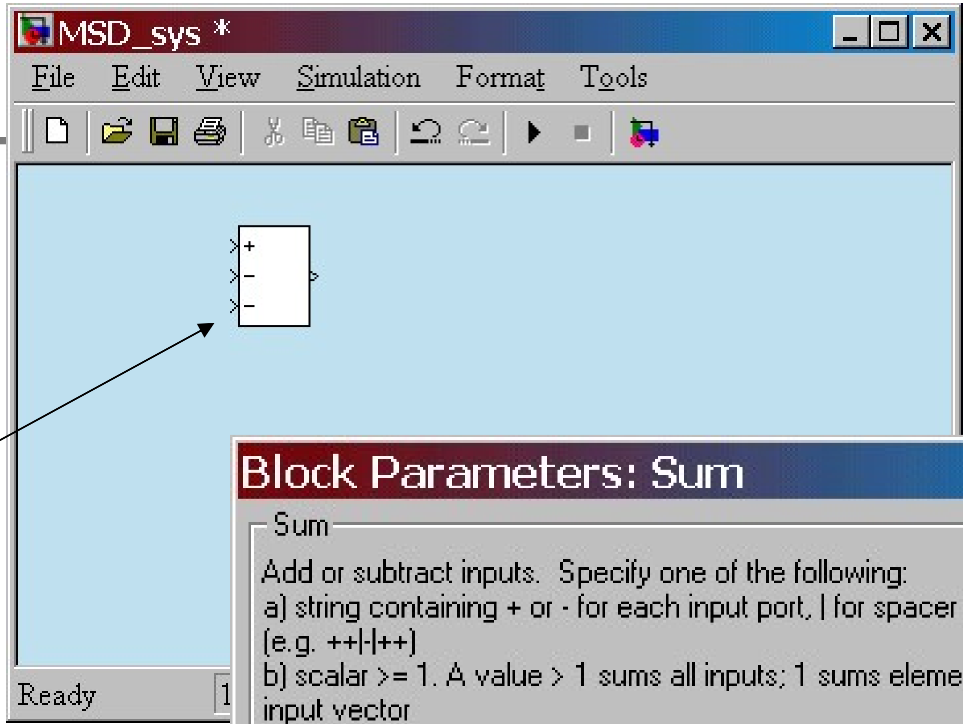
$$m\ddot{x} = f(t) - c\dot{x} - kx$$

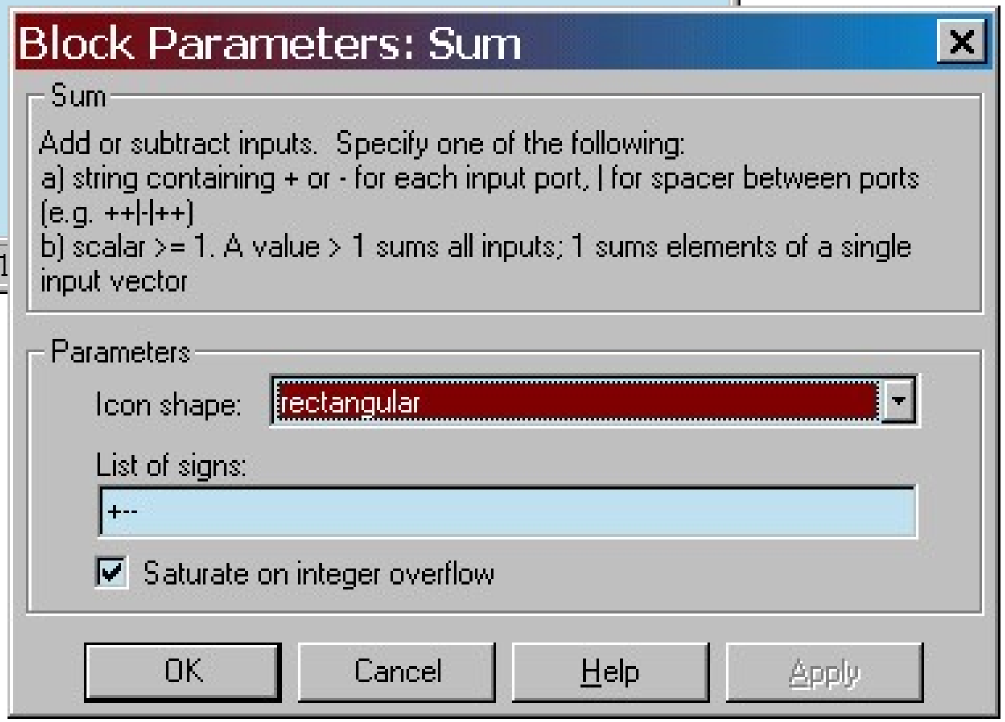
- Make the left-hand side of this equation the output of a summing block





Drag a *Sum* block from the *Math* library

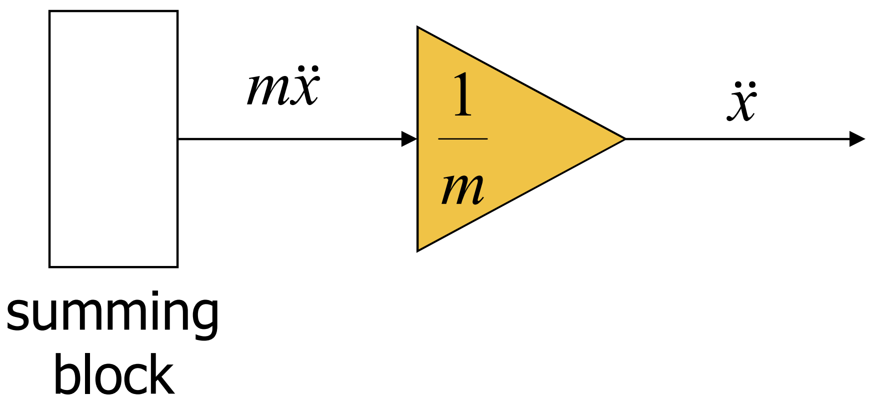


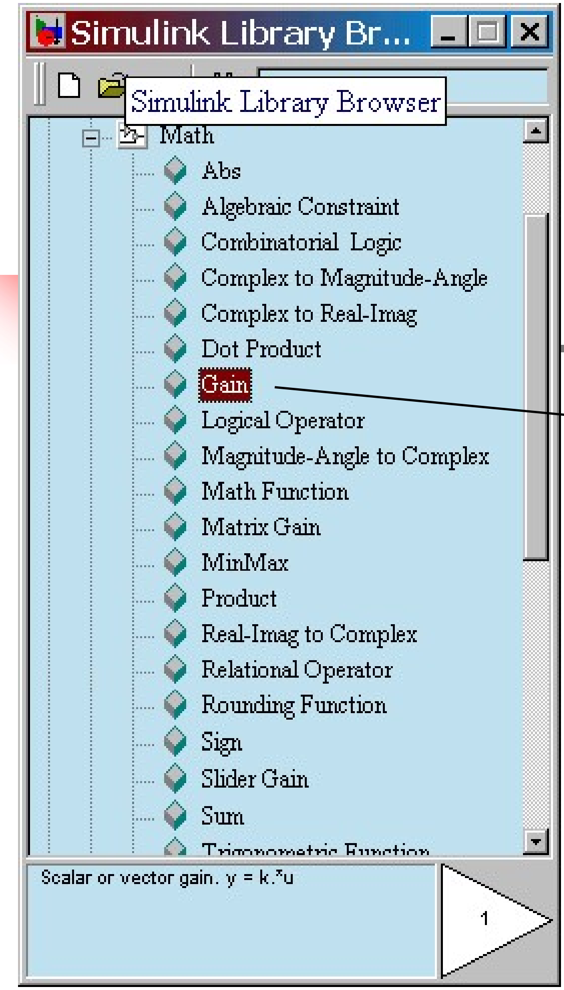


Double-click to change the block parameters to *rectangular* and *+ - -*

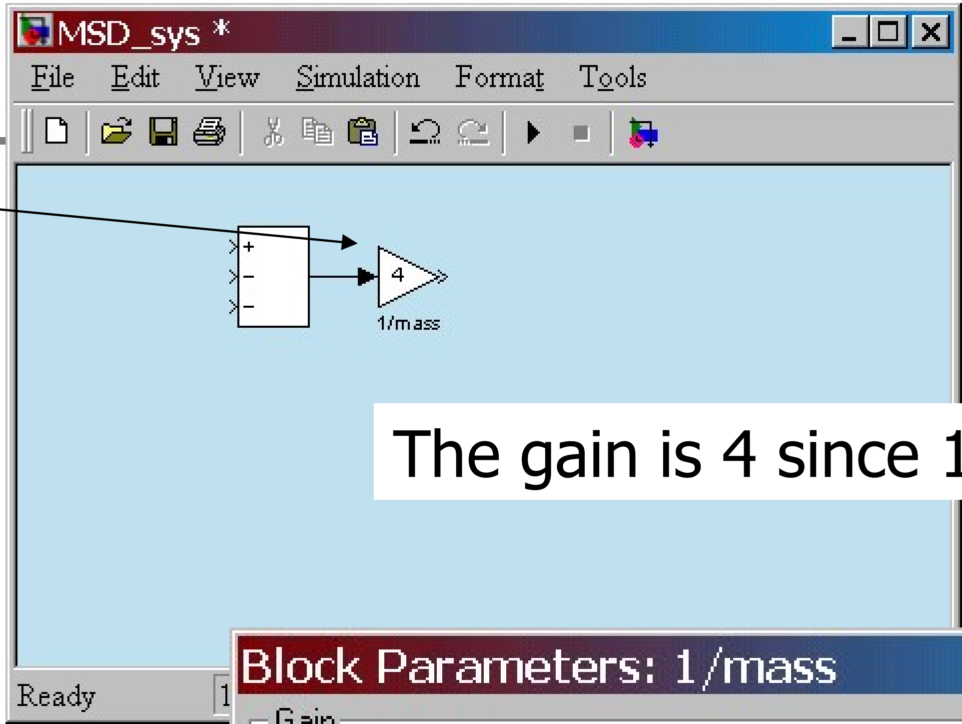
(continue)

- Add a gain (multiplier) block to eliminate the coefficient and produce the highest-derivative alone



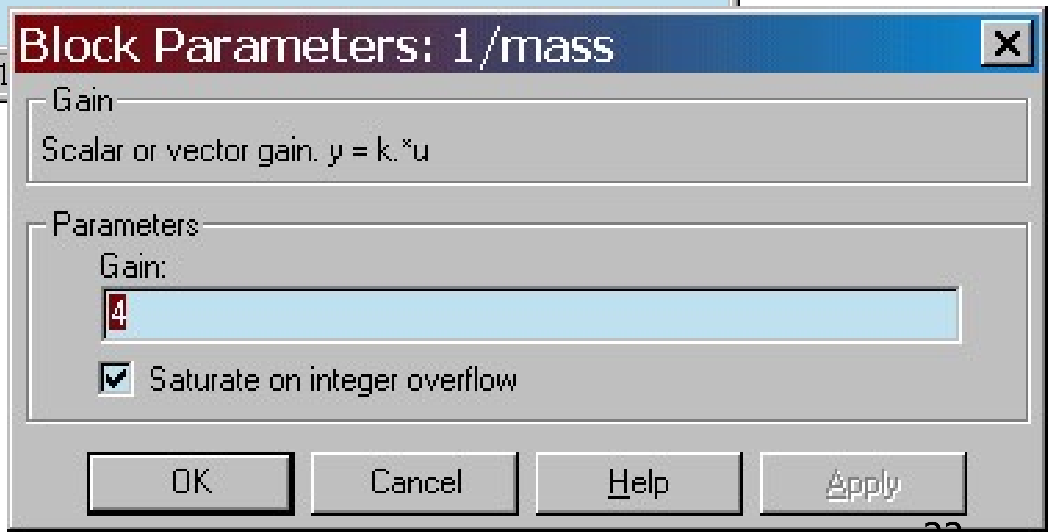


Drag a *Gain* block from the *Math* library



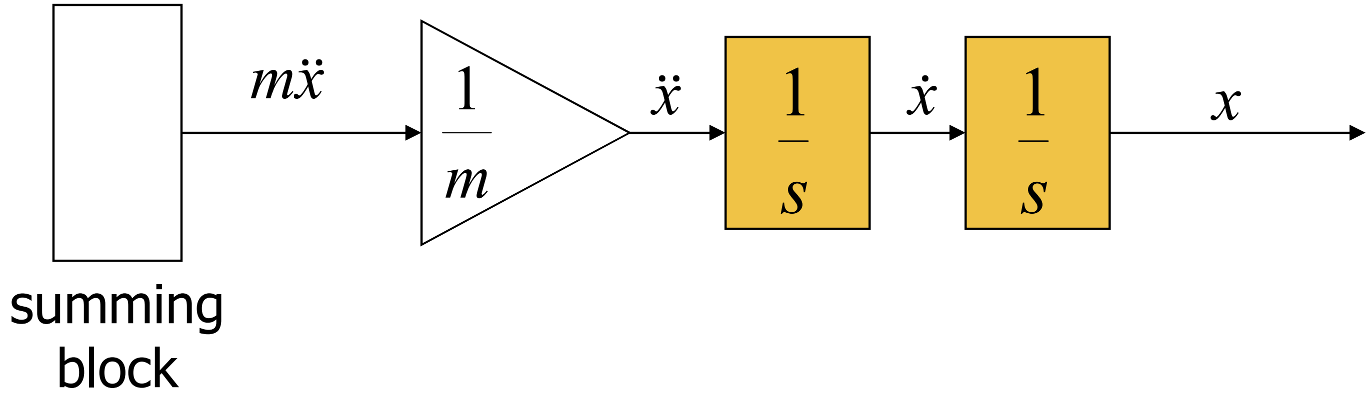
The gain is 4 since 1/m=4.

Double-click to change the block parameters.
Add a title.

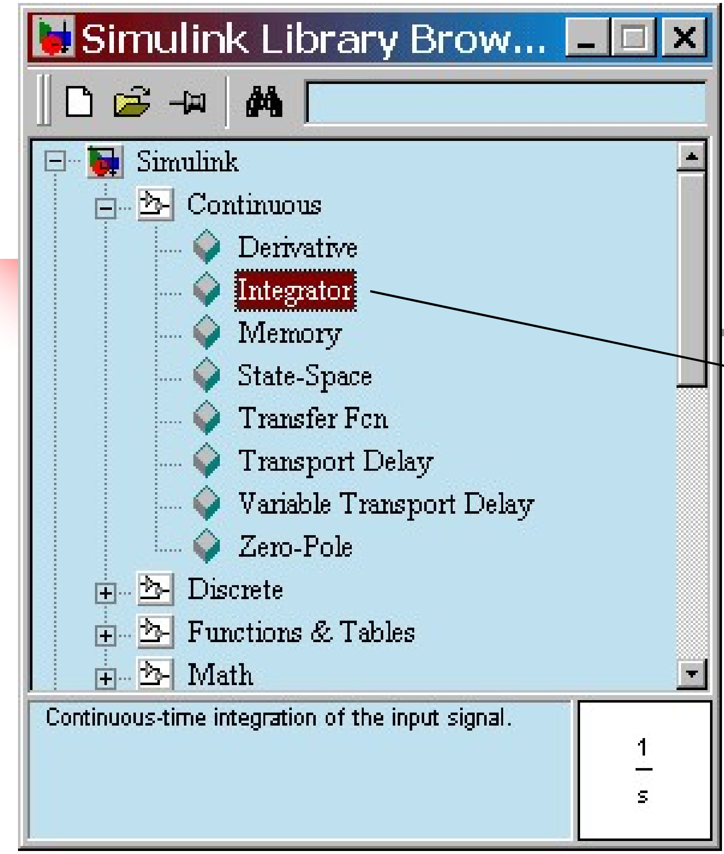


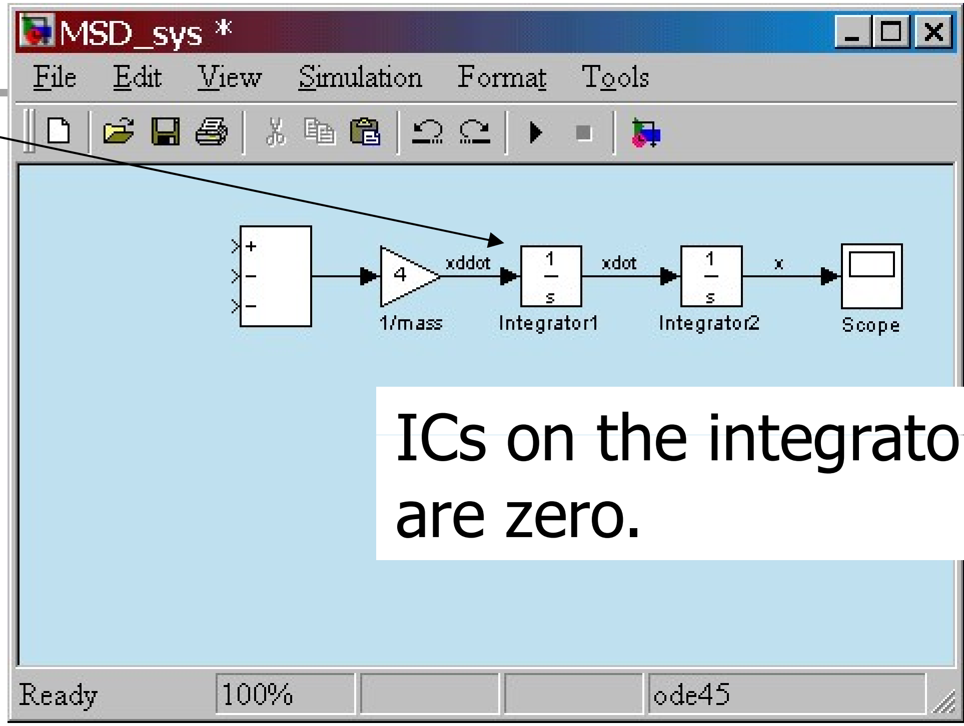
(continue)

- Add integrators to obtain the desired output variable



Drag *Integrator* blocks from the *Continuous* library



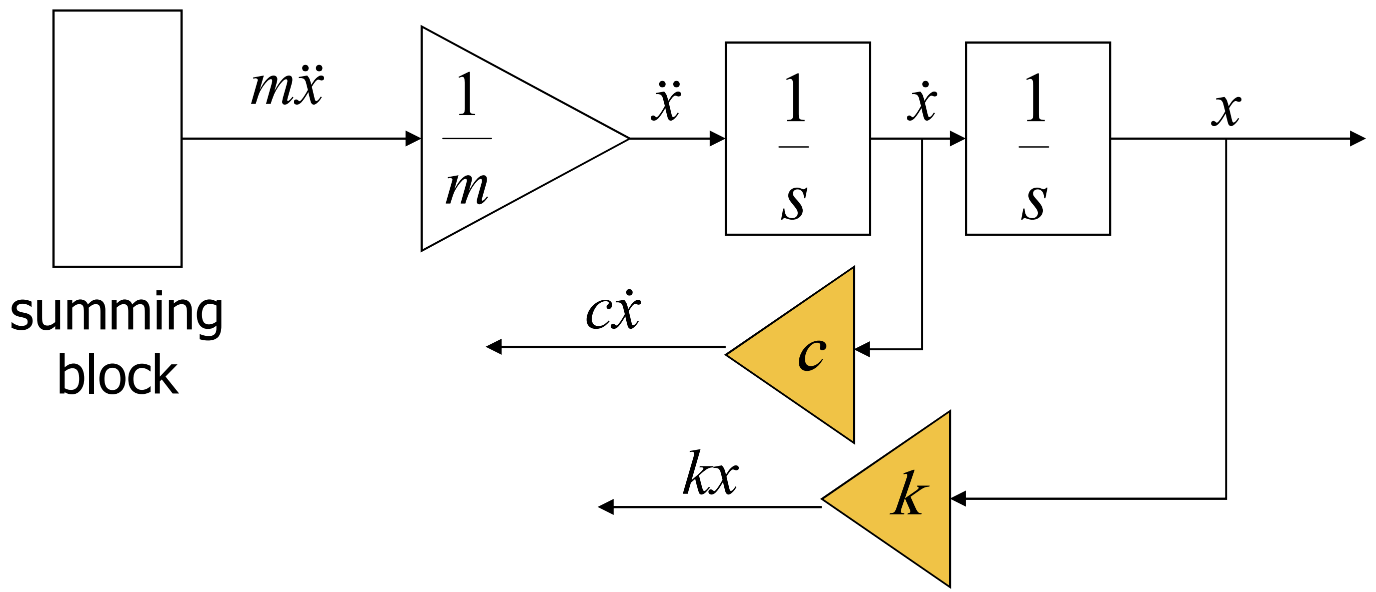


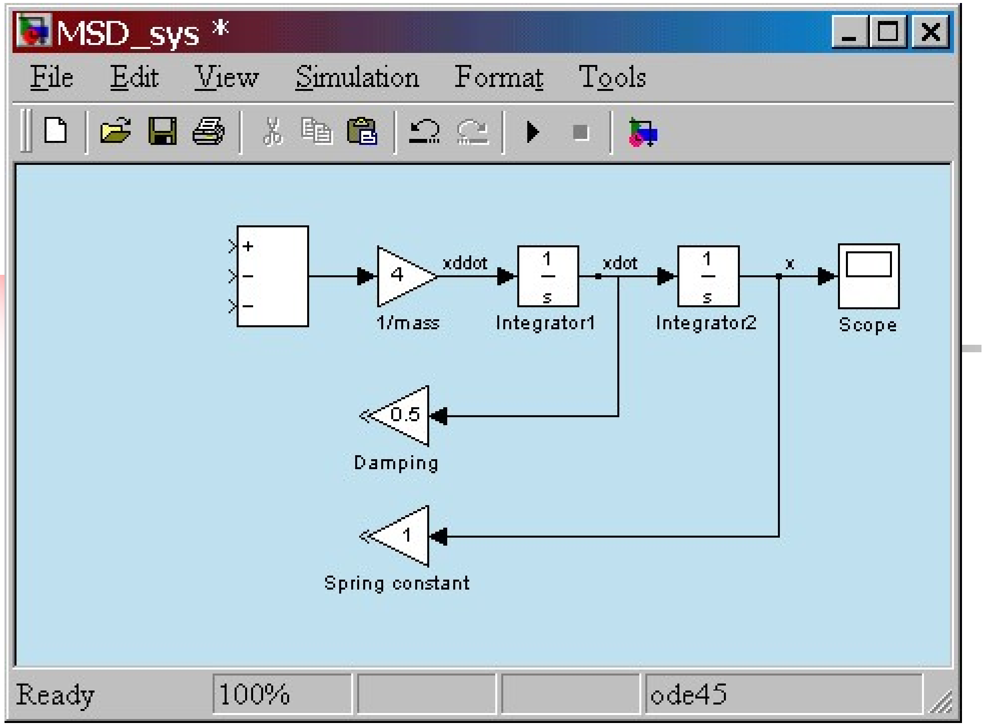
ICs on the integrators are zero.

Add a scope from the *Sinks* library.
Connect output ports to input ports.
Label the signals by double-clicking on the leader line.

(continue)

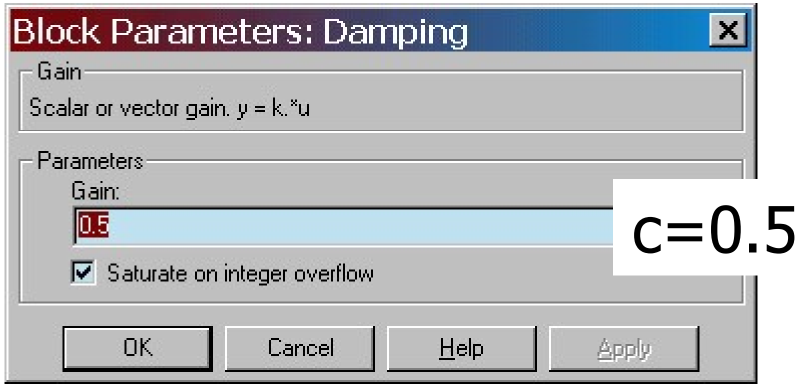
- Connect to the integrated signals with gain blocks to create the terms on the right-hand side of the EOM



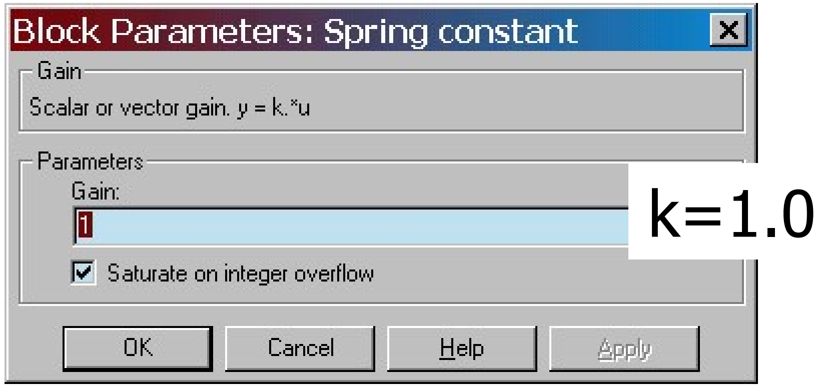


Drag new *Gain* blocks from the *Math* library

To flip the gain block, select it and choose *Flip Block* in the *Format* pull-down menu.

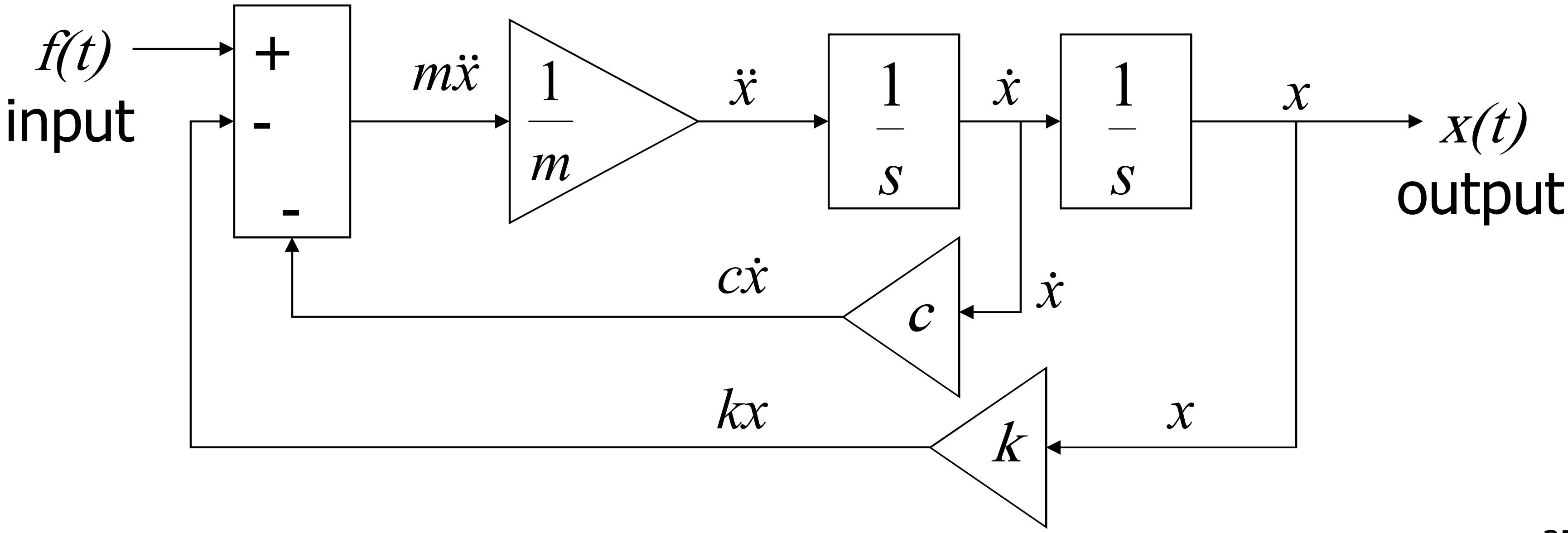


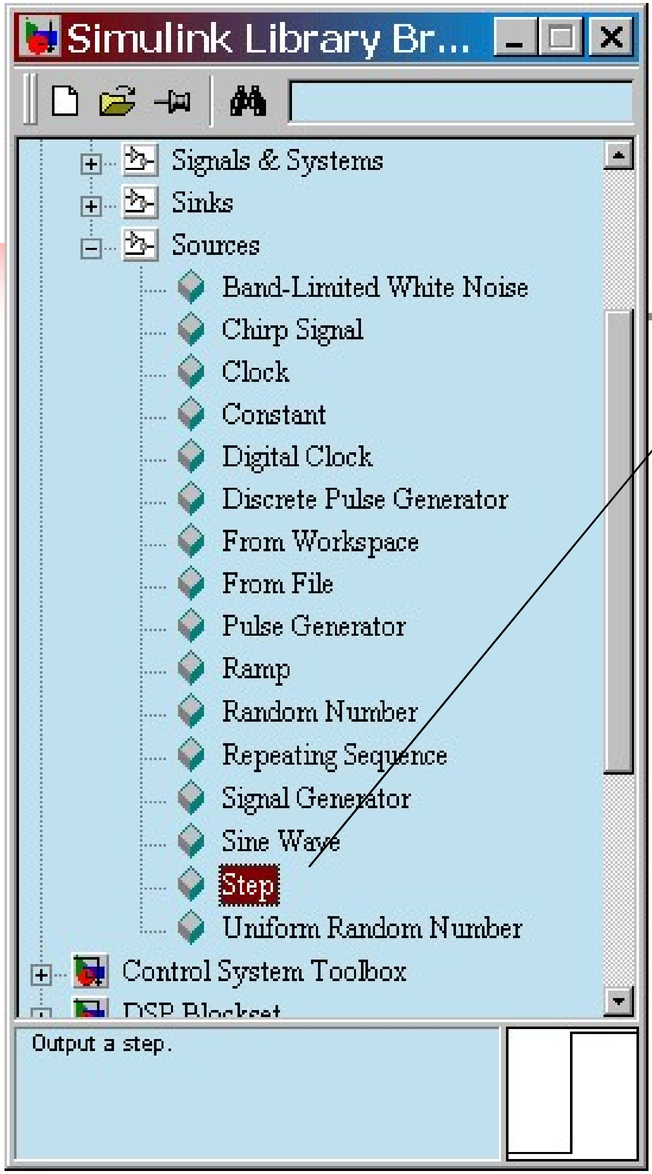
- Double-click on gain blocks to set parameters
- Connect from the gain block input backwards up to the branch point.
- Re-title the gain blocks.

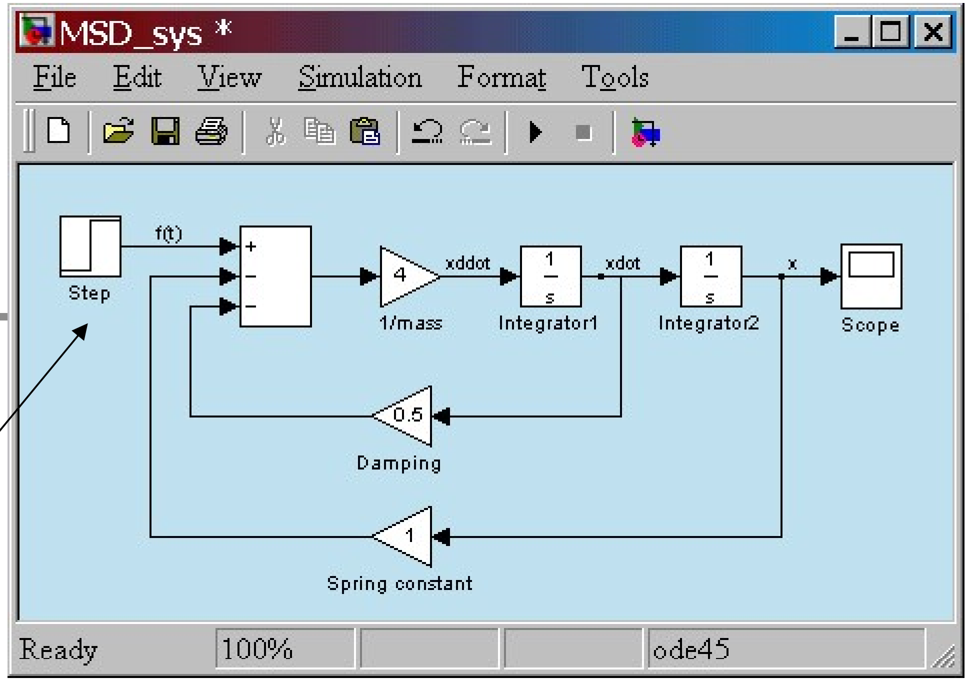


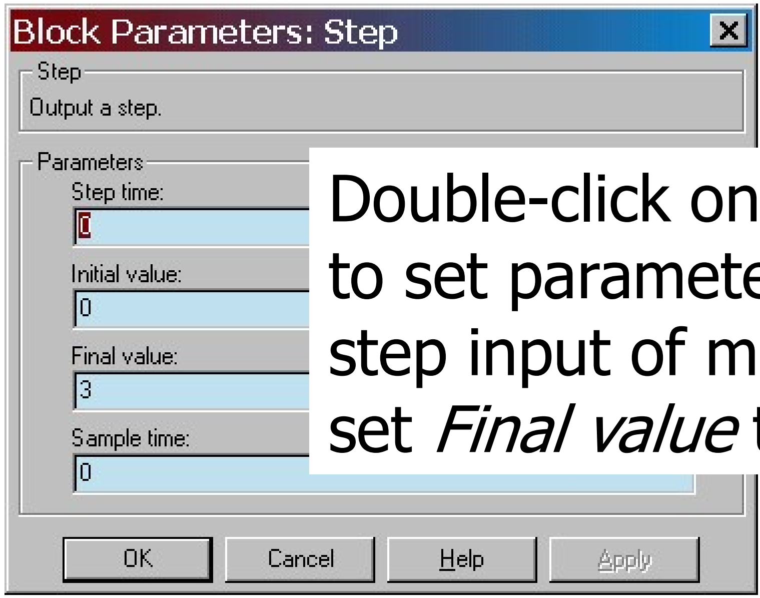
Complete the model

- Bring all the signals and inputs to the summing block.
- Check signs on the summer.



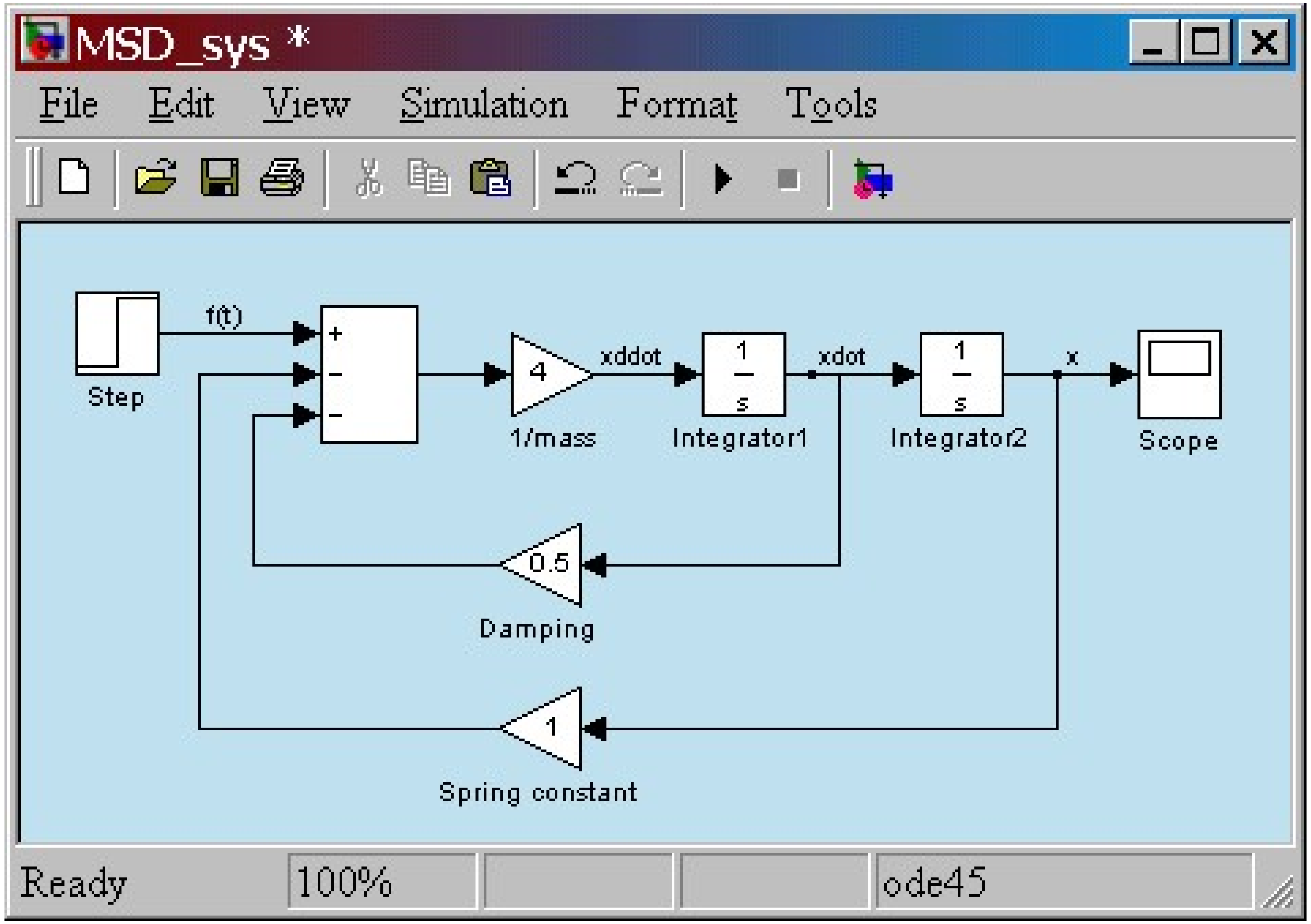




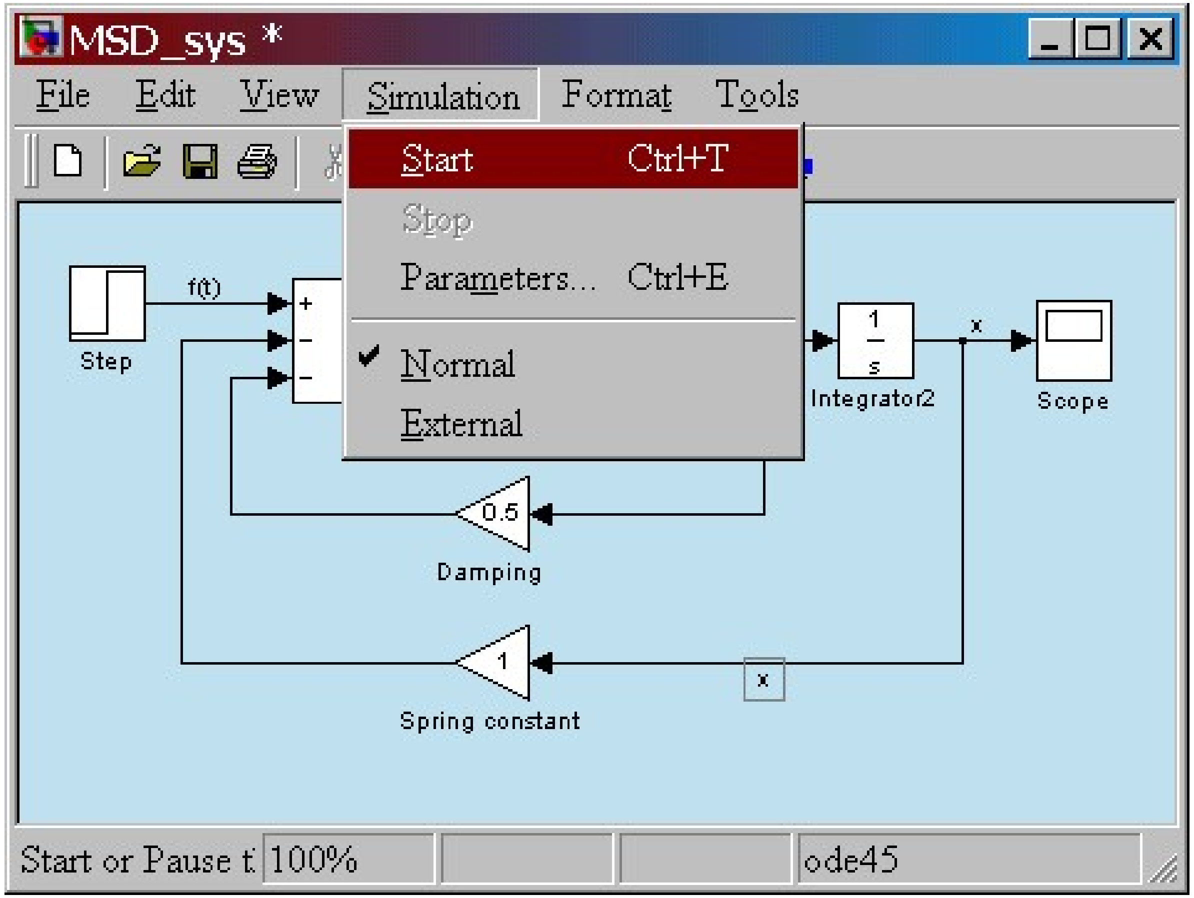


Double-click on *Step* block to set parameters. For a step input of magnitude 3, set *Final value* to 3

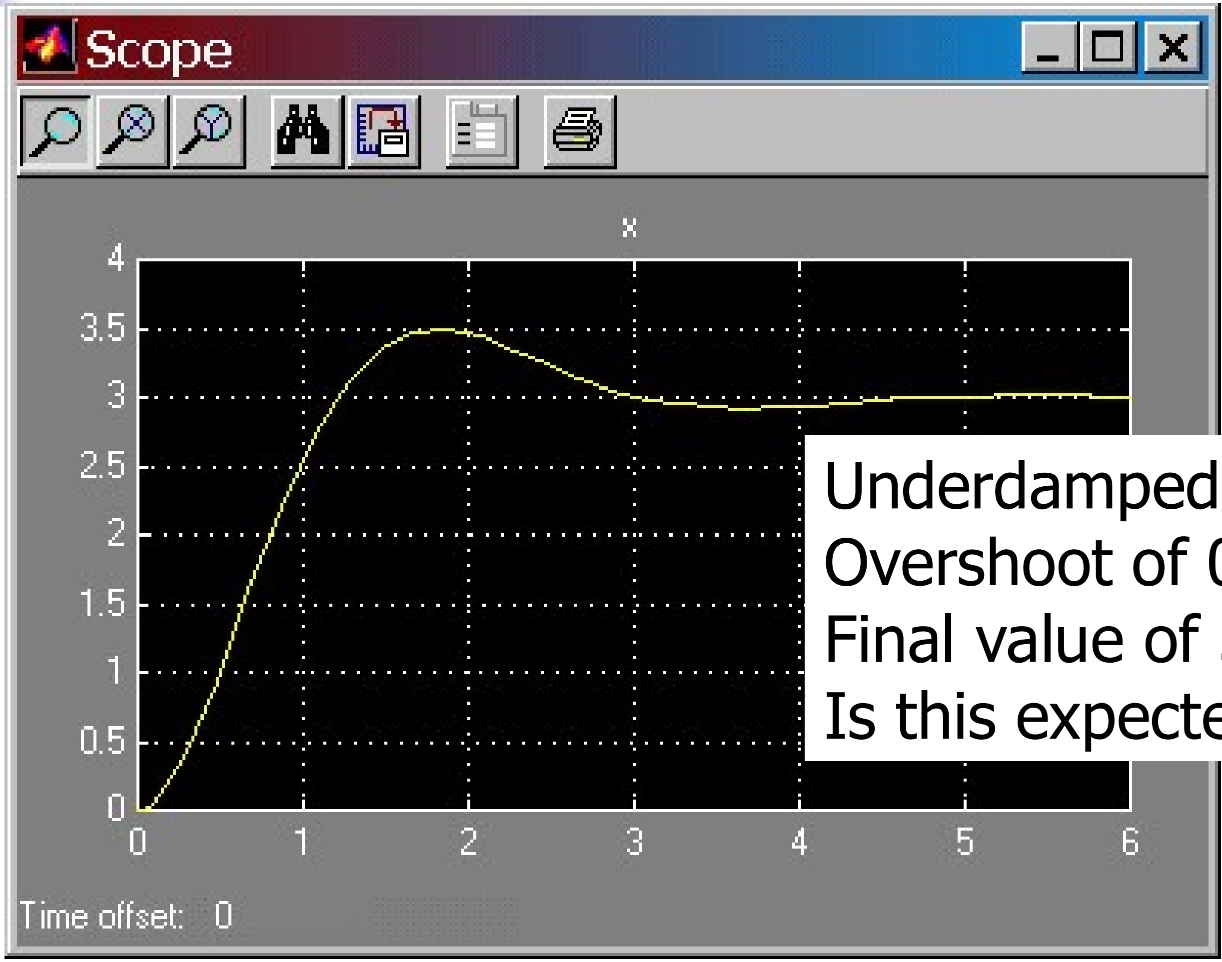
Final Simulink model



Run the simulation



Results



Underdamped response.
Overshoot of 0.5.
Final value of 3.
Is this expected?