MATLAB SIMULINK ® - Simulation and Model Based Design

http://www.mathworks.com

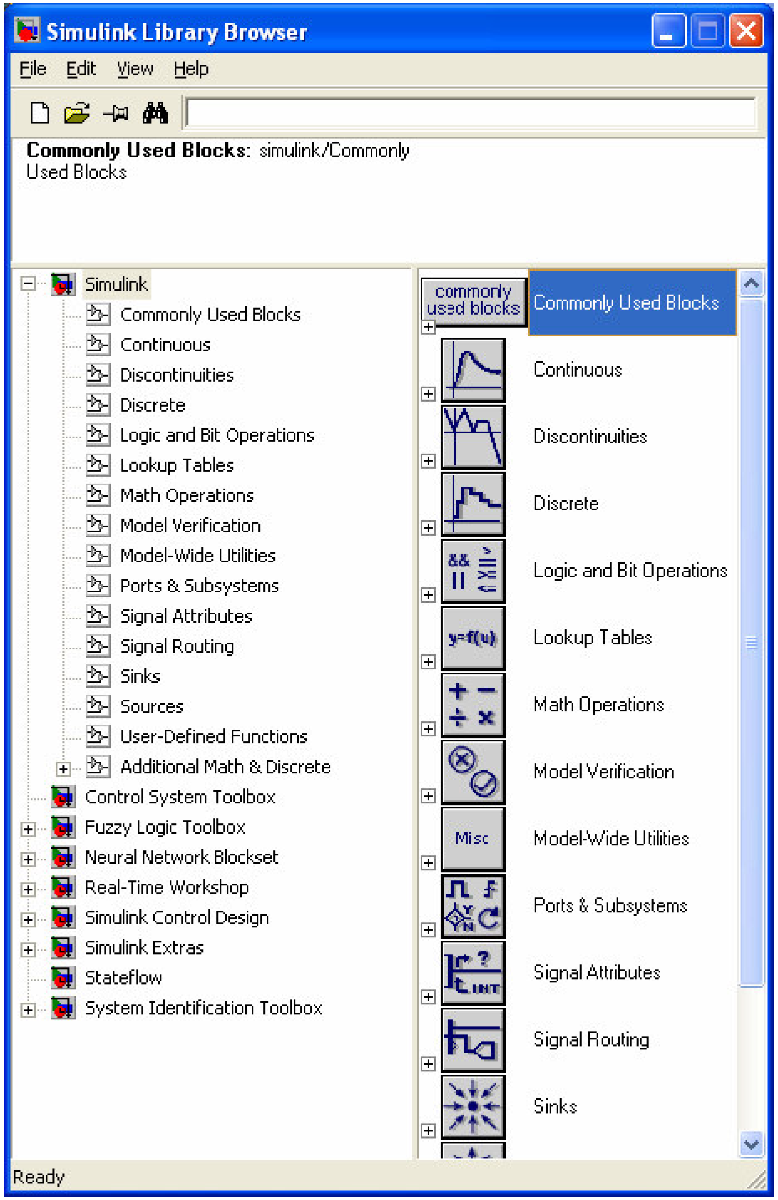
What is Simulink good for?

-Modeling/designing dynamic systems (including nonlinear dynamics)

-Modeling/designing control systems (including nonlinear controllers and plants)

-Signal processing design/simulation

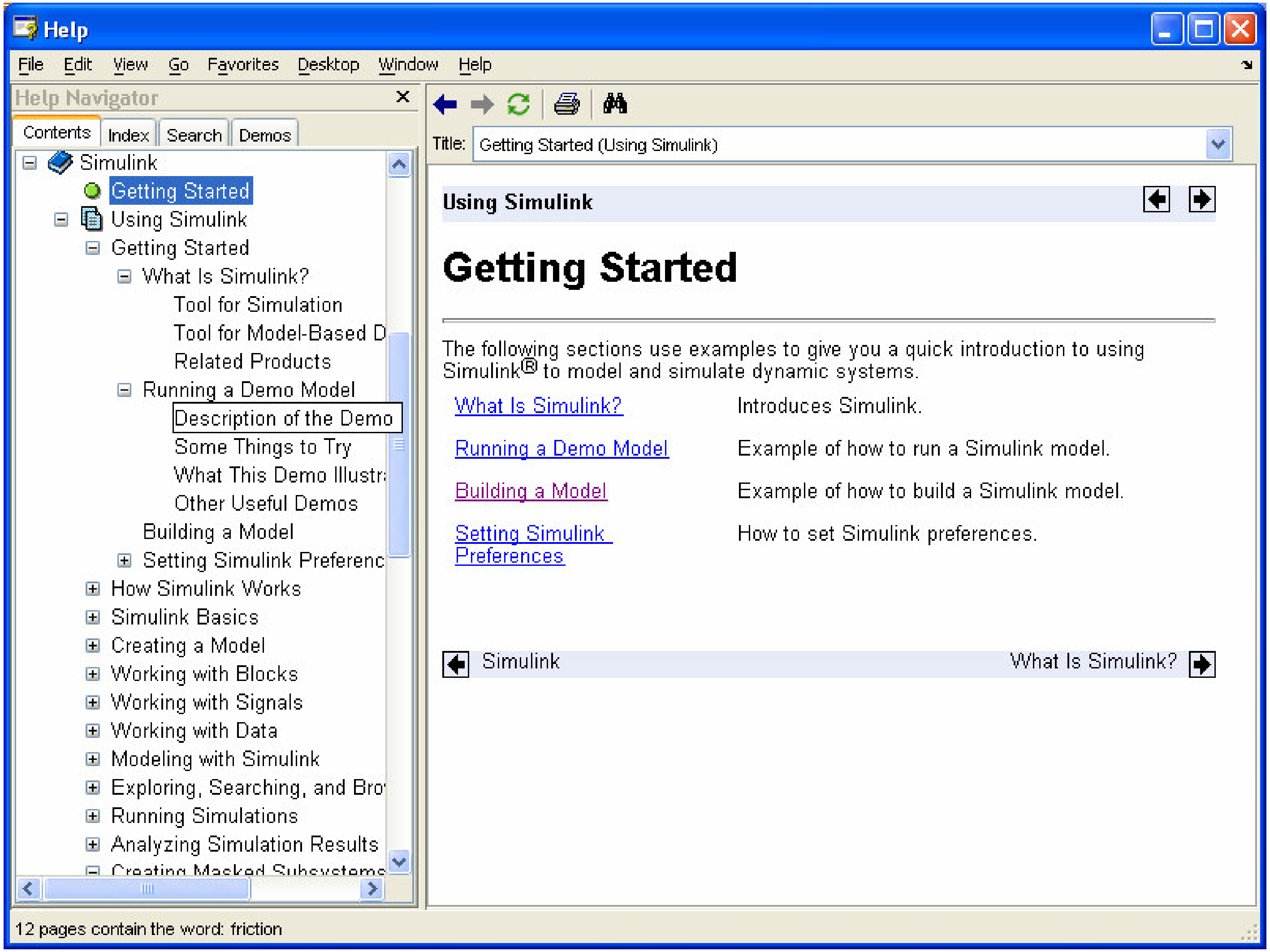
Simulink runs under Matlab. First start Matlab, then type “simulink” at the Matlab prompt.



The first window that pops up is the **Library Browser**.

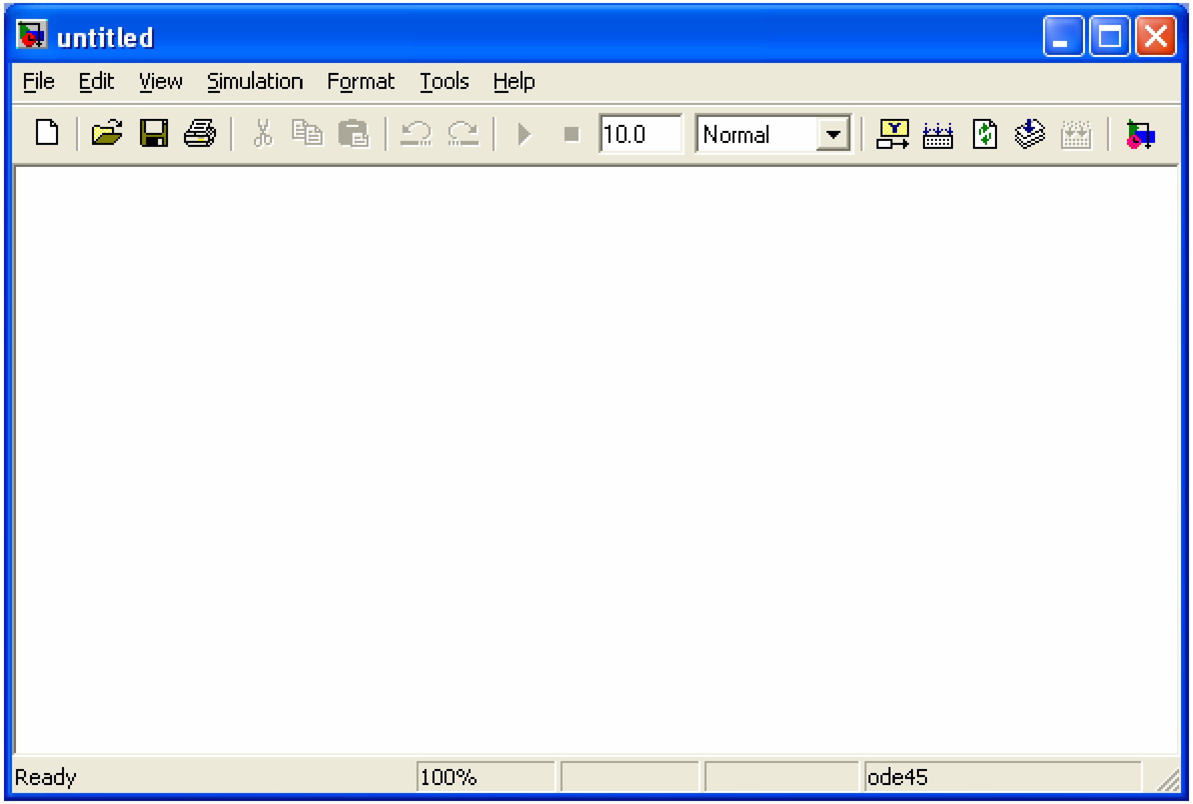
This is a library of blocks that are available for putting into the Simulink block diagram.

Simulink Help

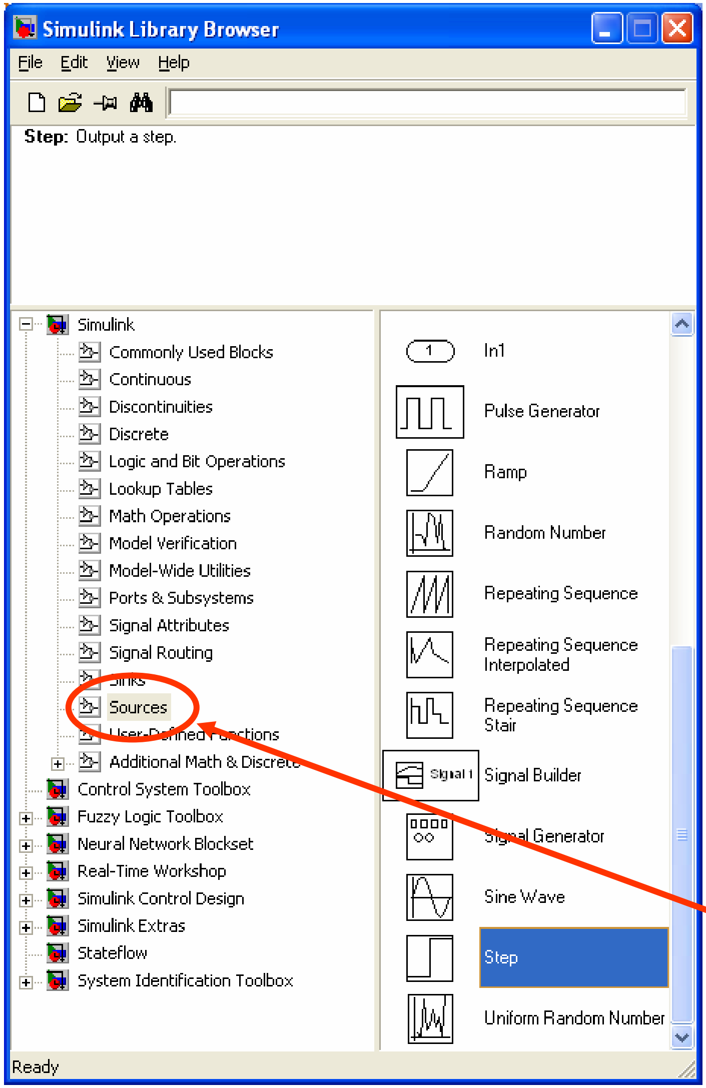


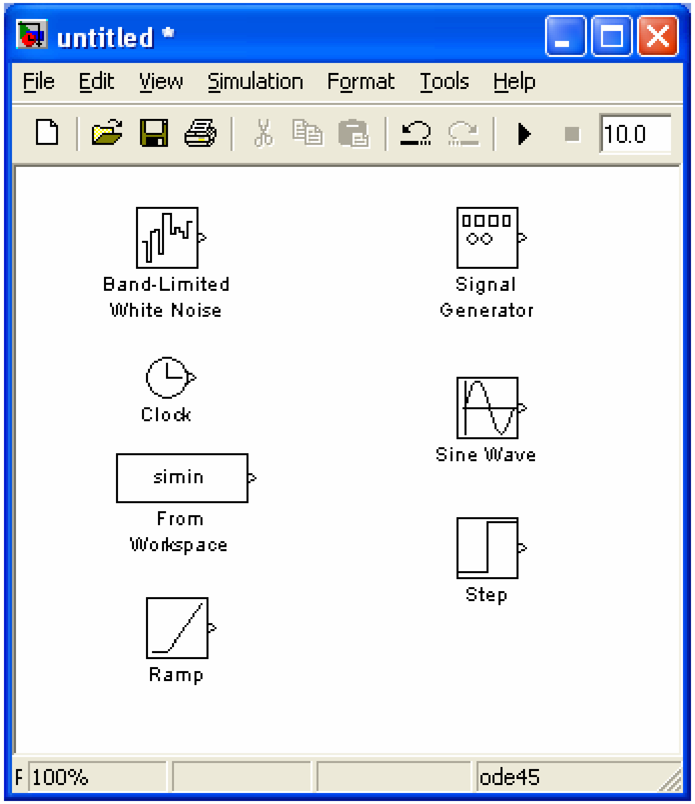
Select "Simulink Help" from the help menu in the library browser. Here you can find tutorials, demos, information on available blocks, and so on.

A Simulink model is a block diagram. Click "File|New|Model" in the Library Browser. An empty block diagram will pop up. You can drag blocks into the diagram from the library.



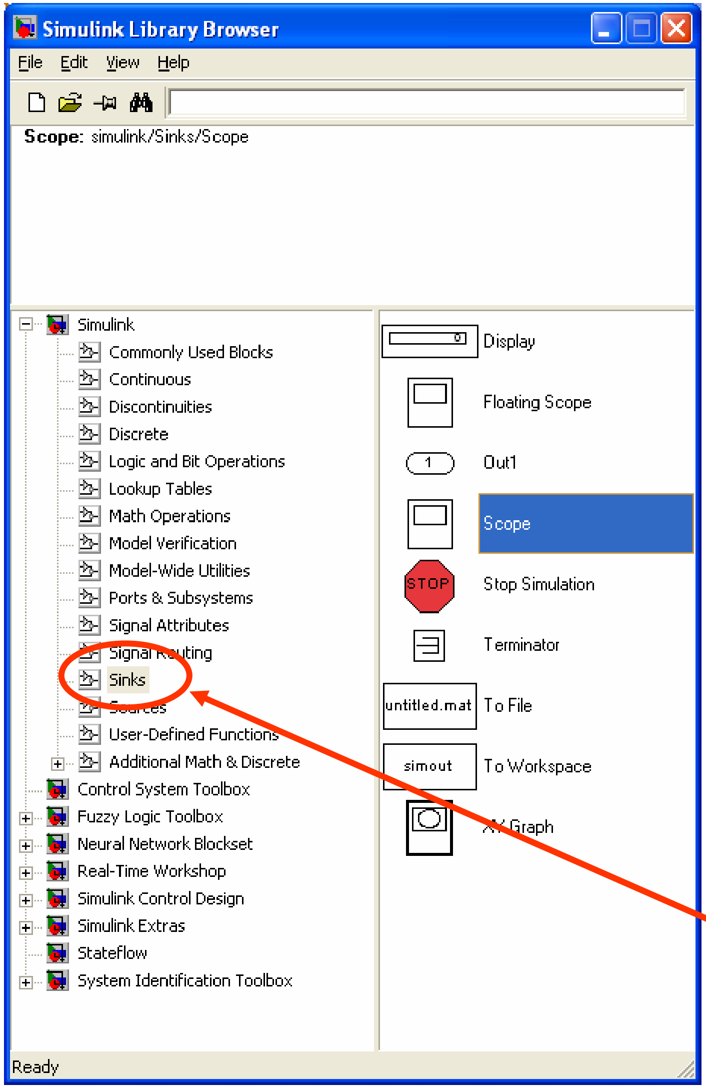
Sources: Produce Signals

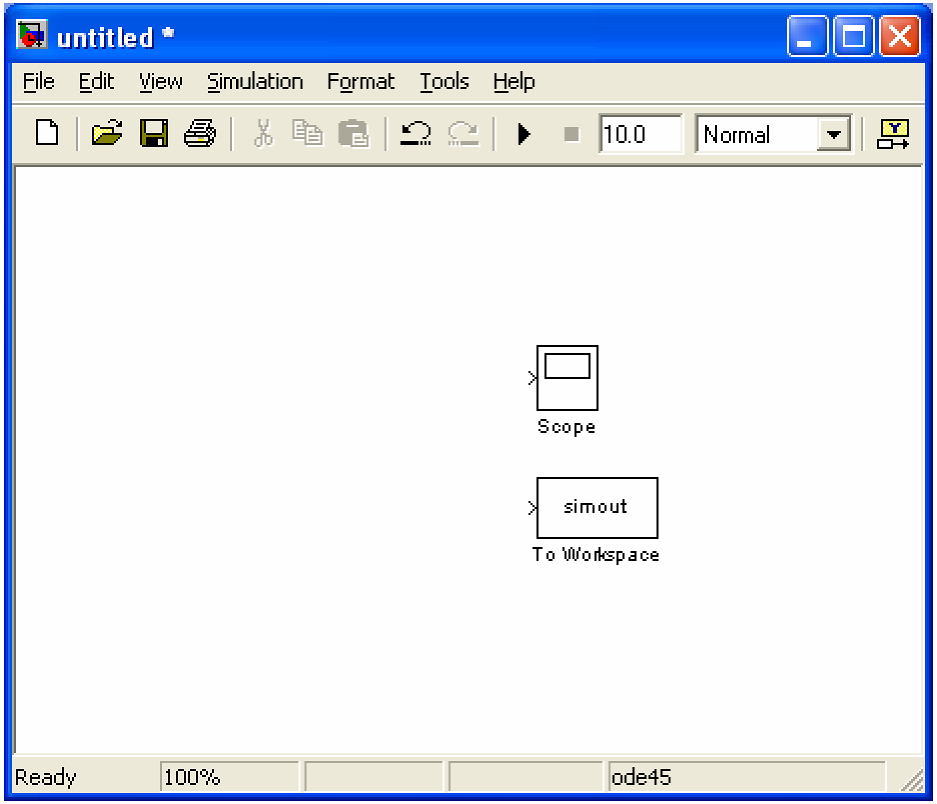




Select “sources” from the library. Drag any block you want to use into the model.

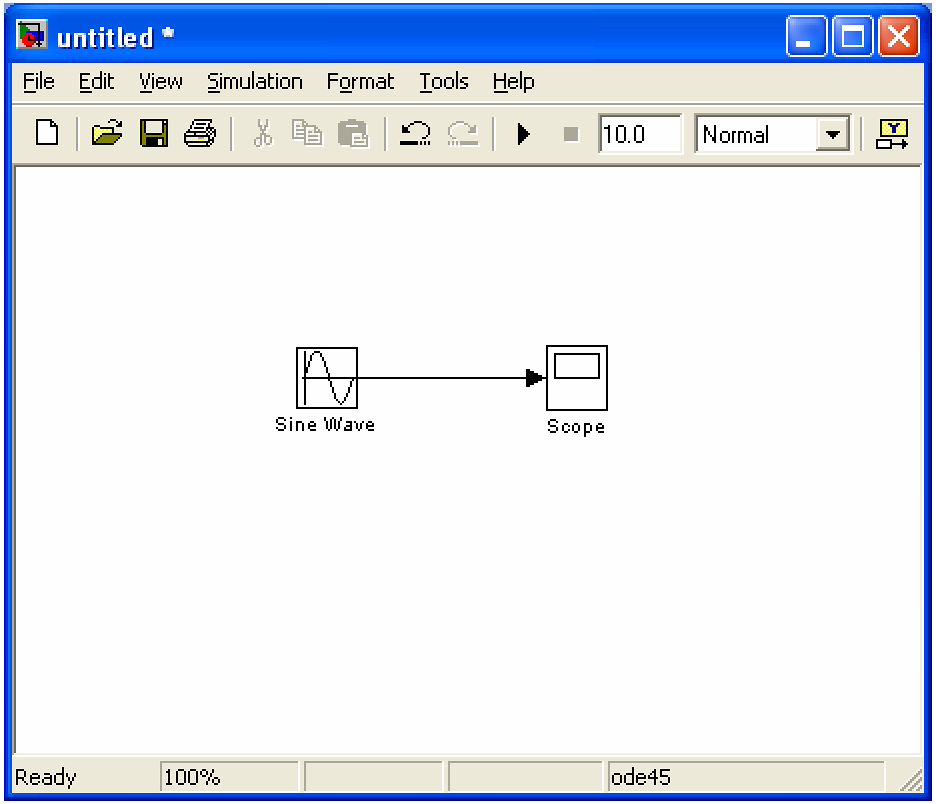
Sinks: Terminate Signals





Select “sinks” from the library. Drag any block you want to use into the model.

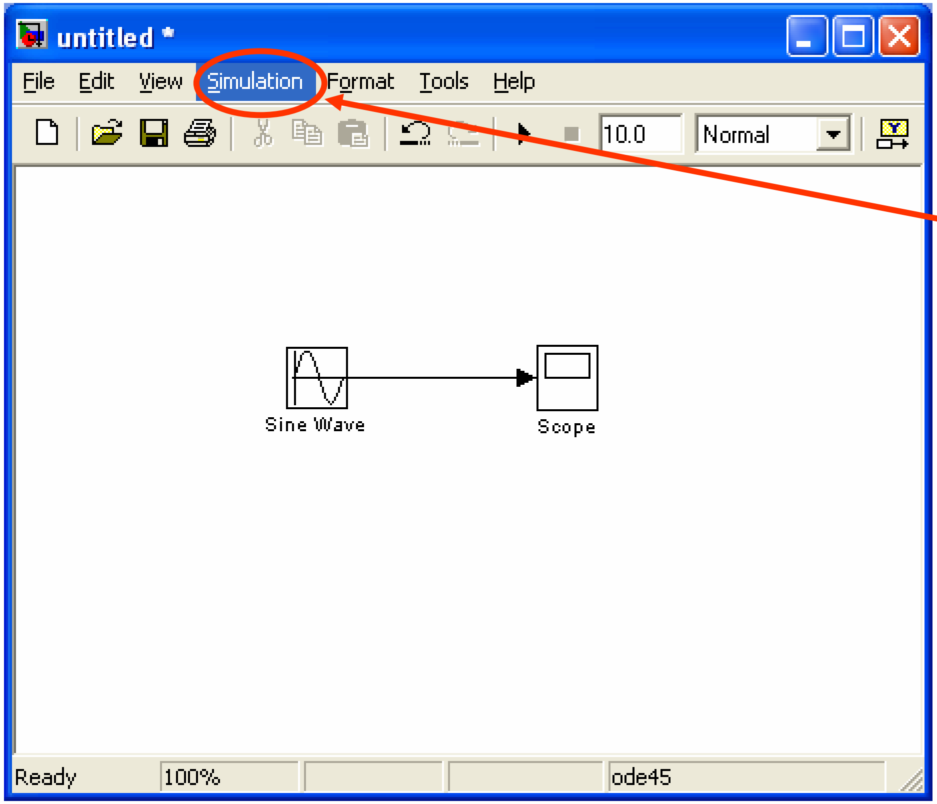
Connecting Blocks



Drag a signal line from the output of a block to the input of another block.

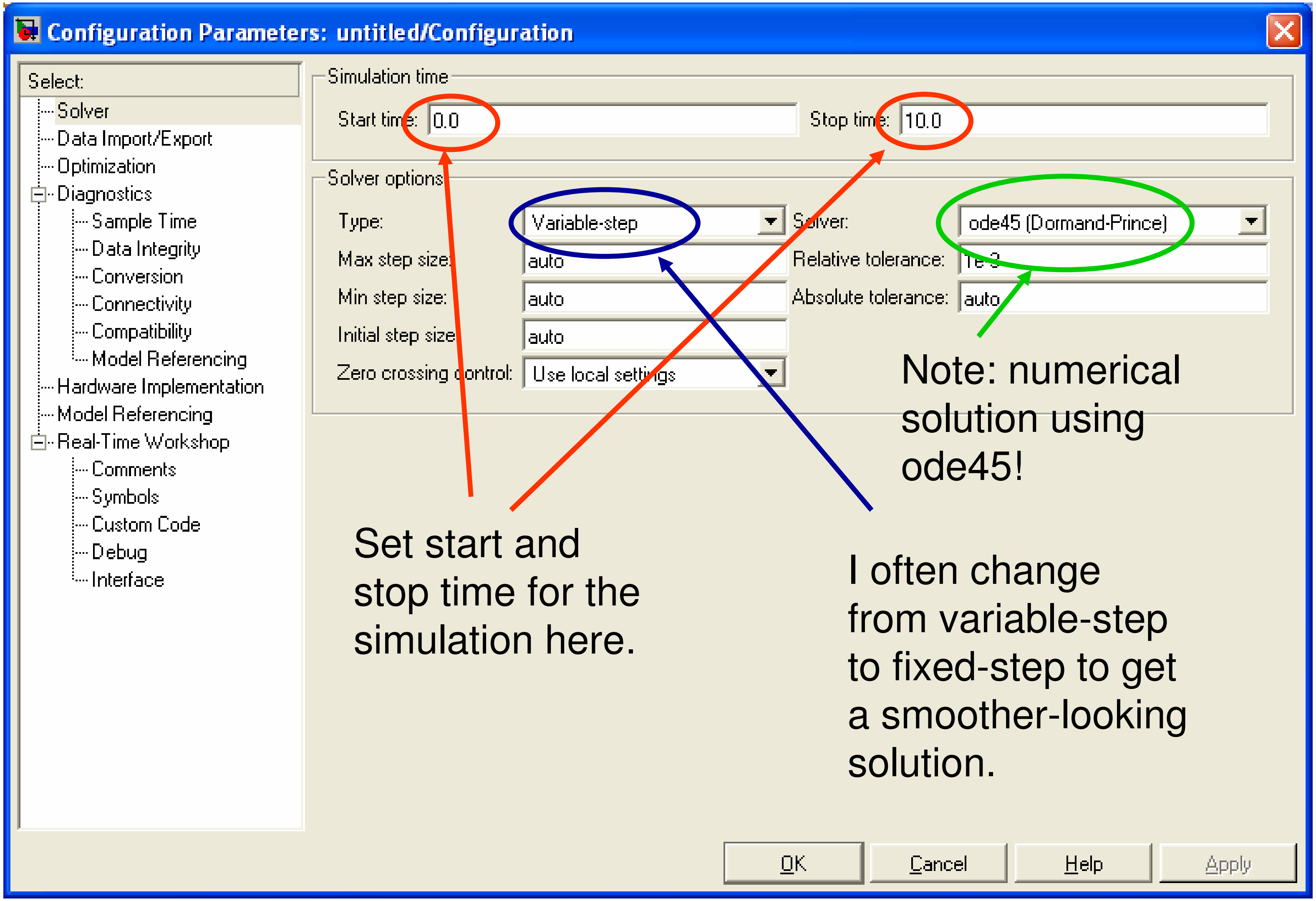
Ctrl-Click will automatically connect.

Running the Simulation

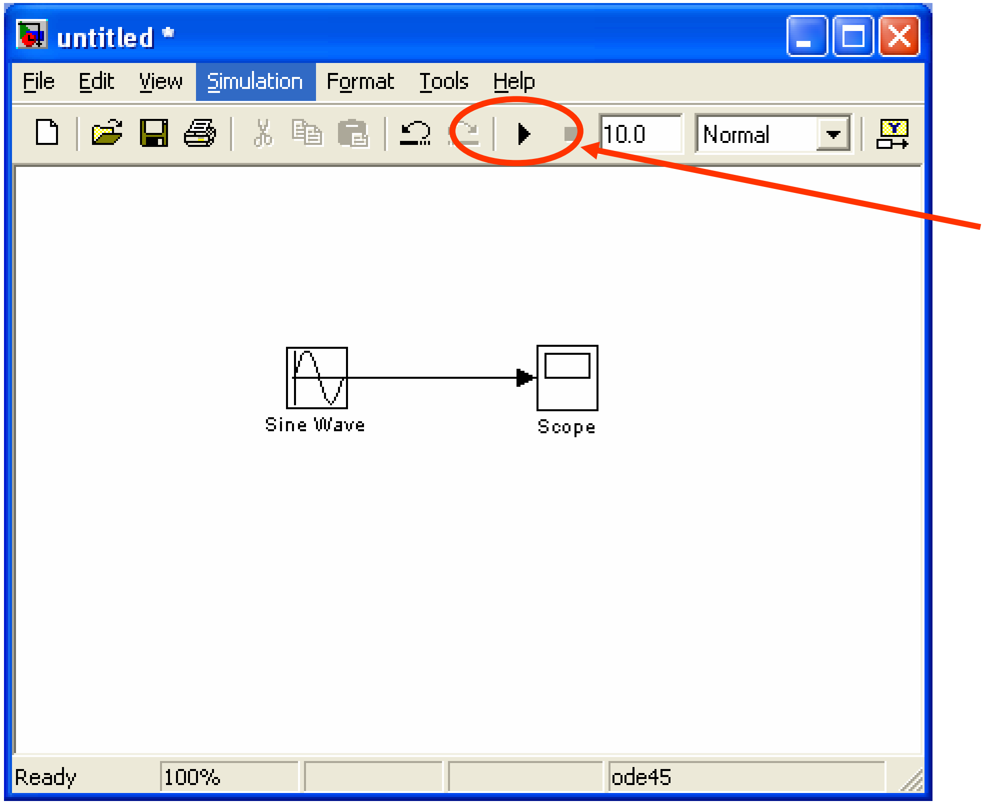


Change parameters under Simulation | Configuration Parameters.

Running the Simulation

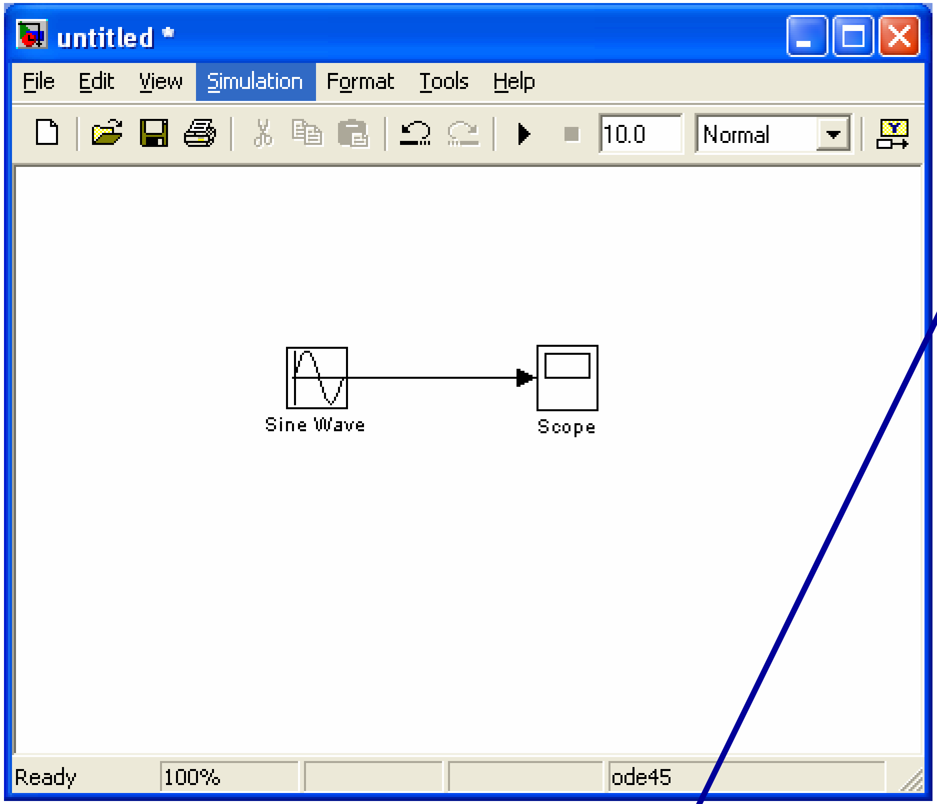


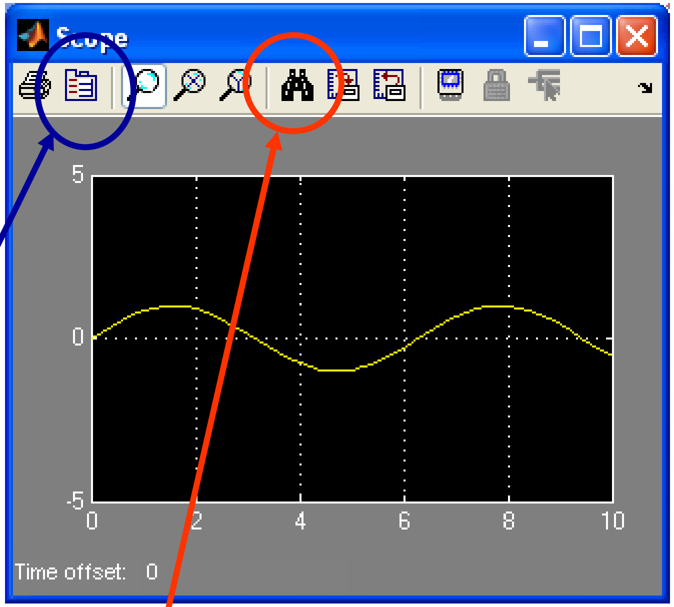
Running the Simulation



Once the parameters are all set, click the play button to run the simulation.

Viewing Results: Scope

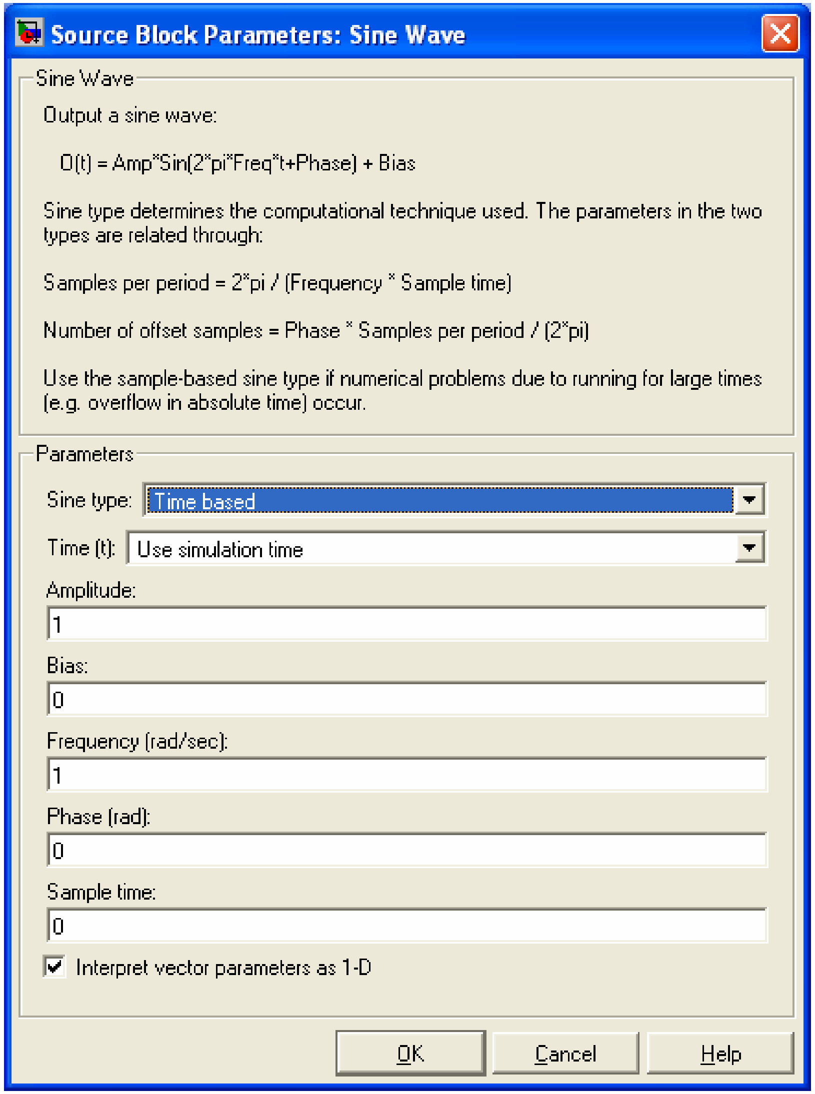




You can save data from the scope to the workspace using the “Parameters”, “Data History” tab.

Double click on the scope icon to open up the viewer. You often have to zoom out using the binocular icon if the curve doesn’t fit in the default axes.

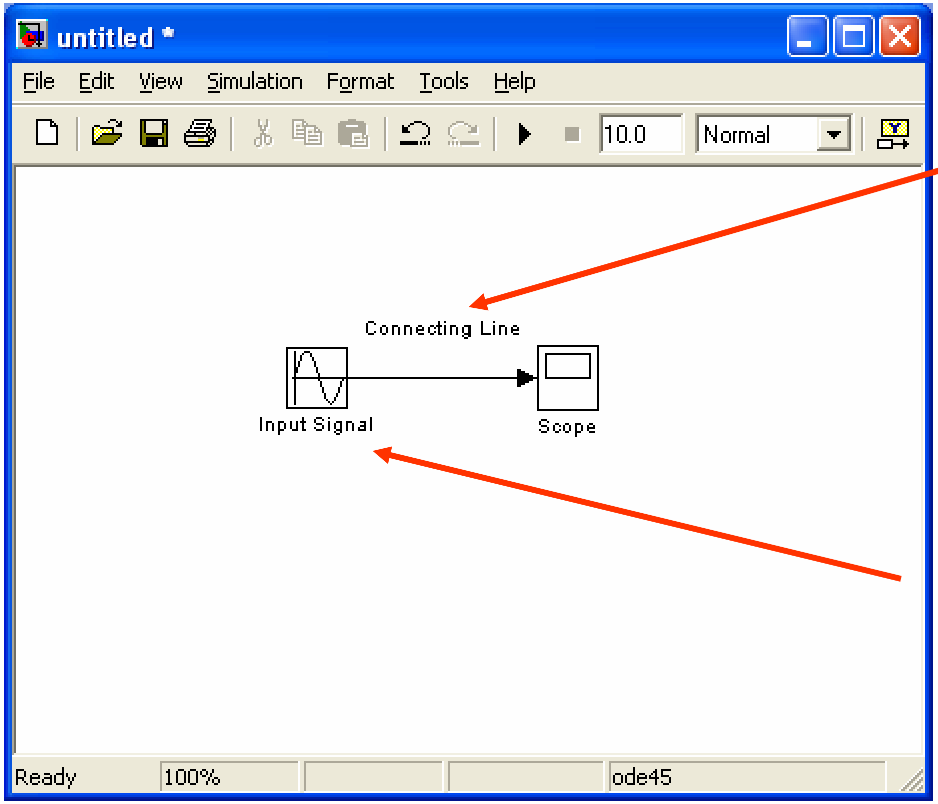
Modifying Block Properties



Double click on any block to bring up a properties box.

Here are the “sine wave” properties. If you don’t know what something is… leave it alone!!!

Adding Comments

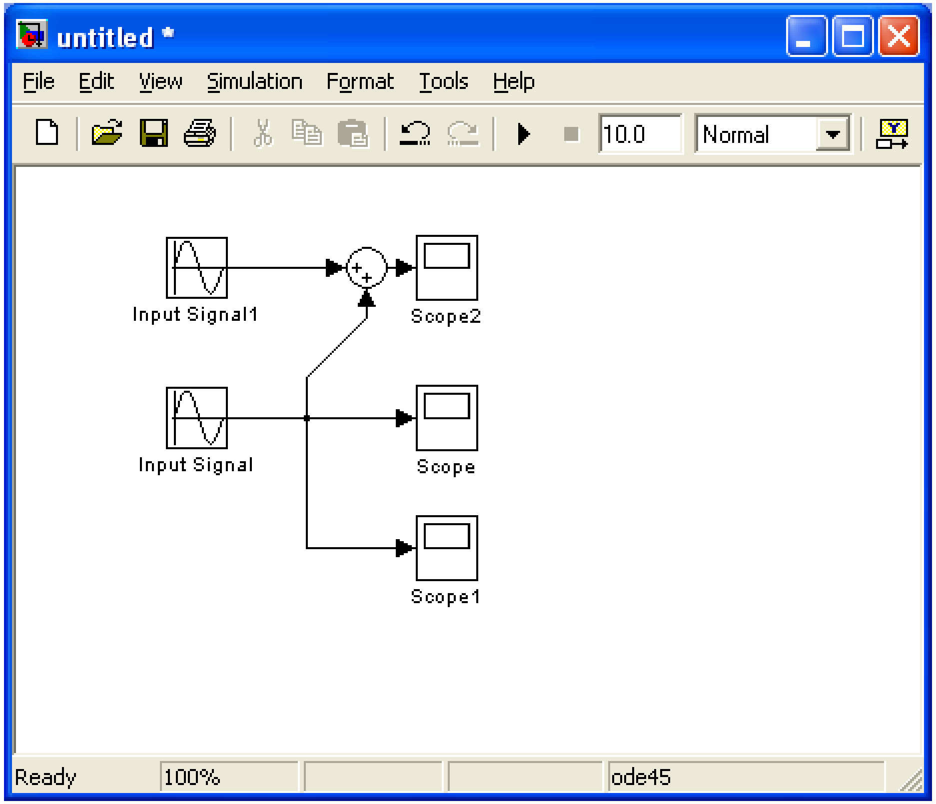


You can add text comments anywhere in the block diagram by double clicking and typing in some text.

You can change the default comments under the blocks by double clicking and editing the text.

Do In-Class Problem #1. Should be 2:00 at the end of the problem.

Signal Routing



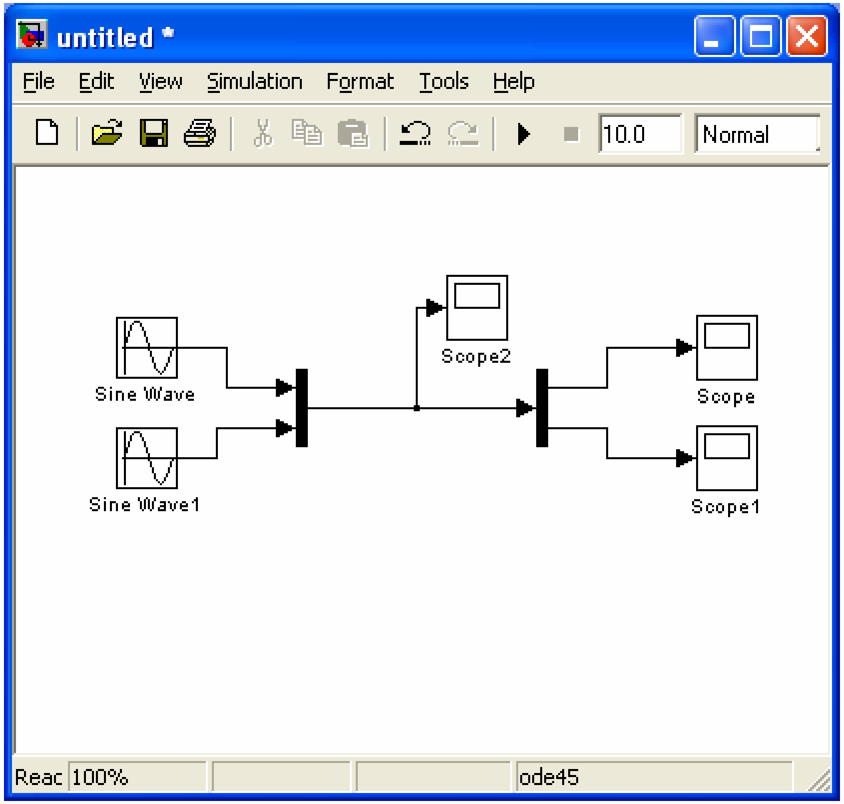
You can create a branch point in a signal line by holding down the CTRL key, and clicking on the line.

A summer block can be found in the “commonly used blocks” library, and in the “math” library.

To change the shape of the summer to rectangular, or to add additional inputs or change the sign, double click on the summer.

You can flip a block over by right clicking and looking under “Format”, or by selecting it and typing CTRL-i

Signal Routing



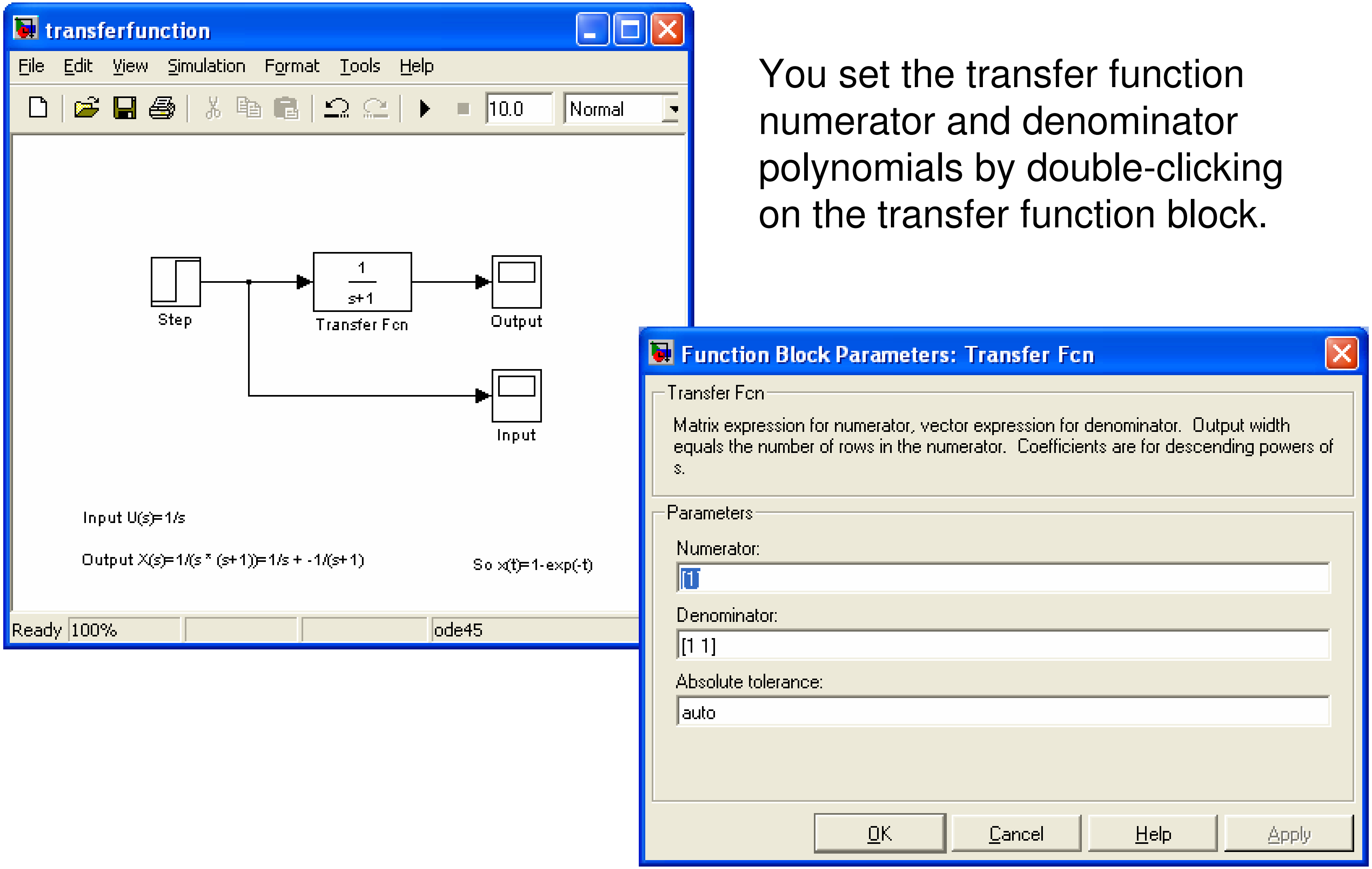
Under the "signal routing" library, the MUX block can be used to bundle a group of signals together into a single line.

The DEMUX block does the reverse.

This can be useful to:

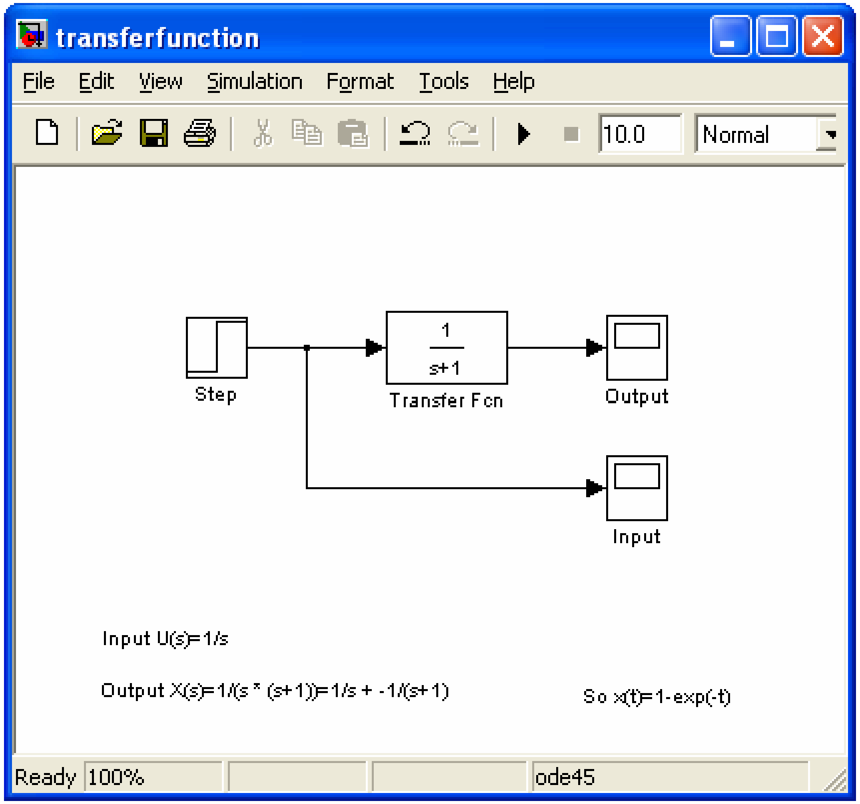
1. Clear up clutter in a complicated block diagram.
2. Send multiple signals to the same scope; then both signals will be displayed on the same plot.

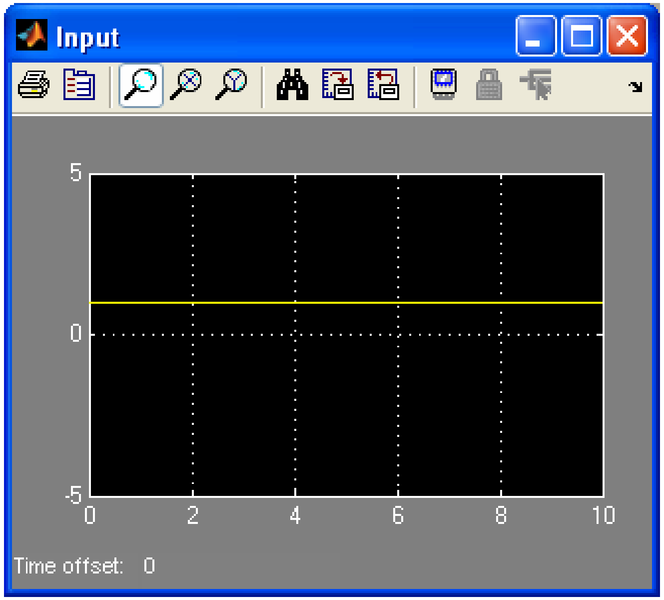
Transfer Functions

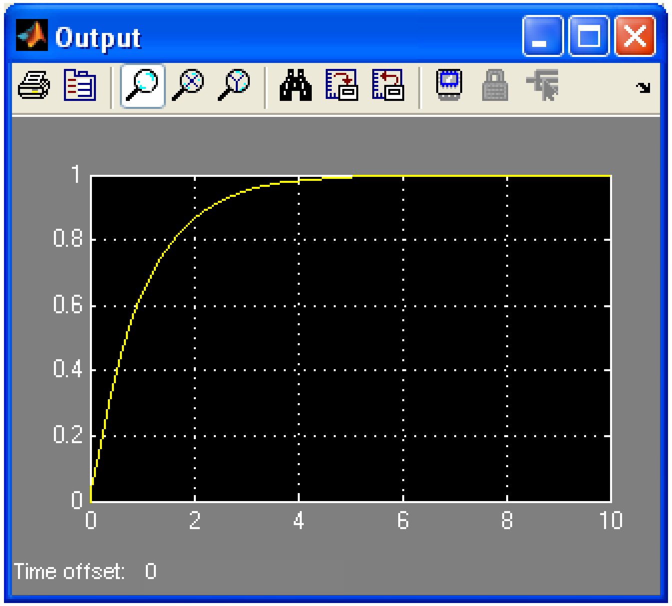


You set the transfer function numerator and denominator polynomials by double-clicking on the transfer function block.

Transfer Functions







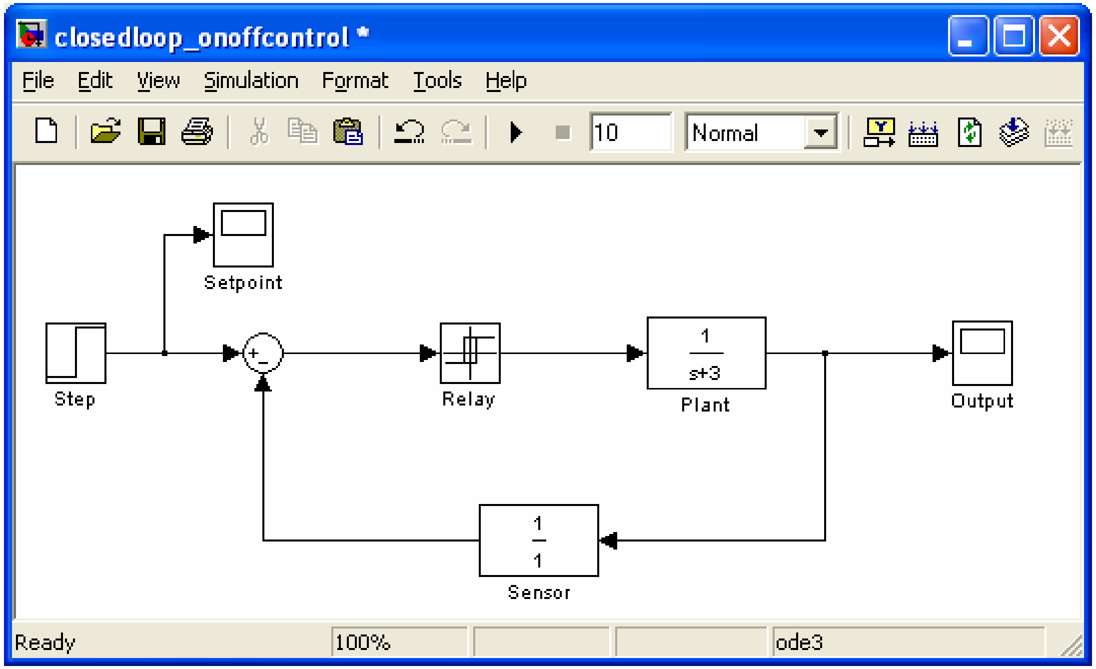
$U(s) = 1/s$

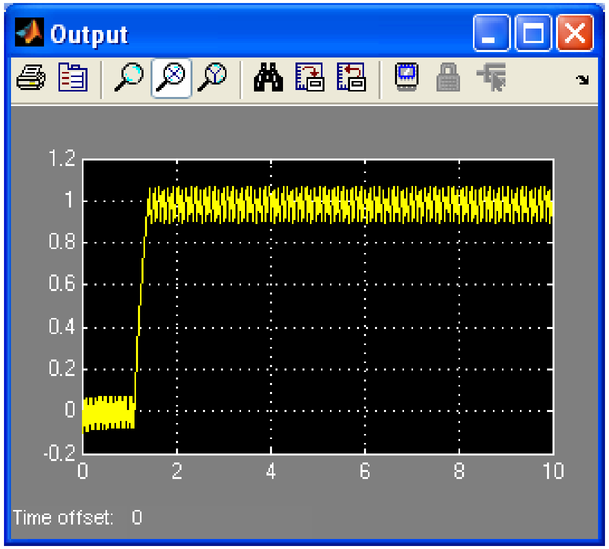
$X(s)=1/(s(s+1))=1/s-1/(s+1)$

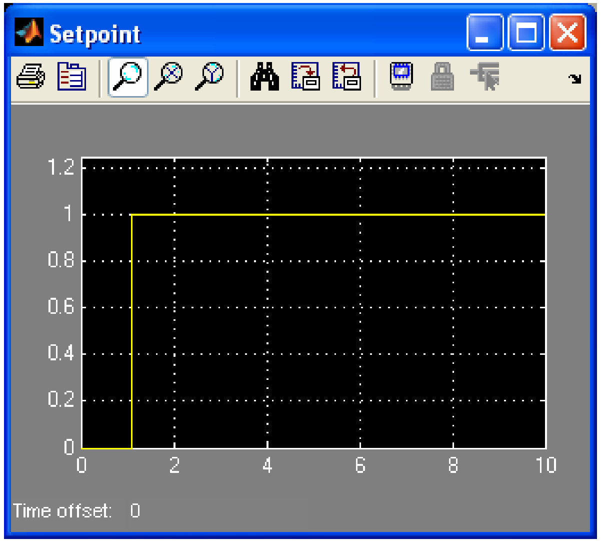
So $x(t)=1-exp(-t)$

Do In-Class Problem #2. It should be 2:20 by the end of the problem.

Closed Loop Control System:

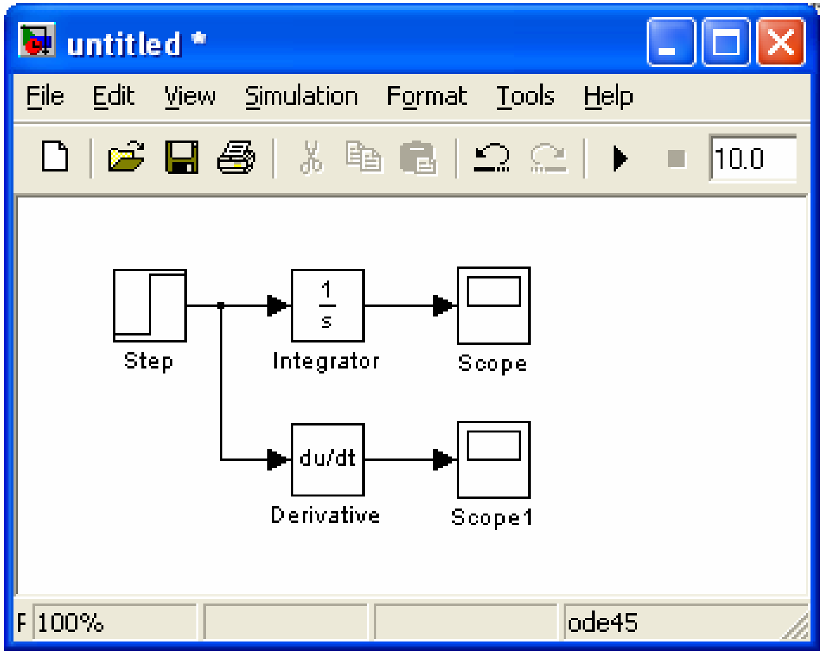


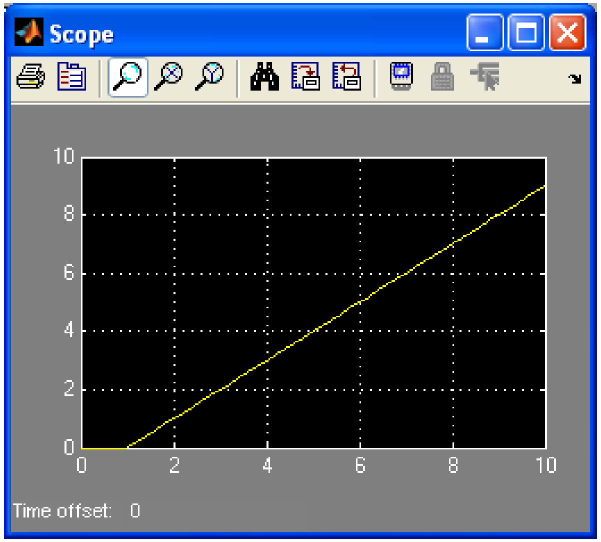


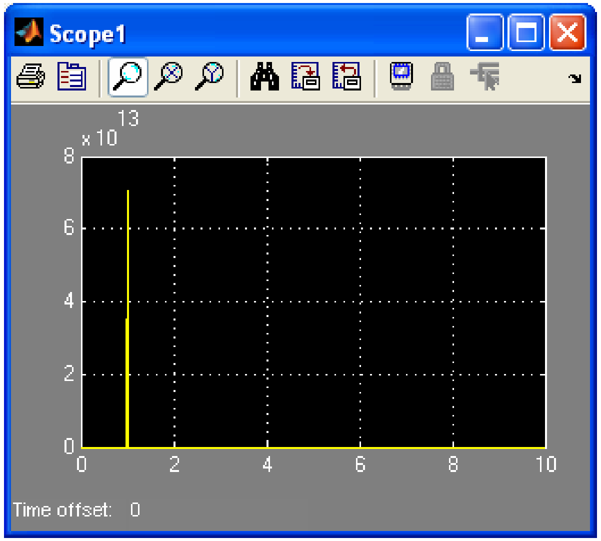


Here is an example of a closed-loop system with an on-off controller. Notice the oscillations in the response.

Integrators and Derivatives

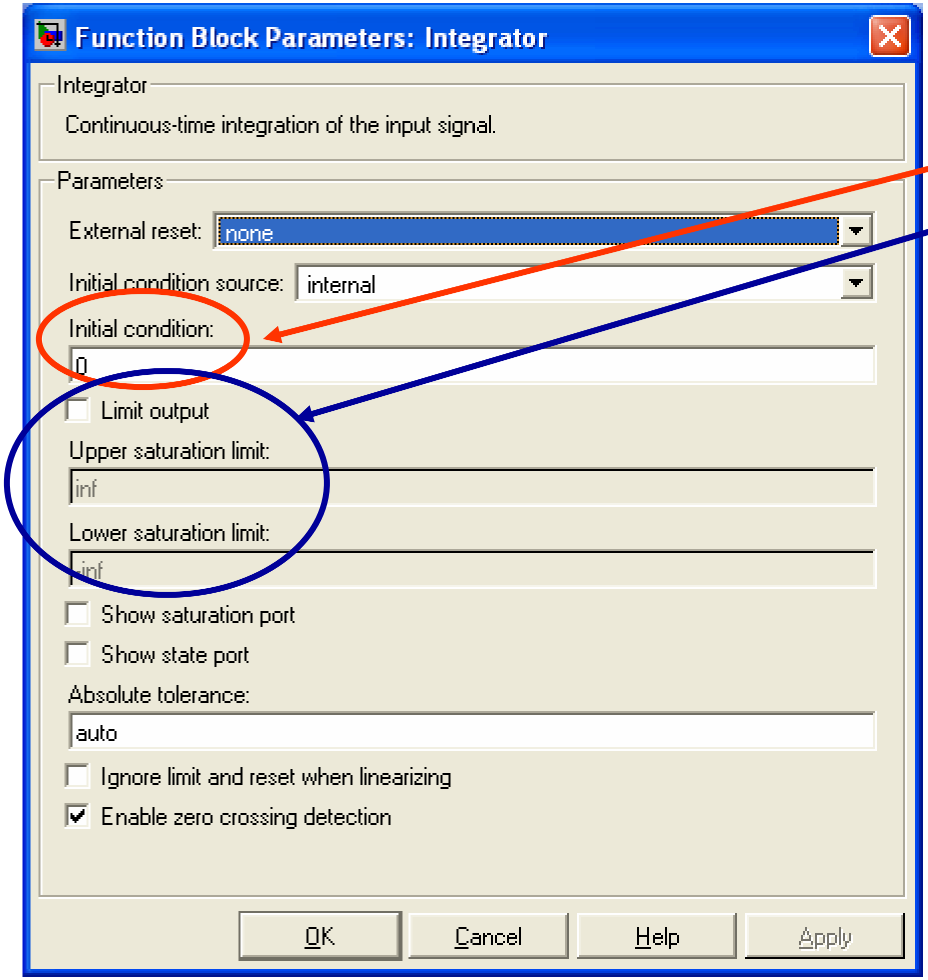






Integrators and derivatives are available in the “continuous” library.

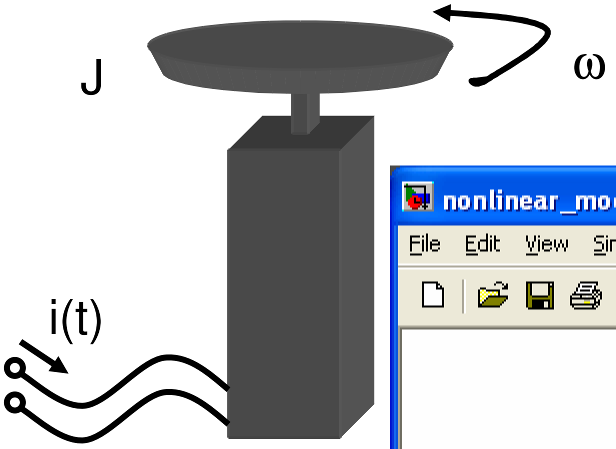
Integrators



For integrators, you can set the initial condition and limit the output to not be allowed to go above or below some value on the properties for that block.

Setting Up Systems with Integrators

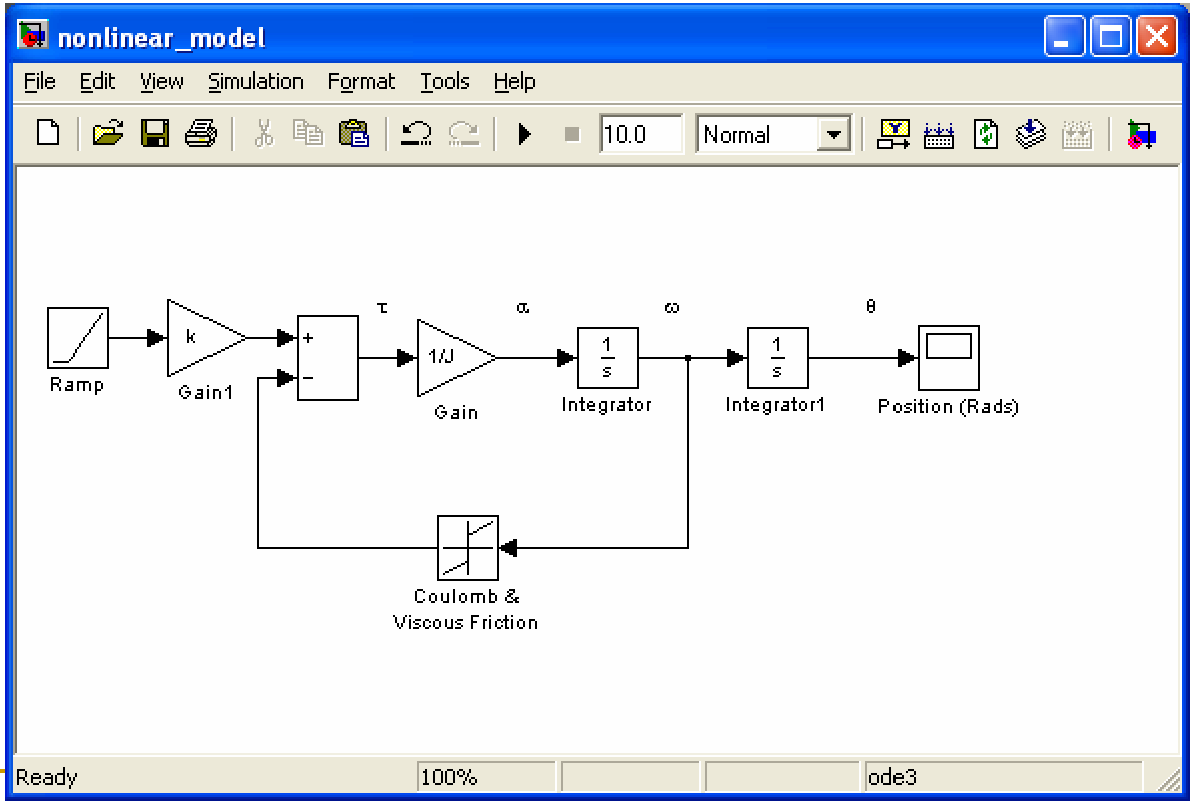
If you have a nonlinear equation system, you **can't** describe it with a transfer function. One option is to put all of the operations in as individual blocks:



$\tau(t)=ki(t)-f(\omega)$

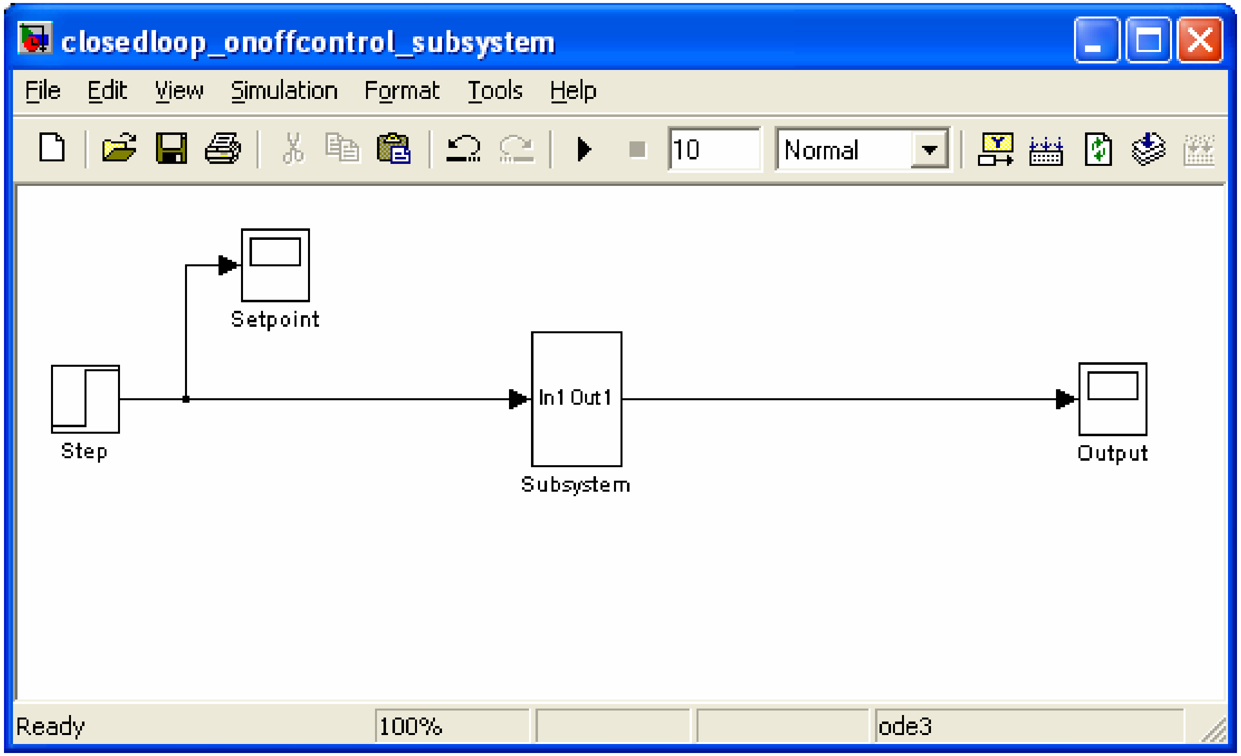
where f(w) is coulomb and viscous friction.

Use integrators rather than derivatives, and put in as many integrators as there are states. Then "bootstrap"!



Do in-class problem #3. It should be 2:40 at the end of the problem.

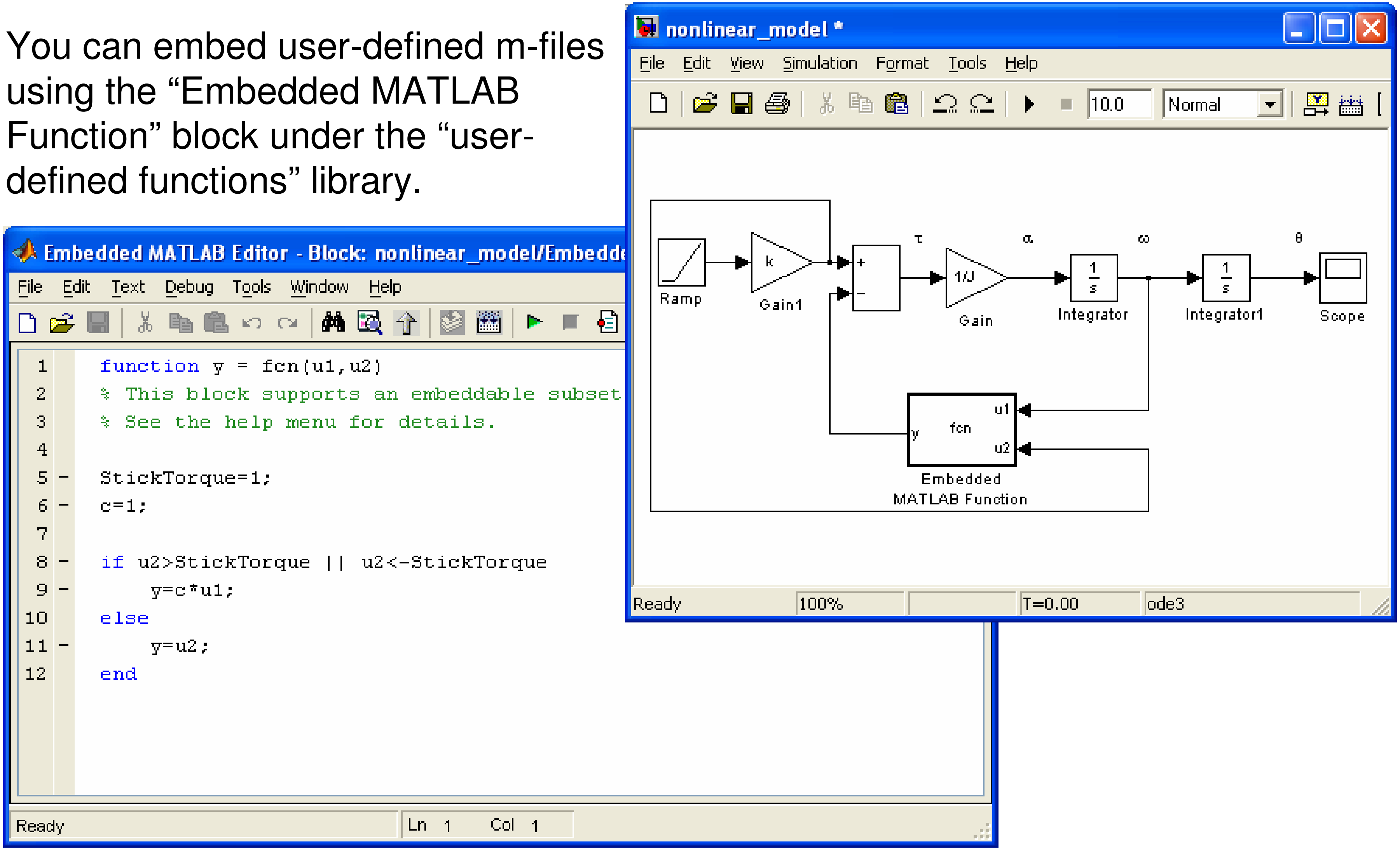
Subsystems



You can group a set of blocks together into a subsystem, by selecting them and right clicking and saying “Create Subsystem”. They will all go under a single block. If you double click the subsystem, you can see what is under the “mask”.

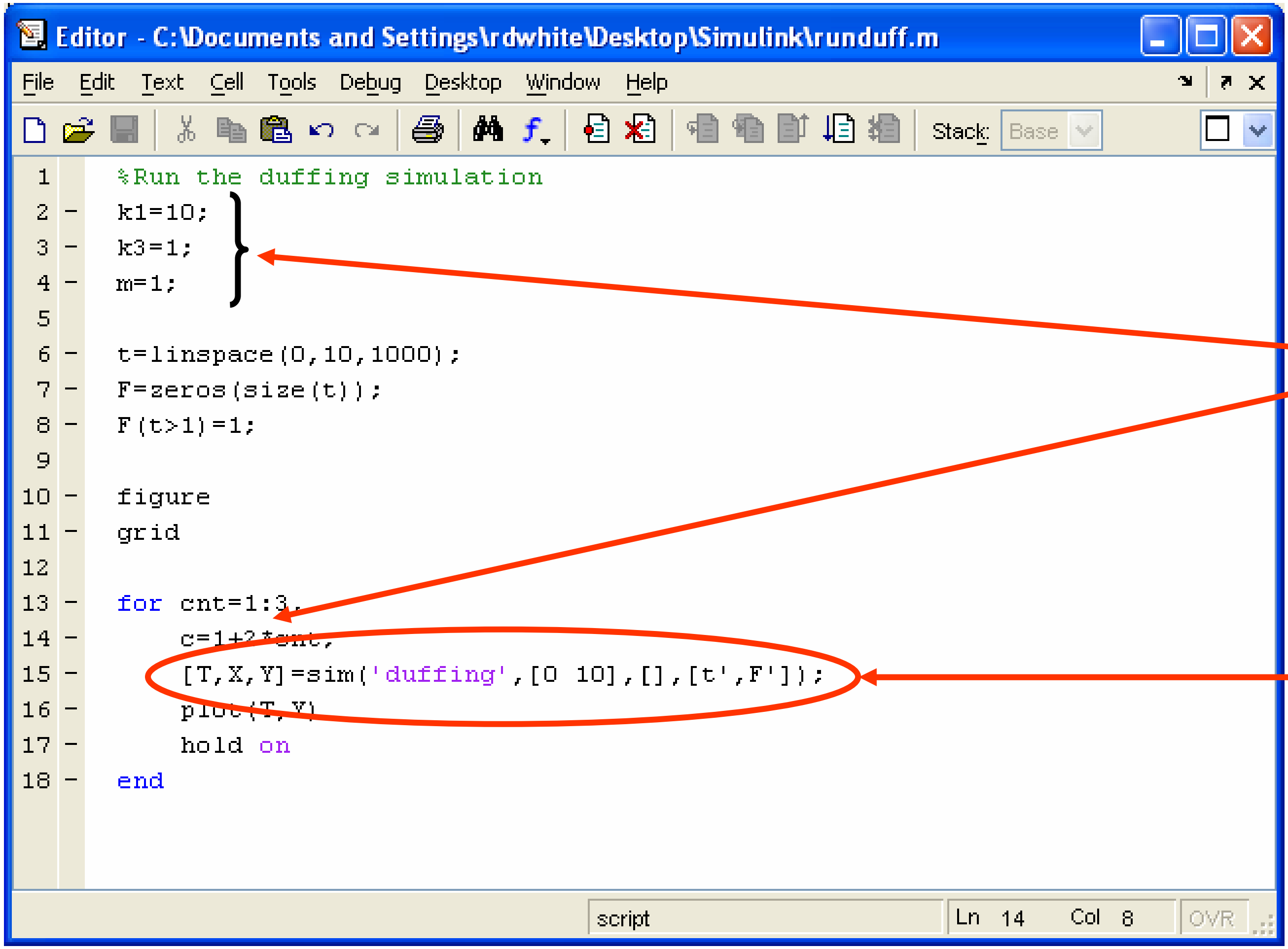
User Defined Functions

You can embed user-defined m-files using the “Embedded MATLAB Function” block under the “user-defined functions” library.



Running Simulink Models from M-files

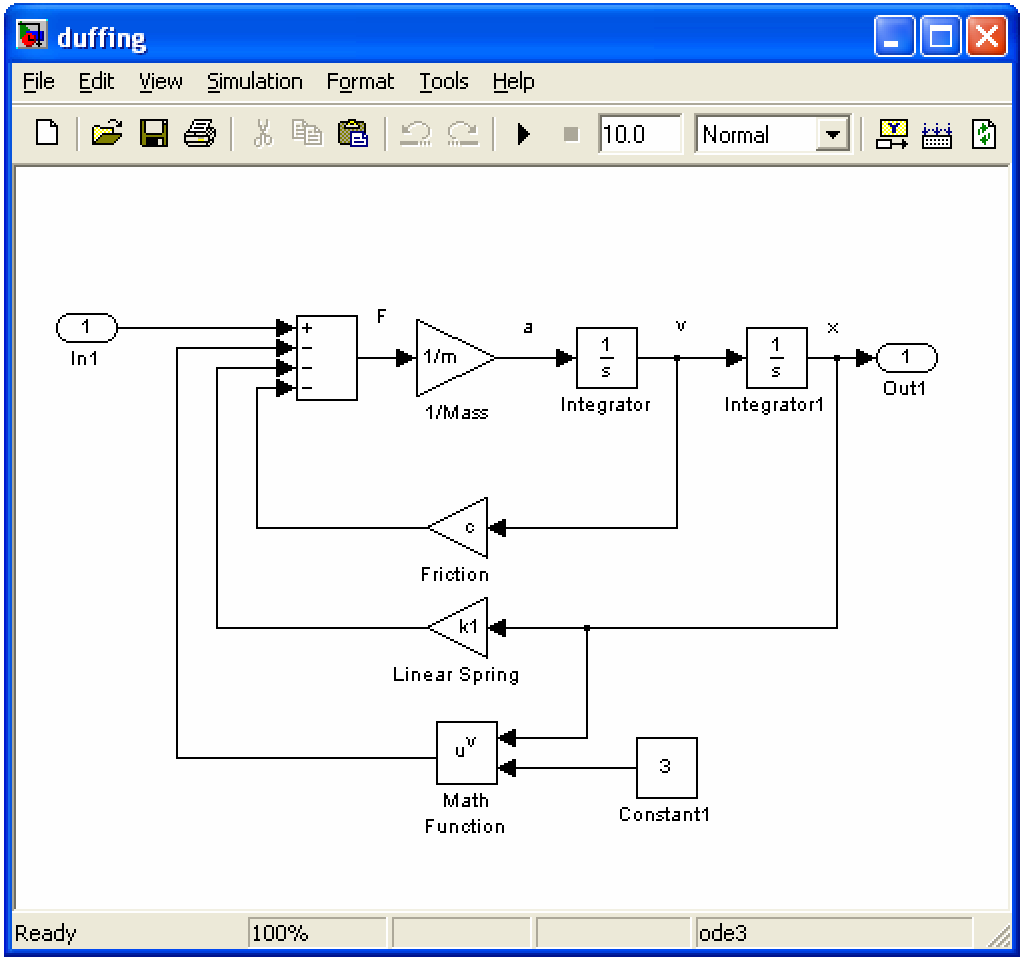
[T,X,Y] = SIM('model',TIMESPAN,OPTIONS,UT)



Constants in the simulink model can be defined in the workspace.

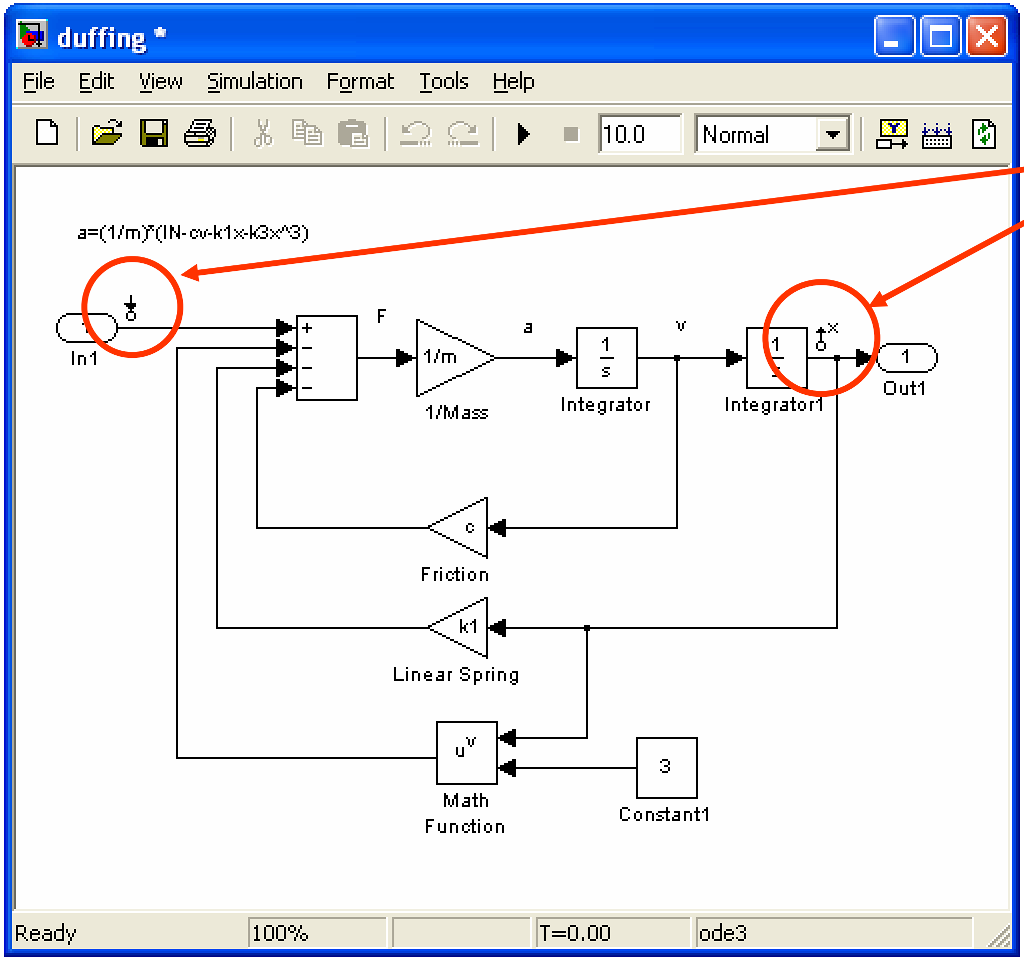
Here is the heart of the m-file.

Running Simulink Models from M-files



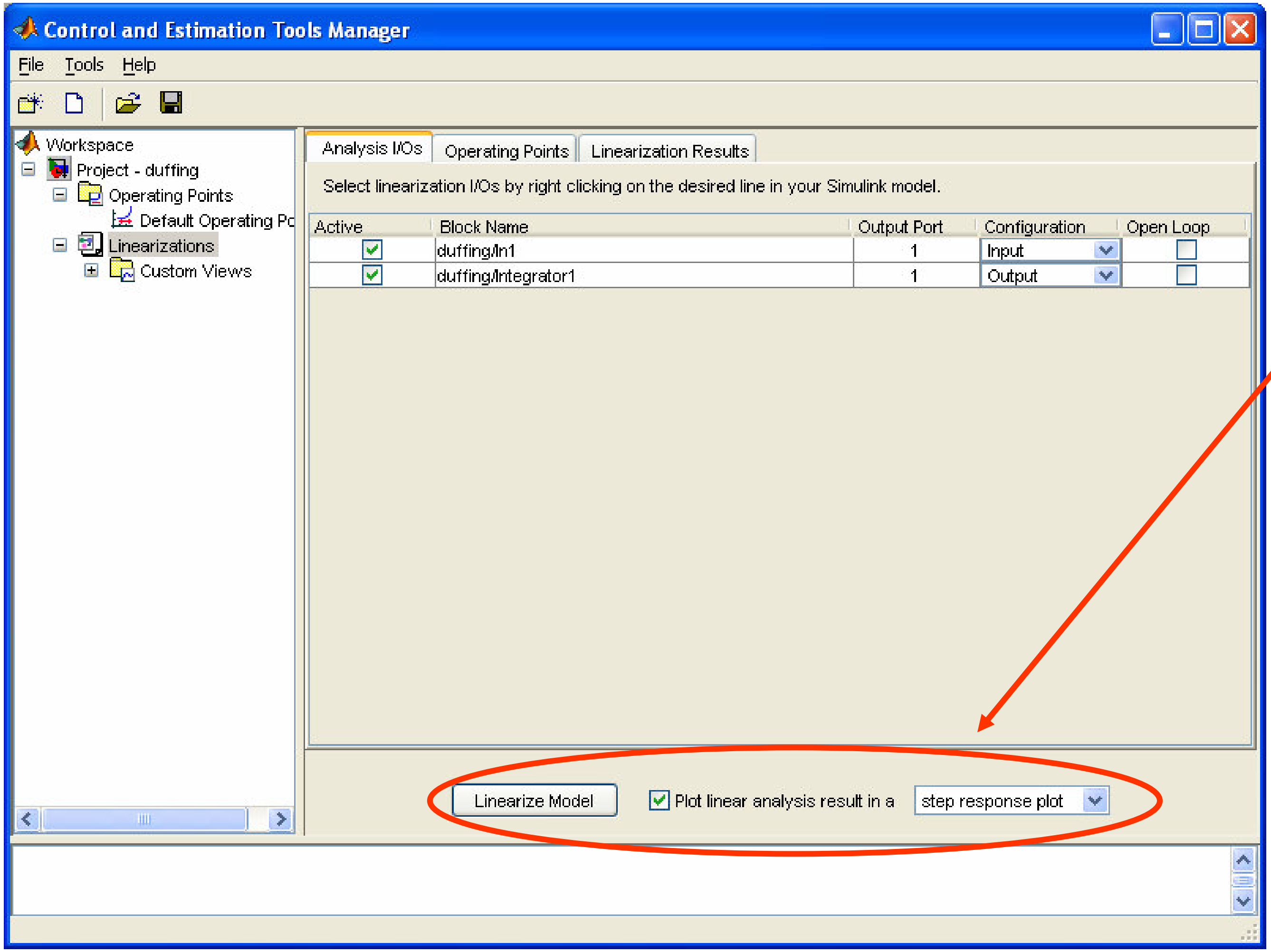
The input and output of the simulink model are defined in the block diagram using input and output sources and sinks.

Control and Estimation Tool



Set input and output points by right clicking on a signal, and selecting “Linearization Points”.

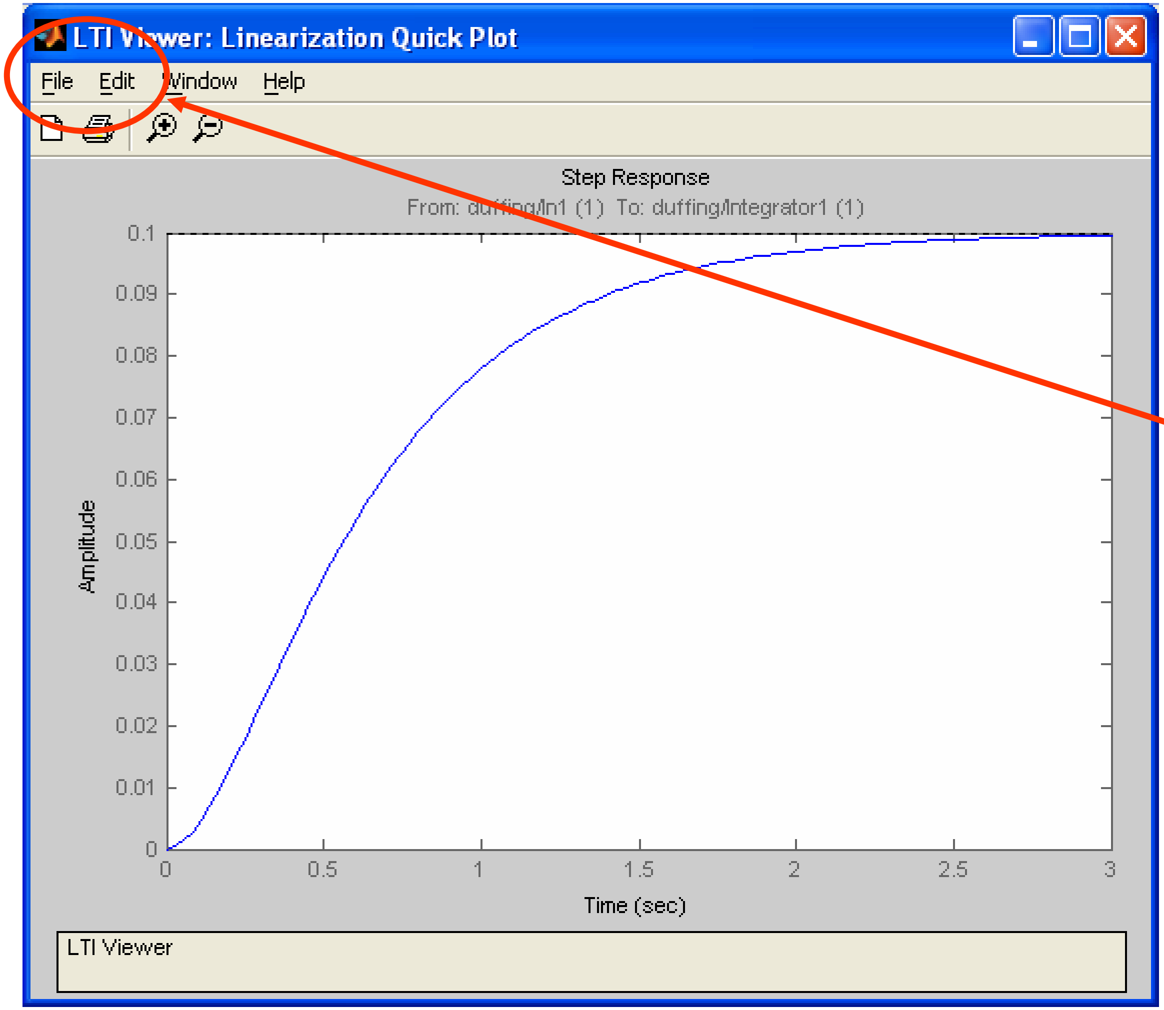
Control and Estimation Tool



Select "Tools:Control Design: Linear Analysis" from the simulink menu.

The control and estimation tool will pop up. Select the type of plot you want to generate, and click "linearize model". The system will be linearized about the operating point (see Ogata 3-10 and Simulink Help)

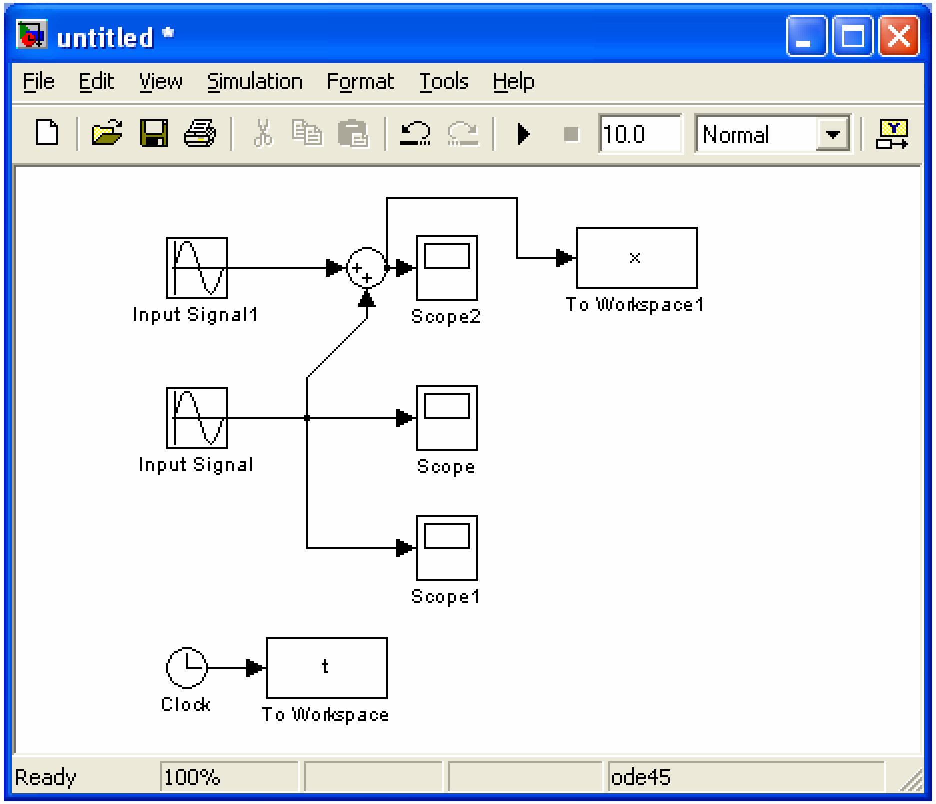
Control and Estimation Tool



The selected type of plot will pop up for your linearized system. If you want a different type of plot, look under Edit:Plot Configurations.

To export the linearized system to the Workspace so you can use it with other design tools in Matlab, select File: Export.

Communicating with the Workspace



Any constant or variable defined in the Matlab workspace is available in the block diagram.

The “simin” and “simout” blocks allow you to pass signals in from the workspace, and out to the workspace. Change the save format to “Array” for easiest use (double click on the To Workspace block for options).

The “clock” source allows you to generate a time signal if you want to send that back to the workspace.

Other Useful Blocks

Under “Discontinuous” you will find coulomb friction, dead zone, saturation, and relay.

Under “Continuous” there is a delay block.

Under “Simulink Extras” there is a PID controller, transfer function with non-zero initial conditions, some useful sinks (such as power spectral density), and radians-to-degrees and Fahrenheit-to-Celsius converters.