ME40064: System Modelling & Simulation
ME50344: Engineering Systems Simulation
Lecture 16

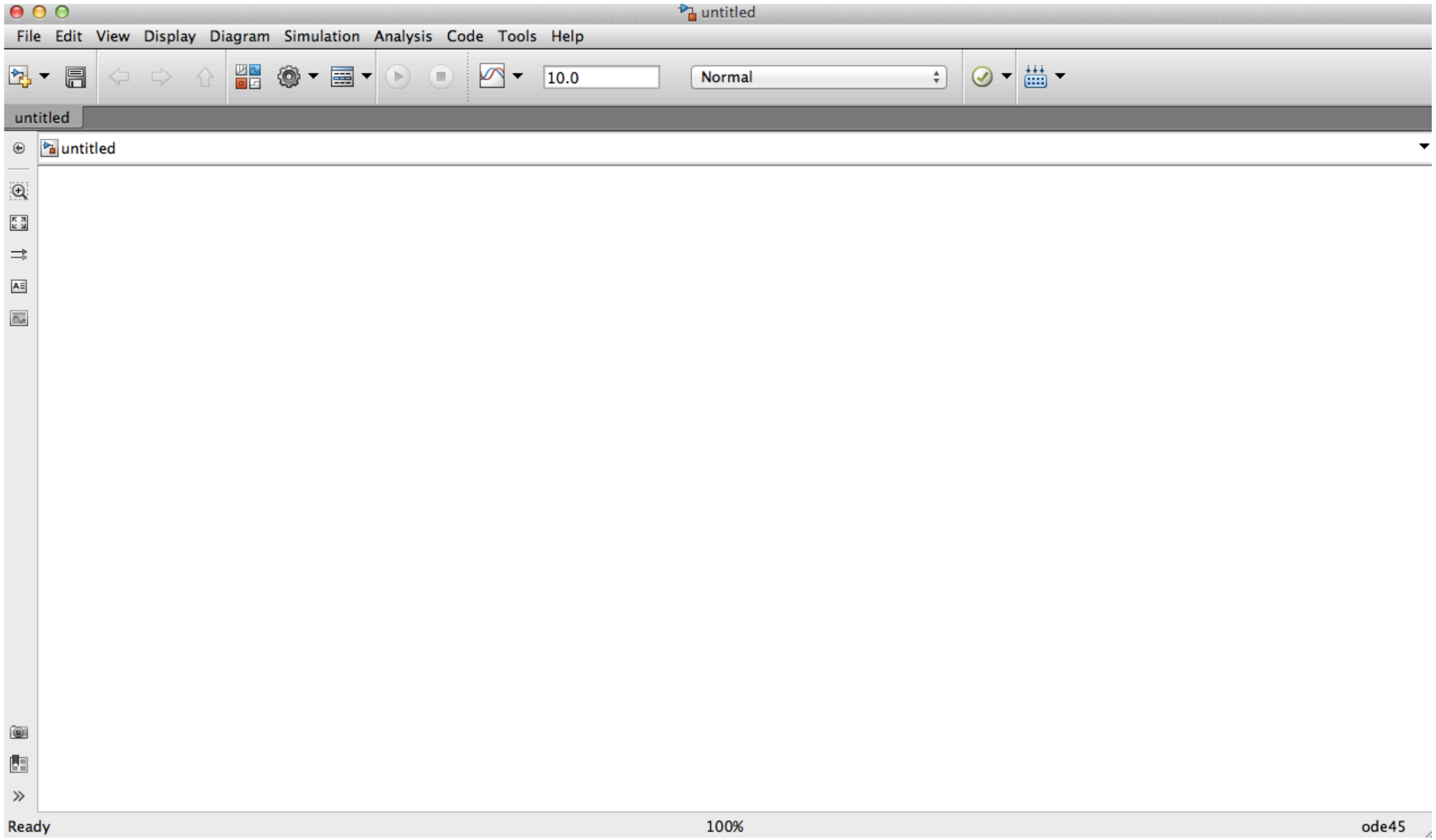
Dr Andrew Cookson
University of Bath, 2019-20

LECTURE 16
Introduction To Using Simulink

- Introduction to Simulink
- Ability to construct and solve a block diagram model in Simulink

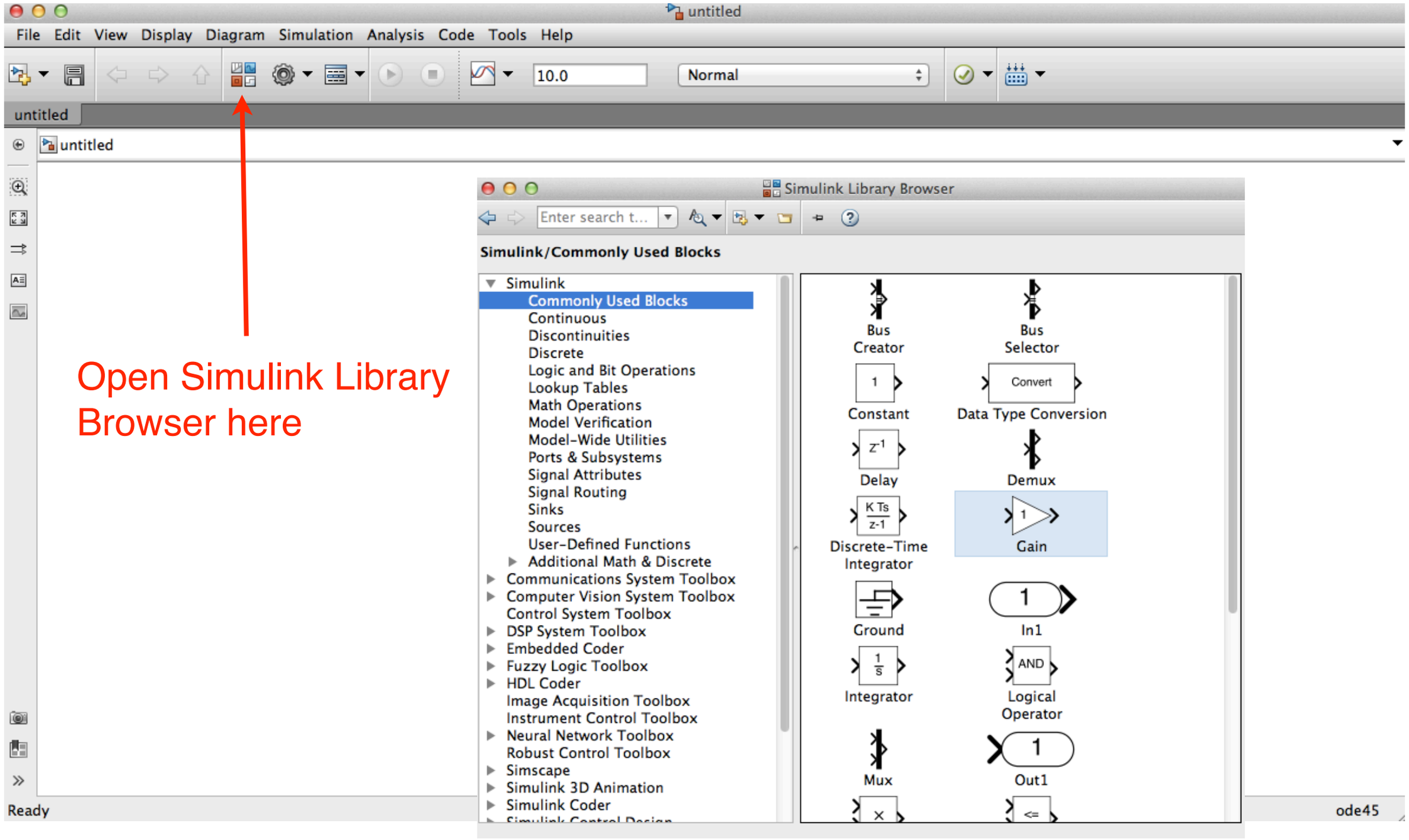
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Open a blank Simulink model:



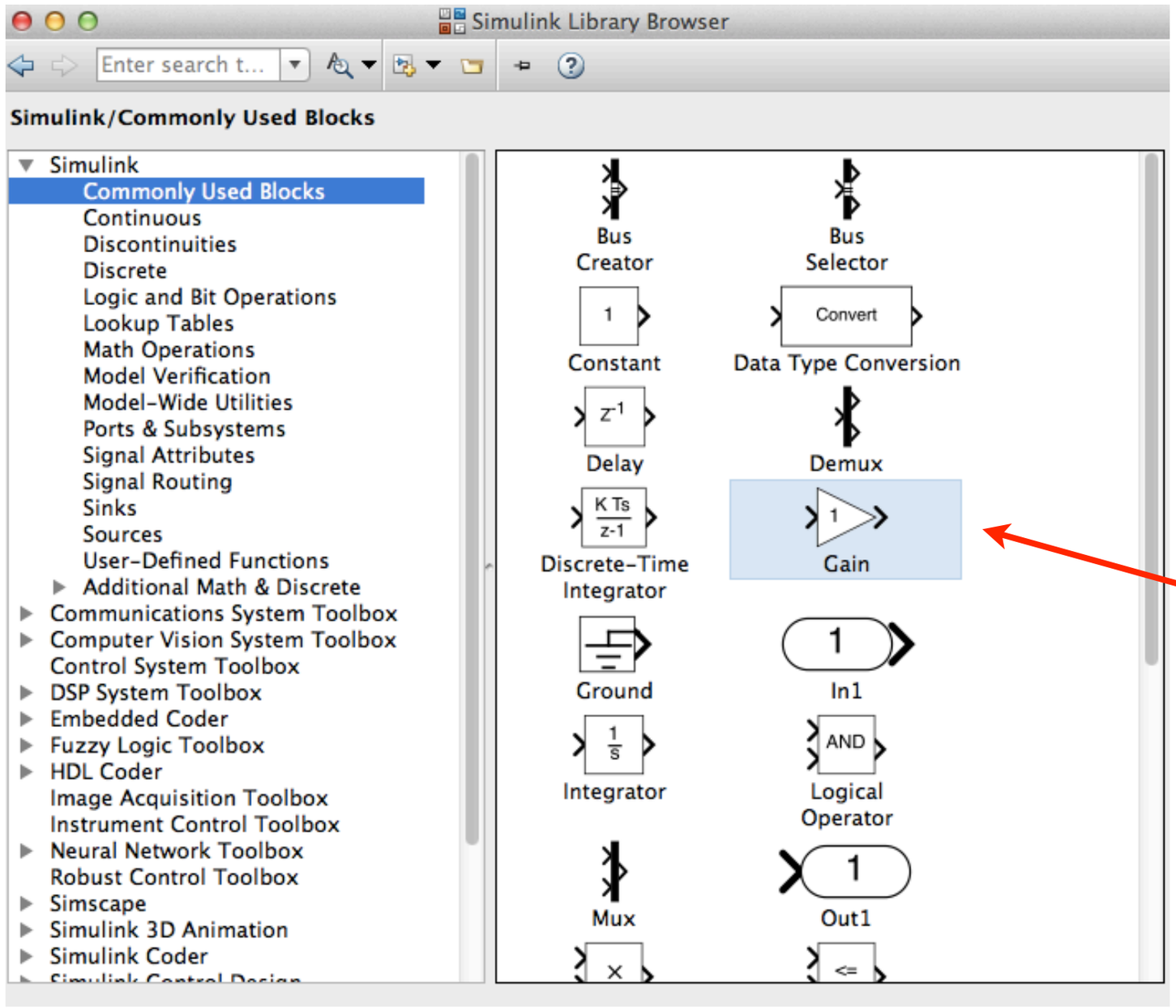
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Open the Simulink Library Browser:



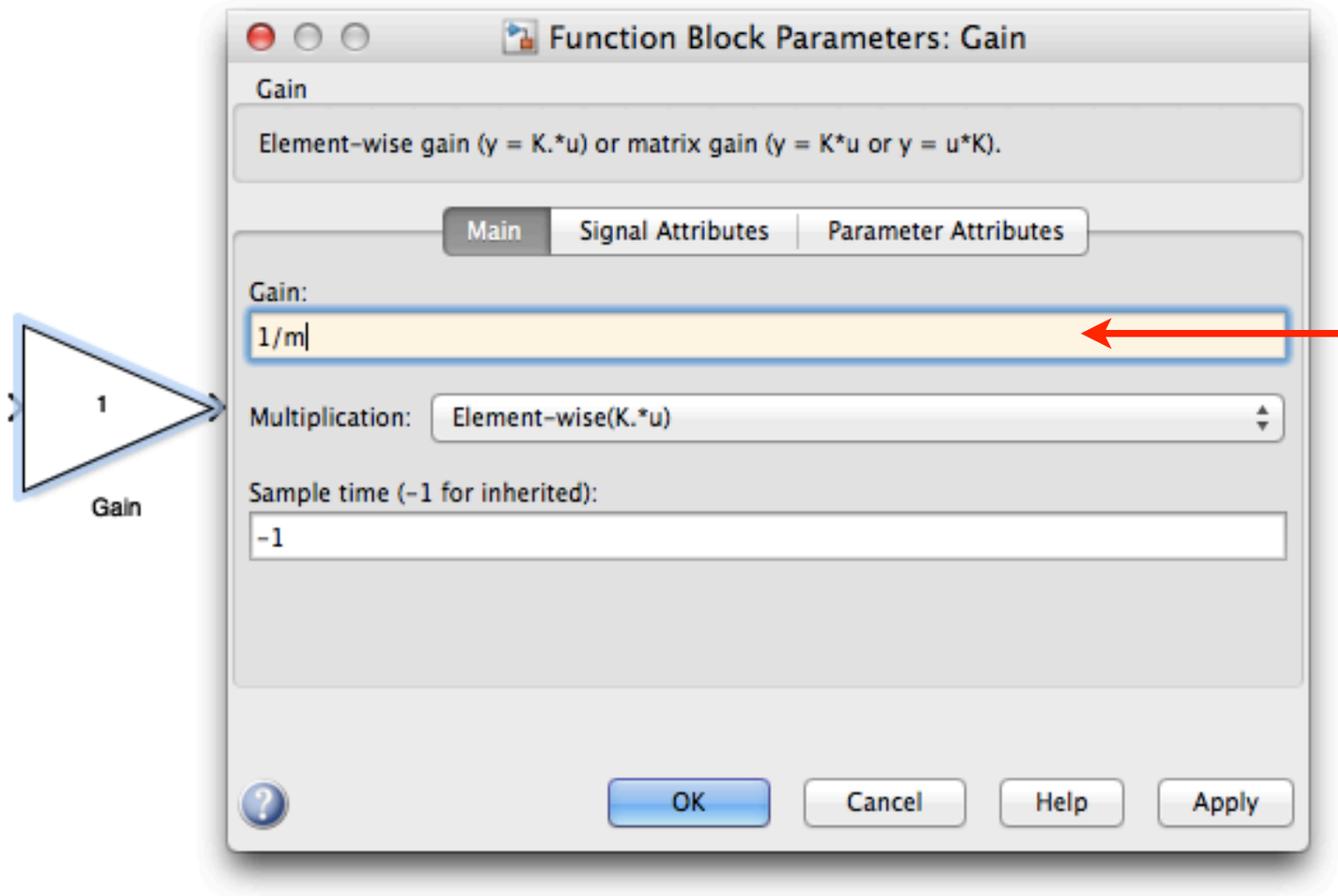
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

We will start by adding a gain block, which will represent the mass of the system:



BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

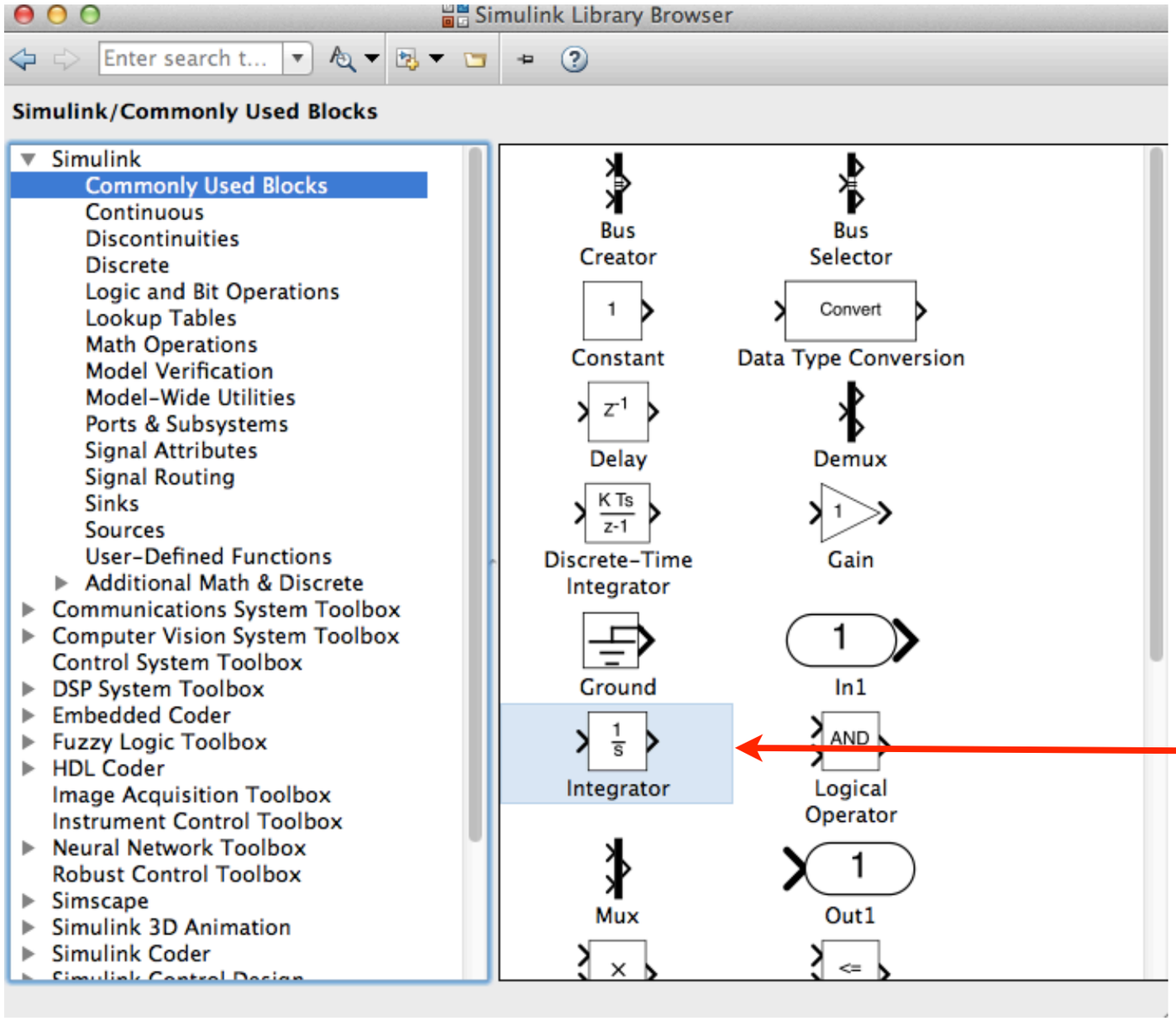
We will start by adding a gain block, which will represent the mass of the system. Double click on the block to access the parameter setting menu:



Set the gain parameter to be 1/m

BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

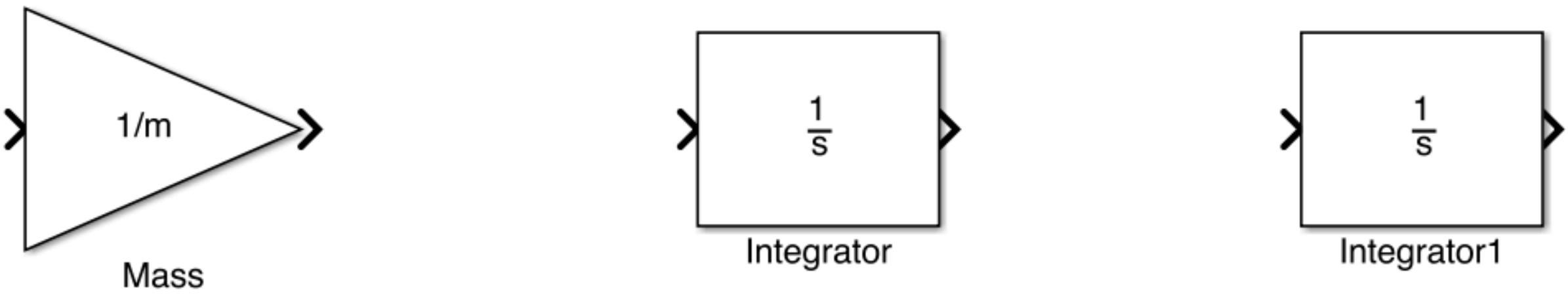
The output of this gain block is acceleration - therefore need to add integrator blocks to produce velocity and position:



Integrator block

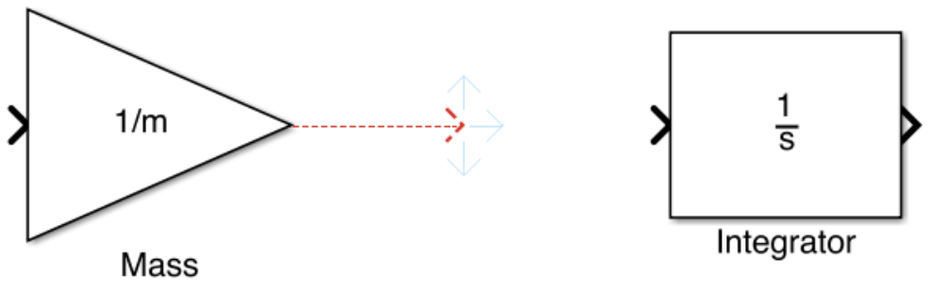
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

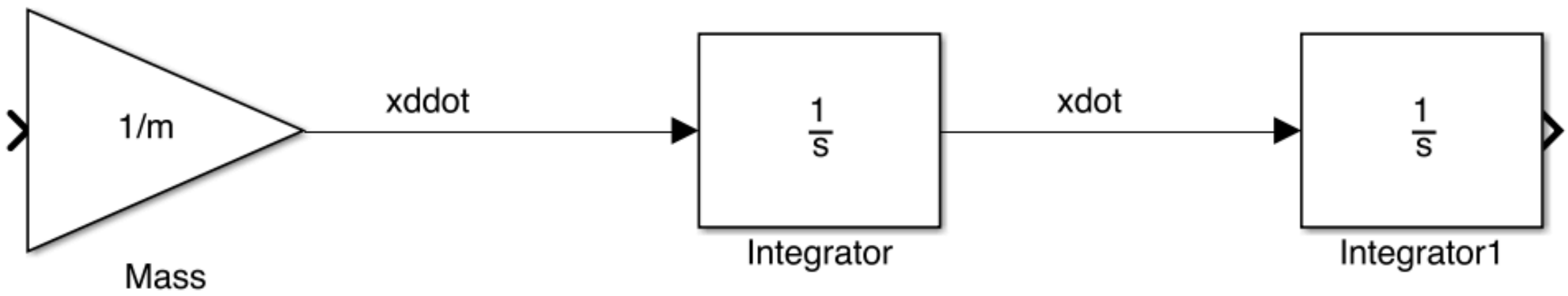
Click and drag two of these blocks onto your model:



BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

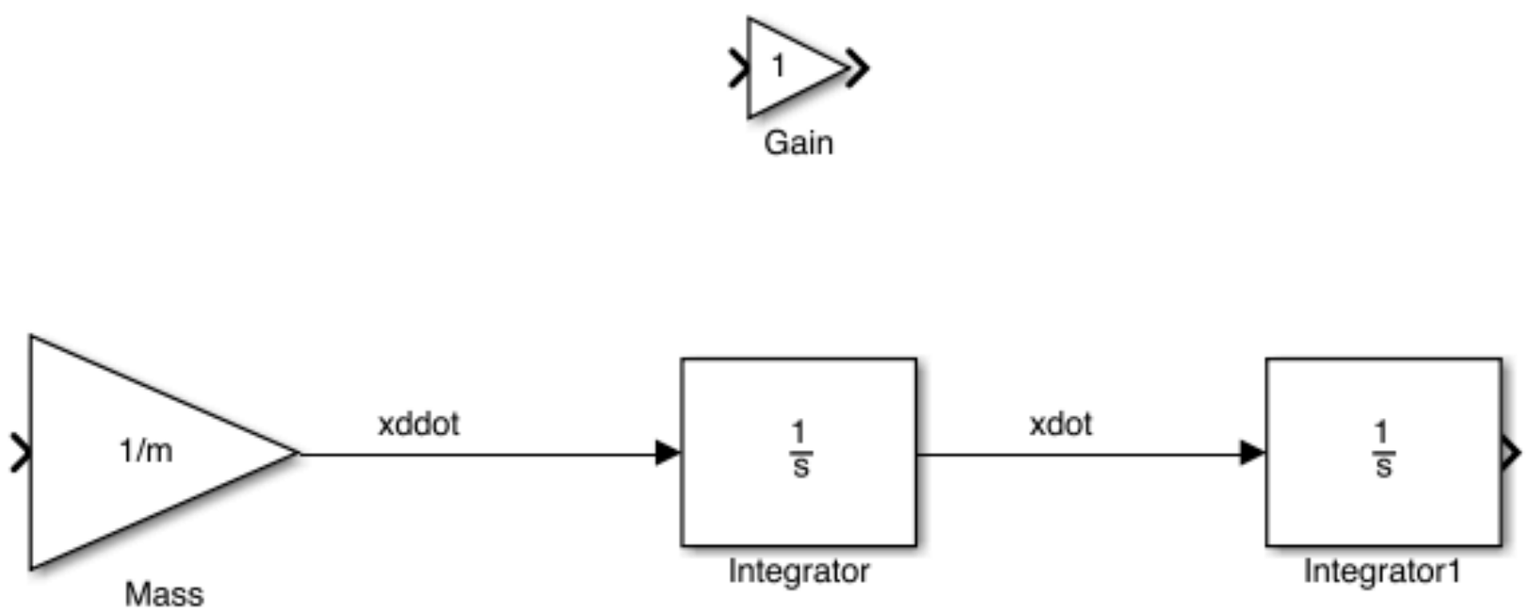
Now want to click and drag arrows to connect the blocks:





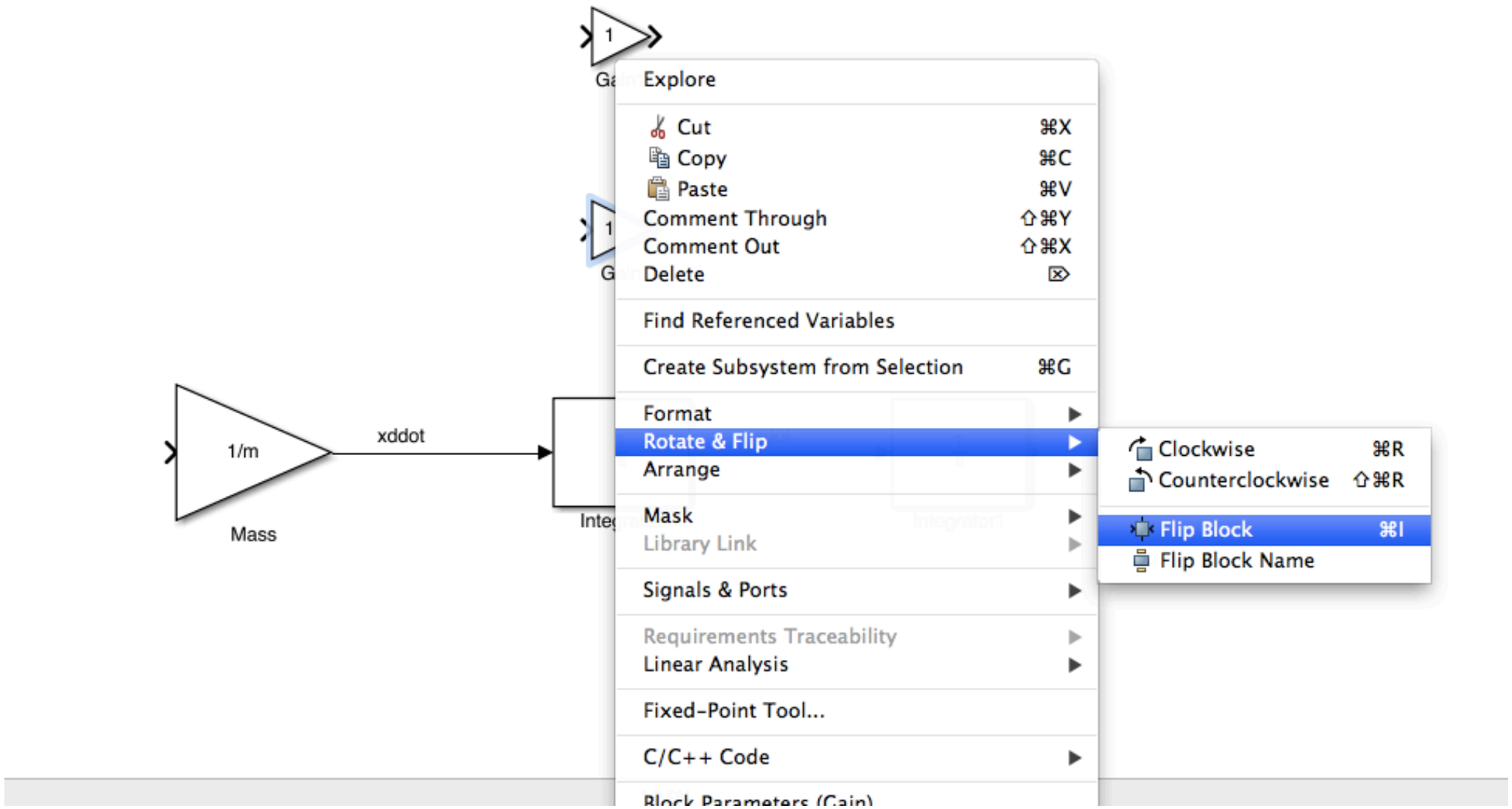
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Now place two additional gain blocks onto your model - these will represent the spring stiffness and damping components of the physical model:



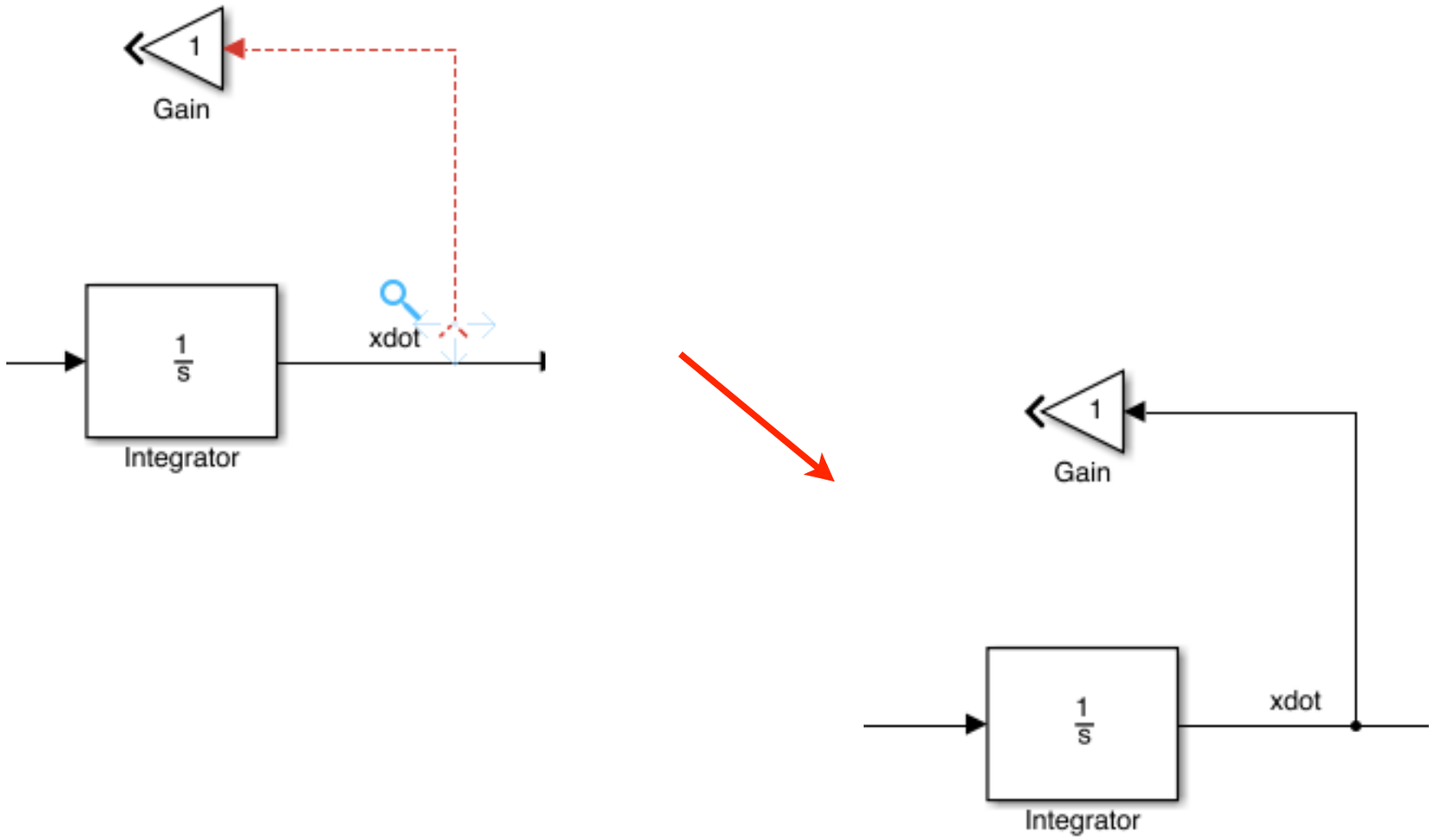
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Need to flip these two gain blocks so that they follow the flow of the feedback loops. Right click on the gain block and select the Rotate & Flip option:



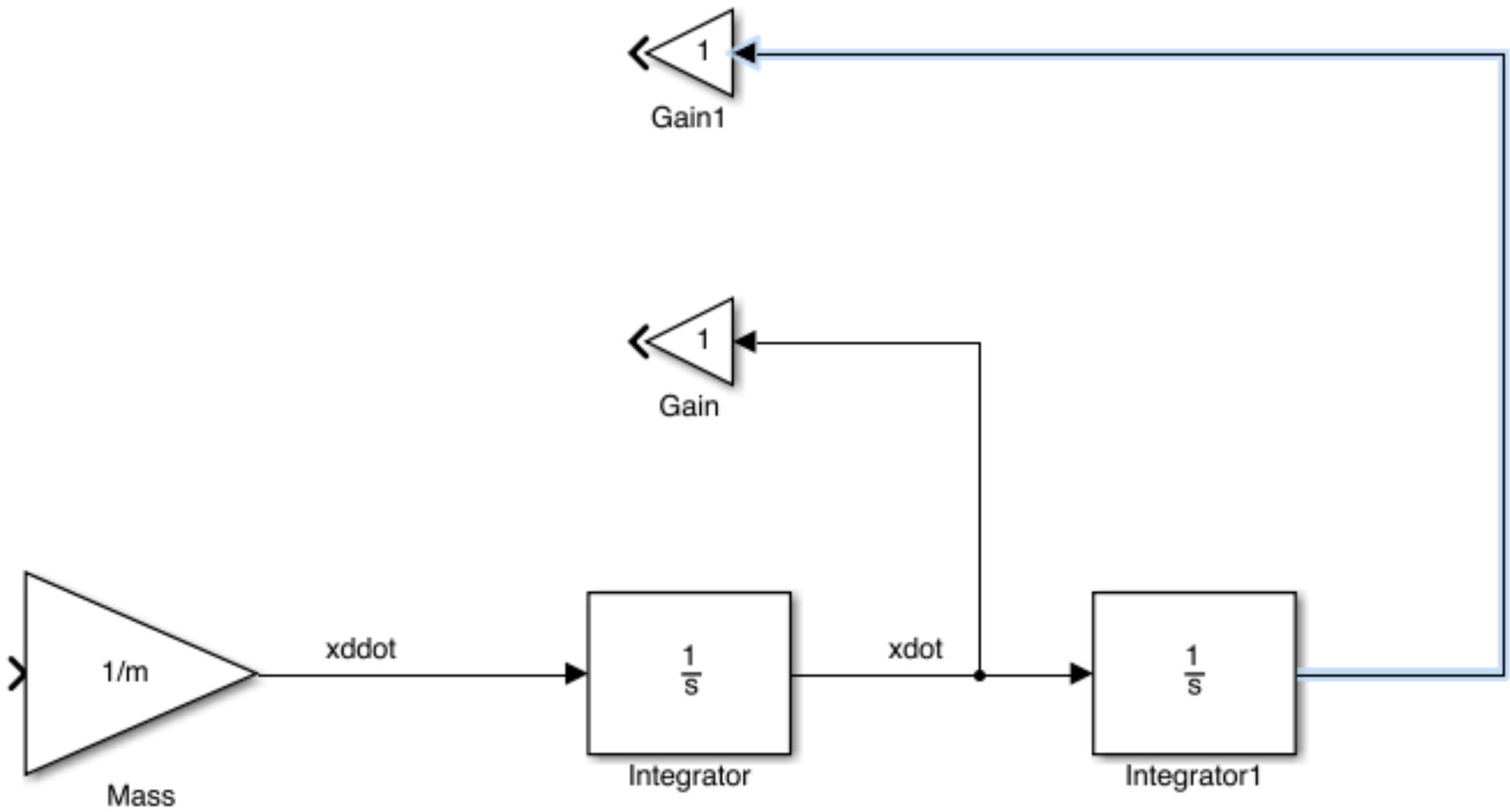
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Now drag arrows to connect these gain blocks to the existing signal paths:



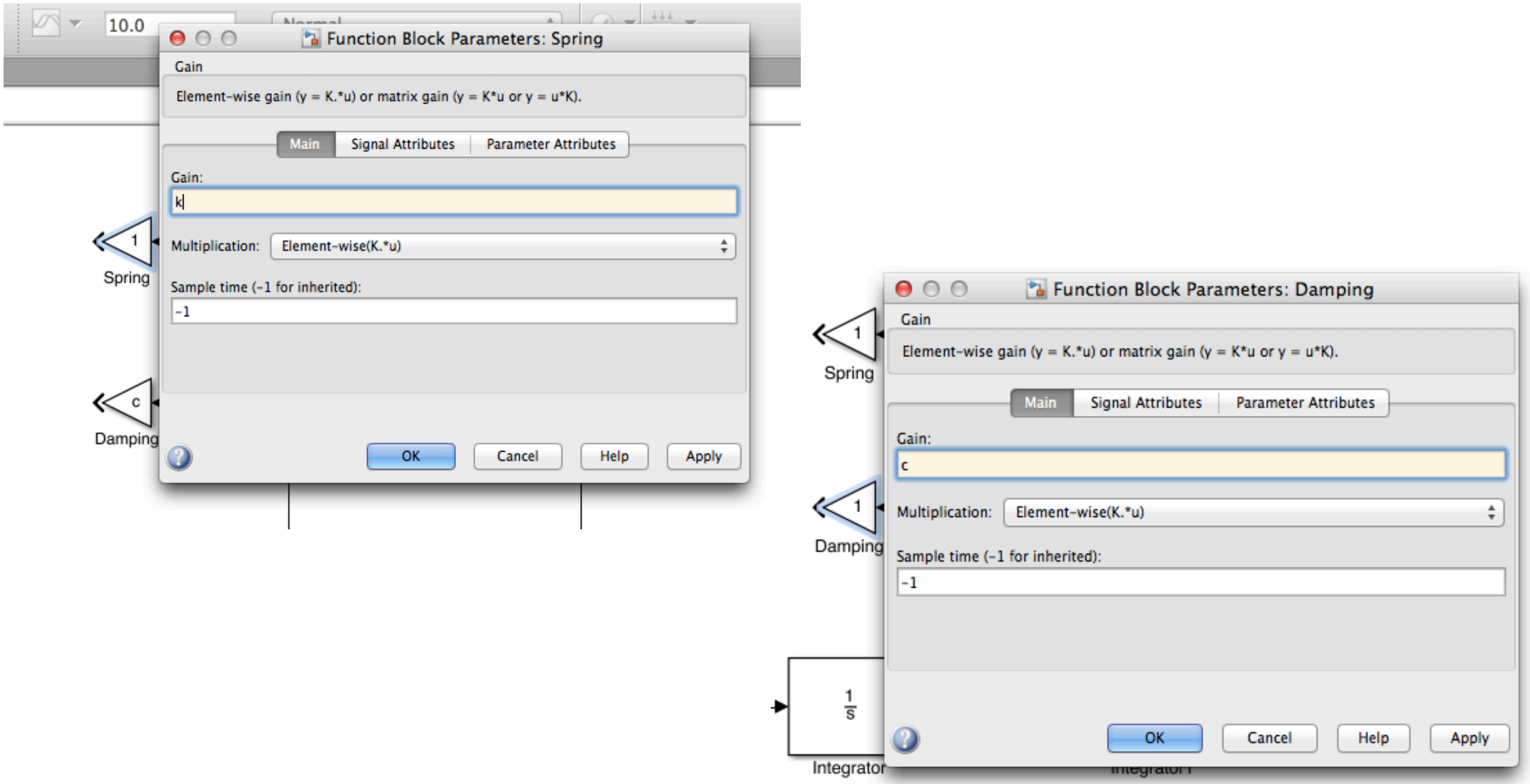
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Now drag arrows to connect these gain blocks to the existing signal paths:



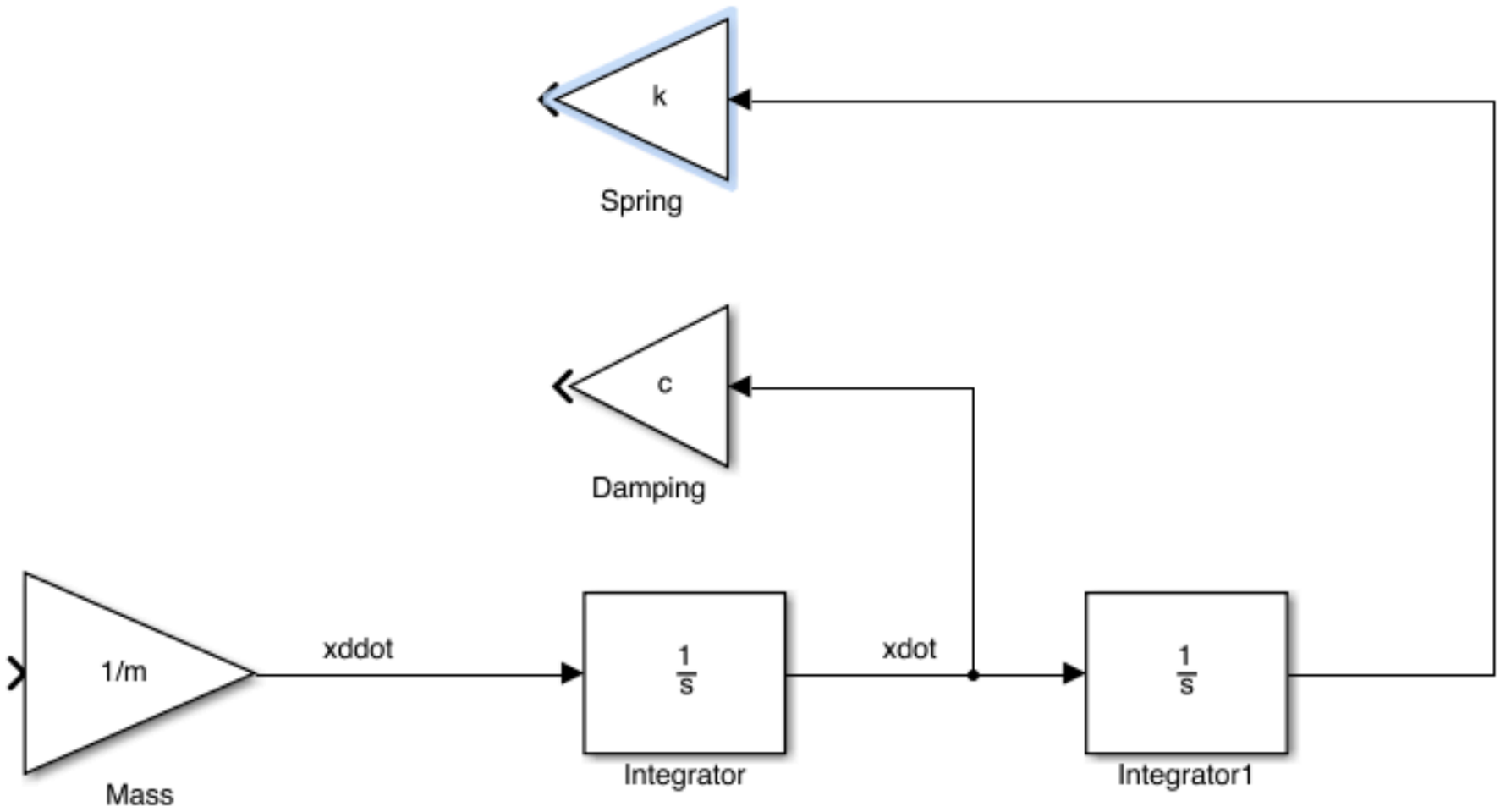
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Now double-click to set the parameters for the spring and damper blocks:



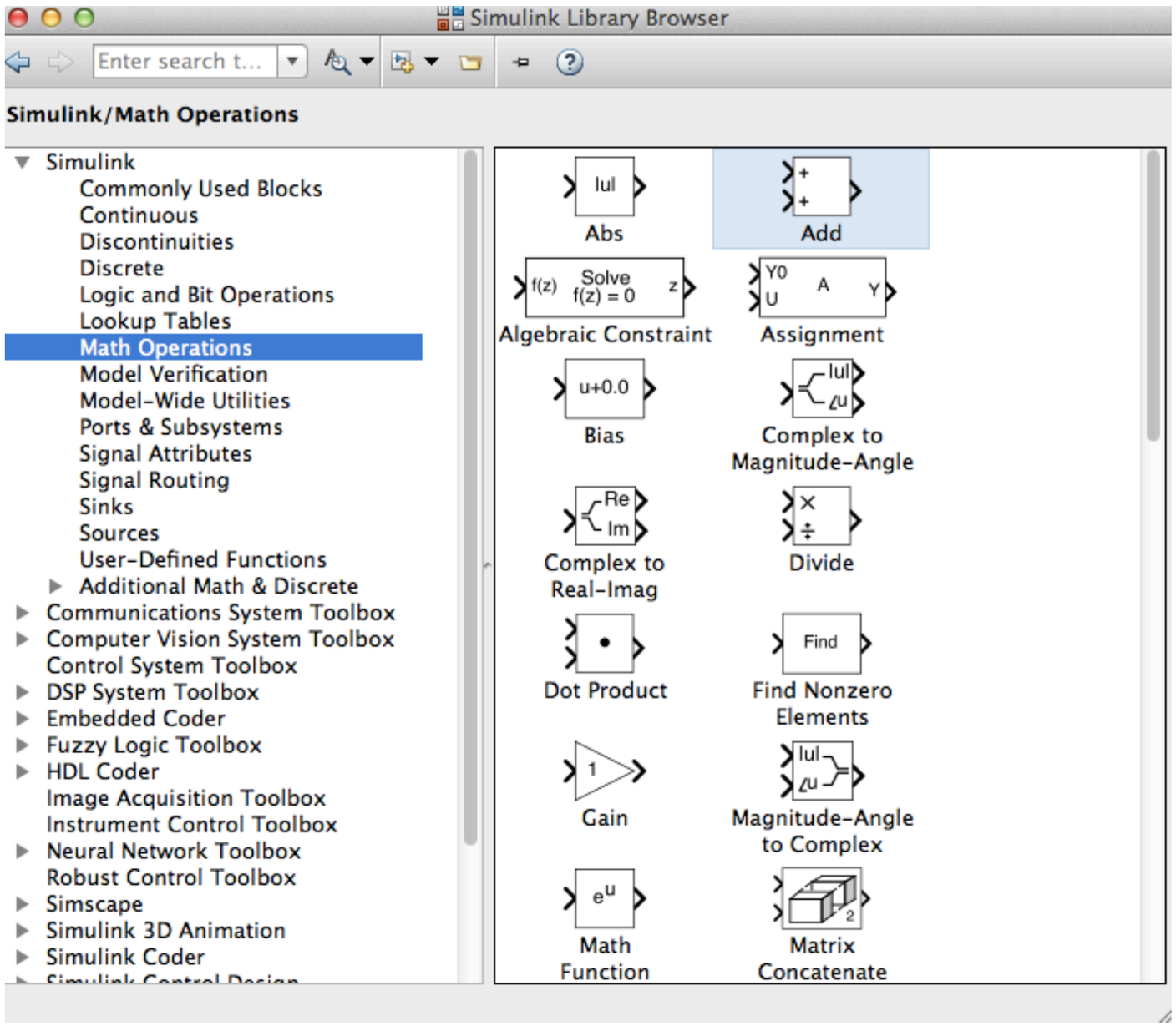
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

The outputs of these gain blocks are the spring force and damping force - these need to be connected as inputs to the system:



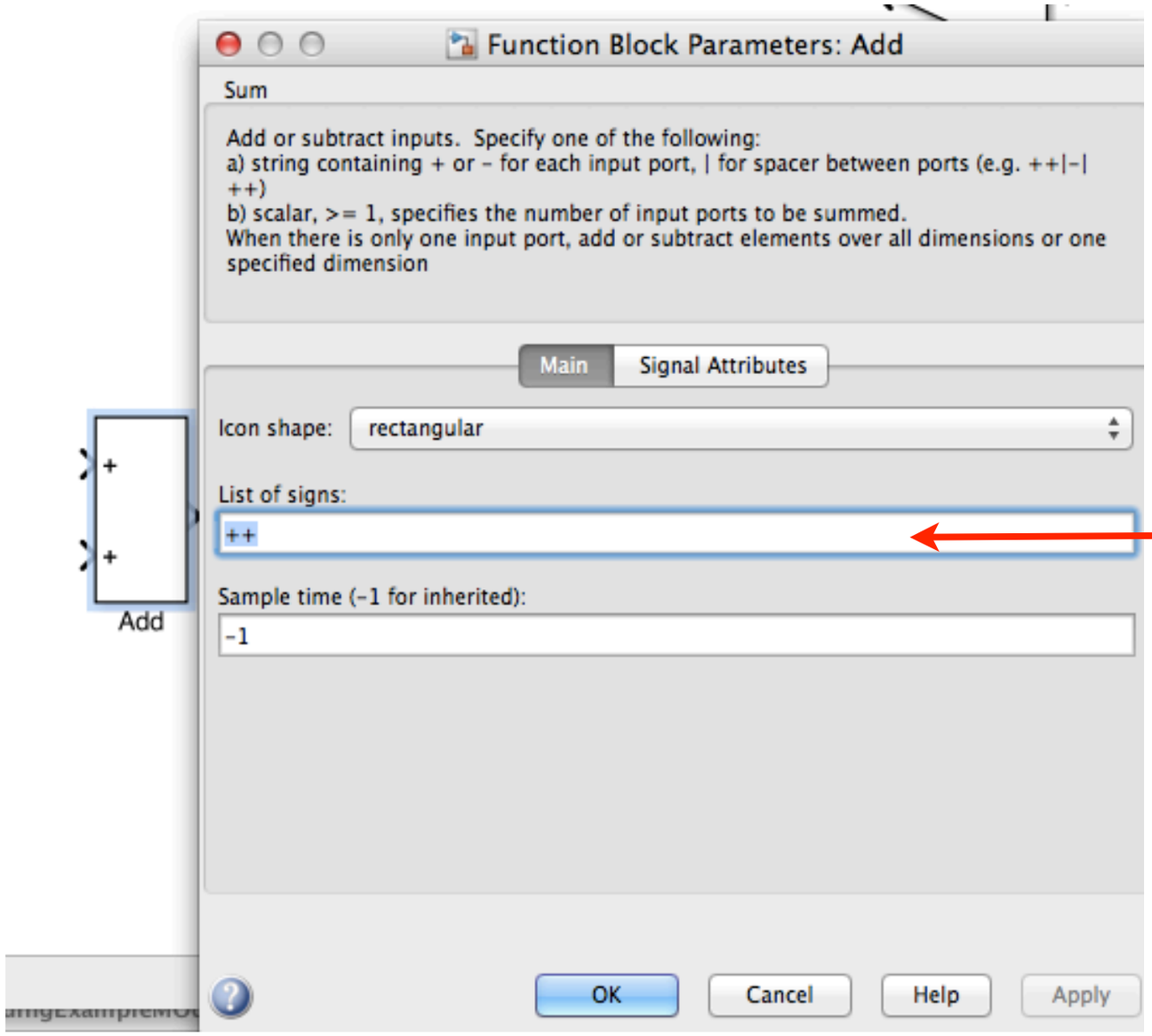
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Select an Add block from the library browser - this will encode the arithmetic in our differential equation:



BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

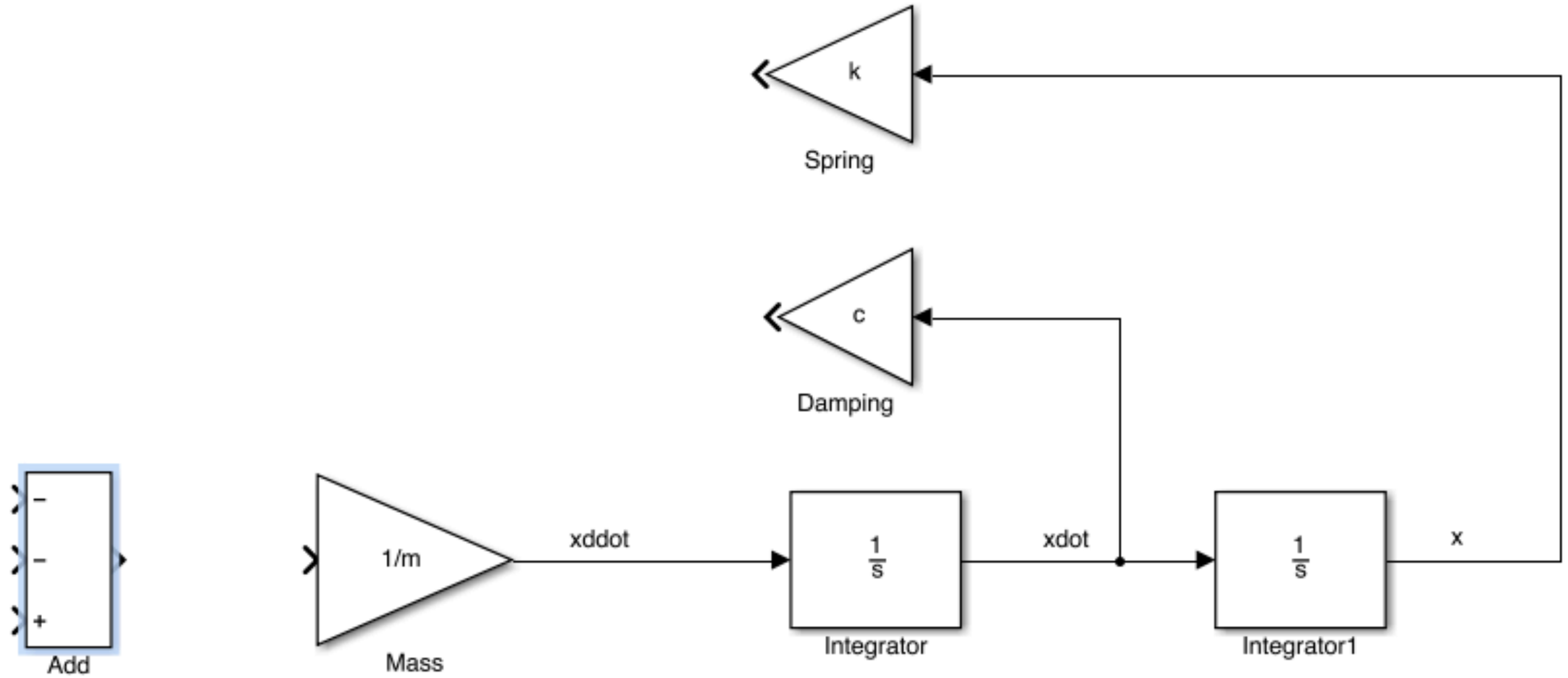
Double-click on the block to set the arithmetic of the Add block:



Edit the List of Signs to be: --+

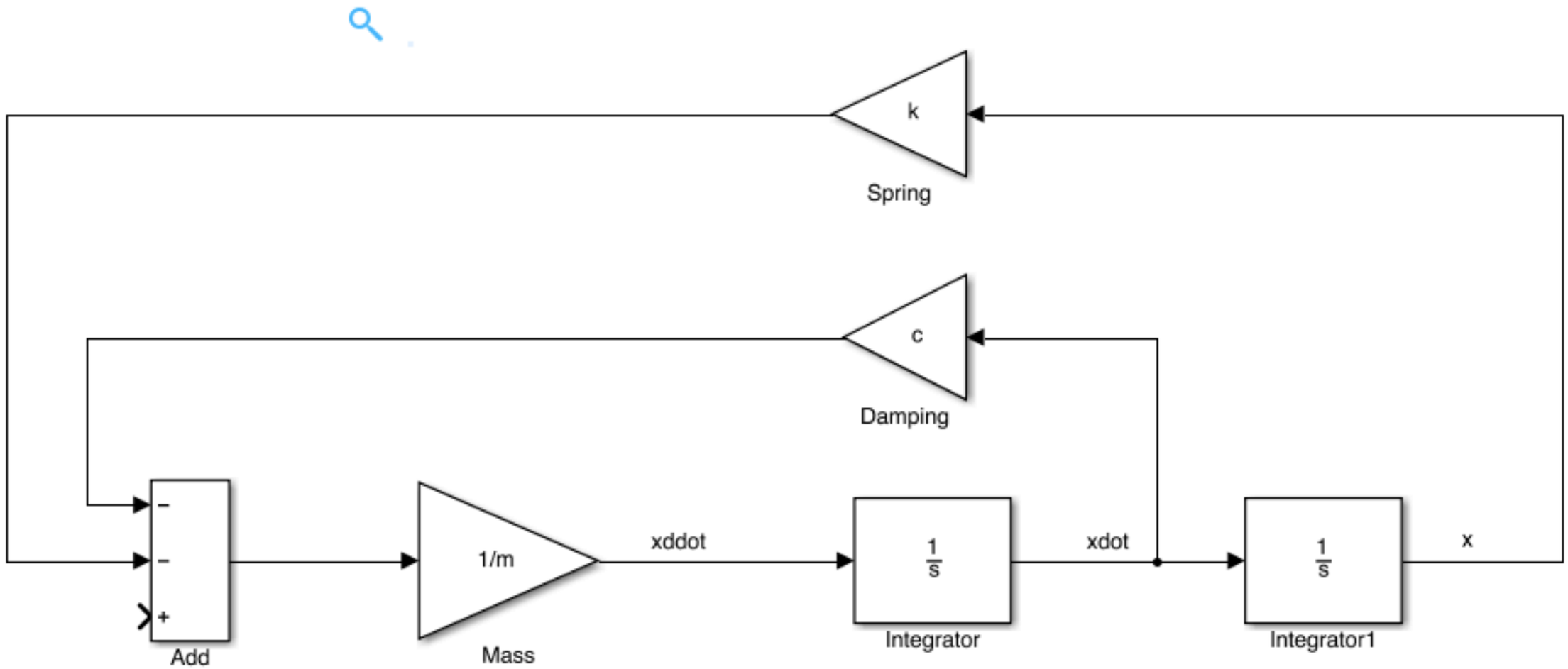
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

This modification is now displayed on the block within the model:



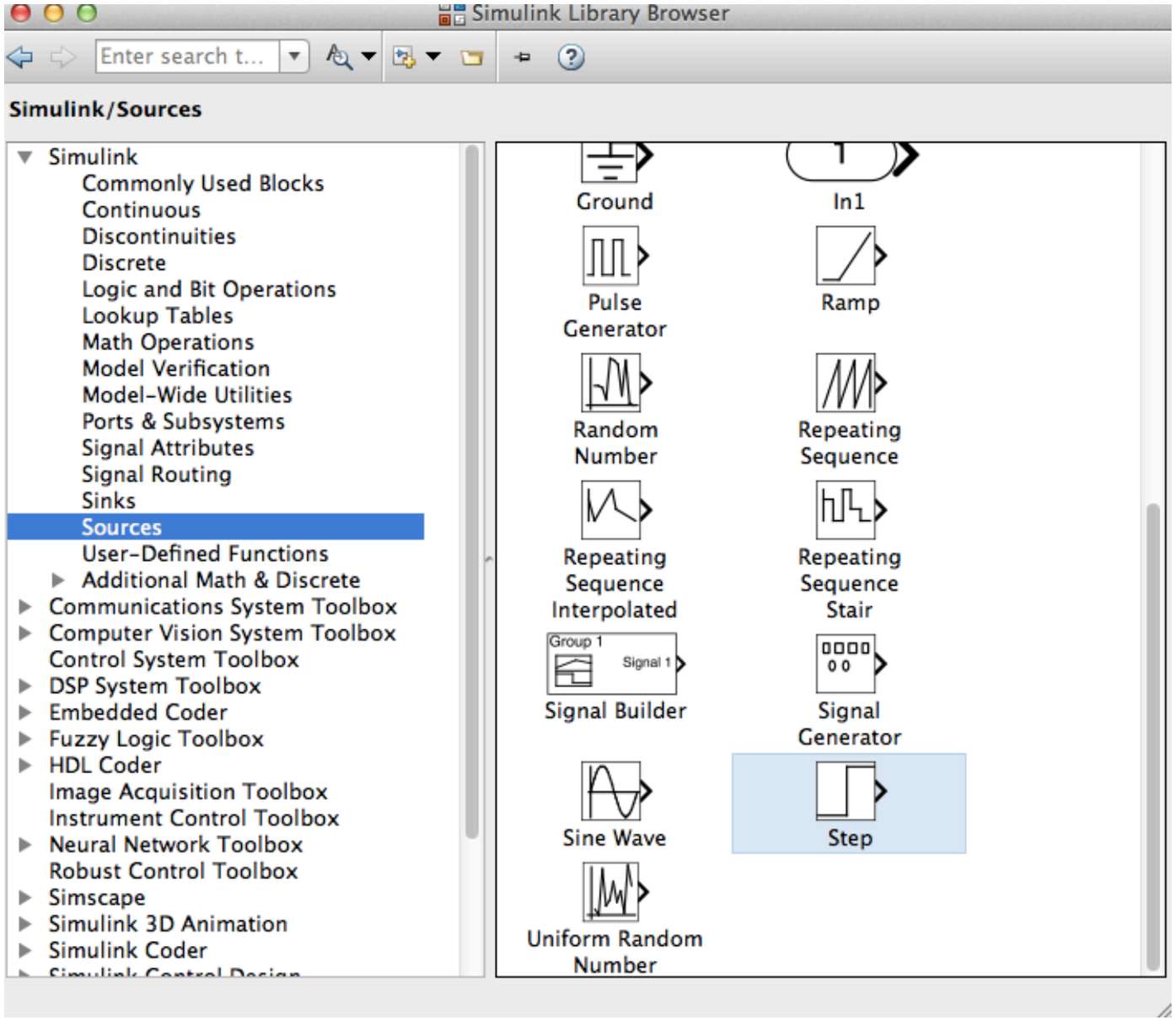
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Connect the gain blocks to the add block - these forces are now being applied to the mass:



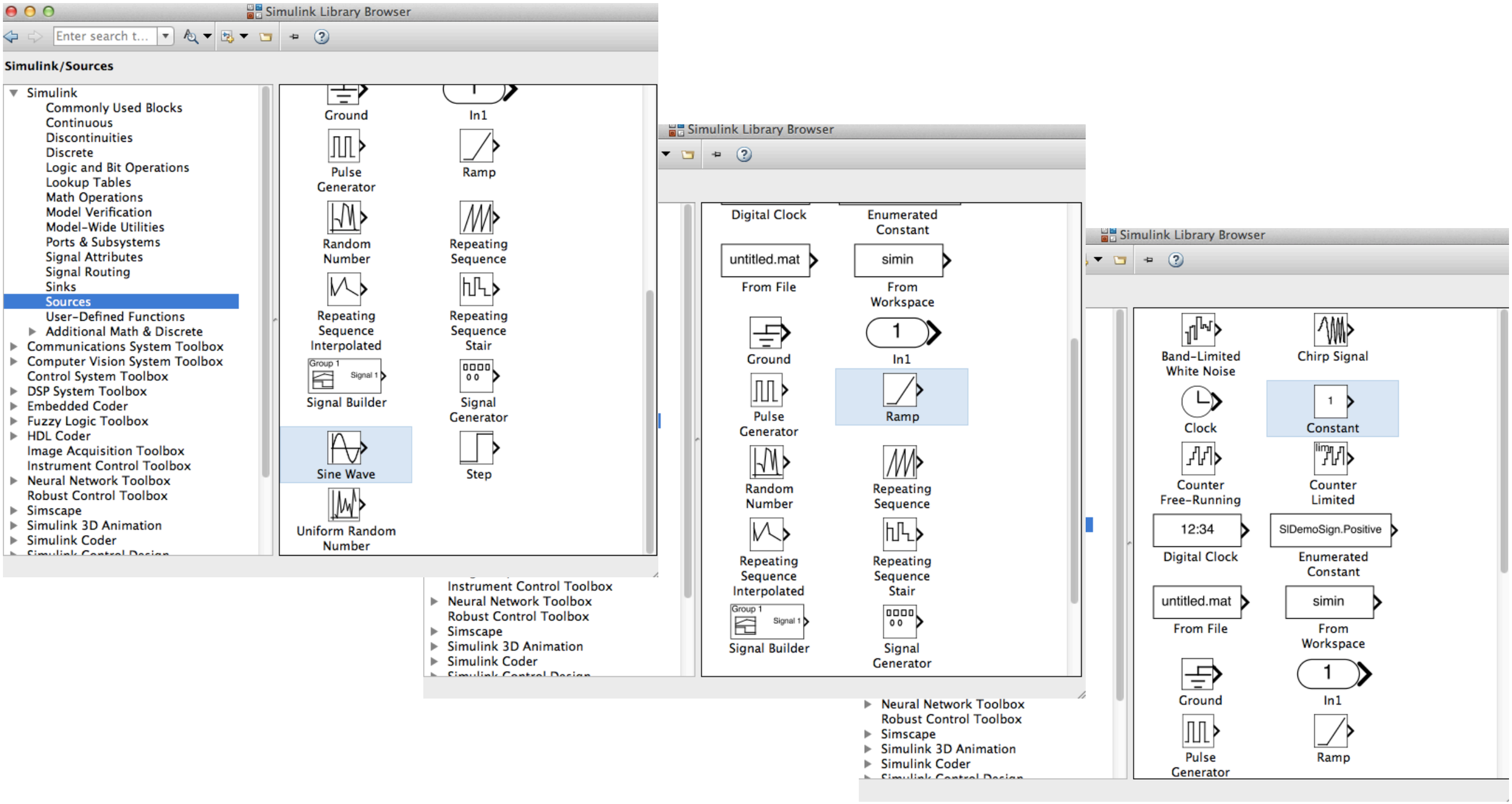
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

However, we also want to apply an external loading to the model. We will use a source block to do this - in this case, the step function:



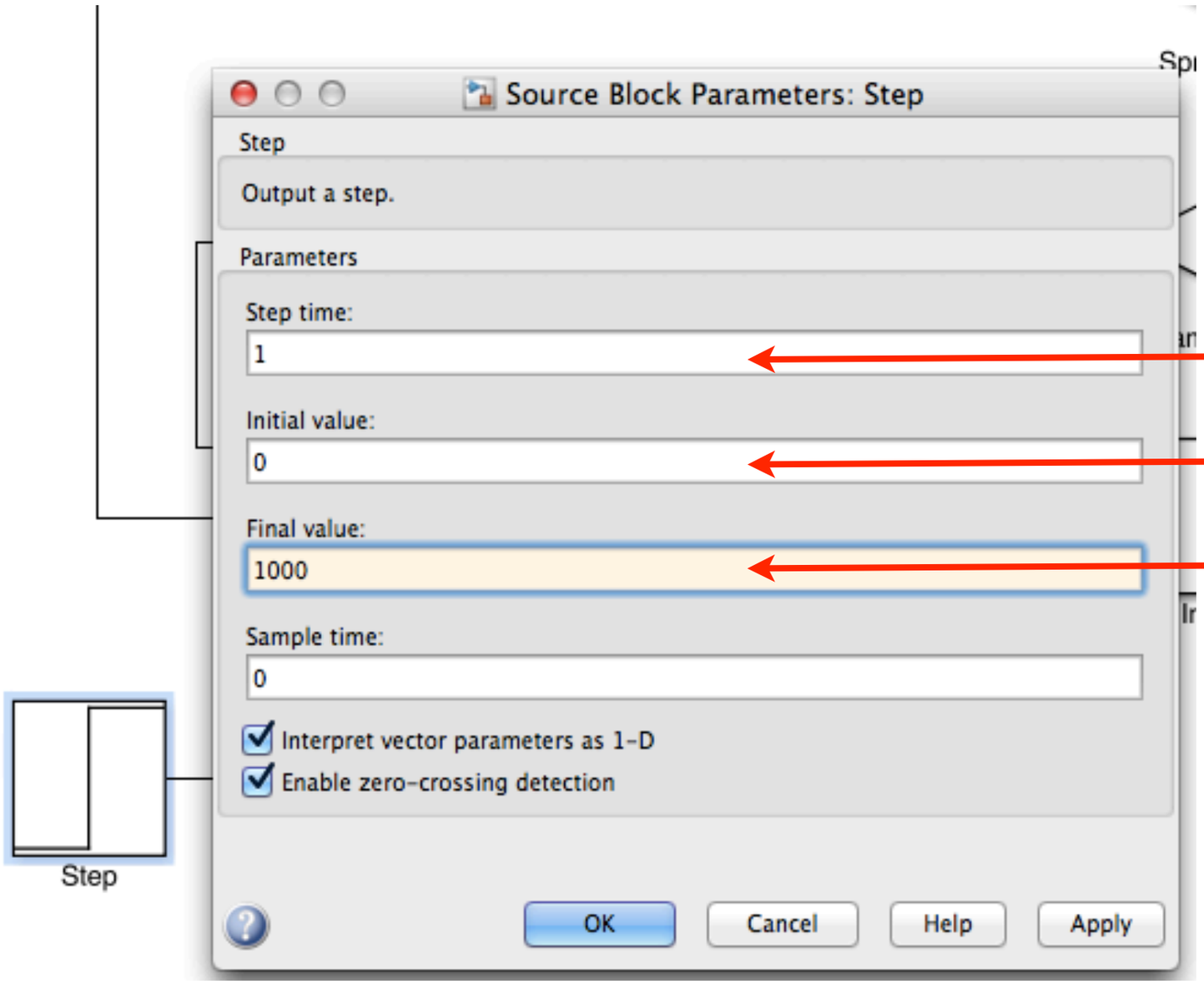
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Other source blocks are available, such as Sine Wave, Ramp, and Constant:



BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Connect this to the Add block and double-click to set the parameters:



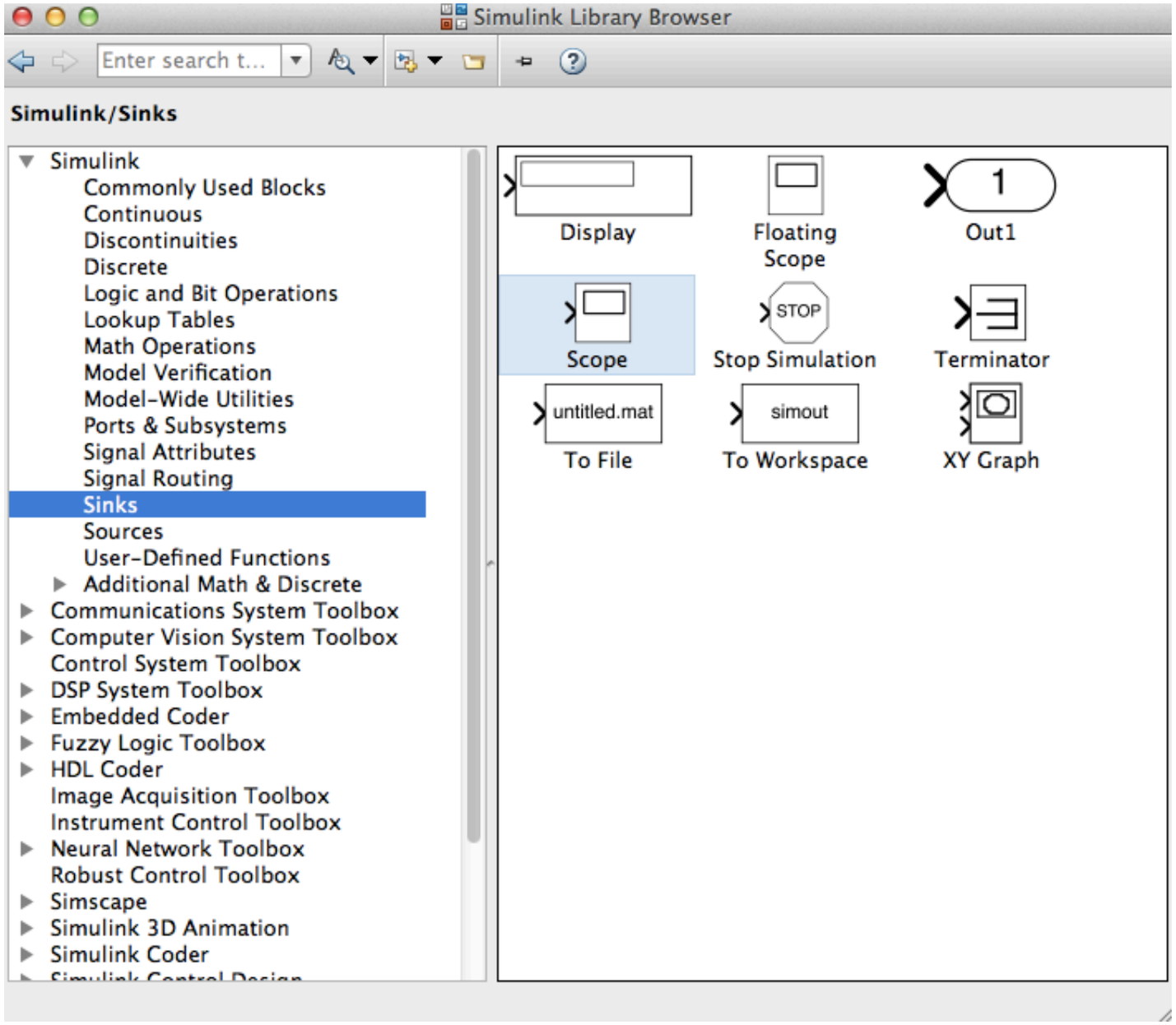
Time point at which step occurs

The initial value of the step

The final value of the step

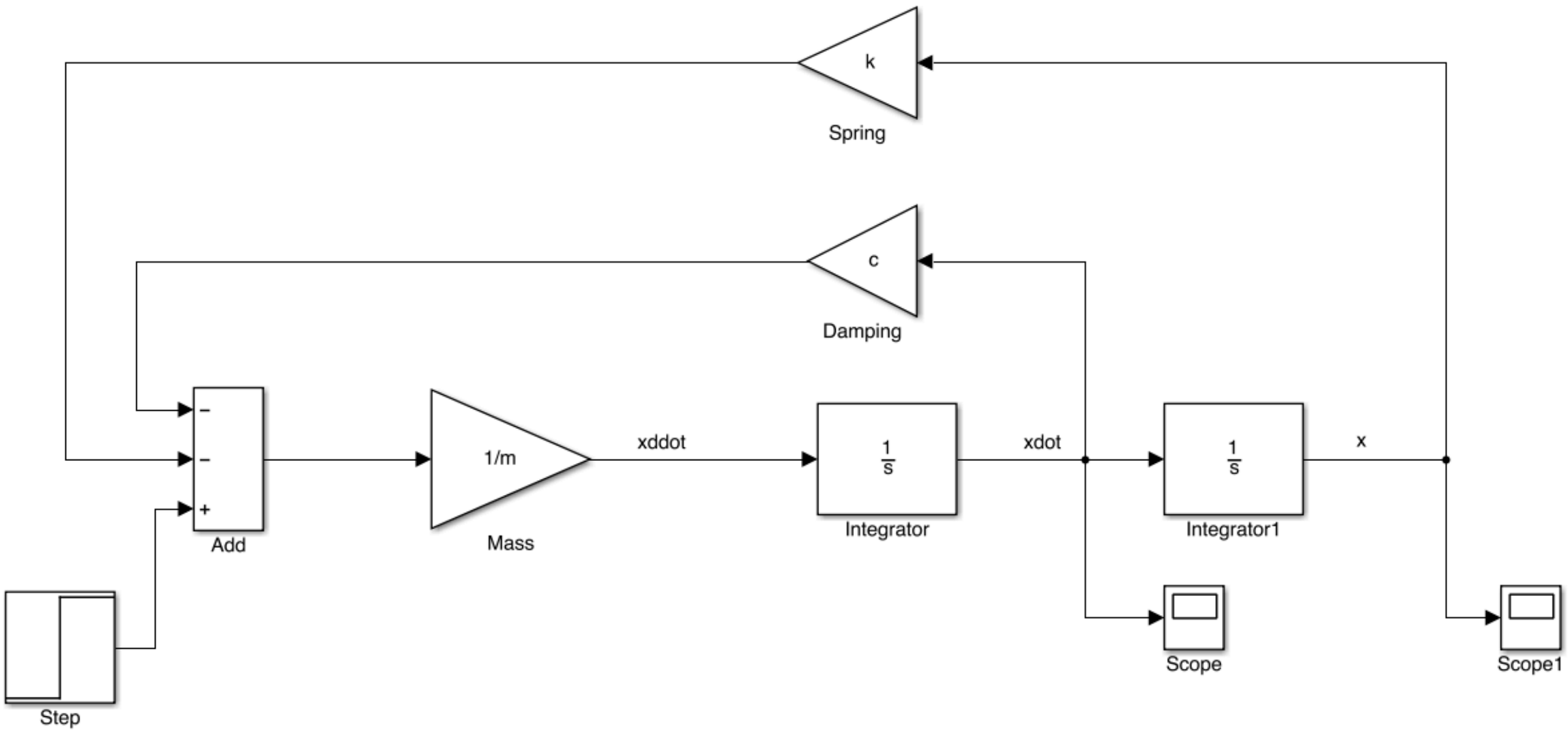
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

We want to add some way of visualising the results of this simulation. One method is to add a Scope block to the signal of interest:



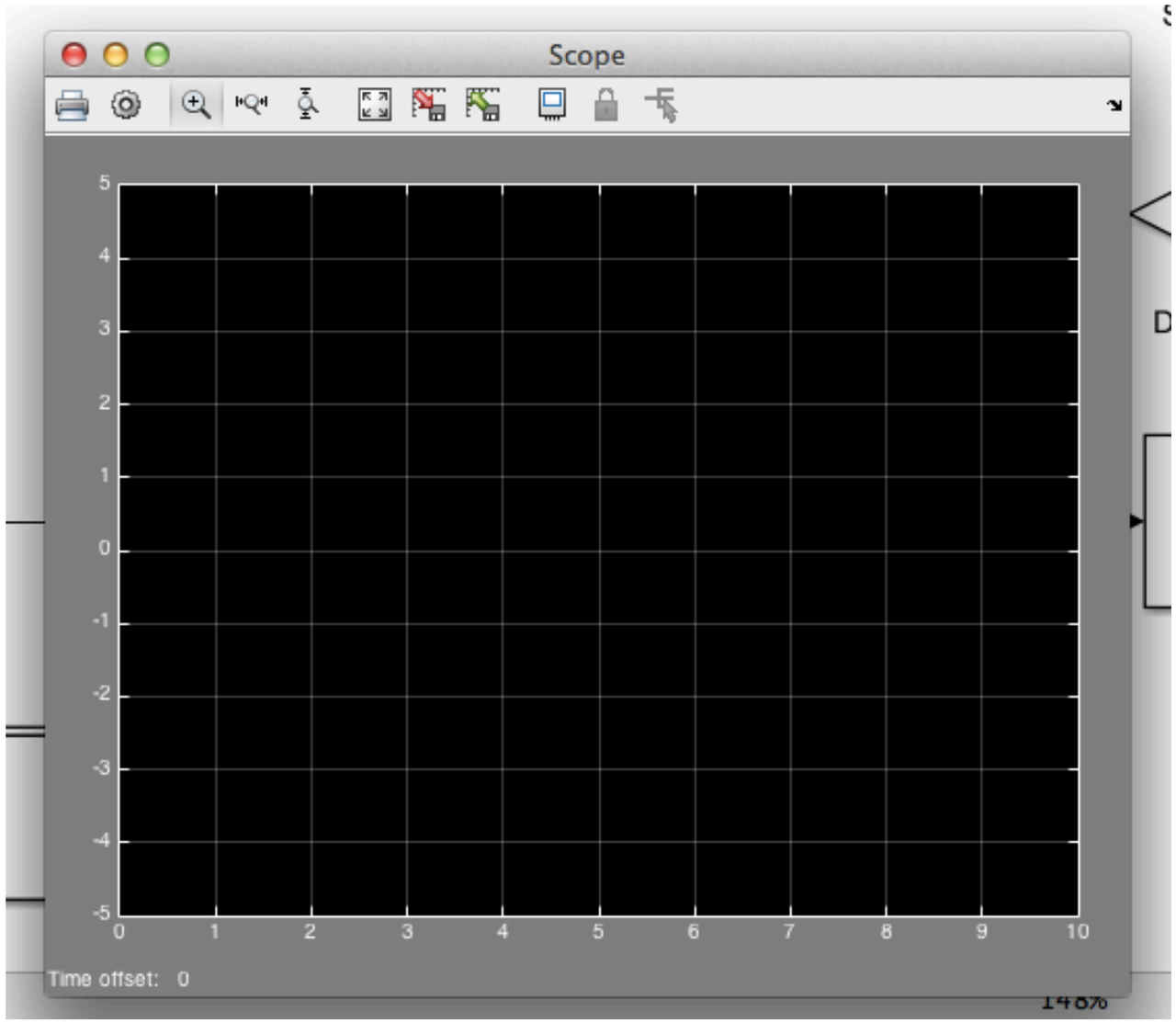
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

In this case add a two scopes, one to the velocity signal, and one to position:



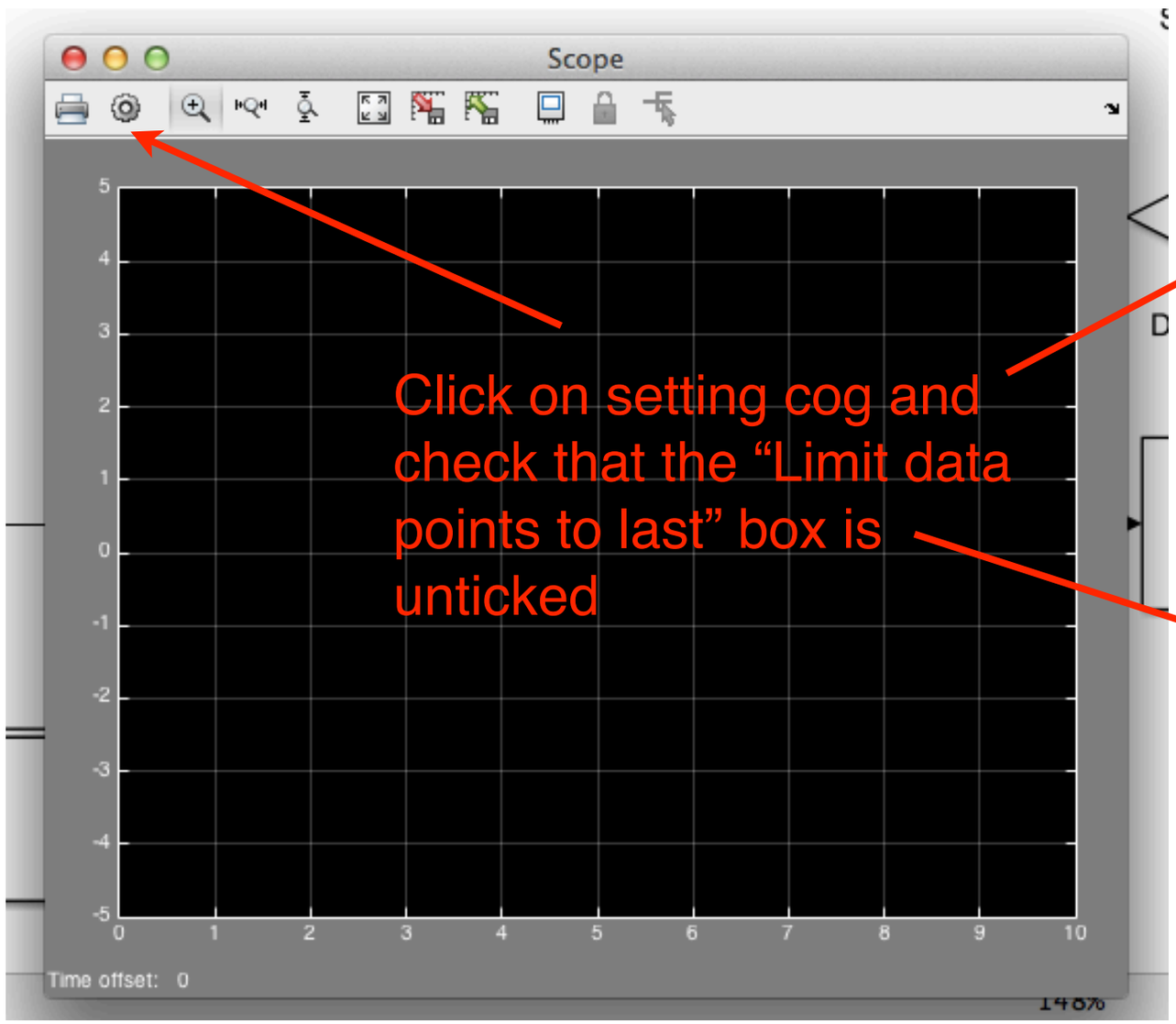
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

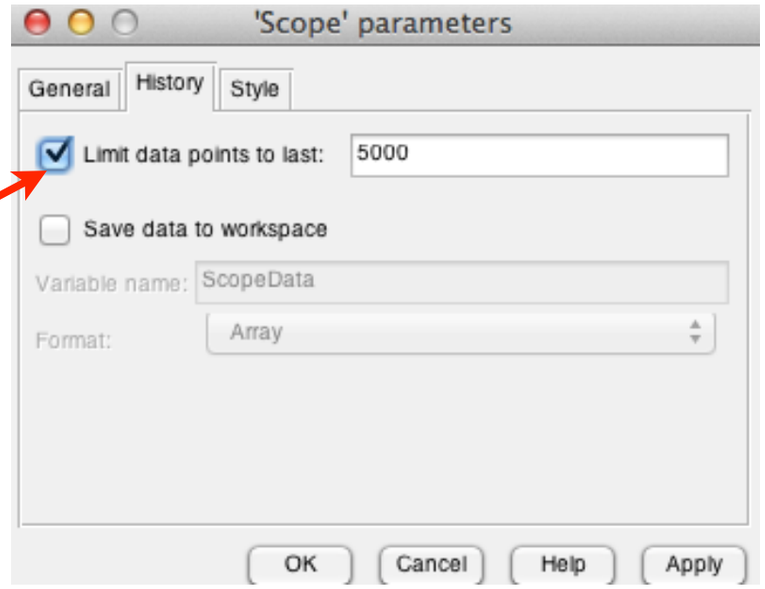
Double-clicking on the Scope opens a window showing the axes and current data plotted:

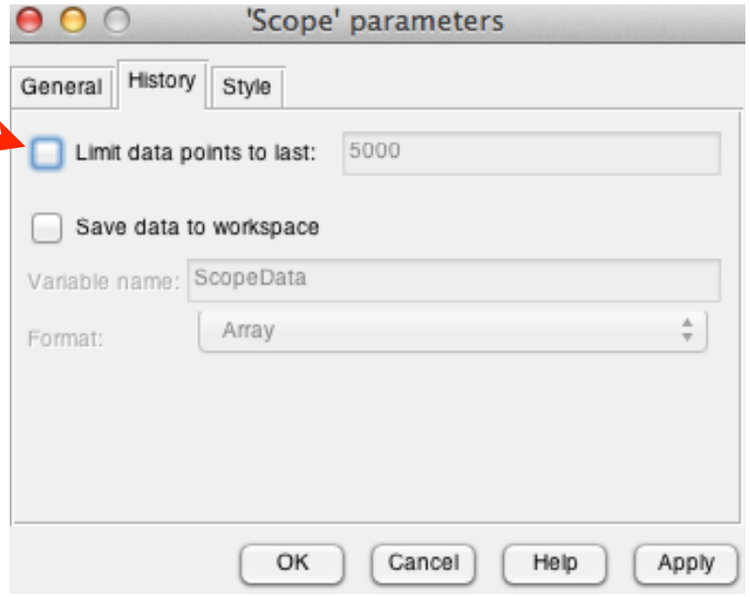


BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Double-clicking on the Scope opens a window showing the axes and current data plotted:

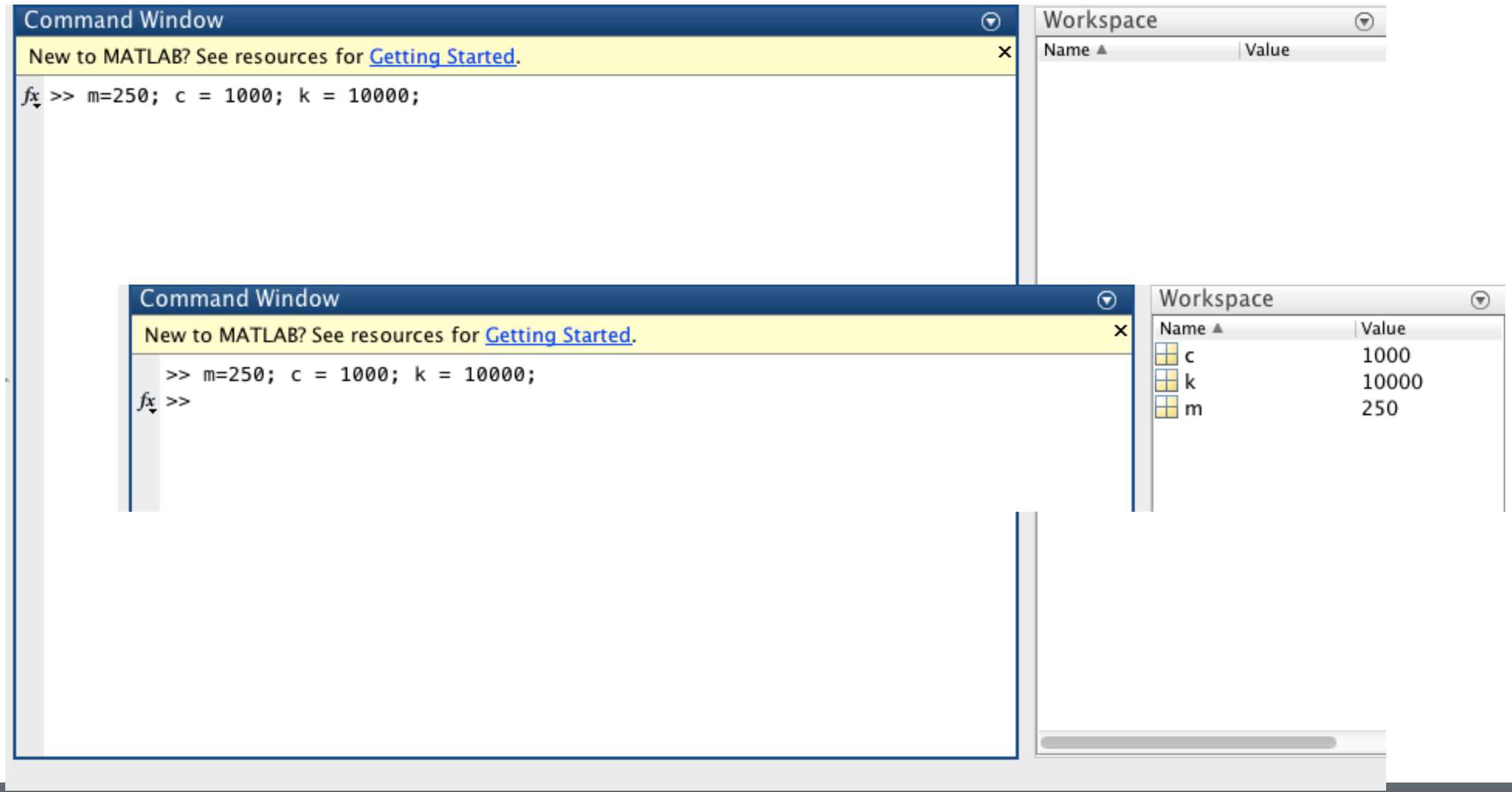






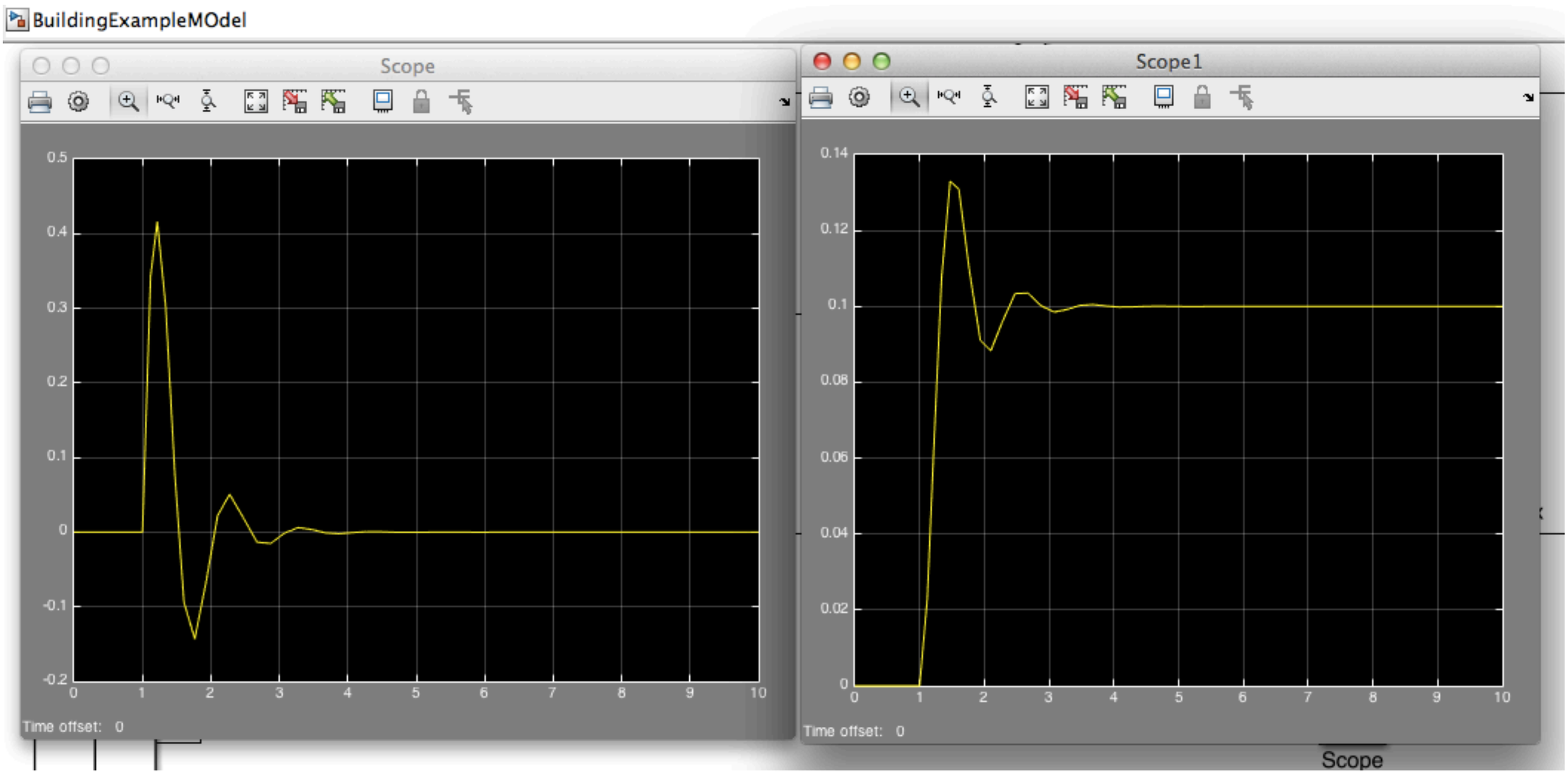
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

To be able to run the model, we must set the parameter values. Do this by typing them into the Matlab Command Window:



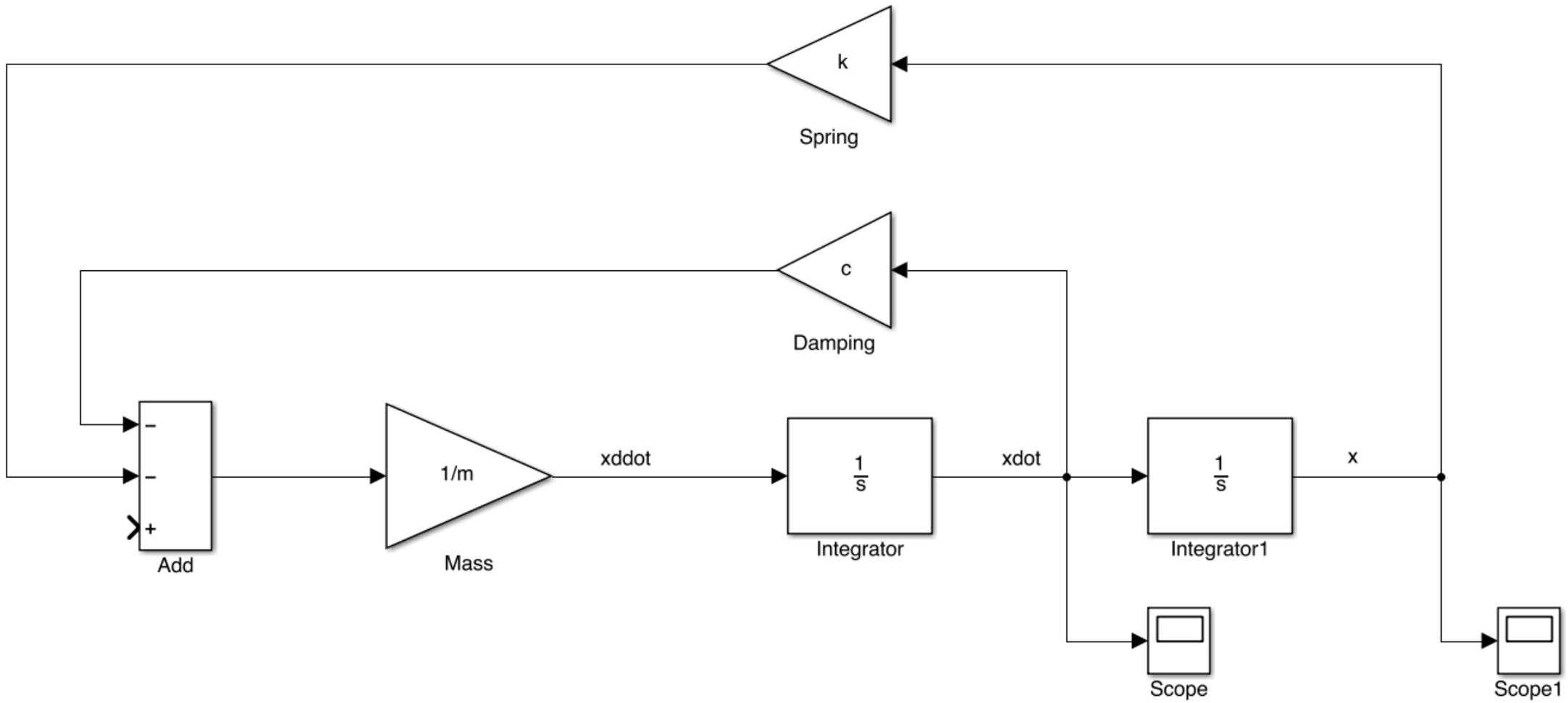
BUILDING A SIMPLE MODEL
Spring-Mass-Damper In Simulink

Run the model by clicking the Play button at the top of the model and view the results:



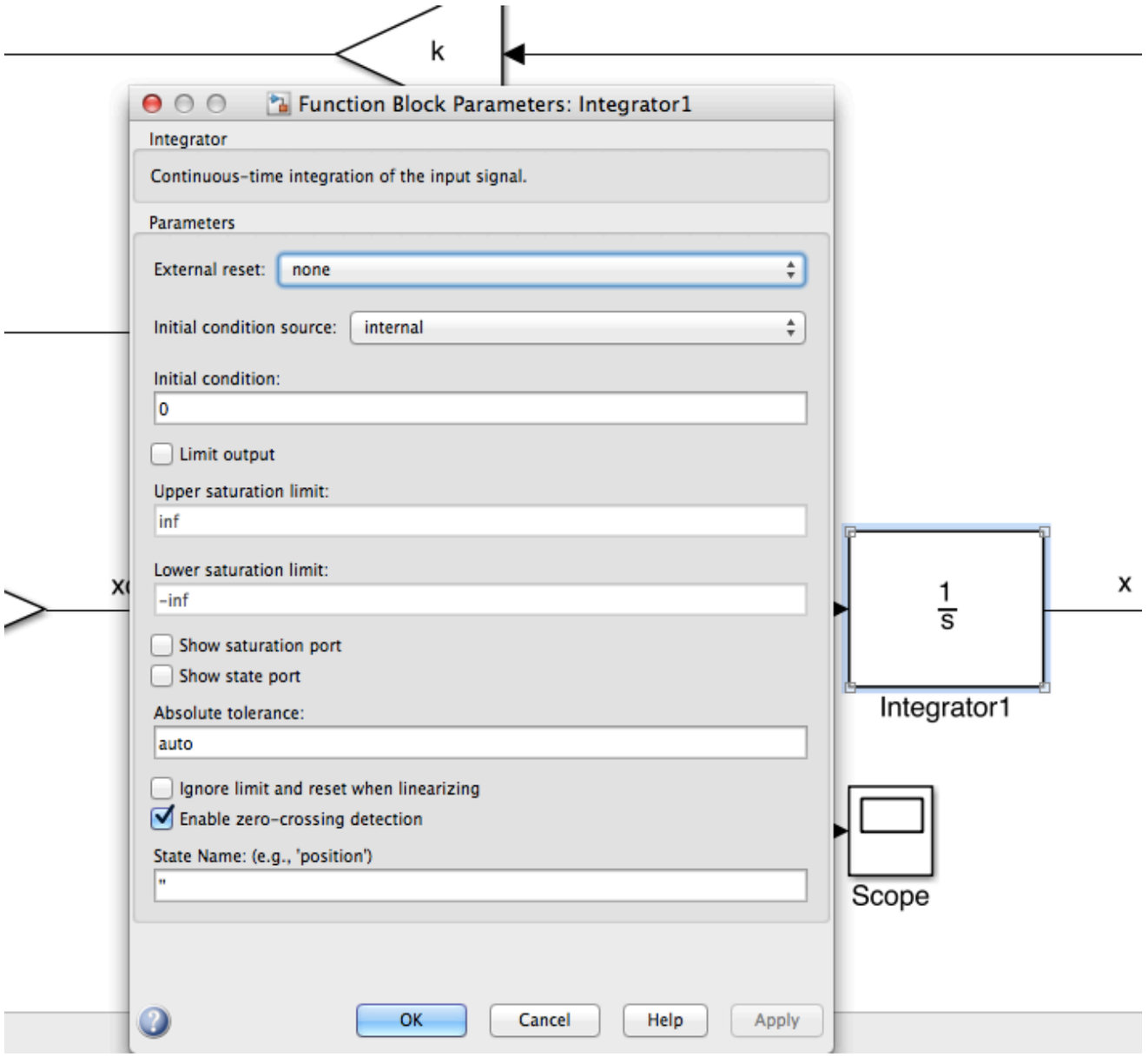
RUNNING SIMULATIONS
Setting Initial Conditions

In this example, we will run the model without a forcing function, but instead have a non-zero initial condition specified on the displacement



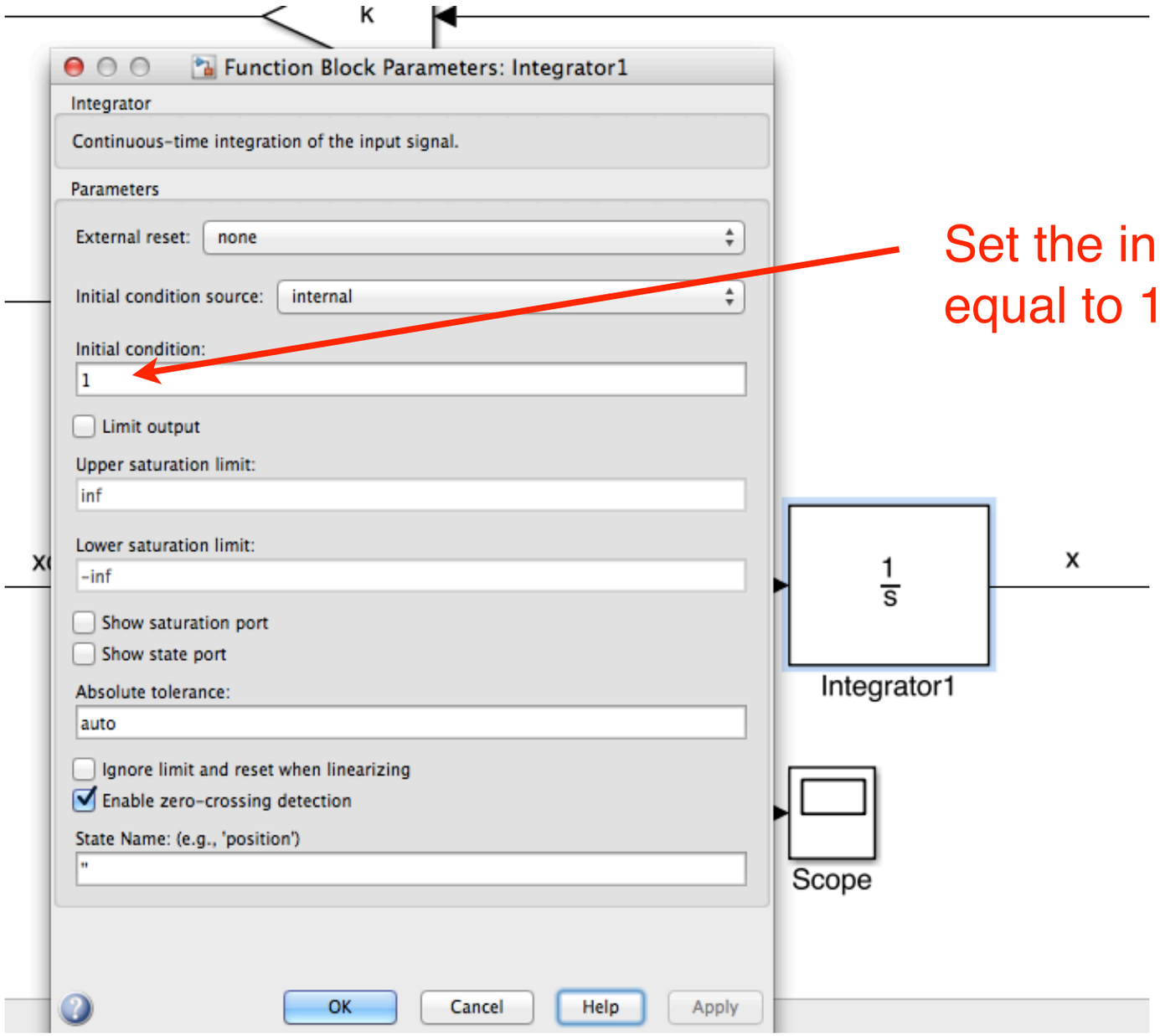
RUNNING SIMULATIONS
Setting Initial Conditions

As the initial condition is on position, we must set this value in the integrator block that is outputting position:



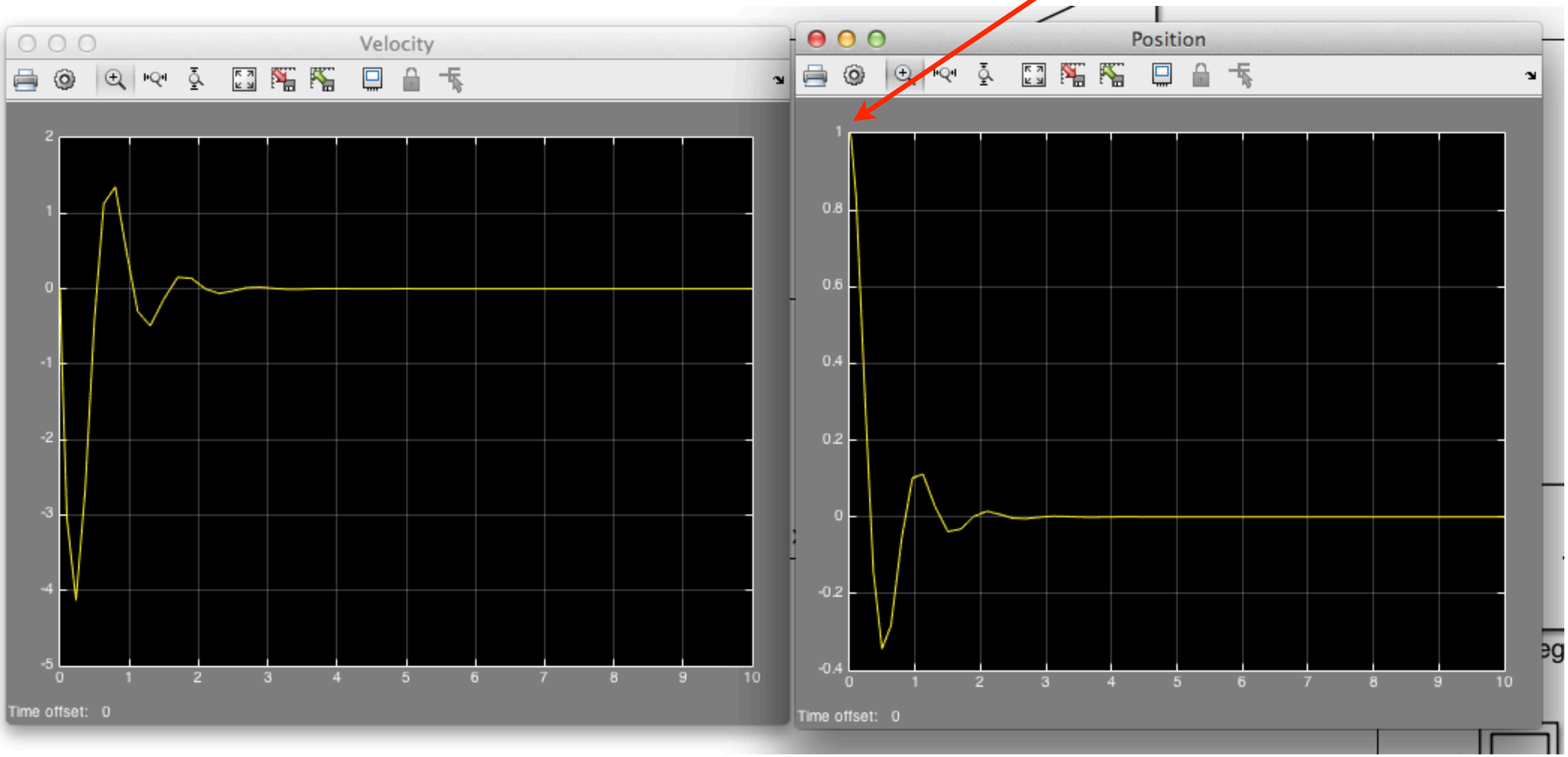
RUNNING SIMULATIONS
Setting Initial Conditions

As the initial condition is on position, we must set this value in the integrator block that is outputting position:



RUNNING SIMULATIONS
Setting Initial Conditions

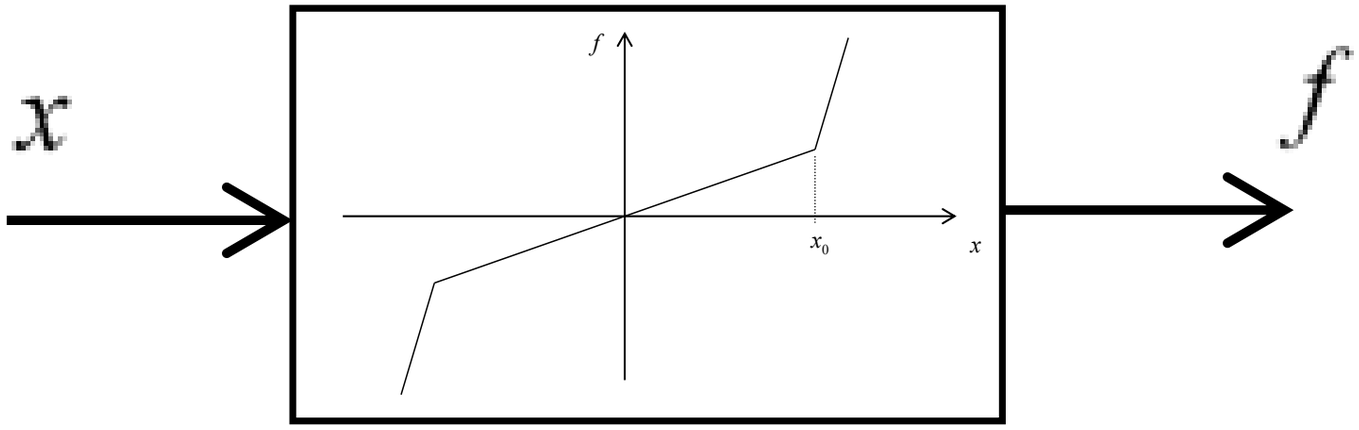
Running this model, produces the following outputs:



NONLINEARITIES
Using The Lookup Table In Simulink

Nonlinear parameter/component
Hardening or softening of spring stiffness

In Simulink this can be represented by a look-up table

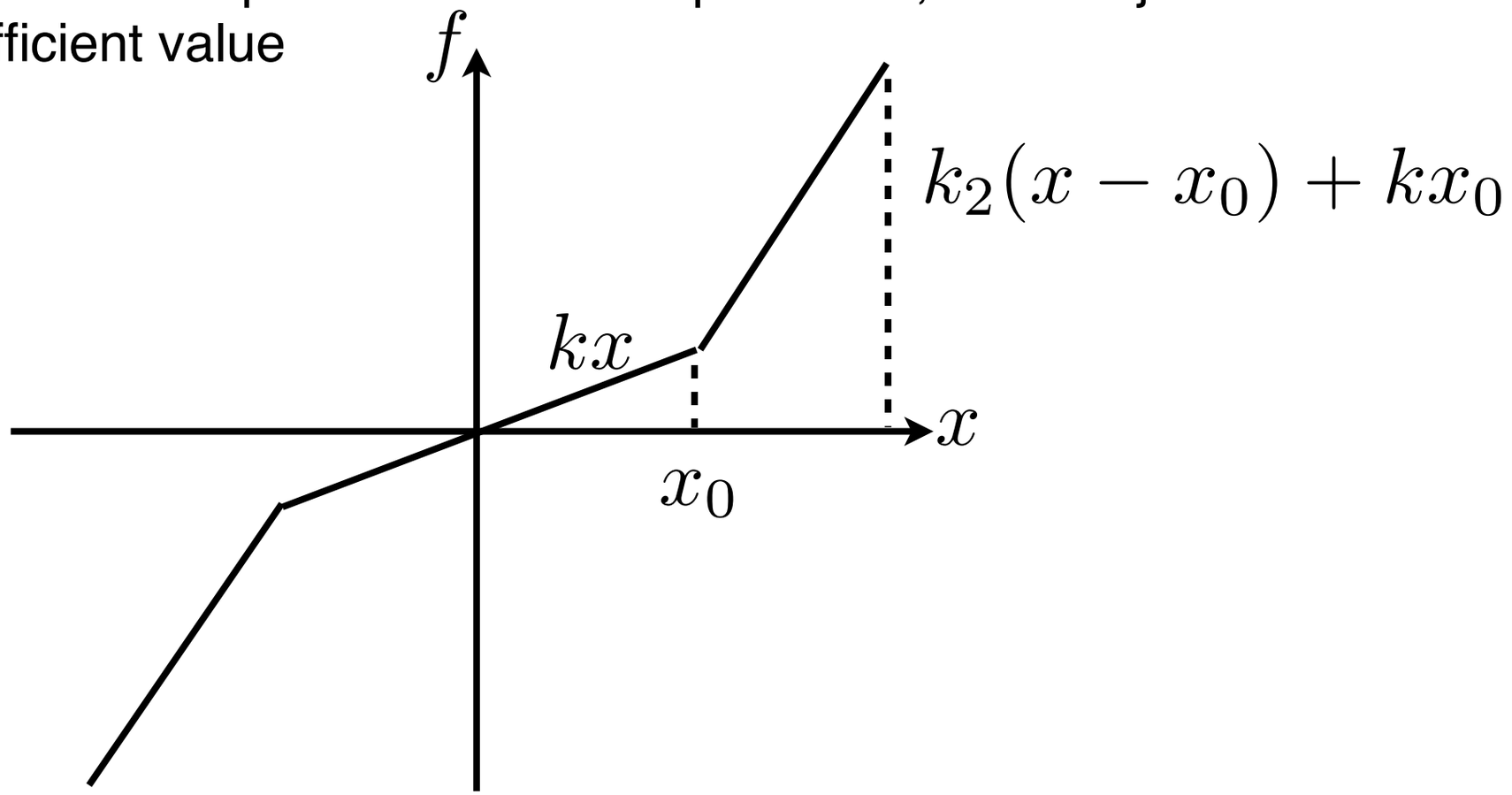


NONLINEARITIES
Using The Lookup Table In Simulink

Discrete data points that characterise the function are specified in the look-up table

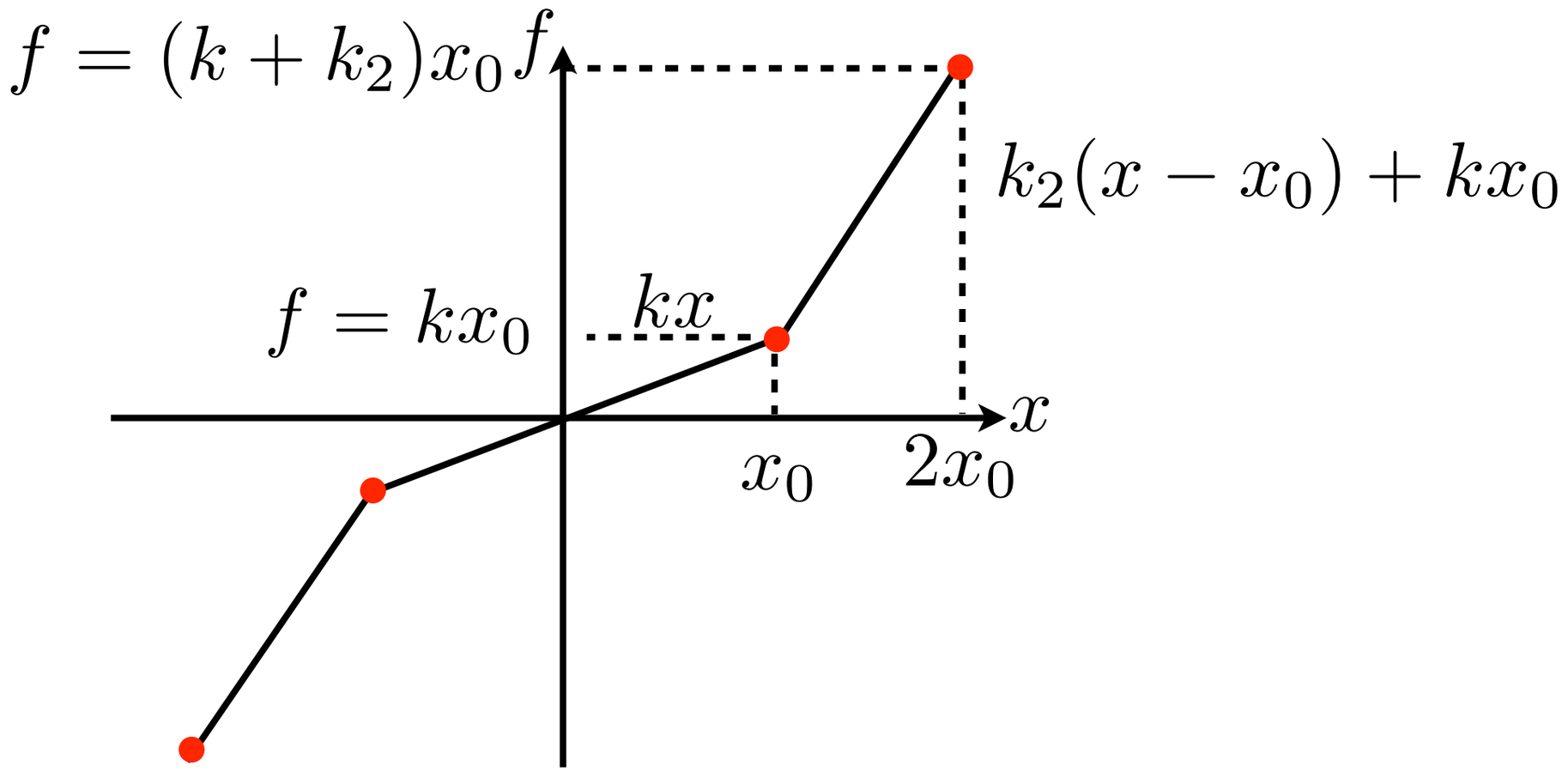
When supplied with an input, the look-up table block will either interpolate in between the specified data points or extrapolate beyond them

These look-up tables will replace the gain block currently used in the model - note that the output of the lookup table is the force produced, and not just the interpolated coefficient value



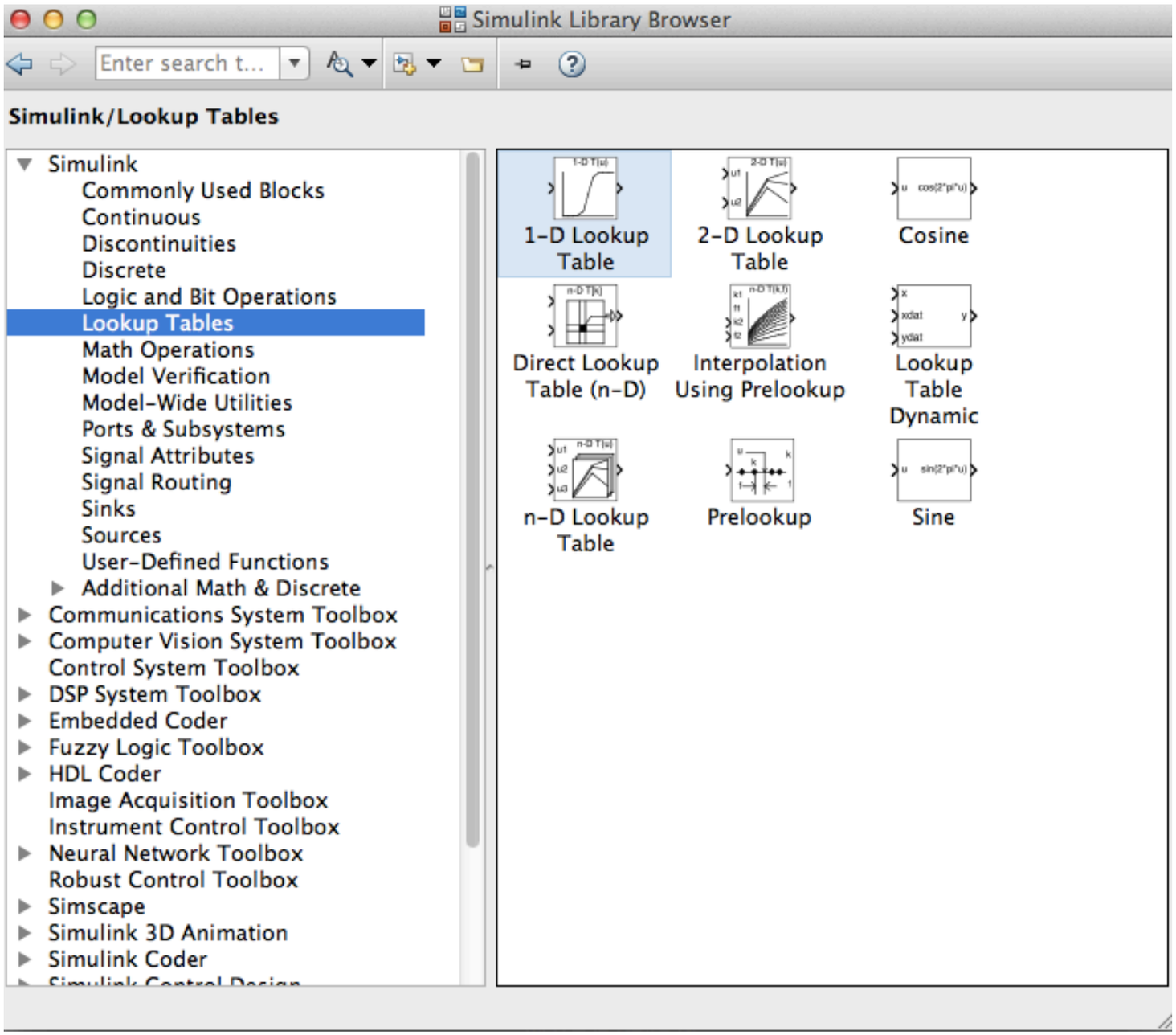
NONLINEARITIES
Using The Lookup Table In Simulink

Just need to specify the coordinates of the four red dots to characterise this function:



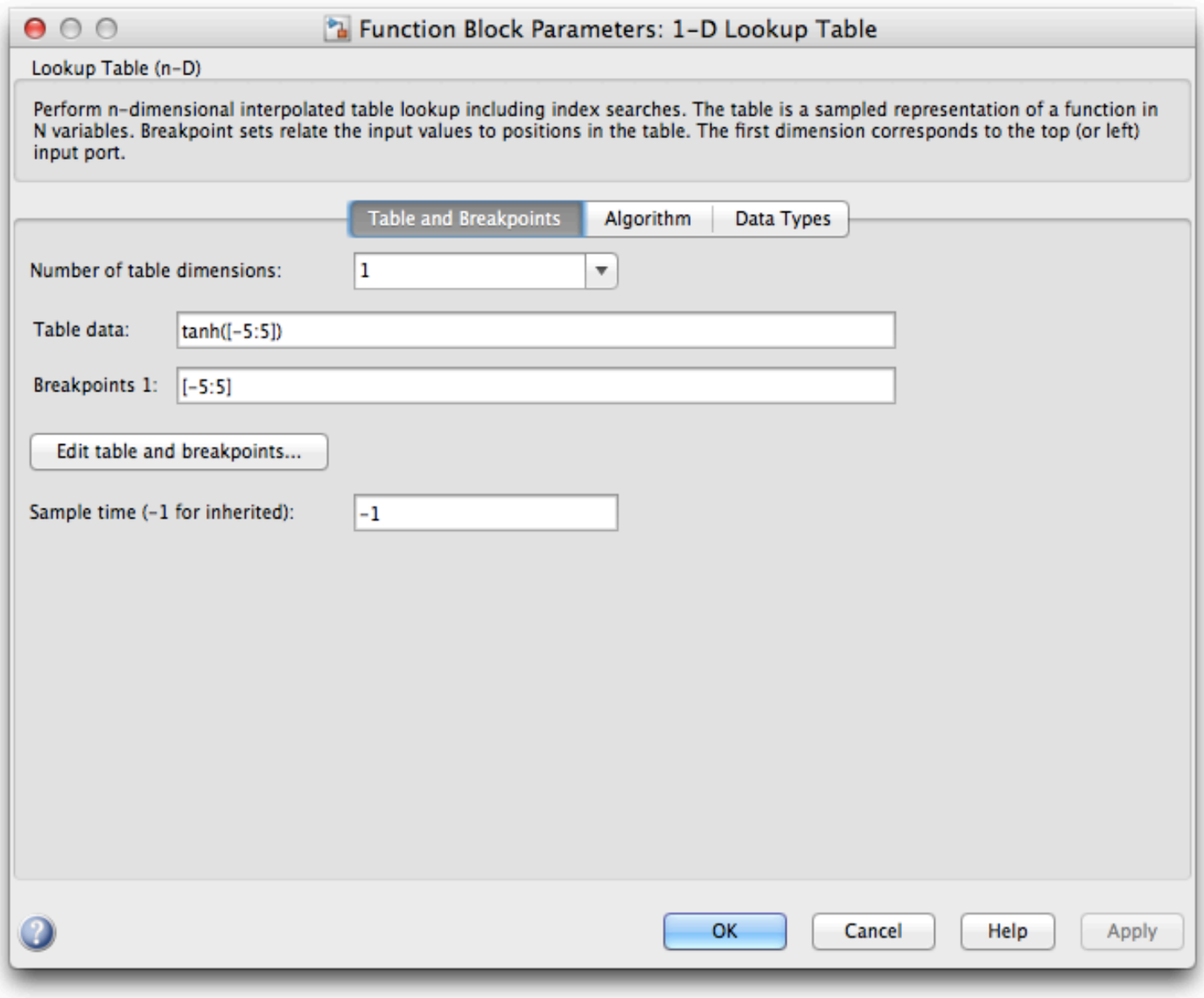
NONLINEARITIES
Using The Lookup Table In Simulink

Discrete data points that characterise the function are specified in the look-up table



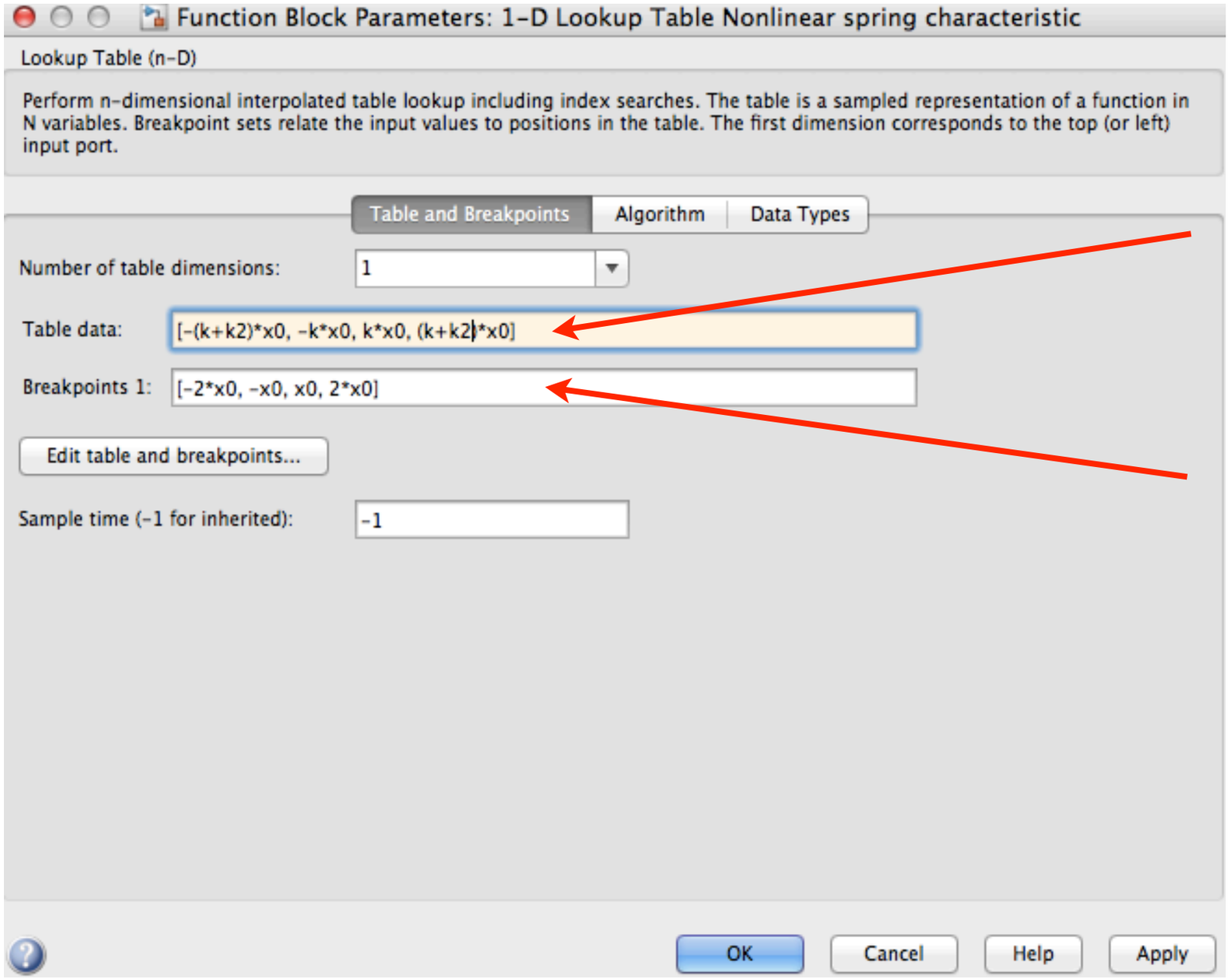
NONLINEARITIES
Using The Lookup Table In Simulink

Drag and drop into your model and double-click to open the parameter setting menu:



NONLINEARITIES
Using The Lookup Table In Simulink

Now enter the data points as two Matlab vectors



These are the y values that will be outputted

These are the x coordinates at which the function is changing value