Chapter 10: Simulink

- Simulation Diagrams
- Simulink Models
- Library Browser
- Commonly-Used Blocks
- Transfer-Function Models
- Linear State-Variable Models
- Piecewise-Linear Models
- Subsystems

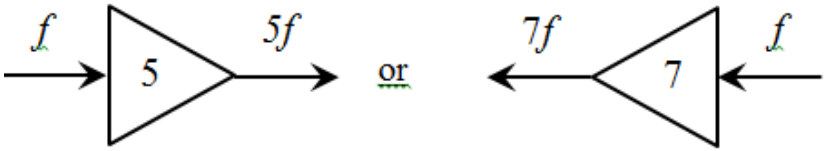
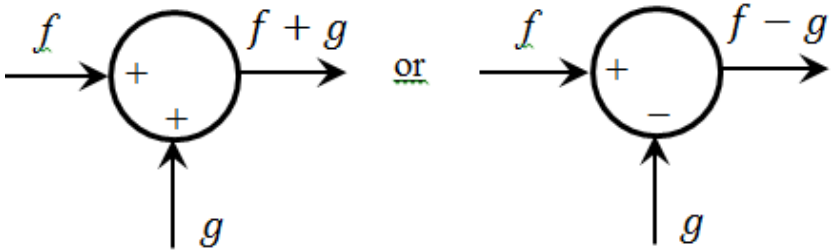
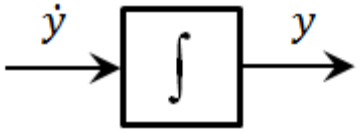
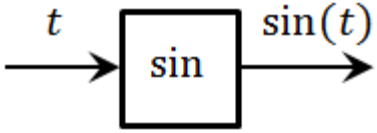
Simulink: Introduction

- Graphical User Interface built onto MATLAB
- Blocks and interconnecting wiring create a dynamic system
- Simulation Diagrams describe the differential equation
- A Simulink Model can solve the differential equation subject to initial conditions
- Results can be exported to the MATLAB environment for further processing

Simulation Diagrams

- A Simulation Diagram is used to represent a mathematical equation
- Blocks are used to modify the flow of data
- Interconnecting wiring and arrows indicate the direction of the flow of data
- Blocks have either Inputs or Outputs or Both
- Many differential equations are solved using a Feedback Loop

Simulation Diagrams

Object	Graphical Description	Function
Gain Block		Multiply Incoming Signal by a Constant Value
Summer		Adds or Subtracts Multiple Signals
Integrator		Integrates Incoming Signal
Trig Functions		Computes the Sine of the Incoming Signal

Simulation Diagrams

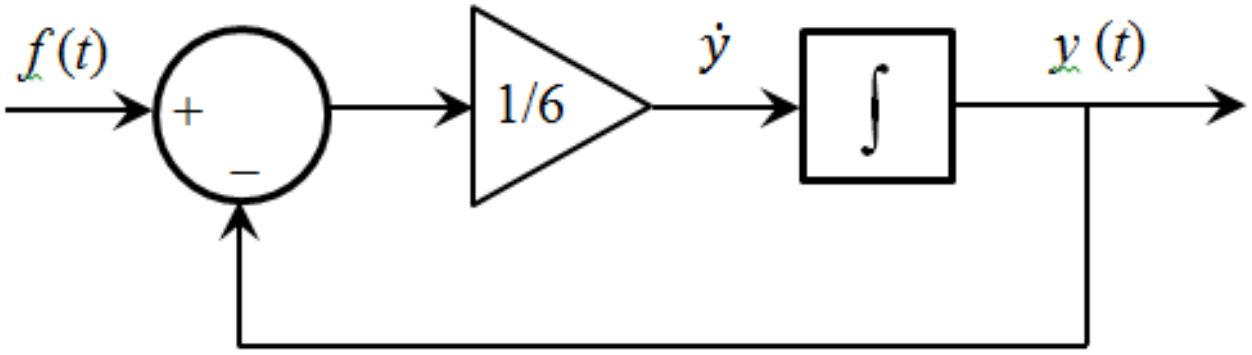
22. Plot the solution of the equation

$$6\dot{y} + y = f(t)$$

if $f(t) = 0$ for $t < 0$ and $f(t) = 15$ for $t \geq 0$. The initial condition is $y(0) = 7$.

$$\dot{y} = \left(\frac{1}{6}\right)[f(t) - y]$$

$$y = \int \left\{\left(\frac{1}{6}\right)[f(t) - y]\right\}$$



Simulation Diagrams

30. The following equation describes the motion of a certain mass connected to a spring, with viscous friction on the surface

$$3\ddot{y} + 18\dot{y} + 102y = f(t)$$

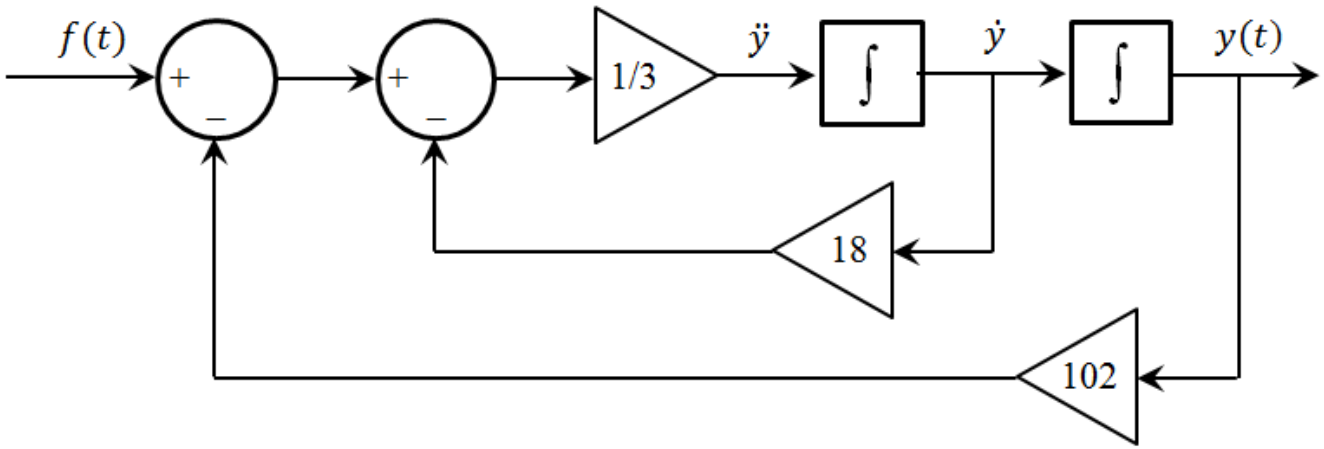
where $f(t)$ is an applied force. Suppose that $f(t) = 0$ for $t < 0$ and $f(t) = 10$ for $t \geq 0$.

a. Plot $y(t)$ for $y(0) = \dot{y}(0) = 0$.

b. Plot $y(t)$ for $y(0) = 0$ and $\dot{y}(0) = 10$. Discuss the effect of the nonzero initial velocity.

$$\ddot{y} = \frac{1}{3}[-18\dot{y} - 102y + f(t)]$$

$$y = \iint \left\{\frac{1}{3}[-18\dot{y} - 102y + f(t)]\right\}$$



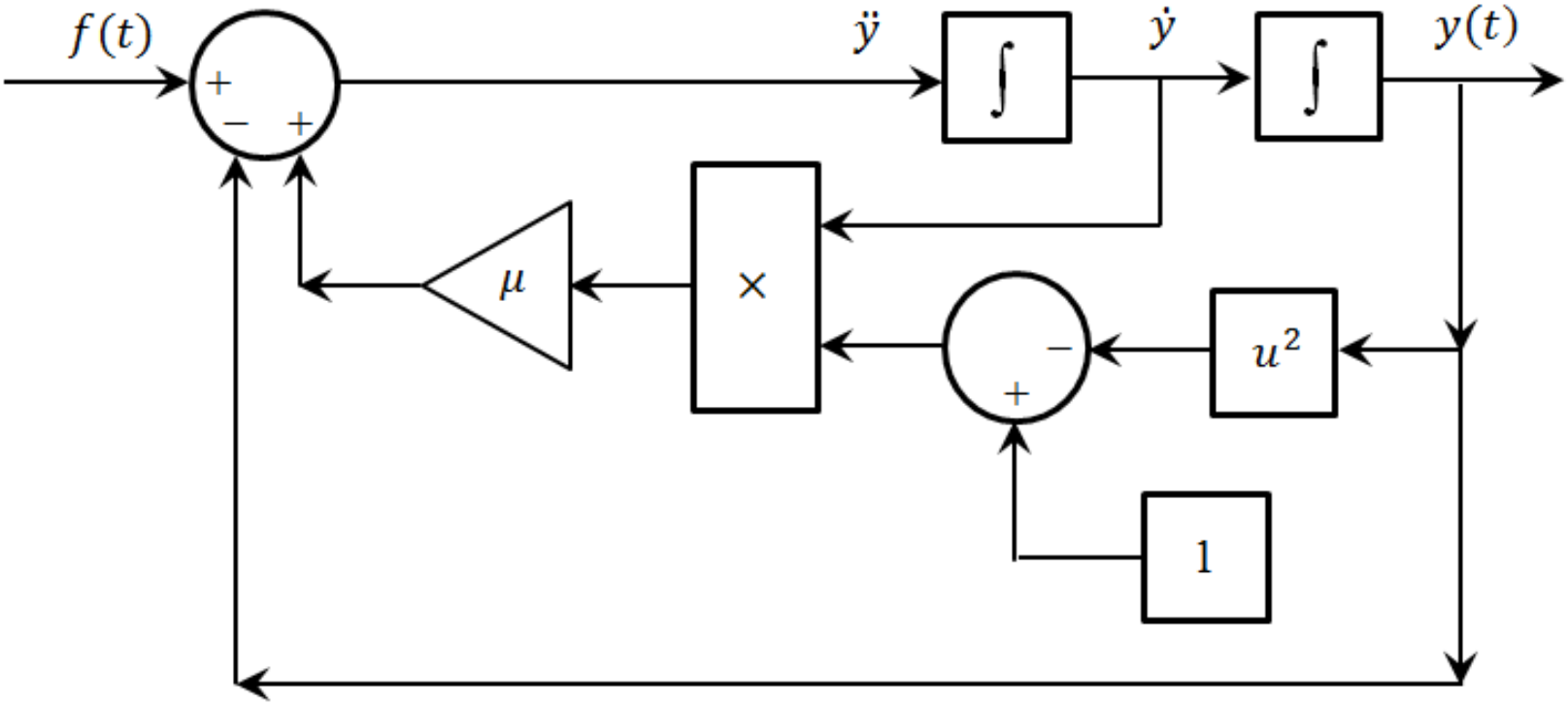
Simulation Diagrams

33. Van der Pol's equation has been used to describe many oscillatory processes. It is

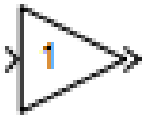
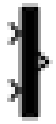
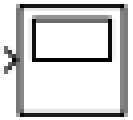
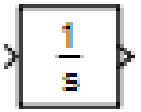
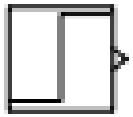
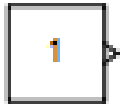
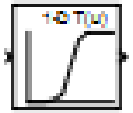
$$\ddot{y} - \mu(1 - y^2)\dot{y} + y = f(t)$$

$$\ddot{y} = \mu(1 - y^2)\dot{y} - y + f(t)$$

$$y = \iint [\mu(1 - y^2)\dot{y} - y + f(t)]$$



Simulink Blocks

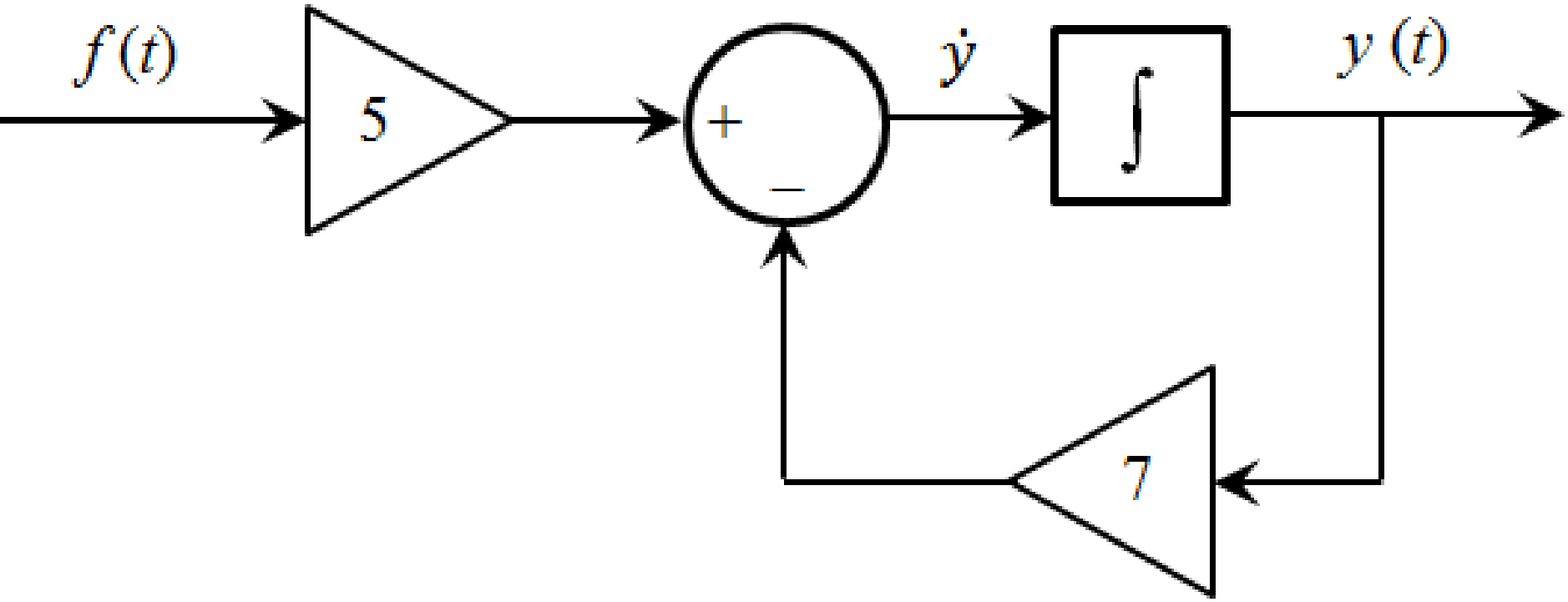
Object	Graphical Symbol	Object	Graphical Symbol
Gain Block		Mux (Multiplexer)	
Summer		Scope	
Integrator		To Workspace	
Trig Functions		Step	
Constant		1-D Lookup Table	
Clock		User-Defined Function	

Simulink Models

Use Simulink to solve the following differential equation:

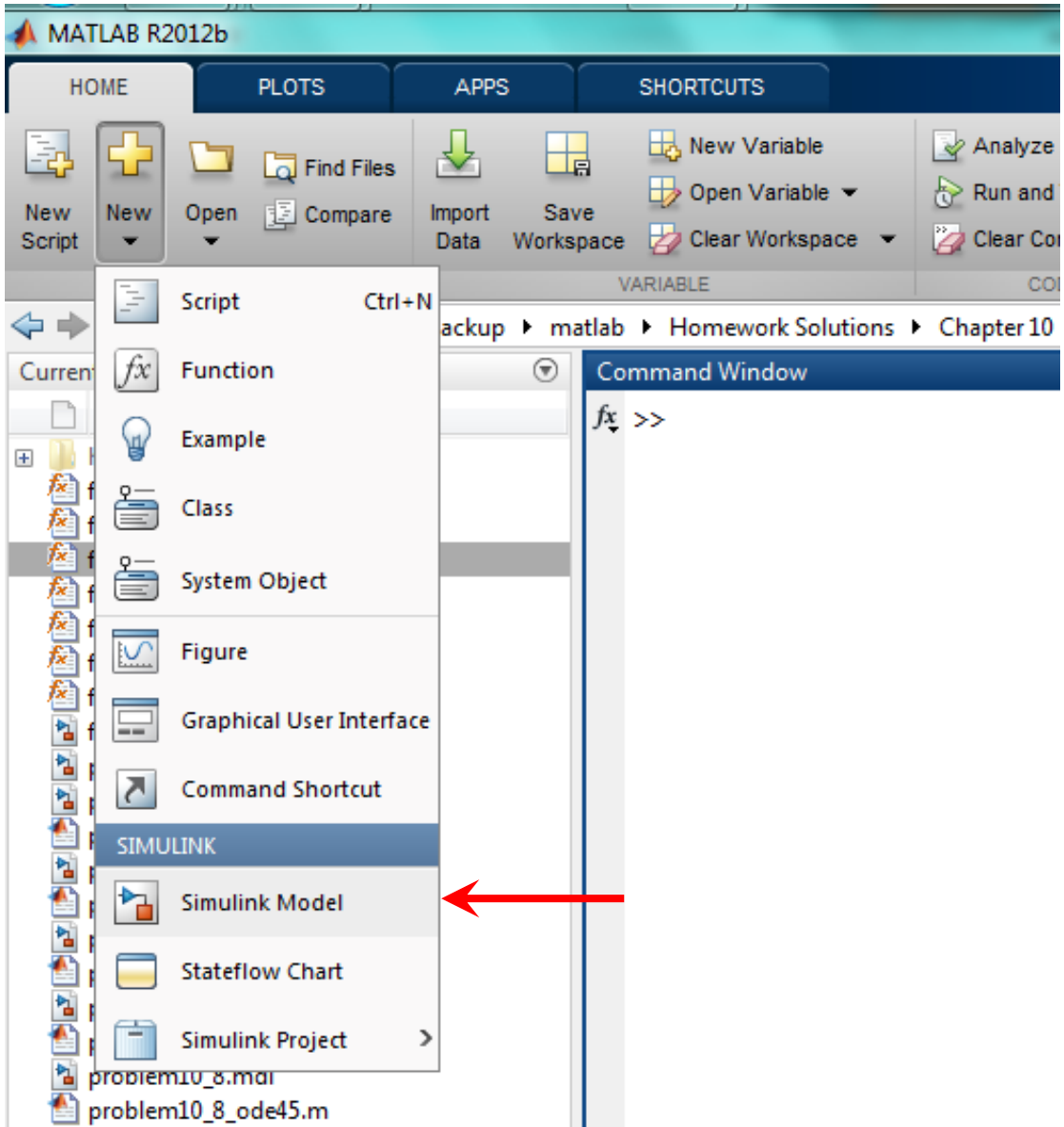
$$\dot{y} = 5f(t) - 7y; \quad y(0) = 3$$

$$f(t) = \begin{cases} 0 \text{ for } t < 2.0 \\ 5 \text{ for } t \geq 2.0 \end{cases}$$



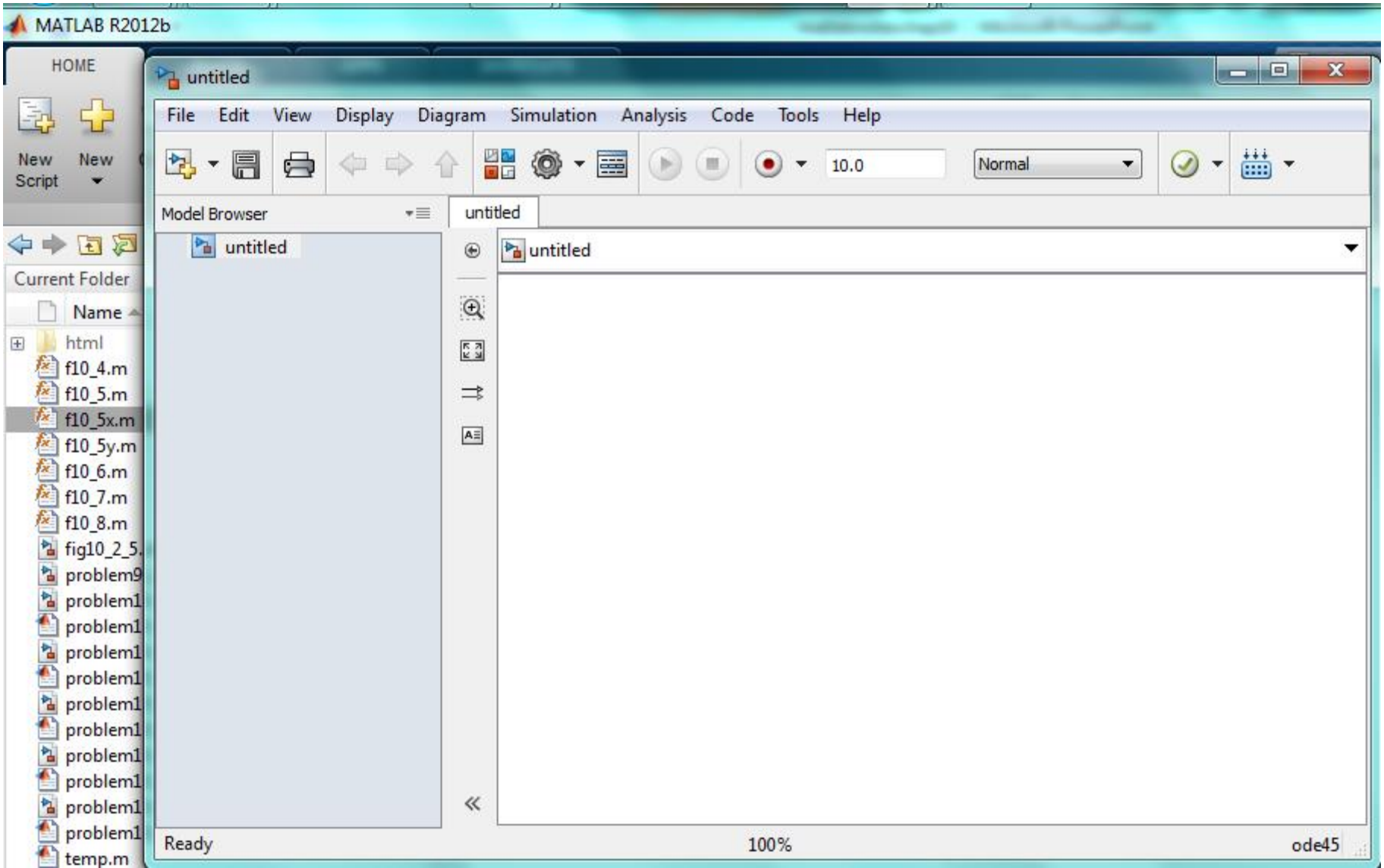
Simulink Models

Create a new Simulink Model



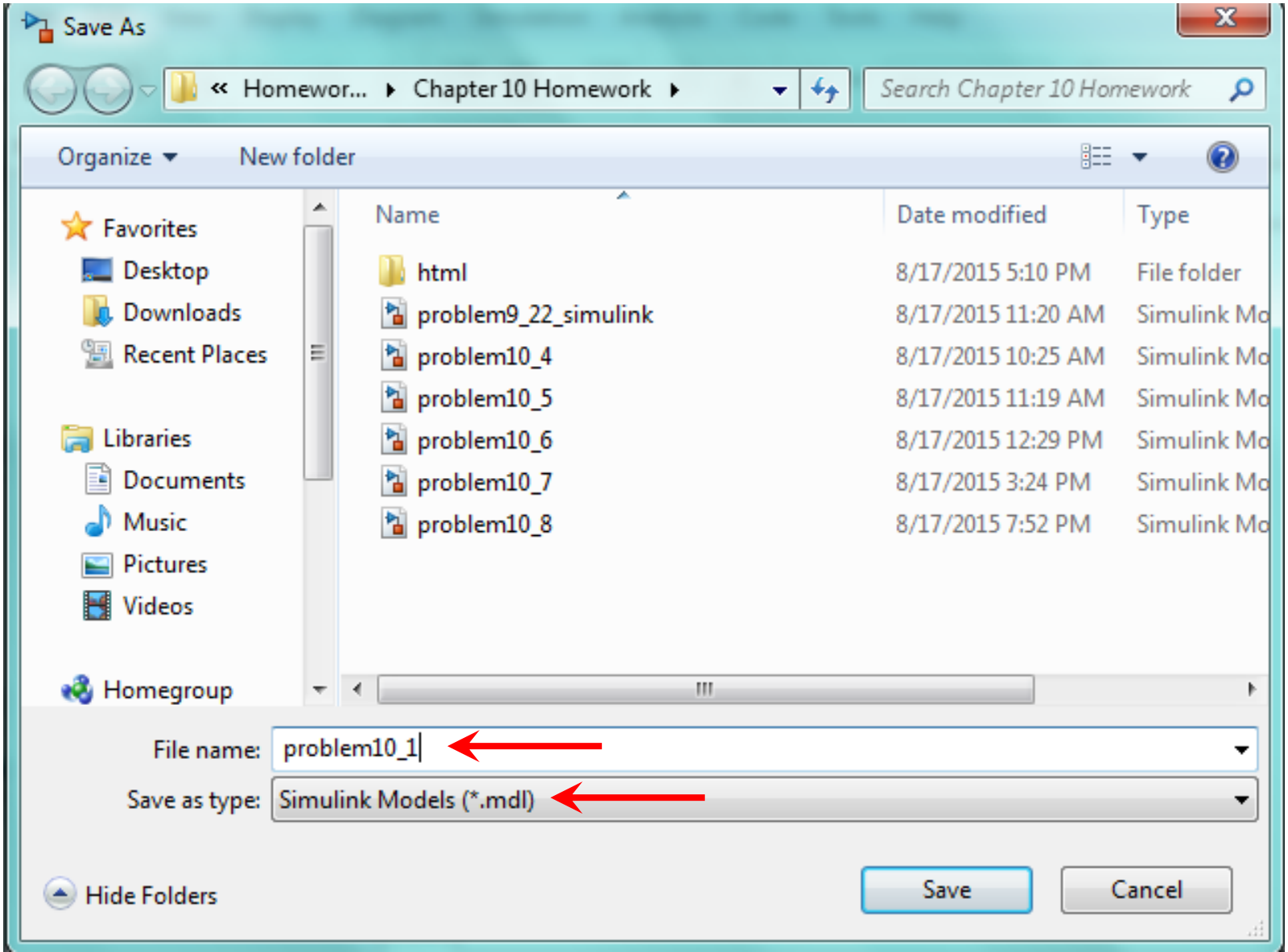
Simulink Models

The Simulink Model Window appears



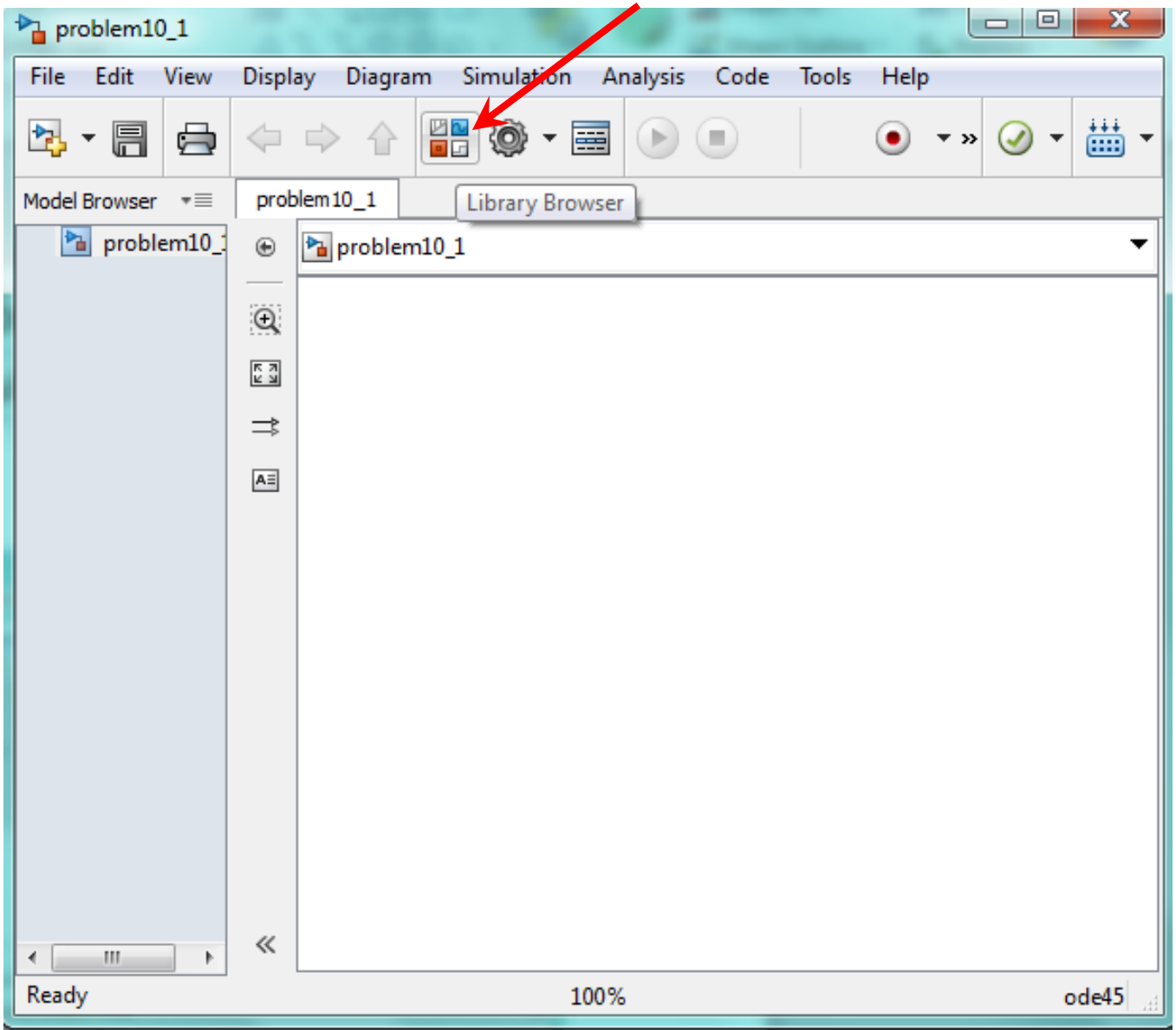
Simulink Models

Save As a new Simulink Model (problem10_1.mdl)



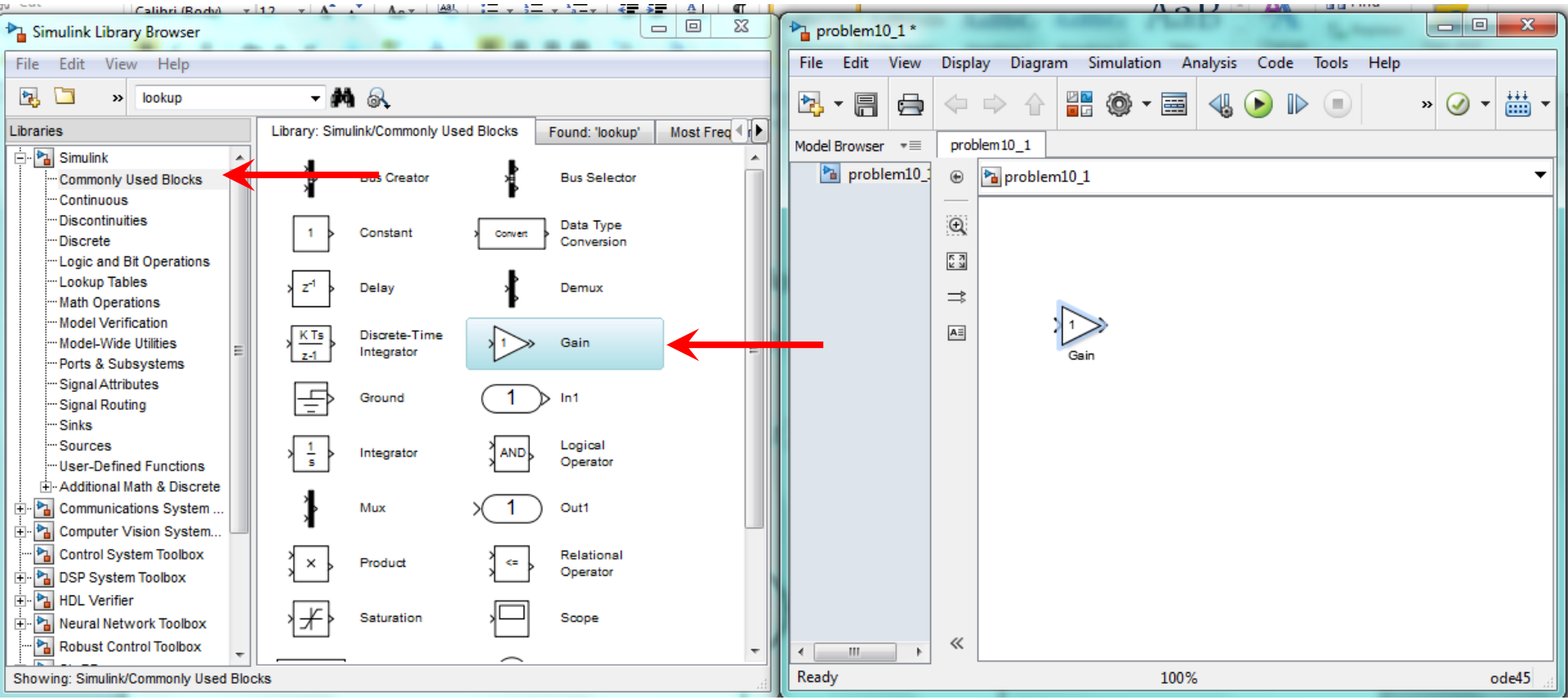
Simulink Models

Open the Simulink Block Library Browser



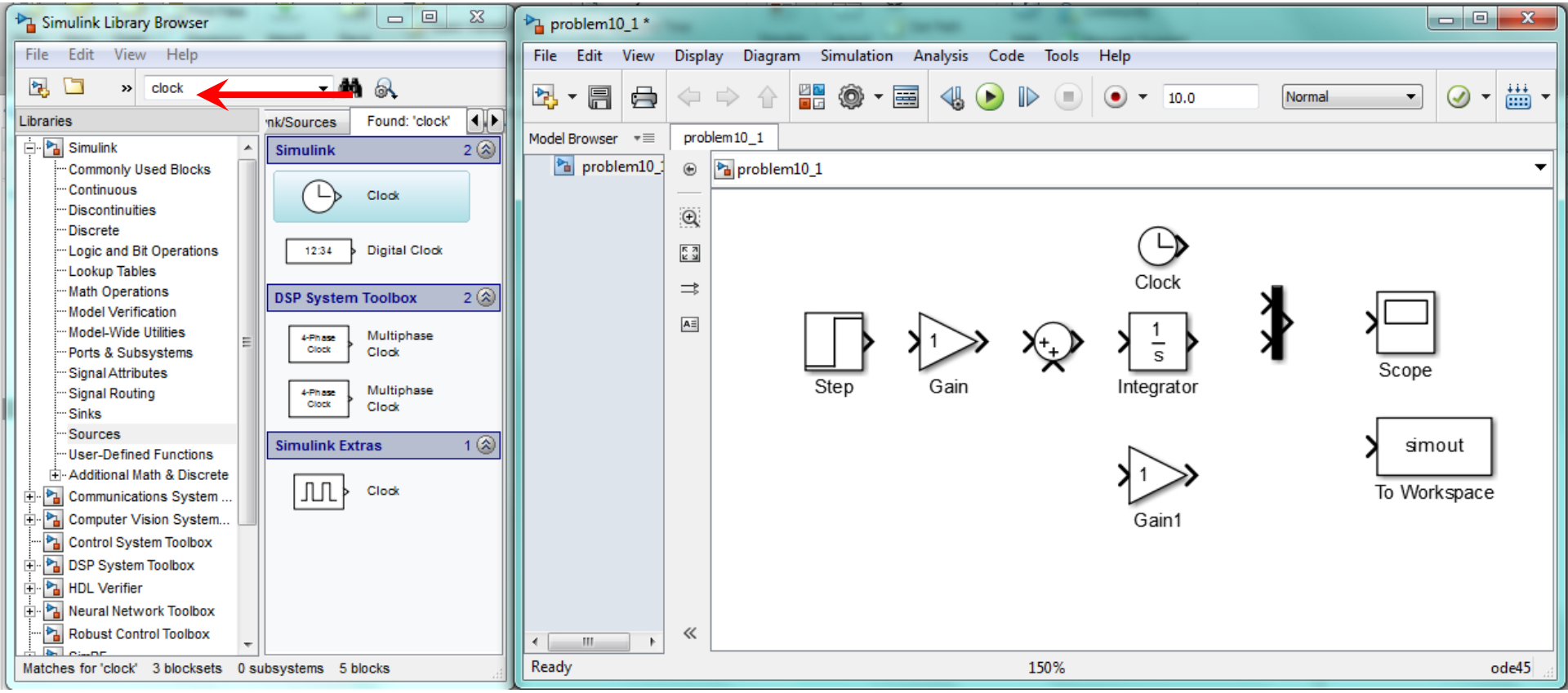
Simulink Models

Under the Commonly Used Blocks tab, drag-and-drop a Gain Block onto the Model Window by left-click-drag



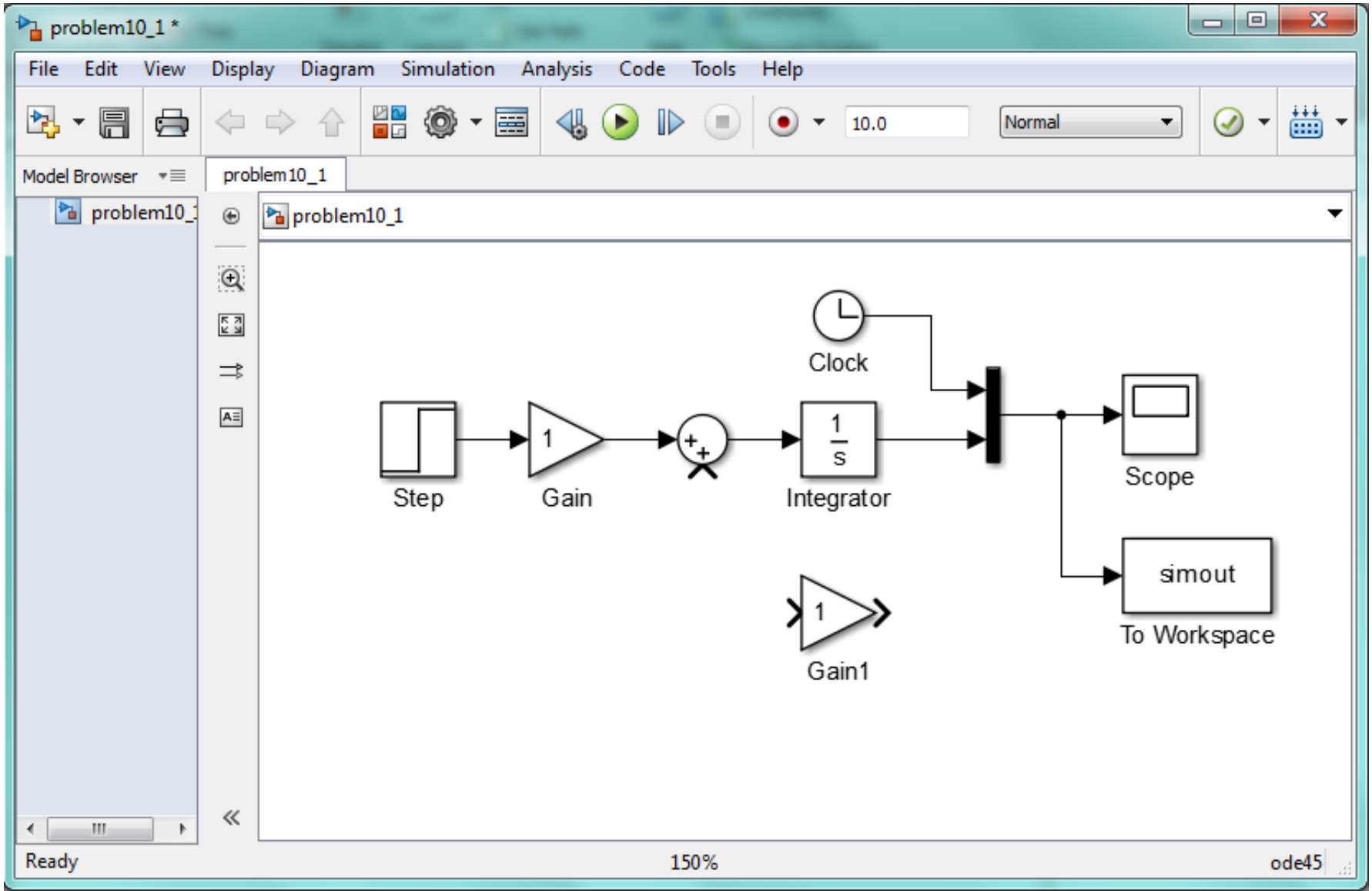
Simulink Models

Place the following blocks onto the Block Diagram Window.
Search for the Clock Function using the Search tab



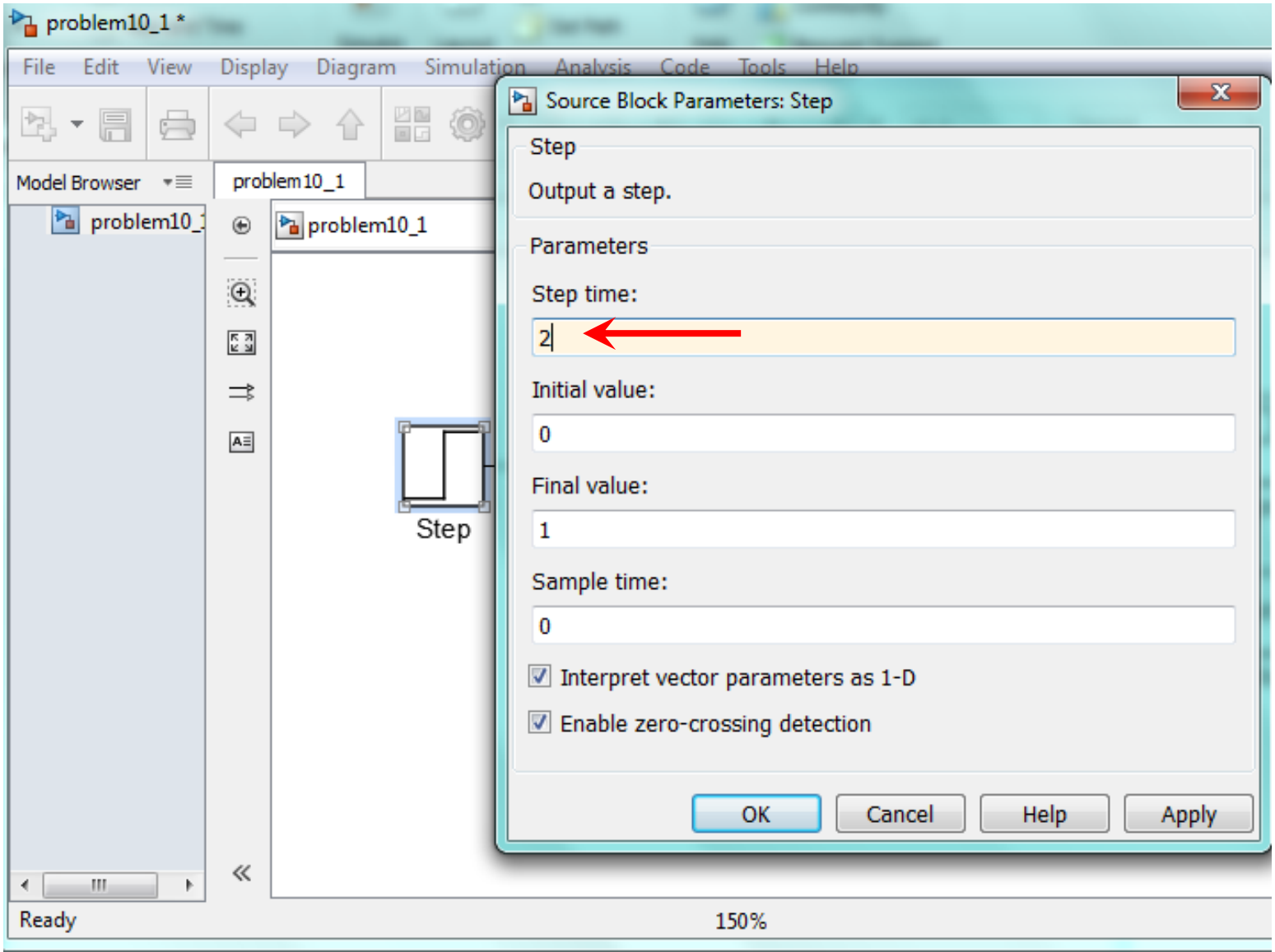
Simulink Models

Wire up the blocks



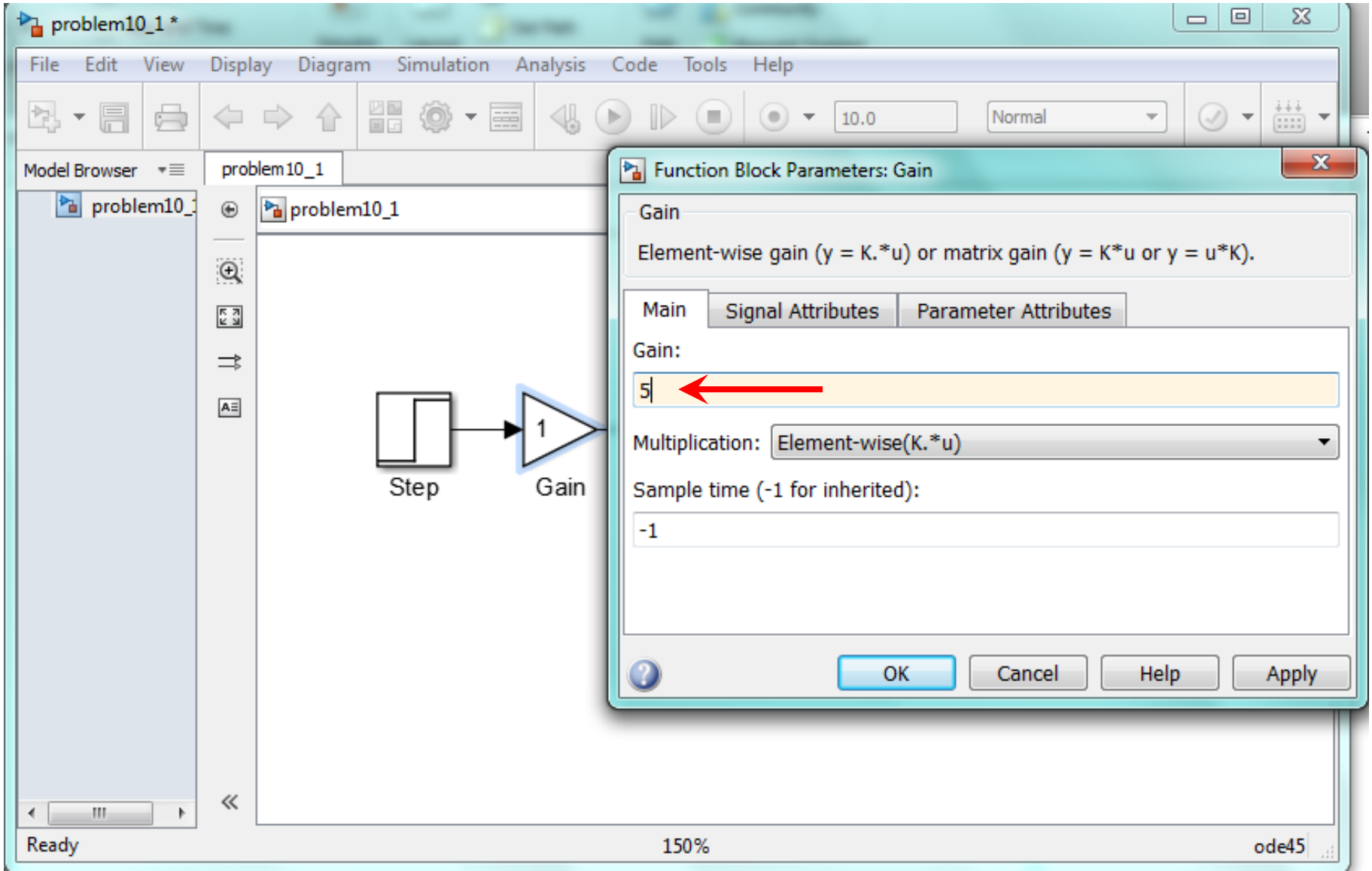
Simulink Models

Double-Click on the Step block and set the Step Time to 2 sec



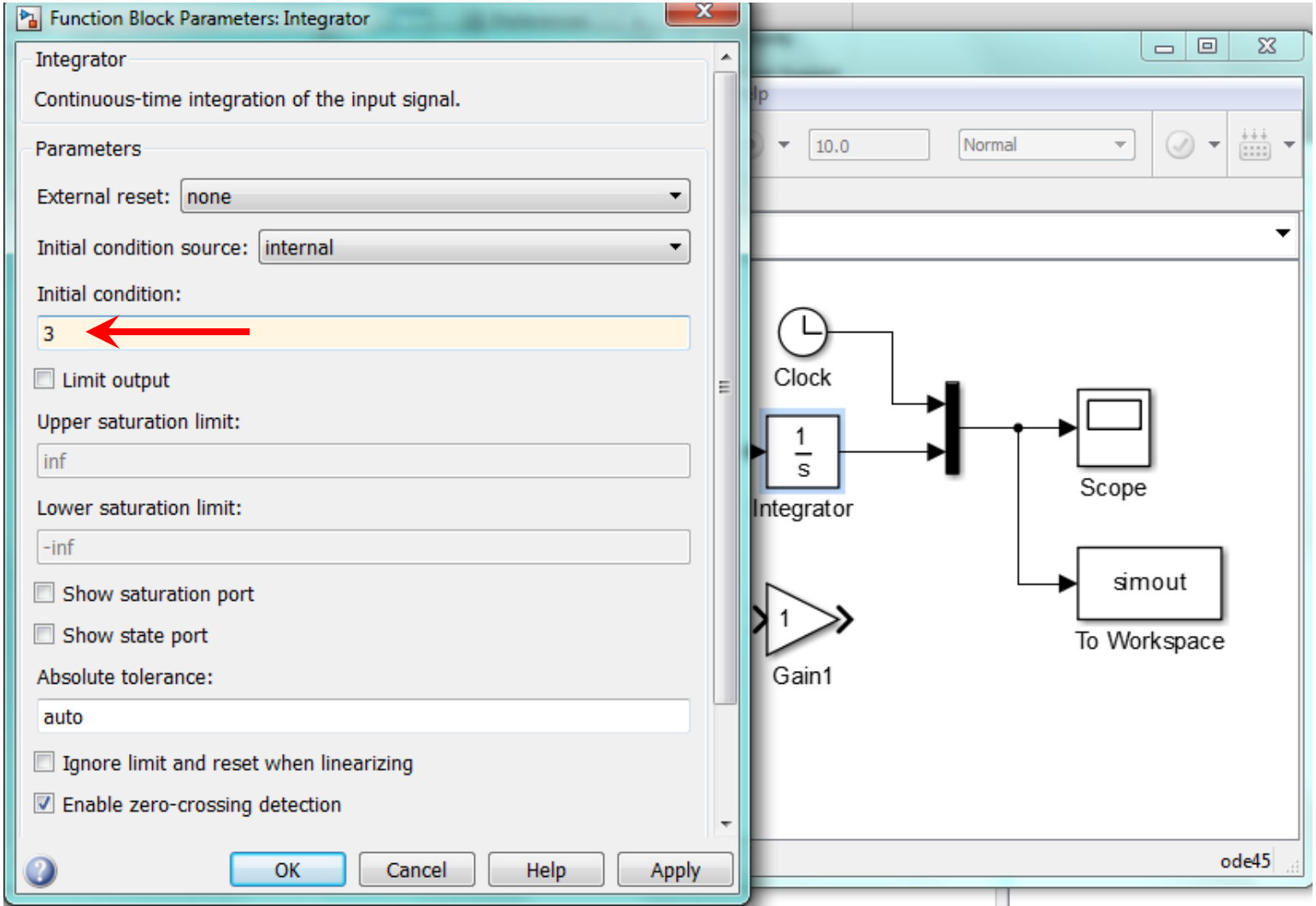
Simulink Models

Double-Click on the Gain block and set the gain to 5



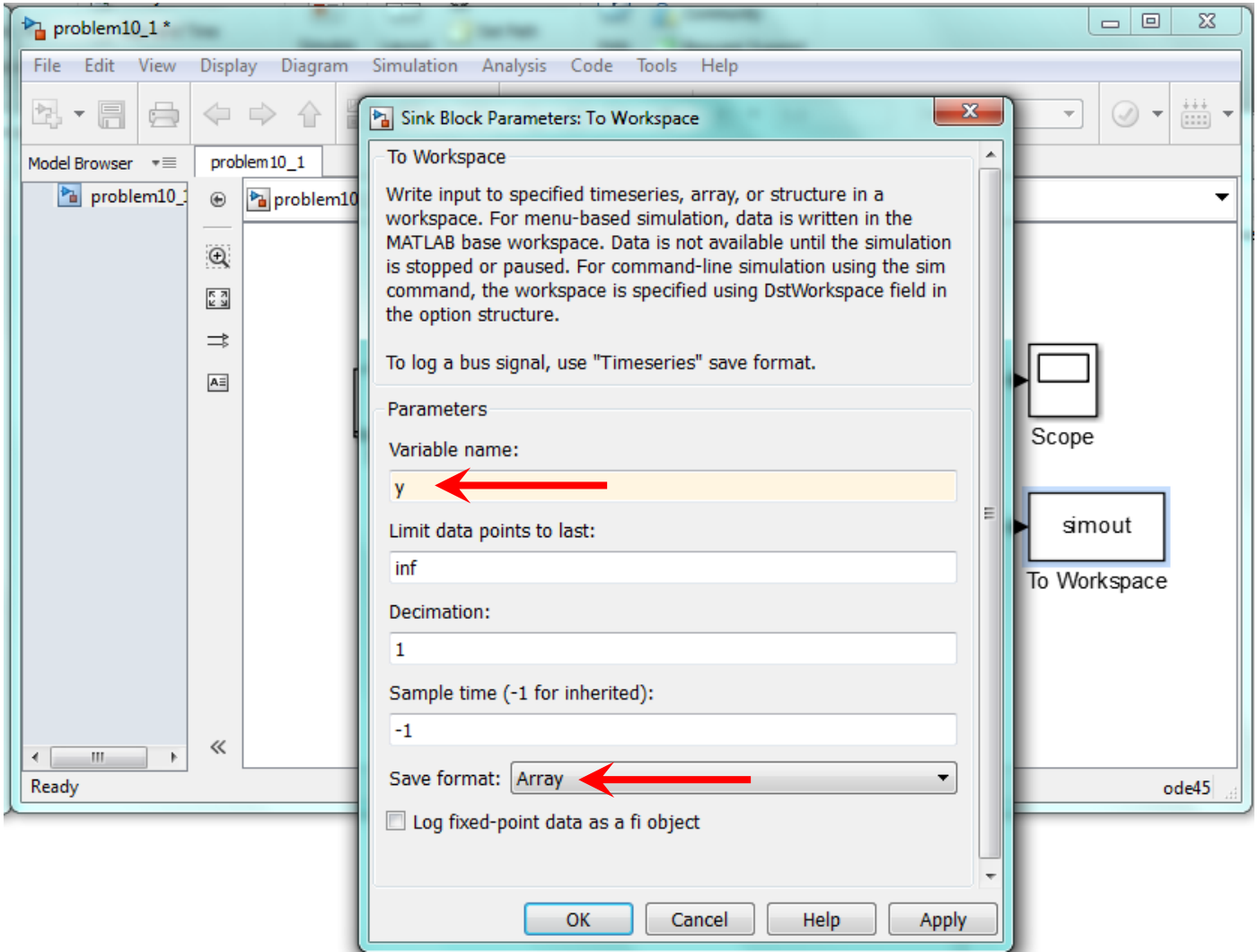
Simulink Models

Double-Click on the Integrator block and set the Initial Condition to 3



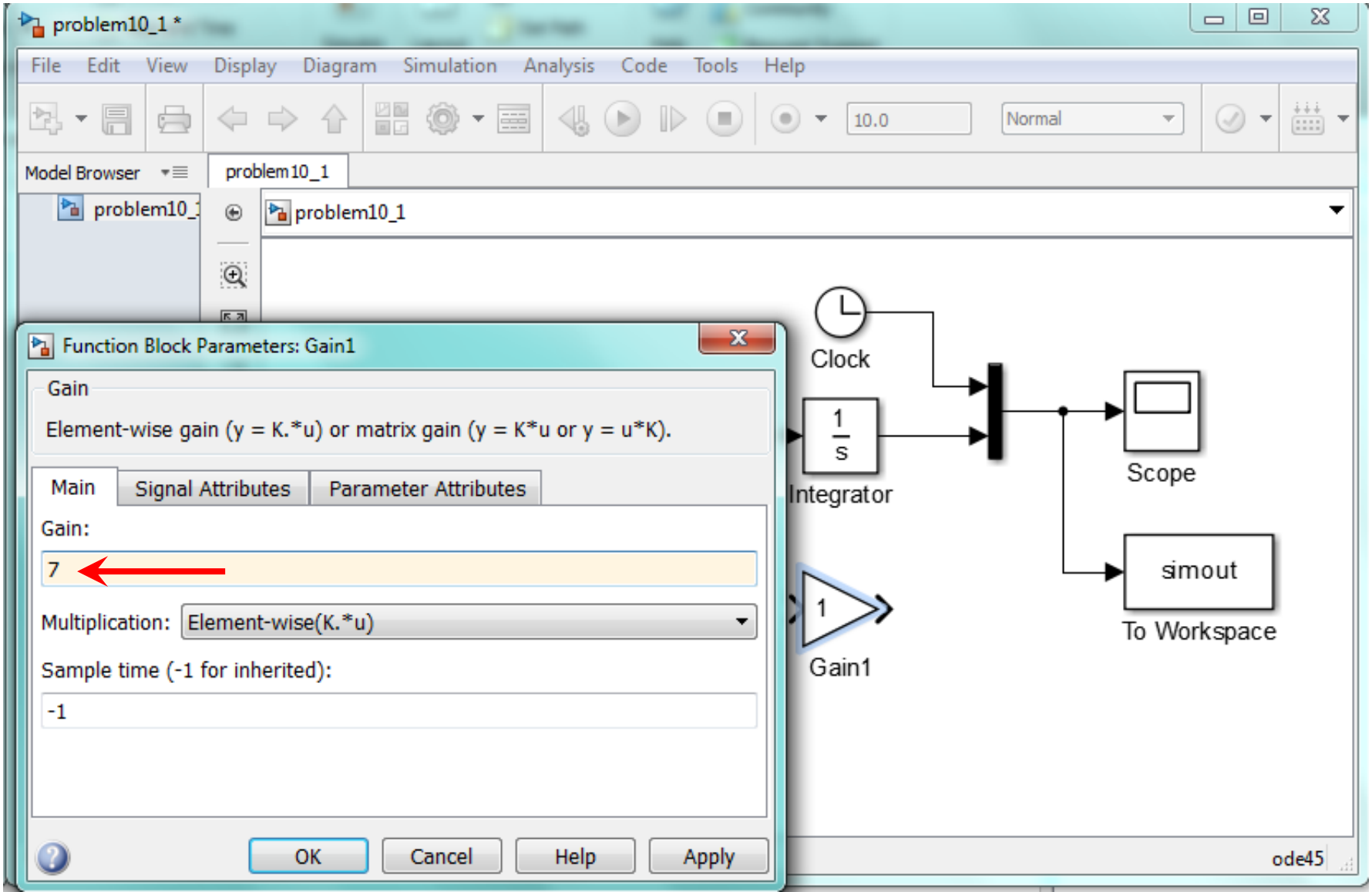
Simulink Models

Double-Click on the To Workspace block and set the Variable Name to y and set the Save Format to Array



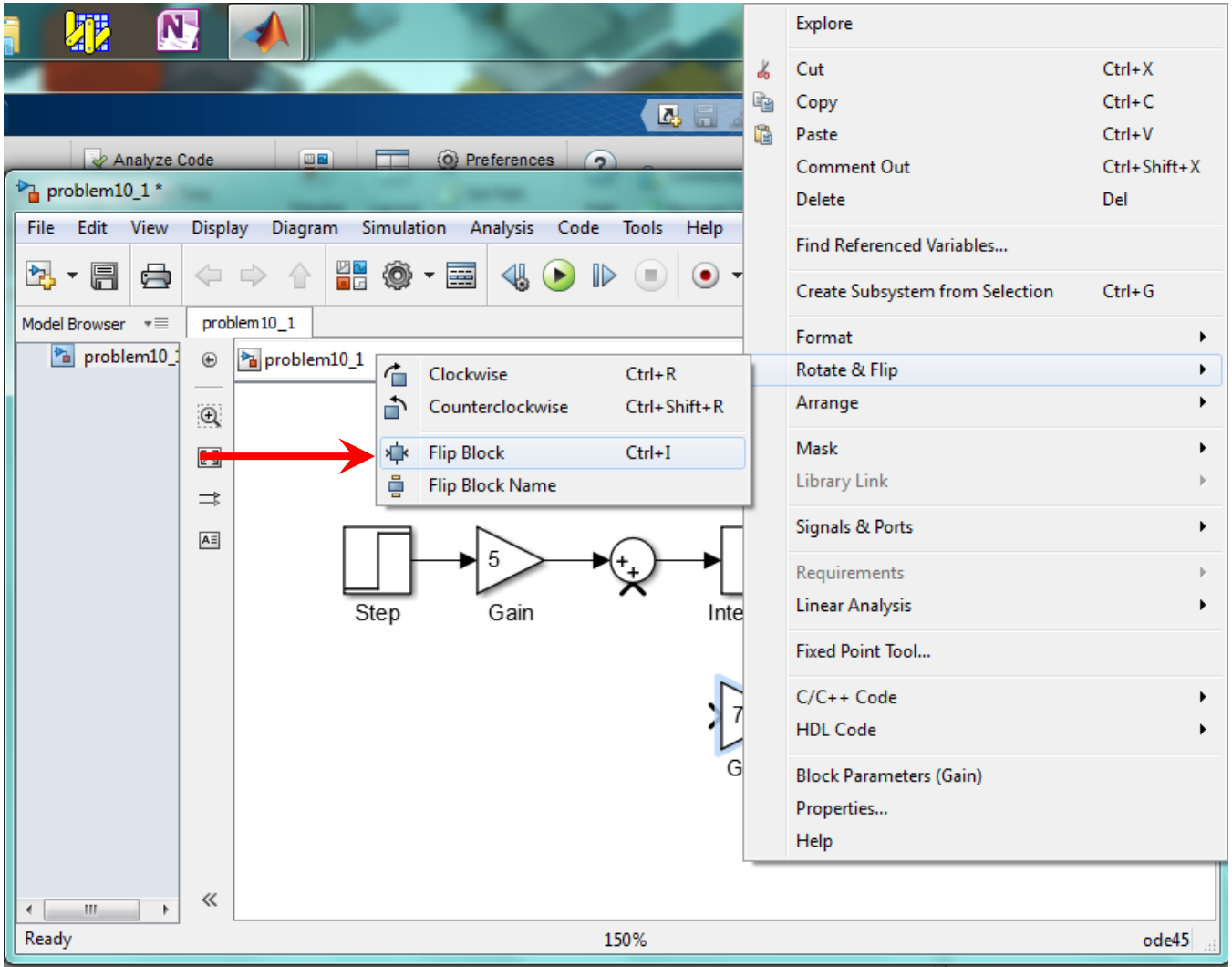
Simulink Models

Double-Click on the lower Gain block and set the value to 7



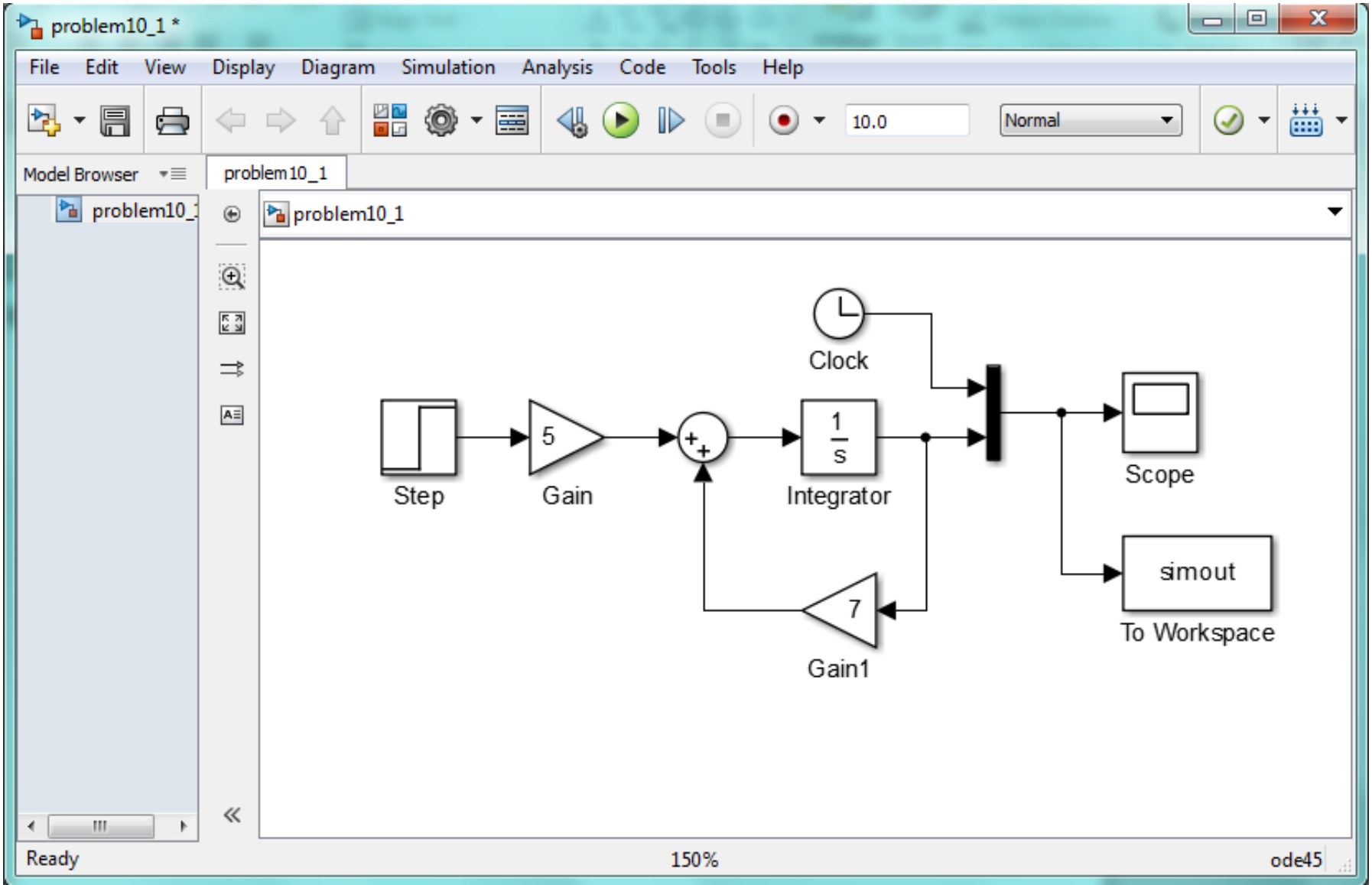
Simulink Models

Right-Click on the lower Gain block and flip the block direction



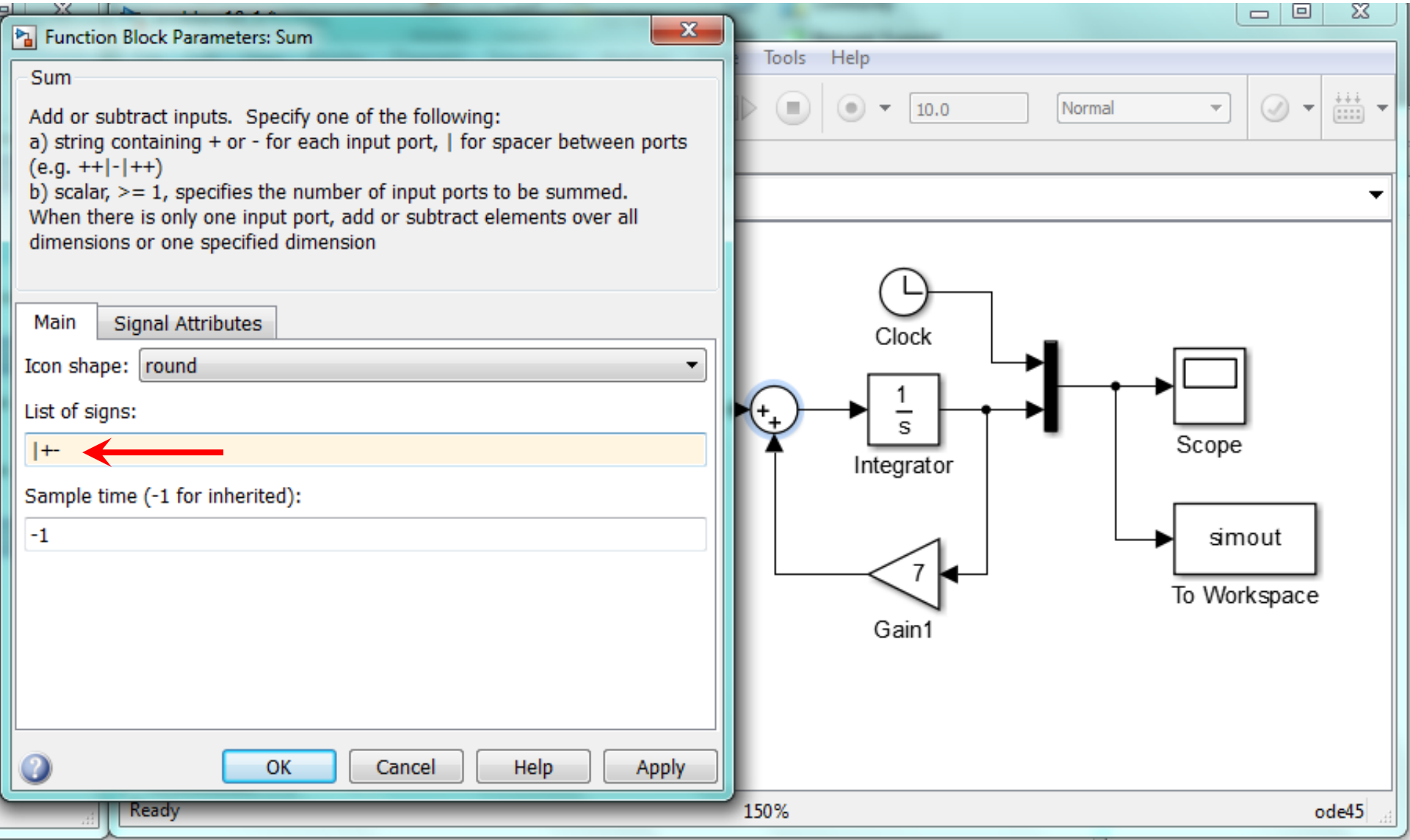
Simulink Models

Complete the wiring on the model



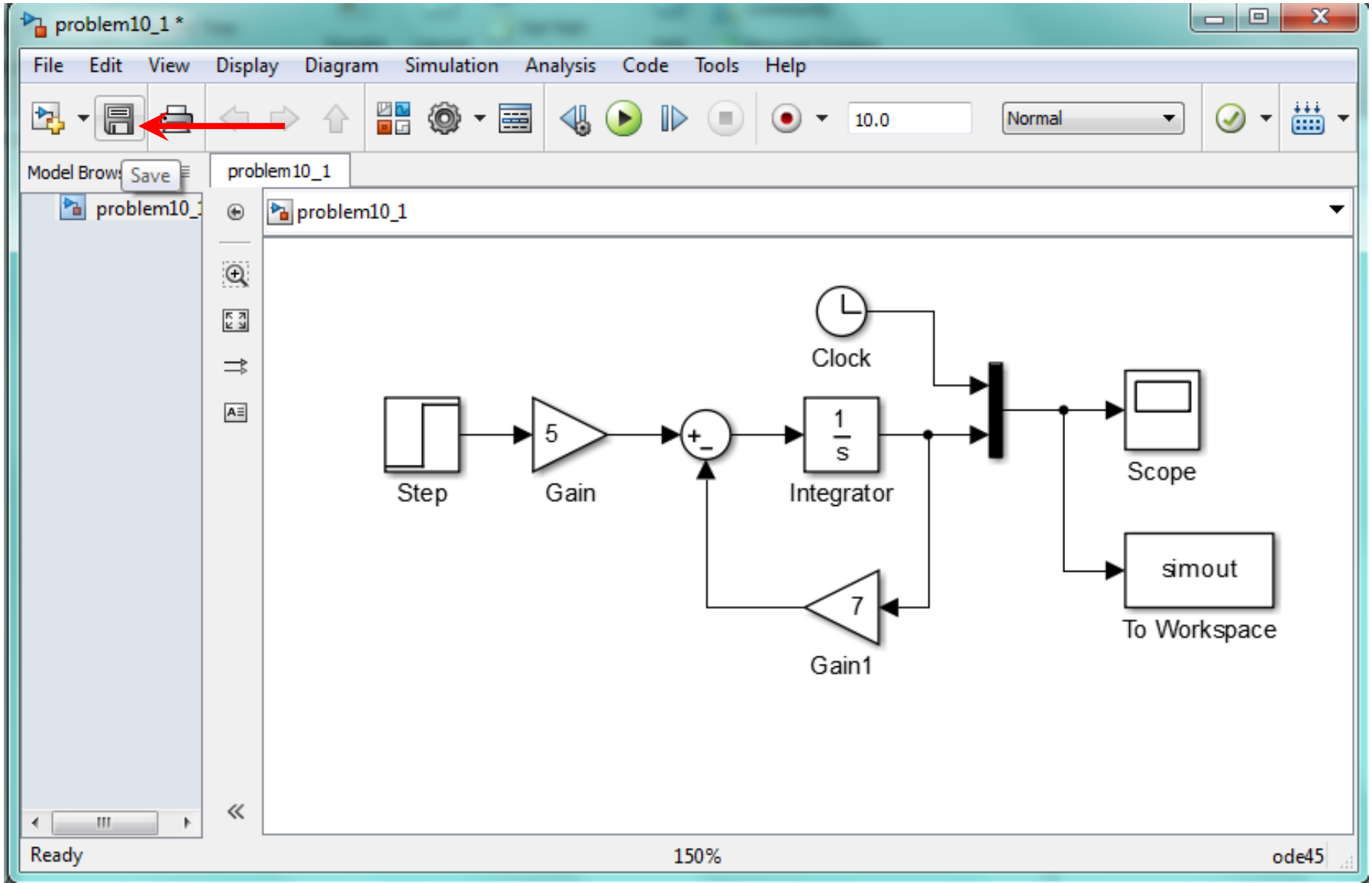
Simulink Models

Double-Click on the Summer block and change the signs



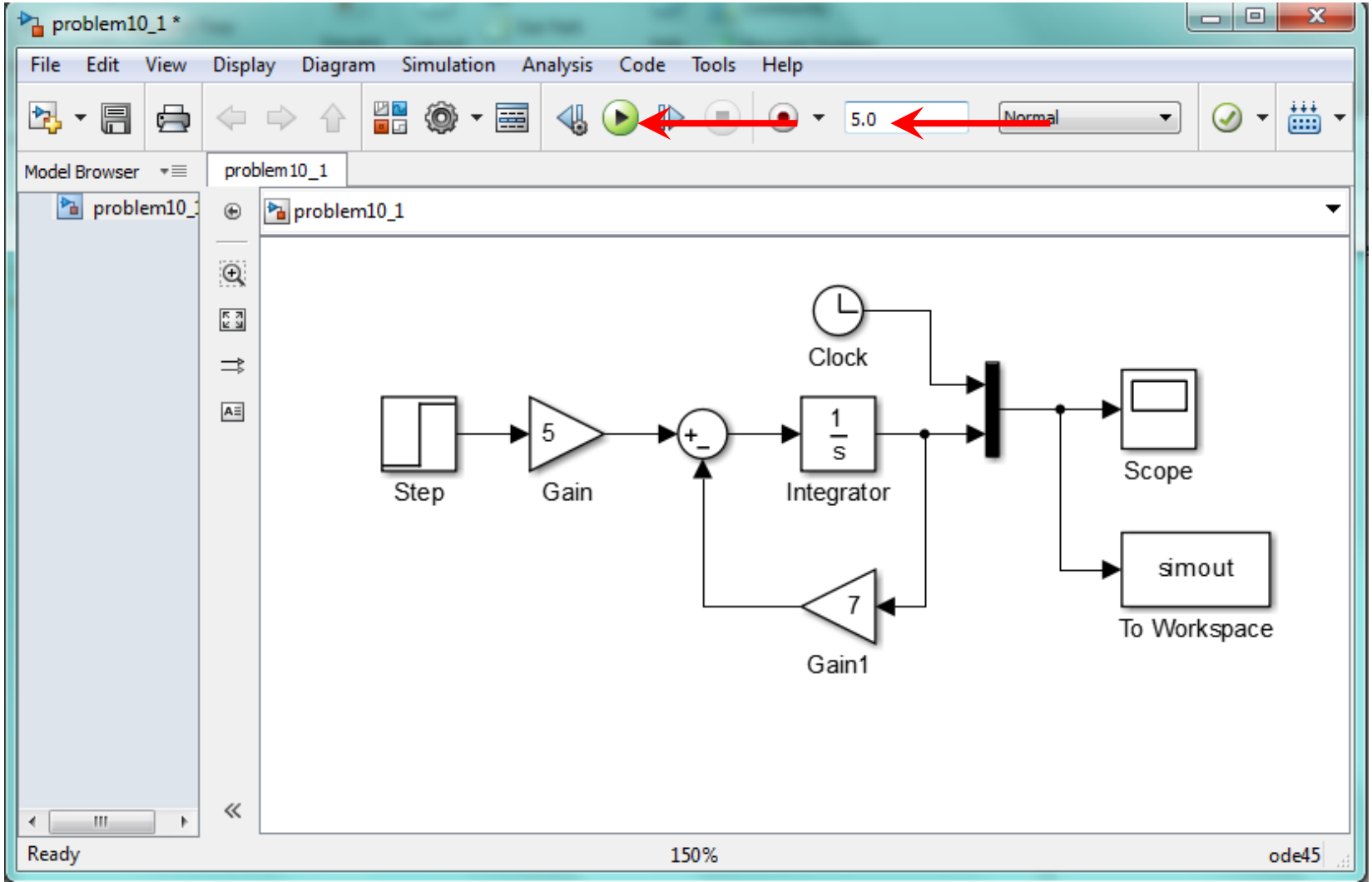
Simulink Models

Save the model often



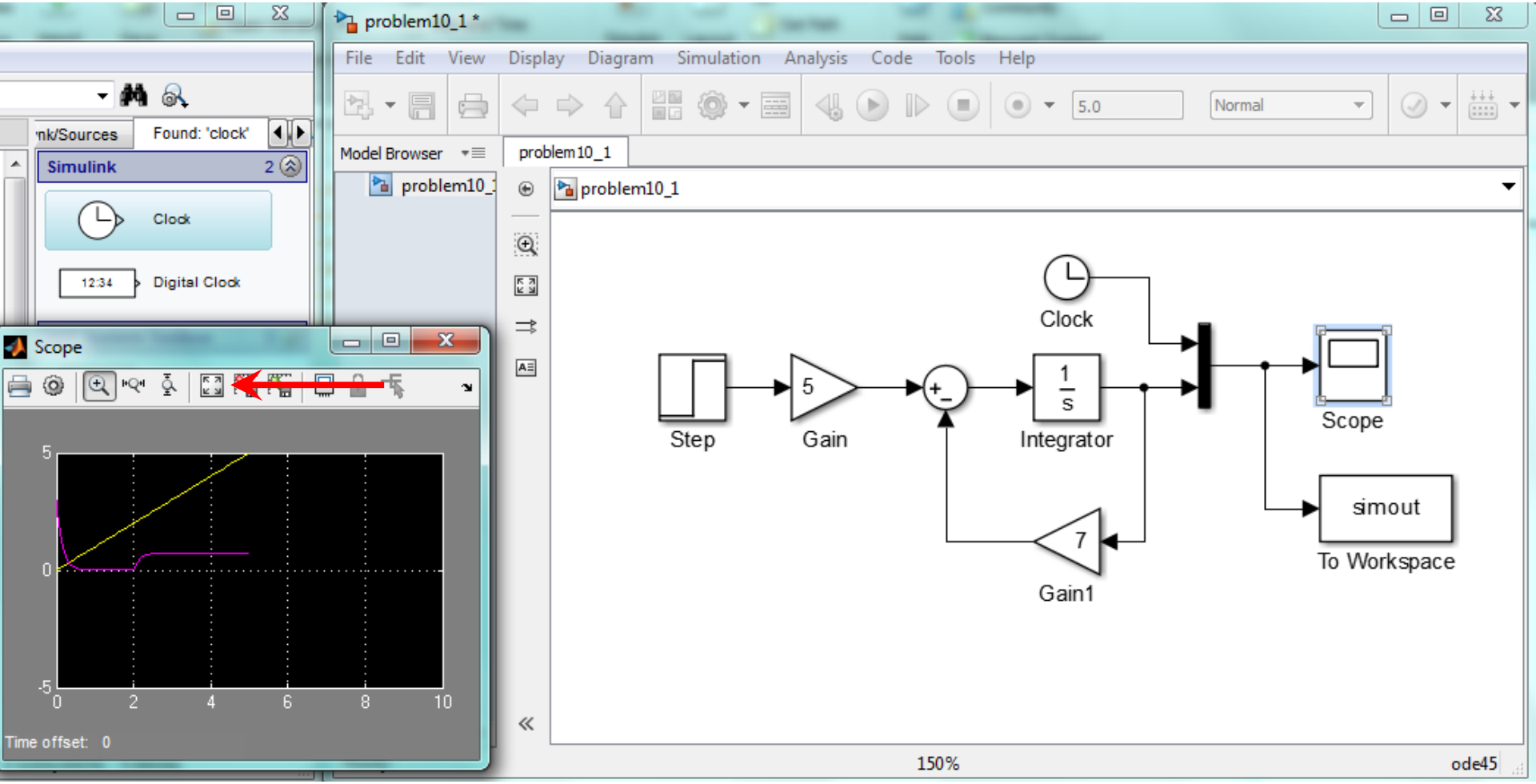
Simulink Models

Change the Run Time to 5 sec and Run the model. Wait for the Ding! Double-click on the Scope block to plot the output.



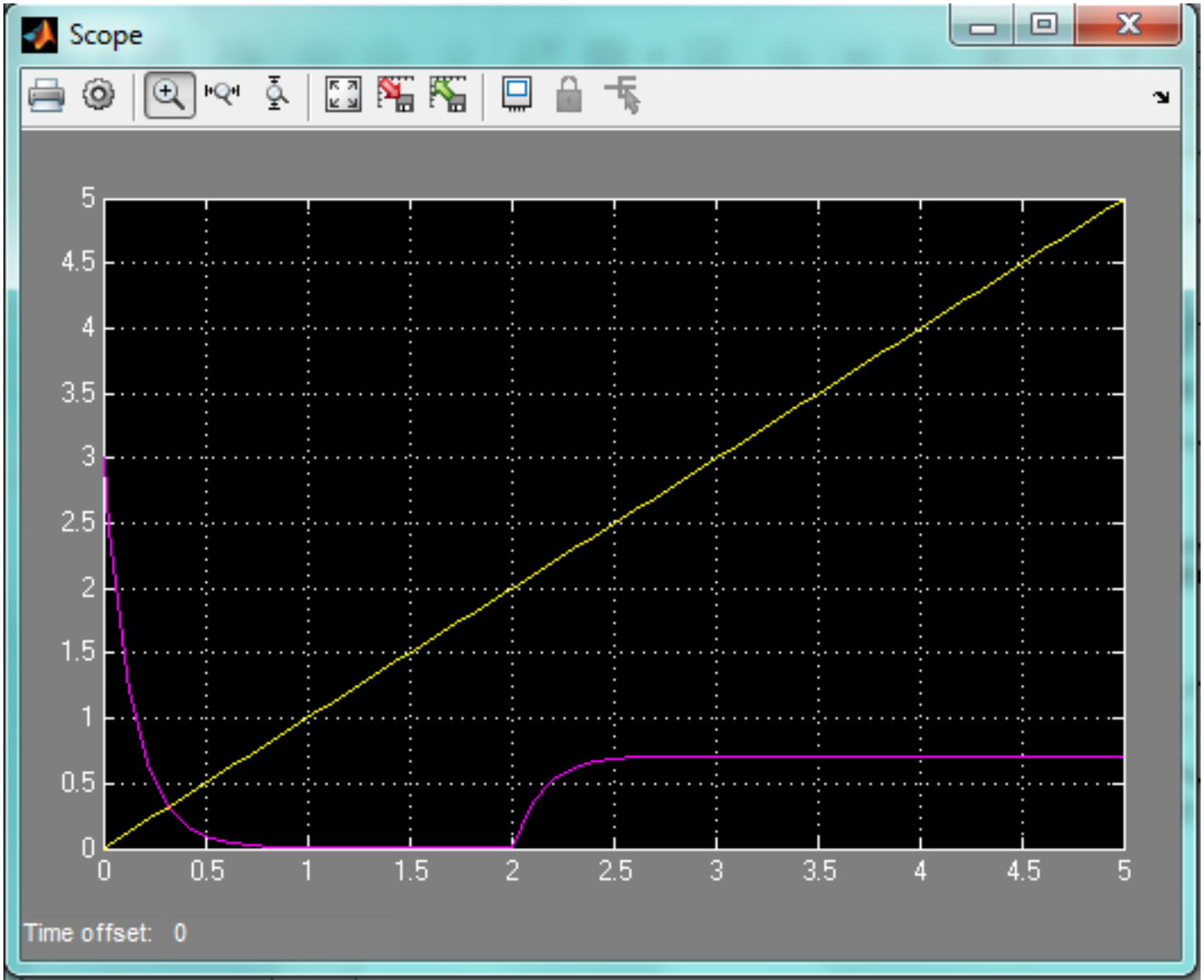
Simulink Models

Press the Autoscale button and expand the size of the output graph



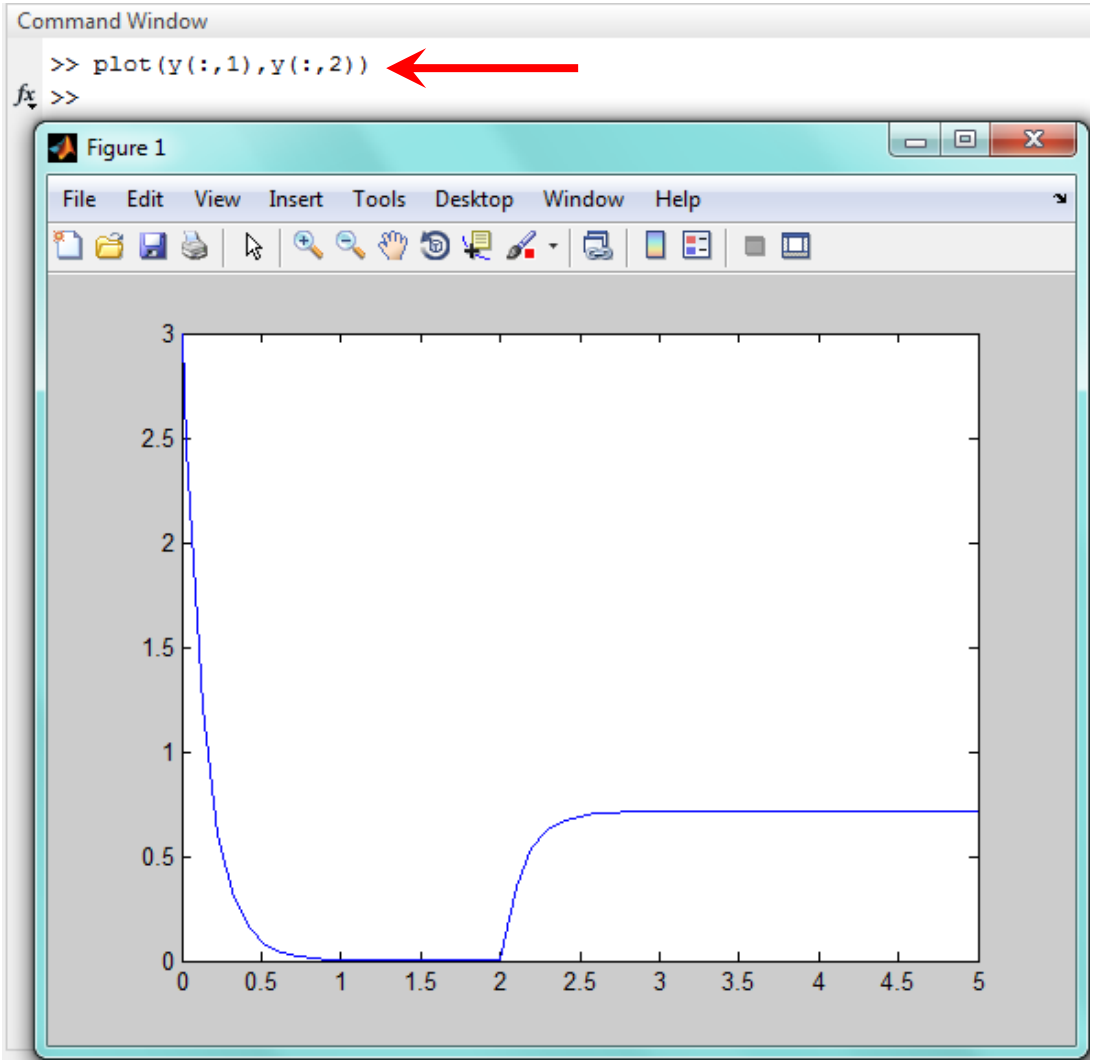
Simulink Models

The purple line is y(t) and the yellow line is t



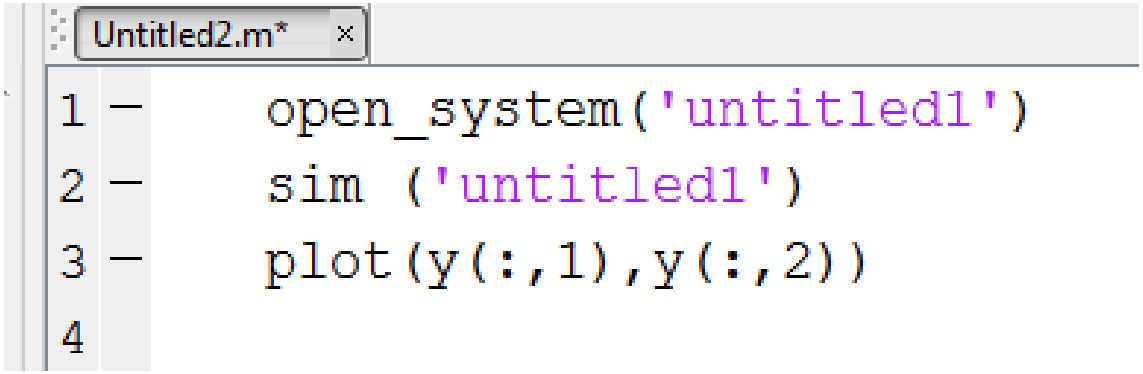
Simulink Models

Click on the MATLAB Command Window and type in the following command: >> plot(y(:,1),y(:,2))



Simulink Models

You can publish the Simulink model and the results by creating a MATLAB Script file that calls it. First, close the Simulink model. The name of the Script file must be different than the Simulink model. Open the Script file and use the Publish function.



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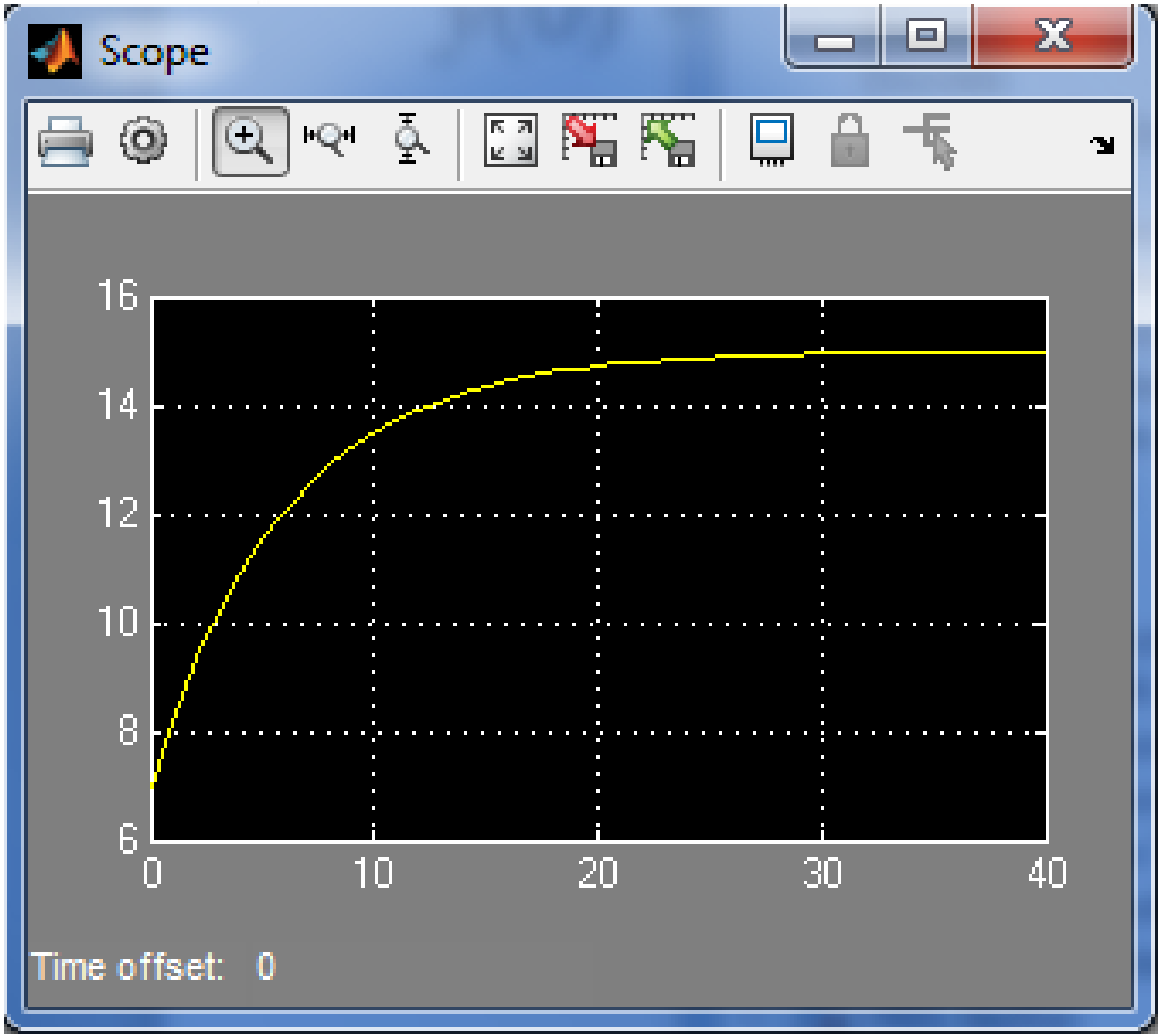

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where $f(t)$ is an applied force. Suppose that $f(t) = 0$ for $t < 0$ and $f(t) = 10$ for $t \geq 0$.

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