

**ECE664**  
**Introduction**  
**to Simulink**

# Simulink Working Environment

The screenshot displays the Simulink Working Environment within MATLAB 7.7.0 (R2008b). The main window, titled 'Open\_Loop', shows a Simulink model with the following components:

- Two input blocks labeled 'Out1' (with signals  $U_1(t)$  and  $U_2(t)$ ) feed into a 'System Dynamics' block.
- The 'System Dynamics' block contains the equations  $x' = Ax + Bu$  and  $y = Cx + Du$ .
- The output of the 'System Dynamics' block is connected to three scopes: 'Scope1', 'Scope2', and 'Scope3'.
- The signal from 'Scope1' passes through an 'Integrator' block (transfer function  $\frac{1}{s}$ ) to produce  $w(t)$ .
- The signal from 'Scope2' passes through another 'Integrator' block (transfer function  $\frac{1}{s}$ ) to produce  $v(t)$ .
- The signal from 'Scope3' passes through a third 'Integrator' block (transfer function  $\frac{1}{s}$ ) to produce  $x(t)$ .
- The signals  $w(t)$  and  $v(t)$  are combined and fed into a 'Fcn' block labeled 'System Kinematics'.
- The 'System Kinematics' block contains the function  $f(u) = u(2) * \sin(u(1))$ .
- The output of the 'System Kinematics' block is fed into a fourth 'Integrator' block (transfer function  $\frac{1}{s}$ ) to produce  $y(t)$ .
- The signal  $y(t)$  is connected to an 'XY Graph' block.

The 'Simulink Library Browser' window on the left shows the 'Commonly Used Blocks' category, including:

- Bus Creator
- Bus Selector
- Constant
- Data Type Conversion
- Demux
- Discrete-Time Integrator
- Gain
- Ground

The MATLAB command window at the bottom right displays the following simulation results:

```
0.1953*cos(-2.4469)
0.1953*sin(-2.4469)
atan2(-0.125, 0.15)
0.1953*cos(-0.6947)
0.1953*sin(-0.6947)
```

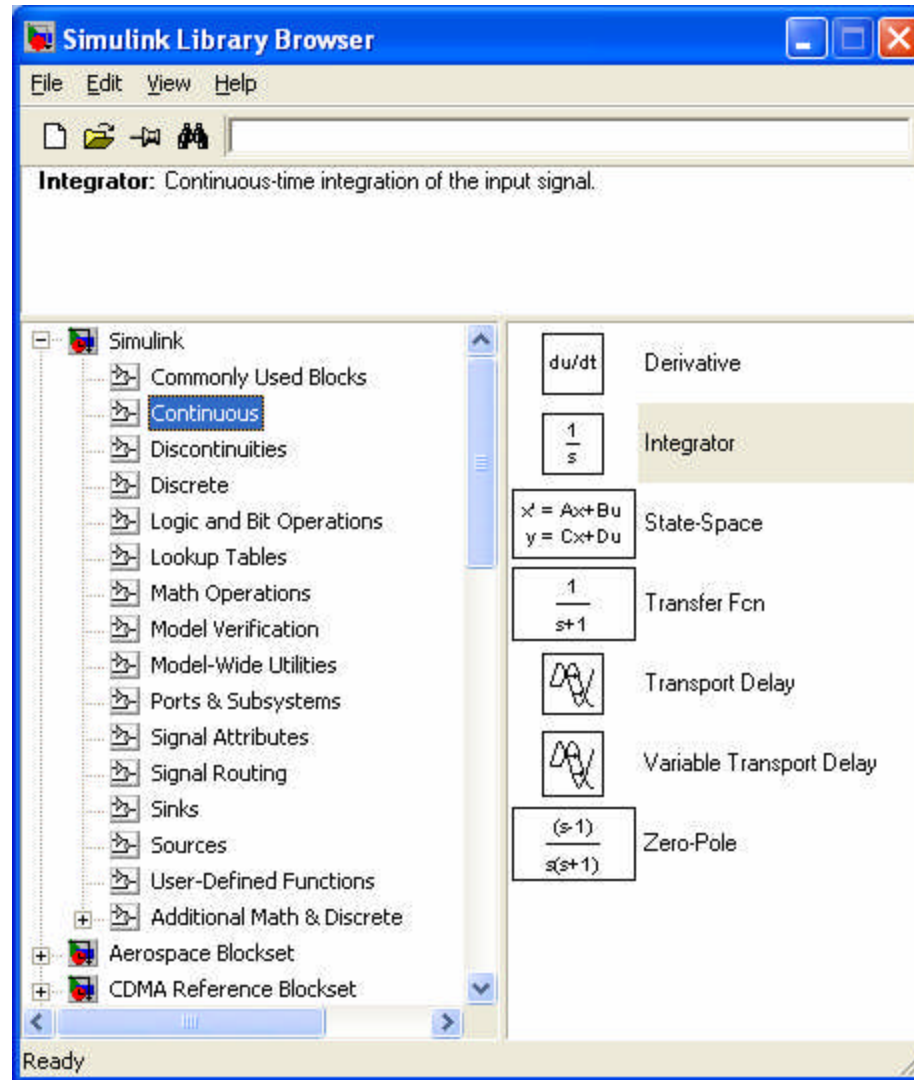
The MATLAB taskbar at the bottom shows the following open applications: Start, 01302009-K..., MATLAB 7..., Editor - E:\..., Simulink Li..., \*Maple 12..., Lecture - D..., 431\_lab\_Si..., Open\_Loop, Lecture -- ..., and the system clock at 11:39 PM.

To start Simulink, one has to first **SIMULINK** double click on the Matlab icon and wait for the Matlab window to open.

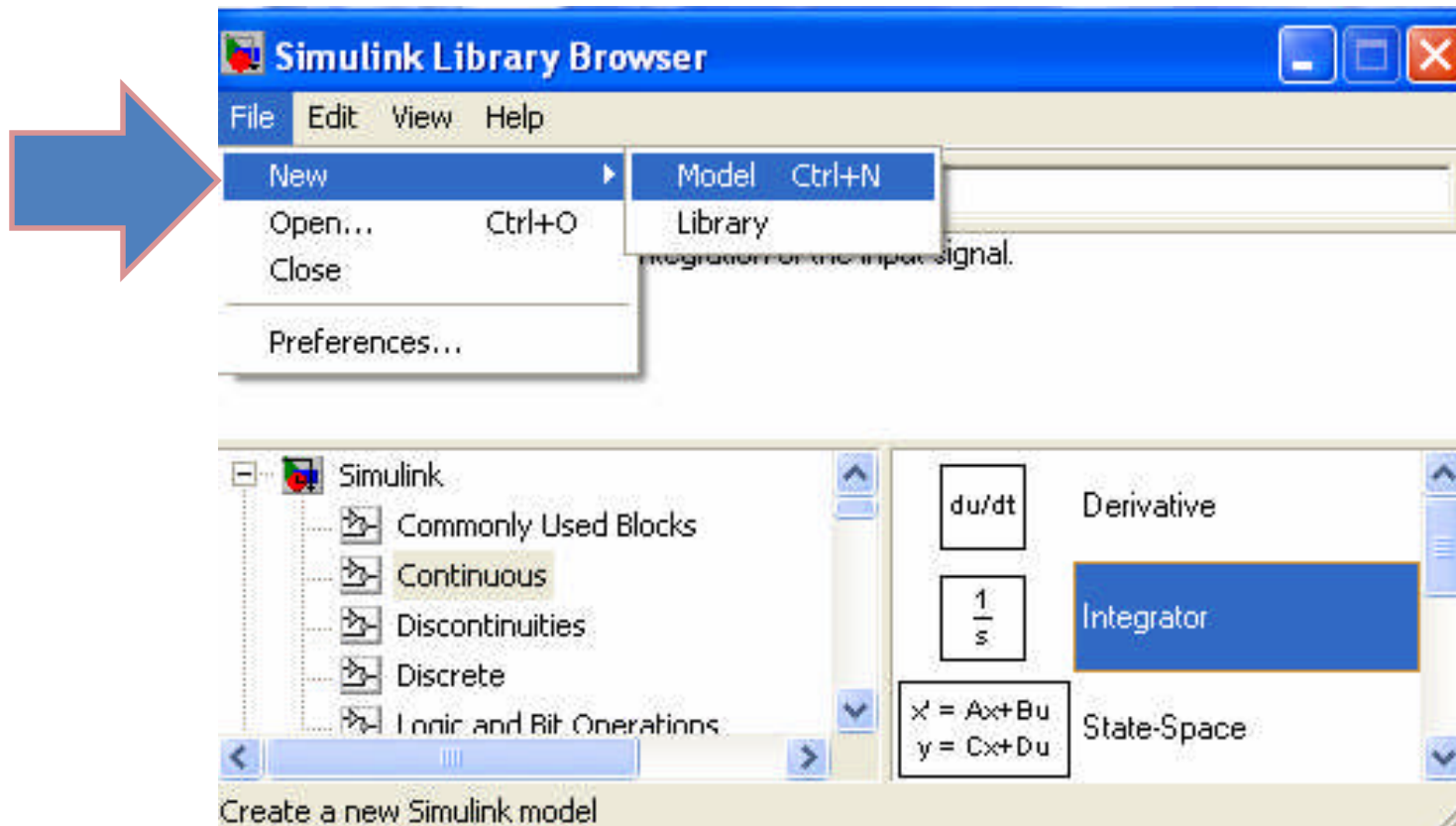
Then, click on the “Simulink” icon



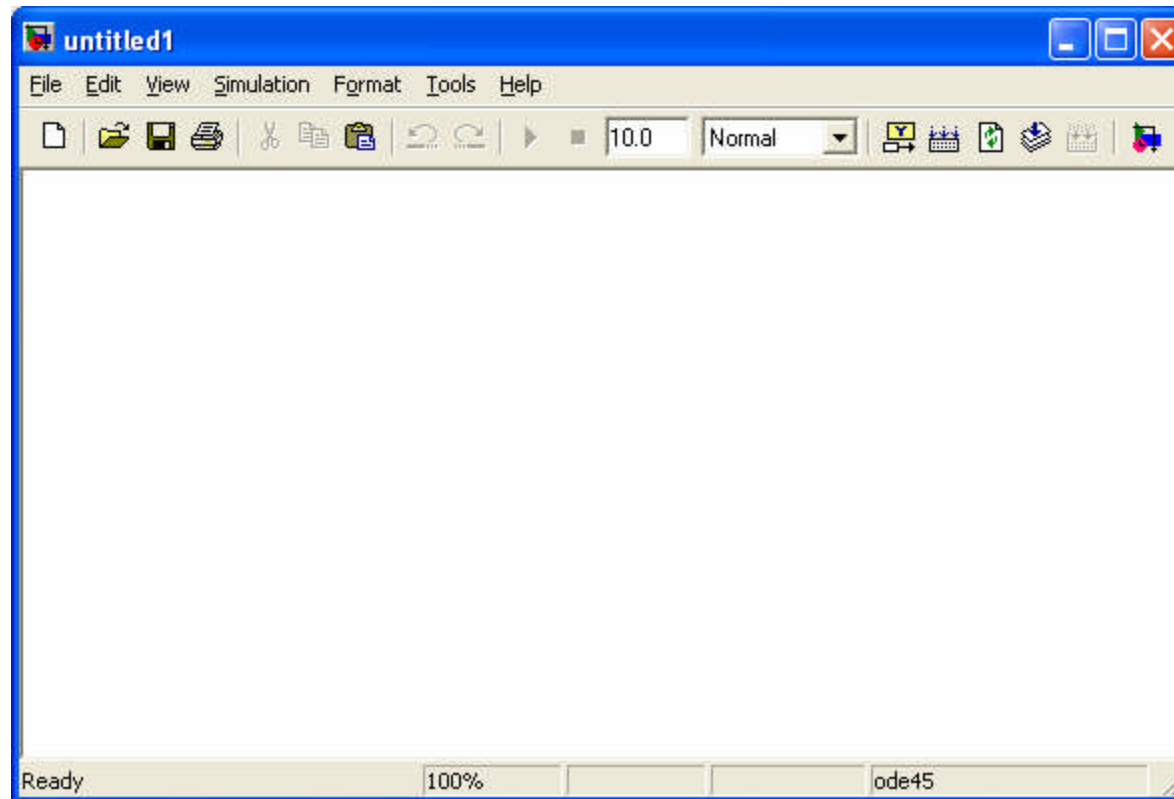
## “Simulink Library Browser”



**Click on the “File” menu item. Select “New” and then click on “Model”**



**A clean window is going to open. New Simulink model is to be built on this window.**

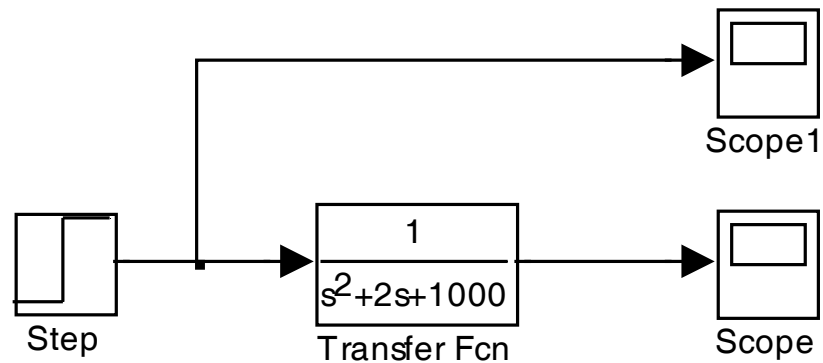


- **Solution to Differential Equation**

- **Laplace Domain:**

- Find the unit step response for the following system

$$G(s) = \frac{1}{s^2 + 2s + 1000}$$



▪ **Time Domain:**

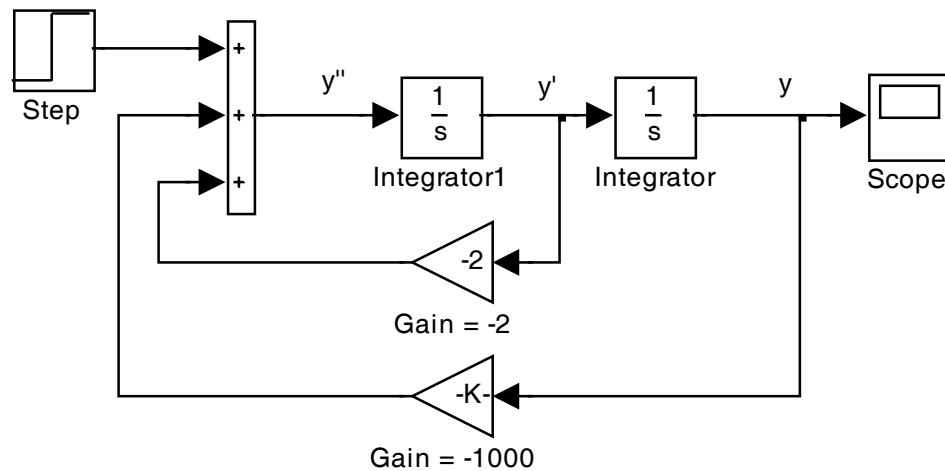
Find the unit step response for the following system

$$\ddot{y}(t) + 2\dot{y}(t) + 1000y(t) = u(t)$$



Rewrite

$$\ddot{y}(t) = -2\dot{y}(t) - 1000y(t) + u(t)$$



# Useful discrete time blocks

- To implement linear discrete time controllers

The image displays the Simulink environment with three windows open:

- Simulink Library Browser:** Shows the 'Discrete' block category selected. The 'Discrete Transfer Fcn' block is highlighted.
- Model Editor:** Shows a block diagram with three blocks: 'Zero-Order Hold', 'Discrete State-Space', and 'Discrete Transfer Fcn'. The 'Discrete State-Space' block contains the equations:
$$y(n) = Cx(n) + Du(n)$$
$$x(n+1) = Ax(n) + Bu(n)$$
- Function Block Parameters: Zero-Order Hold:** Shows the 'Sample time (-1 for inherited):' set to 1.
- Function Block Parameters: Discrete Transfer Fcn:** Shows the 'Numerator coefficient:' set to [1] and the 'Denominator coefficient:' set to [1 0.5].
- Function Block Parameters: Discrete State-Space:** Shows the state-space matrices A, B, C, and D, all set to 1, and the 'Initial conditions:' set to 0.

# Signal routing and capture

- Use “array” instead of “structure” to save data into workspace

The image shows the Simulink environment. On the left is the Simulink Library Browser with the 'Sinks' category selected. The main workspace shows a Simulink model with two input signals,  $u(1)$  and  $u(2)$ , entering a discrete-time system block. The block contains the equations  $y(n) = Cx(n) + Du(n)$  and  $x(n+1) = Ax(n) + Bu(n)$ . The system has two outputs,  $y(1)$  and  $y(2)$ . A Sink block is connected to the outputs, and its parameters are shown in a dialog box titled 'Sink Block Parameters: To Workspace'. The dialog box contains the following fields:

- To Workspace: Write input to specified array or structure in MATLAB's main workspace. Data is not available until the simulation is stopped or paused.
- Parameters:
- Variable name: `simout`
- Limit data points to last: `inf`
- Decimation: `1`
- Sample time (-1 for inherited): `-1`
- Save format: `Array`
- Log fixed-point data as an fi object

Buttons at the bottom of the dialog are OK, Cancel, Help, and Apply.

# Use of function block to code equations

- For example,
- $z = \sin(x) * \exp(2.3 * (-y))$
- Set  $u(1)$  as  $x$ ,  $u(2)$  as  $y$
- code up:  $\sin(u(1) * \exp(2.3 * (-u(2))))$
- Use multiplexer to route  $x$  into the first port (i.e.  $u(1)$ ) and  $y$  into the second port (i.e.  $u(2)$ )

The image shows a Simulink environment with two windows. The left window is the Simulink Library Browser, displaying the 'User-Defined Functions' library. The right window is the 'untitled \*' model, showing a block diagram with a multiplexer block and a function block labeled 'Fcn'. The multiplexer has two inputs,  $u(1)$  and  $u(2)$ , and one output. The function block contains the expression  $\sin(u(1) * \exp(2.3 * (-u(2))))$ . Below the model window is the 'Function Block Parameters: Fcn' dialog box, which is open. The dialog box has the following fields:

- General expression block. Use "u" as the input variable name.  
Example:  $\sin(u[1] * \exp(2.3 * -u[2]))$
- Parameters
- Expression:  $\sin(u(1) * \exp(2.3 * (-u(2))))$
- Sample time (-1 for inherited): -1

Buttons: OK, Cancel, Help, Apply