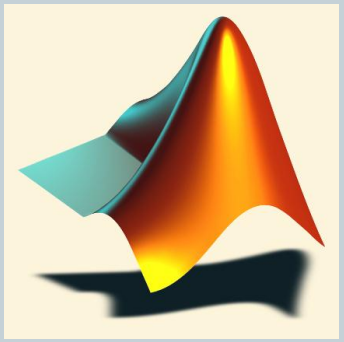
Lecture Series – 9

# Solving Differential equations using SIMULINK





*Shameer Koya*

# Solve the differential equation



$$\frac{dx}{dt} = -2x + 1, \quad t > 0.$$

$$x(0) = 0.$$

- **Note:** The input is 1 after t> 0
- Input - **step function** - stepping time is not t=1 but t=0
- Initial Condition is 0

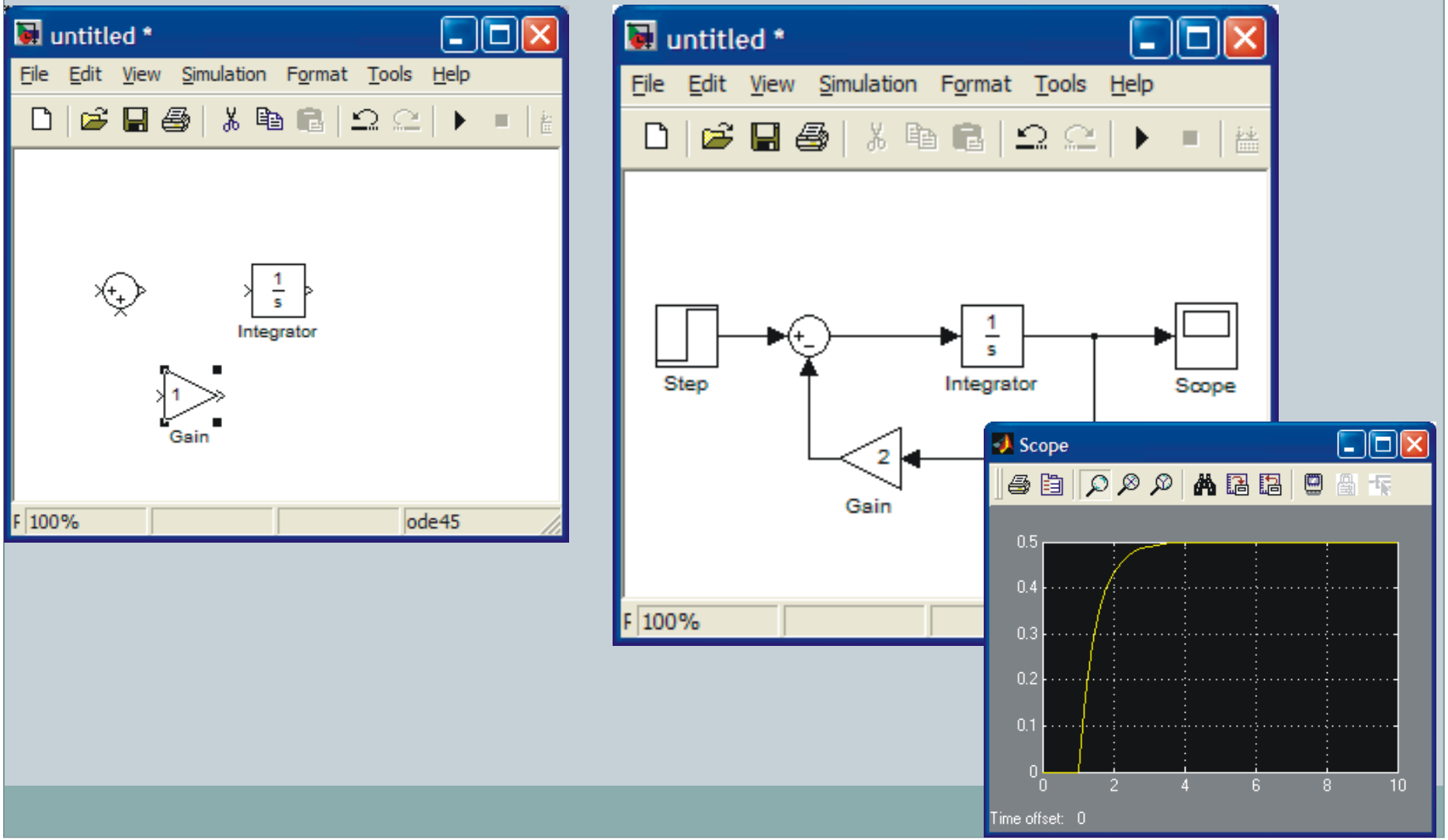
# Solution



- The equation is $Dx = -2x + 1$ where $D = \frac{d}{dt}$
- Instead of differentiation, we do the reverse operation, integration, to solve the equations

- In SIMULINK $\frac{1}{s}$ means integration
- Input to the integrator is $Dx = \frac{dx}{dt}$ and output $x$

- set up the right hand side and connect the everything to the input of the integrator.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1
s
Integrator
1
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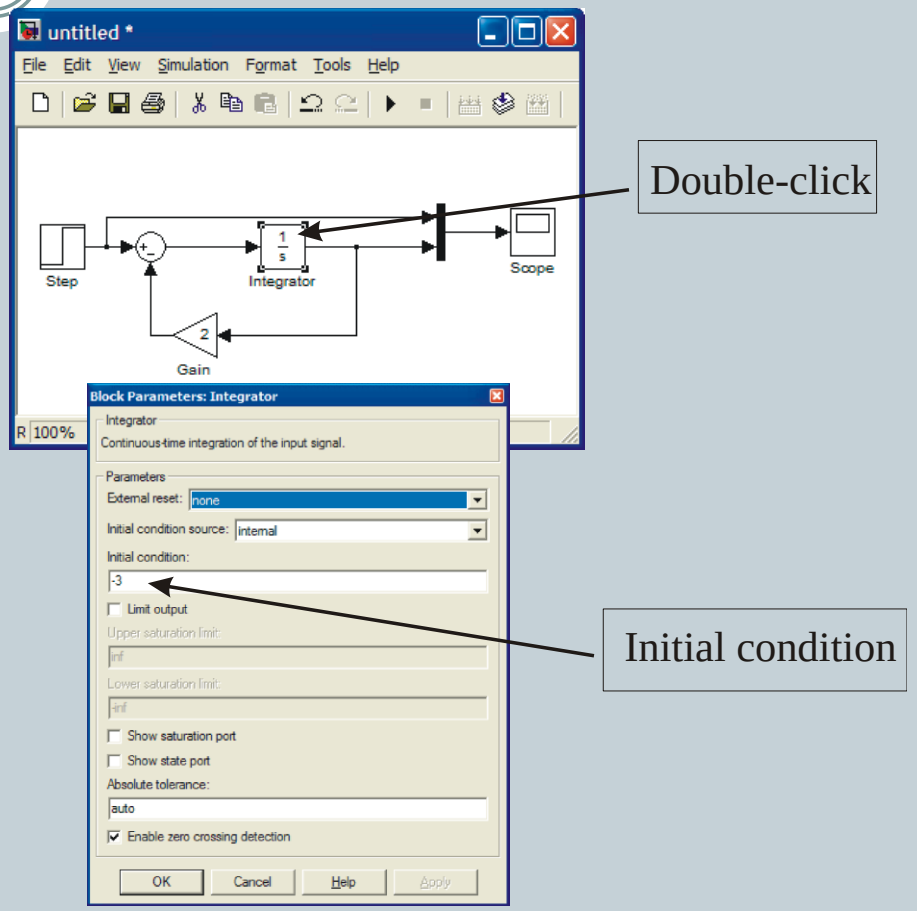
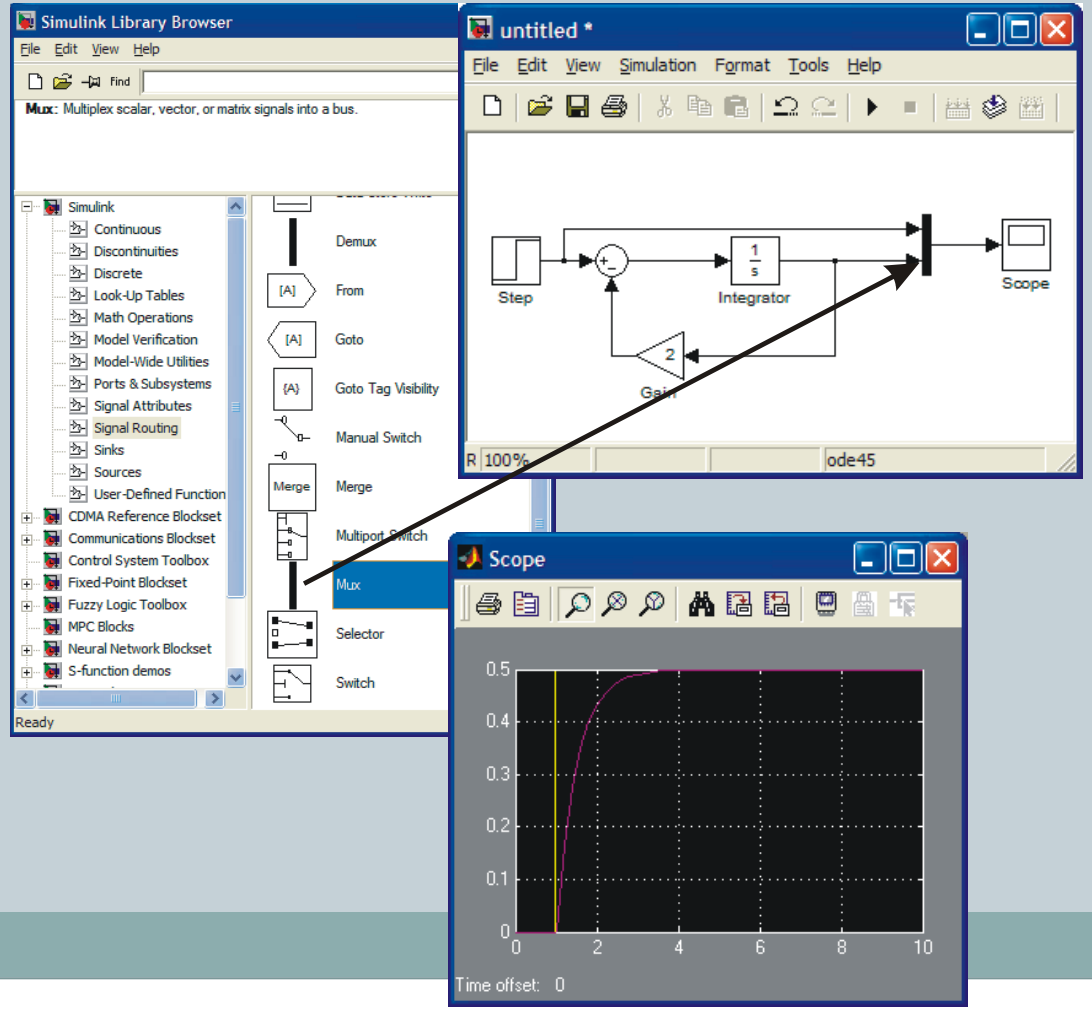
Step
1
s
Integrator
Scope
2
Gain
100%
Scope
0.5
0.4
0.3
0.2
0.1
0
0 2 4 6 8 10
Time offset: 0

- Another issue that we have not considered is initial condition.
- As you know every differential equation should have initial conditions given.
- The default value in SIMULINK is zero.
- To change that click the integrator.



- If you want to see both the input and output at the same time, use *Mux* (multiplexer) block, which you can find under *Signals and Systems* block library



# Higher order differential equation



- Second order equation

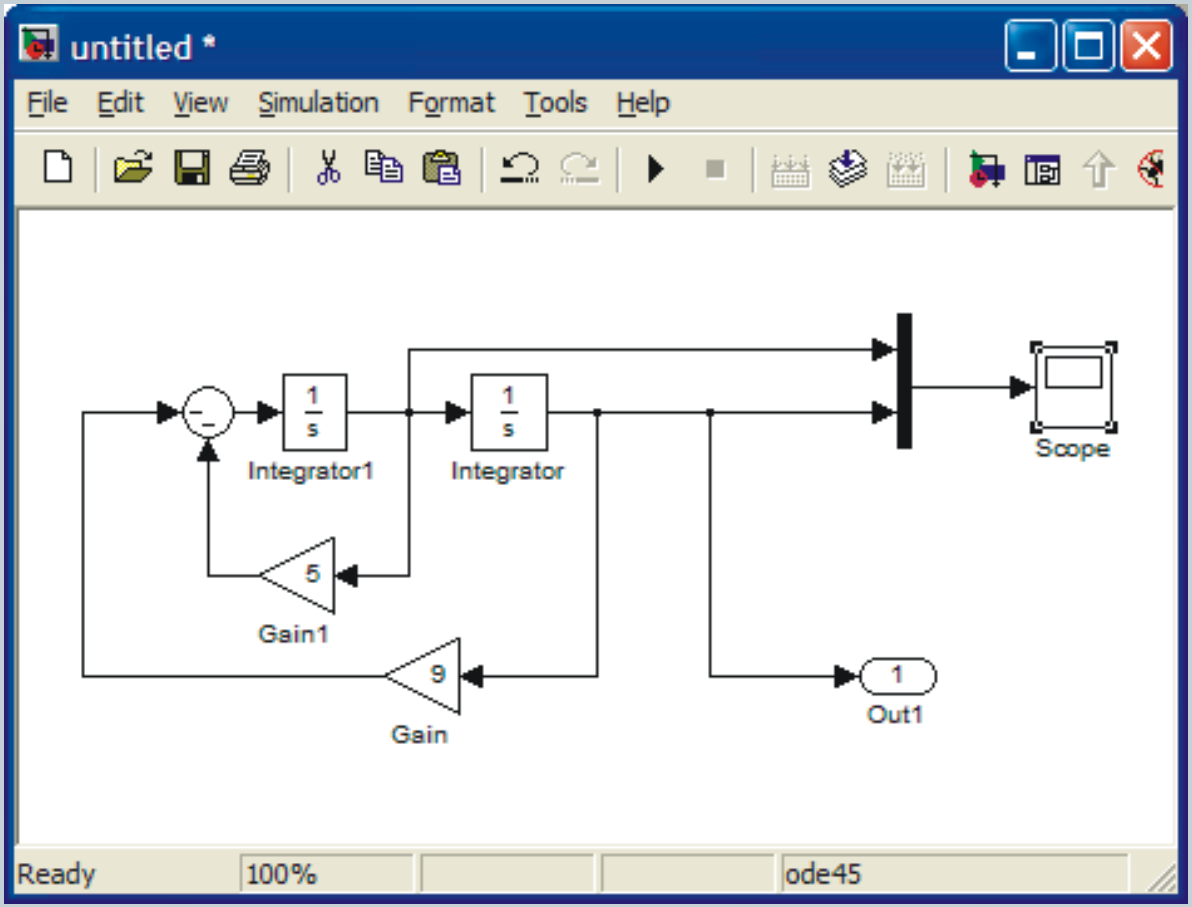
$$\frac{d^2x}{dt^2} = -5\frac{dx}{dt} - 9x$$

$$\frac{dx}{dt} = \dot{x}(0) = -2$$

$$x(0) = 2$$

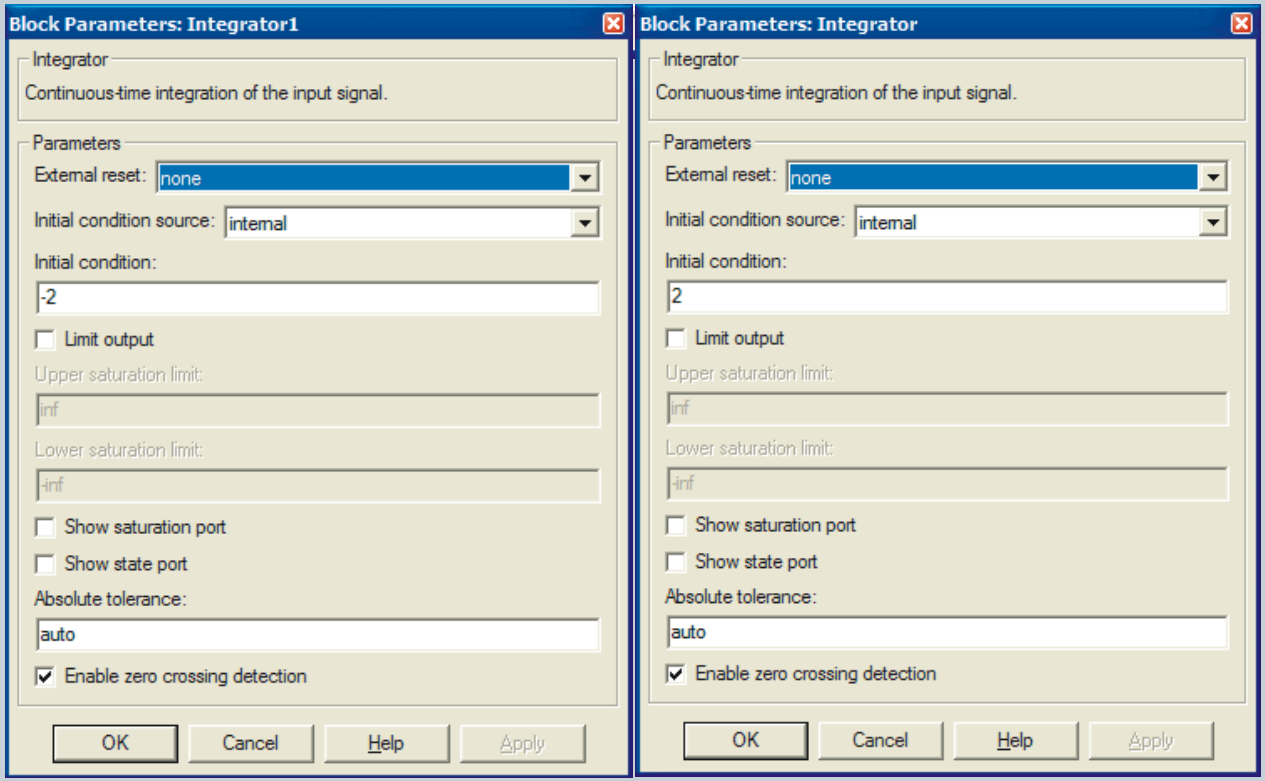
- To set up the right-hand side two integrators are needed
- The input to the first integrator is the second derivative $\frac{d^2x}{dt^2}$ and its output is $\frac{dx}{dt}$
- second integrator producing x(t) at its output

- Assume that u(t) = 0, that is, there is no input.



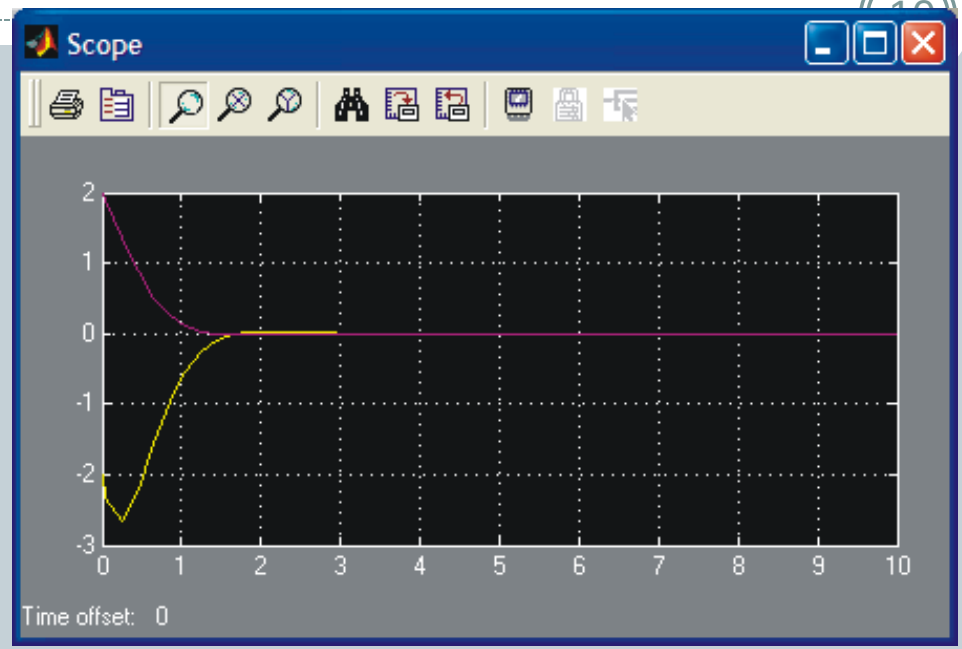

$$\frac{d^2x}{dt^2} = -5\frac{dx}{dt} - 9x$$

- Set the initial conditions of the integrator



# Ouput




Scope
2
1
0
-1
-2
-3
0 1 2 3 4 5 6 7 8 9 10
Time offset: 0

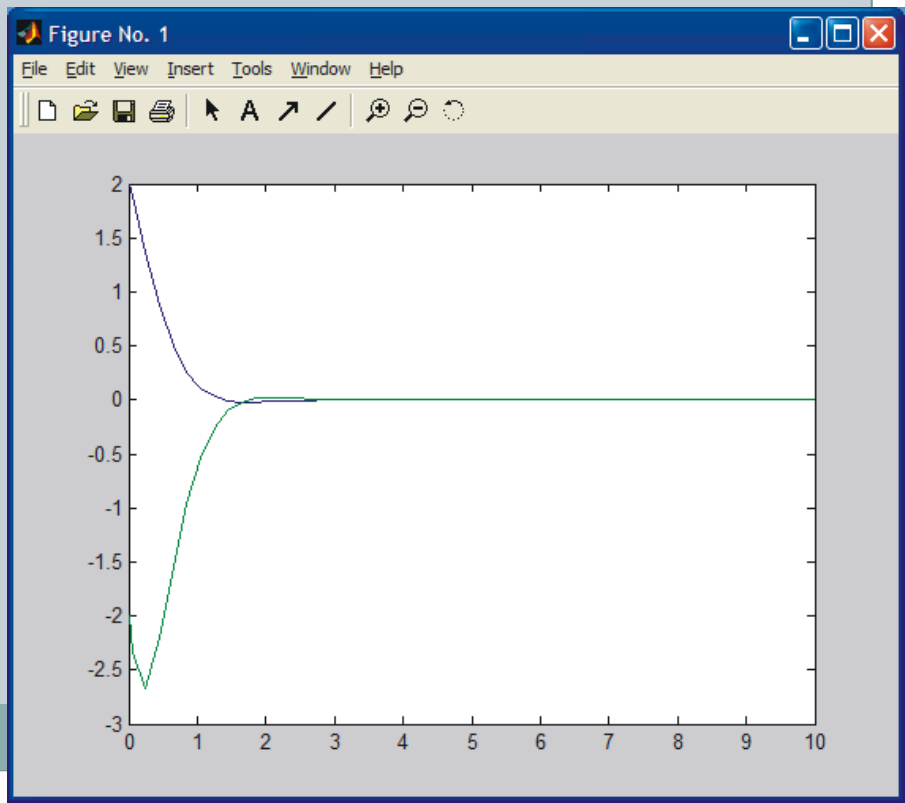


Figure No. 1
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2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
0 1 2 3 4 5 6 7 8 9 10

# Thanks



Questions ??