

EE 1130

Freshman Eng. Design for Electrical and Computer Eng.

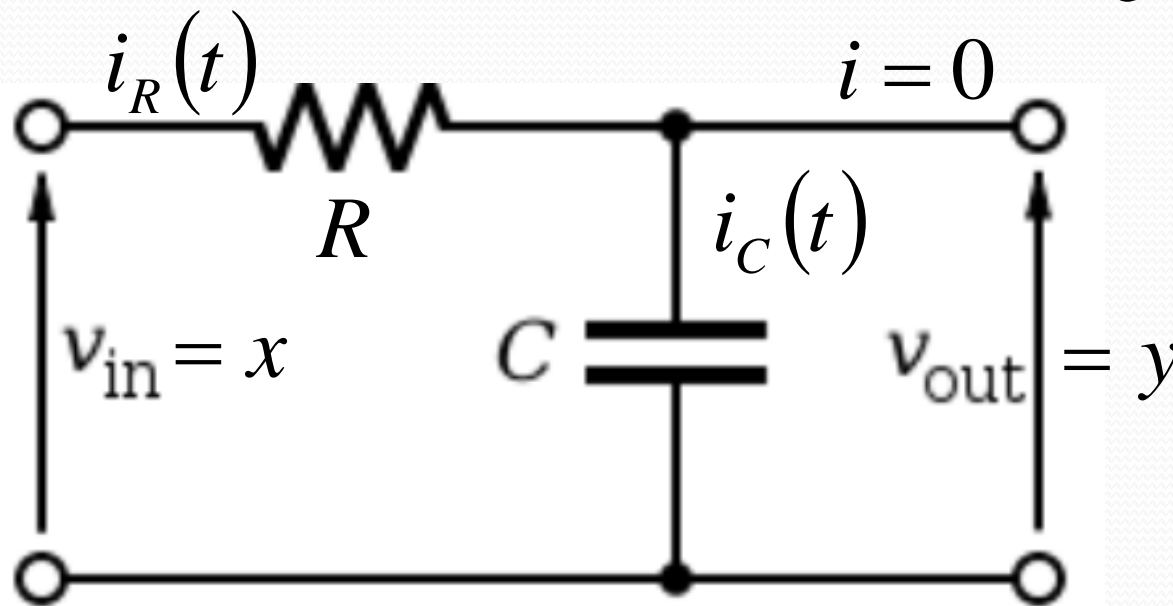
Class 3

Signal Processing Module (DSP).

- Differential Equations.
- Laplace Transform. Transfer Function.
- Simulink with Transfer Functions. Zeros, Poles.

Simulink: Differential Equations.

- Any Linear Time Invariant system could be modeled as the solution of a differential equation (DE) .
- In the case of Low Pass RC filter shown in next figure:



- The Differential Equation is:

$$RC\dot{y} + y = x$$

Simulink: Differential Equations.

- Next is an algebraic equation (instant equation).

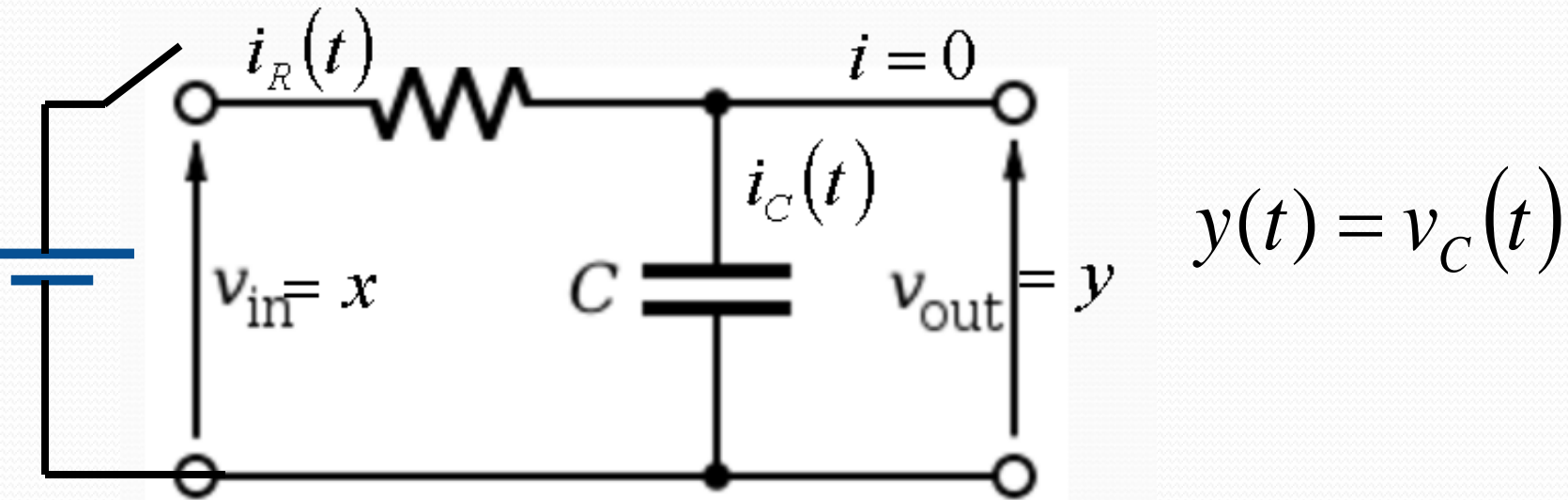
$$y(t) = 2x(t)$$

- A differential equation has into account velocities!!!

$$K \frac{dy}{dt} + y(t) = 2x(t)$$

Simulink: Differential Equations.

- The circuit analysis is shown in next figure:



$$i_R(t) = \frac{v_R(t)}{R}$$

$$v_C(t) = \frac{1}{C} \int_0^t i_C(t) dt$$

$$i_C(t) = C \frac{dv_C}{dt}$$

Simulink: Differential Equations.

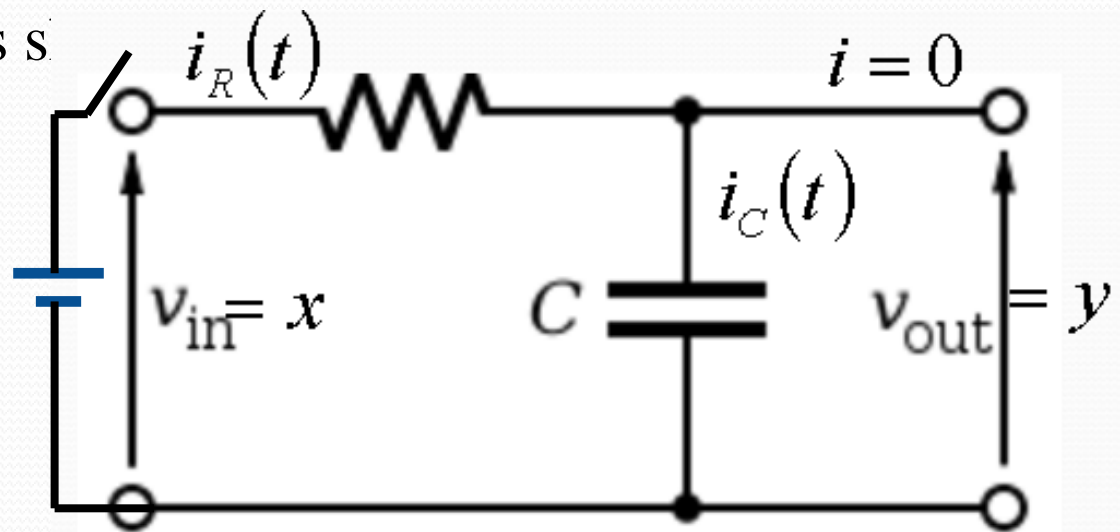
- The circuit analysis is s

$$x(t) = v_R(t) + v_C(t)$$

$$x(t) = i_R(t)R + y(t)$$

$$x(t) = \left(C \frac{dy}{dt} \right) R + y(t)$$

$$RC \frac{dy}{dt} + y(t) = x(t)$$



Simulink: Differential Equations.

$$RC\dot{y} + y = x$$

- Where y with the dot is the first derivative of $y(t)$ and x is $x(t)$. R and C are the values of the Resistor and Capacitor respectively.
- The Differential Equation could be simulated with Simulink.
- However, the Differential Equation must be modified to an Integral Equation, since integrator blocks are more used than derivative blocks.

$$\int (RC\dot{y} + y) dt = \int x dt$$

Simulink: Differential Equations.

- The integral is linear:

$$RC \int \dot{y} dt + \int y dt = \int x dt$$

$$RCy = \int x dt - \int y dt$$

$$y = \frac{1}{RC} \int (x - y) dt$$

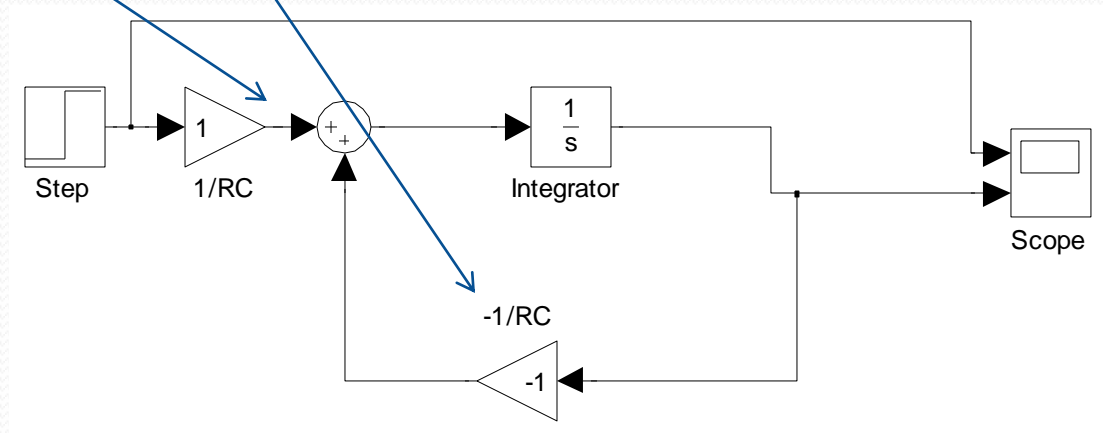
$$y = \int \left(\frac{1}{RC} x - \frac{1}{RC} y \right) dt$$

Simulink: Differential Equations.

- The block diagram could be implemented from this equation:

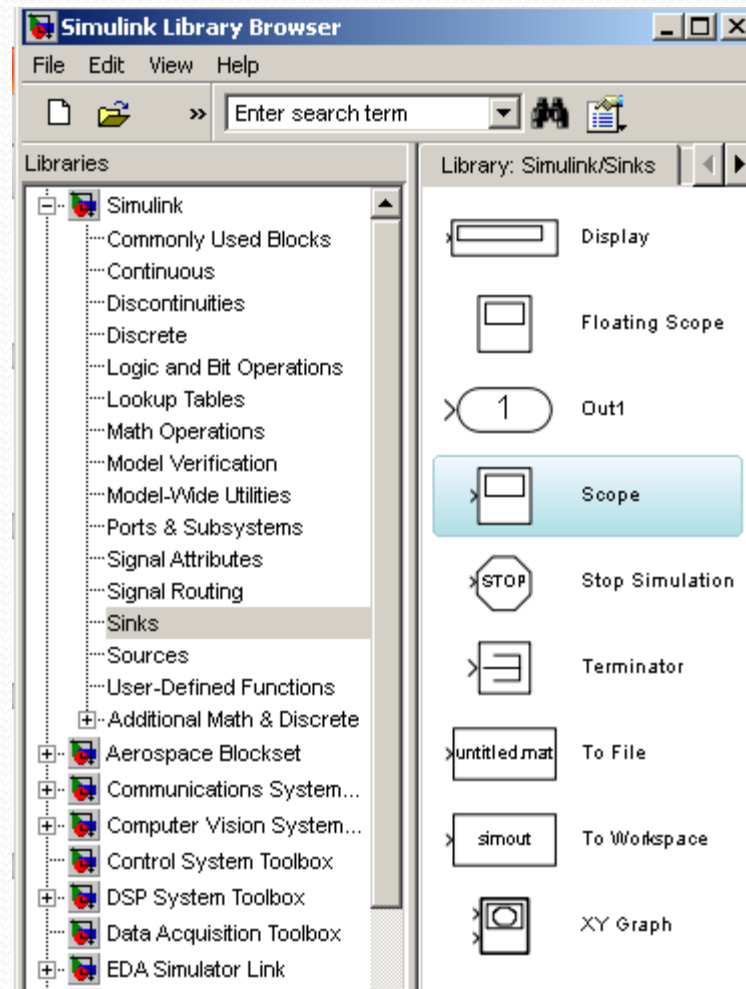
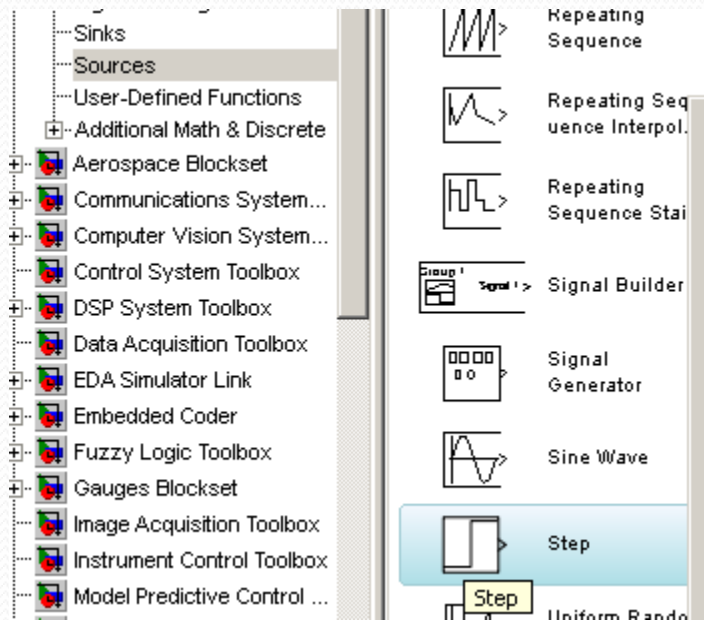
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$$\frac{1}{RC} x - \frac{1}{RC} y$$



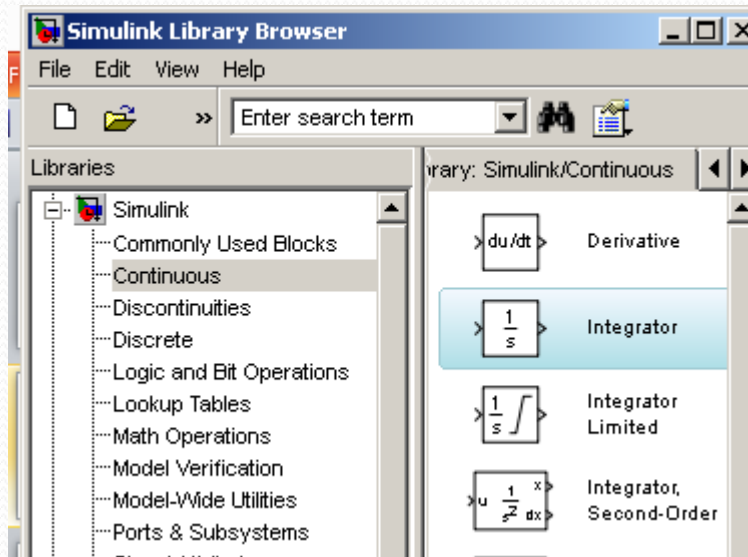
Simulink: Differential Equations.

- To insert the Step and Scope blocks we do:



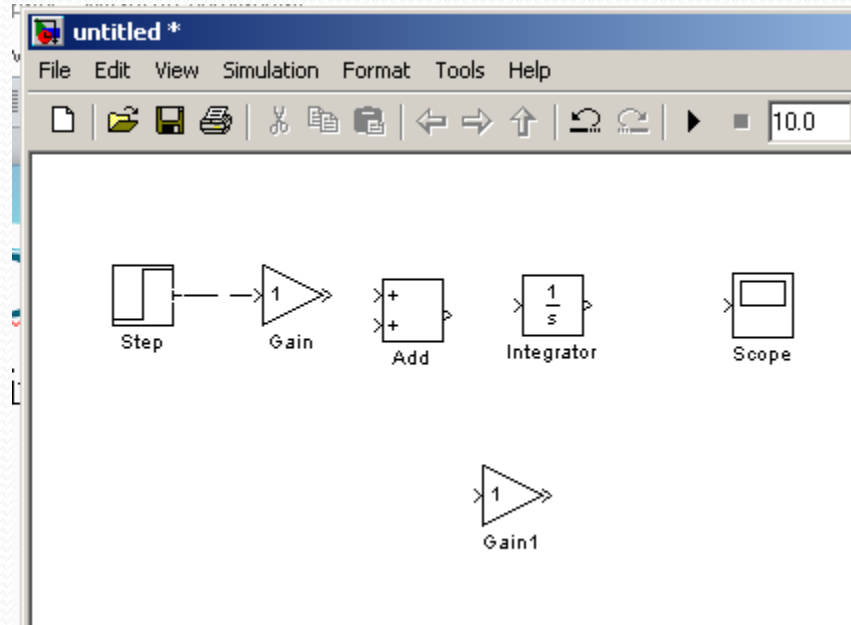
Simulink: Differential Equations.

- To insert the Integrator block we do:



Simulink: Differential Equations.

- Once all elements in the Model, we make the connections:

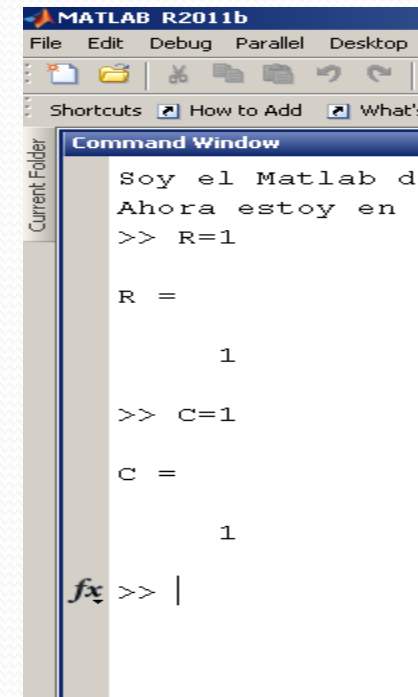
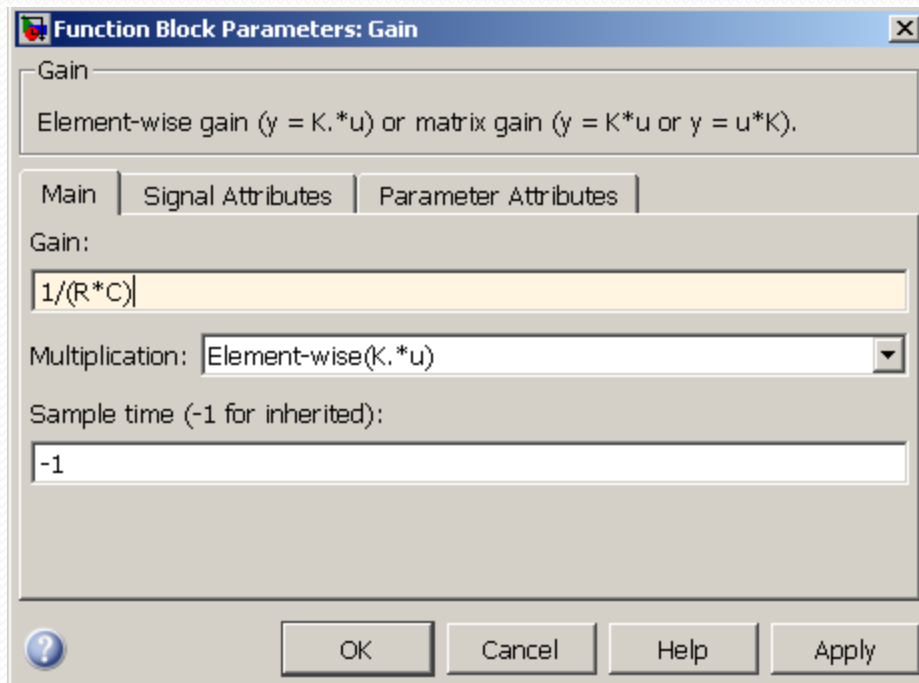


- To flip the Gain1 block we type control+I



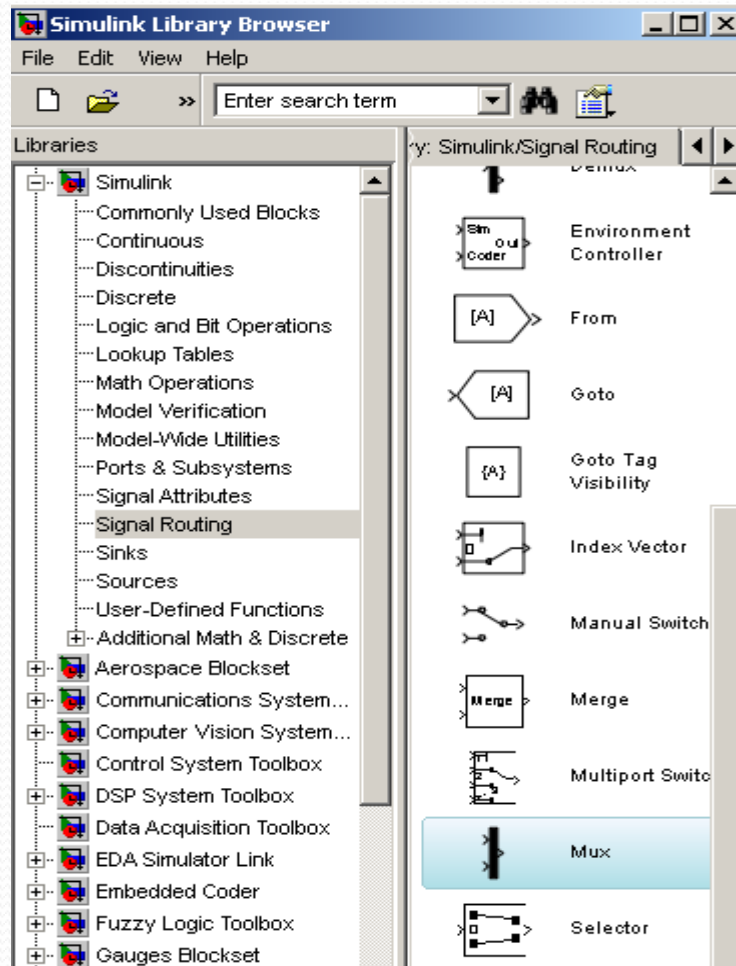
Simulink: Differential Equations.

- Double click on each gain block and change the 1 to $1/(R*C)$ at the first block and $-1/(R*C)$ at the second.
- Type $C=1$ and $R=1$ at the command window to define the variables R and C .



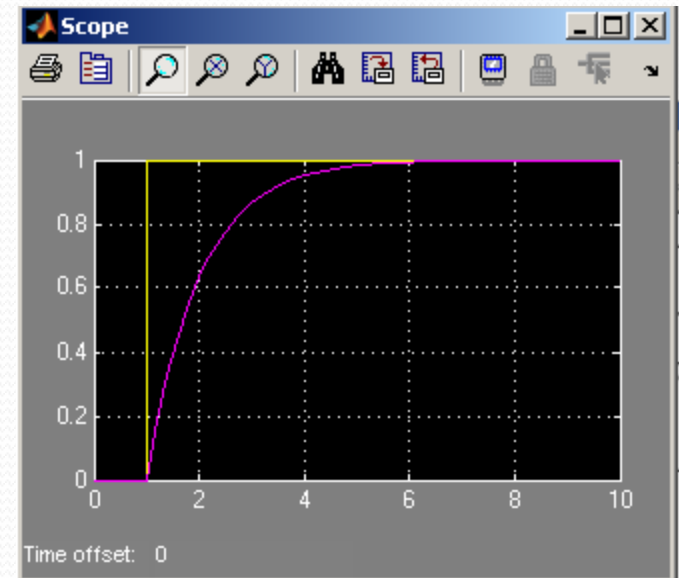
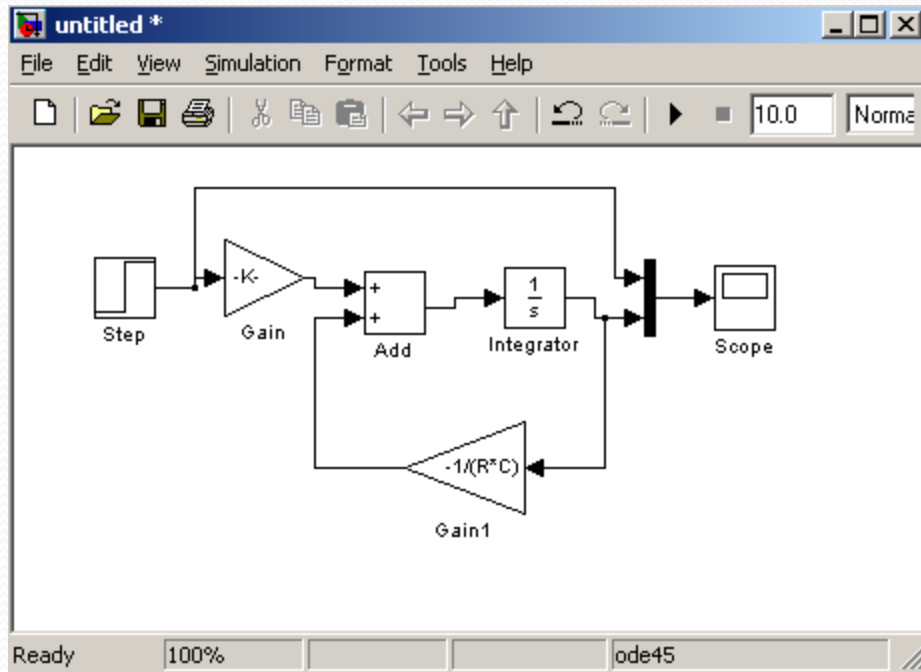
Simulink: Differential Equations.

- To see both traces in one scope we add the MUX.



Simulink: Differential Equations.

- Once all connected, variables defined in command window, we hit play and double click on the scope block to open the scope screen.



End of Class