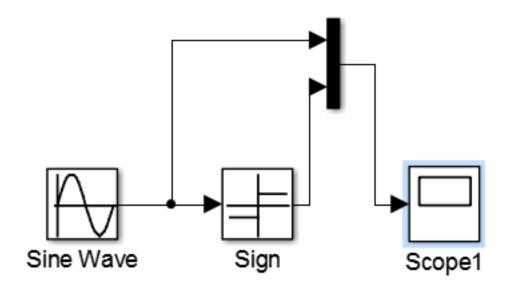
## Problem 10.13:

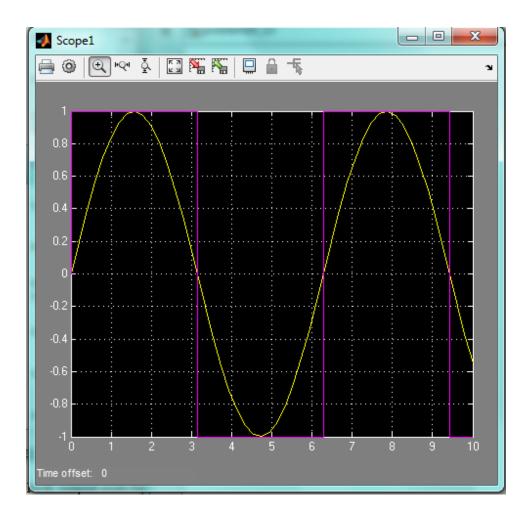
**13.** If a mass-spring system has Coulomb friction on the surface rather than viscous friction, its equation of motion is

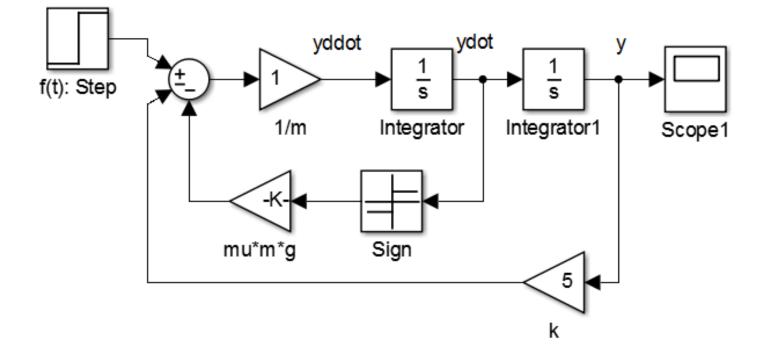
$$m\ddot{y} = \begin{cases} -ky + f(t) - \mu mg & \text{if } \dot{y} \ge 0\\ -ky + f(t) + \mu mg & \text{if } \dot{y} < 0 \end{cases}$$

where  $\mu$  is the coefficient of friction. Develop a Simulink model for the case where m = 1kg, k = 5 N/m,  $\mu = 0.4$ , and g = 9.8 m/s<sup>2</sup>. Run the simulation for two cases: (a) the applied force f(t) is a step function with a magnitude of 10 N and (b) the applied force is sinusoidal:  $f(t) = 10 \sin 2.5t$ . Either the Sign block in the Math Operations library or the Coulomb and Viscous Friction block in the Discontinuities library can be used, but since there is no viscous friction in this problem, the Sign block is easier to use.

Operation of Sign Block: +1 for Input >= 0; -1 for Input < 0







Error for t > 1.4 sec:

Simulation Diagnostics: problem10_13					x
View Font Siz	e				
Message	Source	Reported By	Summary		
Model error	problem10_13	Simulink	At time 1.4049629452795942, simula		
<ul> <li>problem 10_13</li> <li>At time 1.4049629452795942, simulation hits (1000) consecutive zero crossings. Consecutive zero crossings will slow down the simulation or cause the simulation to hang. To continue the simulation, you may 1) Try using Adaptive zero-crossing detection algorithm or 2) Disable the zero crossing of the blocks shown in the following table.</li> <li>Number of consecutive zero-crossings : 1000</li> <li>Zero-crossing signal name : Input</li> <li>Block type : Signum</li> <li>Block path : 'problem 10_13/Sign'</li> </ul>					

Make the following change to the Sign block:

	Function Block Parameters: Sign				
x1	Signum				
Integr	For real inputs, output 1 for positive input, -1 for negative input, and 0 for 0 input. For complex floating point inputs, the outputs follow $sign(u) = u ./ abs(u)$				
_	Parameters				
	Enable zero-crossing detection				
	Sample time (-1 for inherited):				
Sign	-1				
	OK Cancel Help Apply				

