Carleton University

Department of Systems and Computer Engineering

SYSC 3600 Systems and Simulation Fall 2018

Assignment #2 (Due: October 16, 2018, 2:00 pm) In the assignment Box

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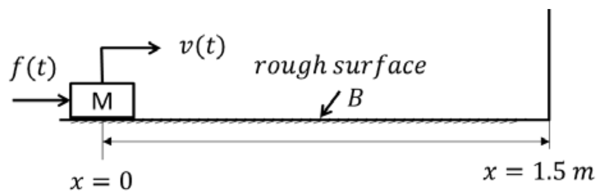
Problem (1) [20 Marks]

Draw a simulation diagram for the system described by the following differential equation, where y(t) is the output and x(t) is the input.

$$2\frac{d^3y(t)}{dt^3} + 6\,\frac{d^2y(t)}{dt^2} + 3\frac{dy(t)}{dt} + y(t) = 5x(t) + 7\frac{dx(t)}{dt} + 9\,\frac{d^2x(t)}{dt^2}$$

Problem (2) [40 Marks]

Consider the simple mechanical system shown below:



f(t) is an external force. The mass M=1 kg moves on a rough surface with friction coefficient B=2 Nt.s/m. The travelling speed is $v(t)\ m/sec$. At time t=0, the mass is at rest at distance $x = 0$. The input force $f(t) = \delta(t)$ where $\delta(t)\ is\ a\ unit\ Dirac - Delta\ function$.

a) Find the first order differential equation that describes the motion of the mass. The input is $f(t)$ and the output is $v(t)$.
b) Find a mathematical expression for $v(t)$
c) Suppose that we do not want the mass to move slower than 0.2 m/s, therefore, when the mass speed at t_1 becomes $v(t_1) = 0.2\ m/s$ we apply another impulse force. Find a mathematical expression for $v(t)$ when $t > t_1$
d) When the speed at t_2 is again reduced to $v(t_2) = 0.2$ we apply a third pulse and find $v(t)\ for\ t > t_2$
e) How many force pulses we have to apply until the mass reaches the wall?

Problem (3) [40 Marks]

Consider a canned beverage in a refrigerator. Once the beverage is removed from the refrigerator into a warmer room, heat will flow into the can. The defining equation for the temperature of the beverage is a first-order differential equation

$$\dot{T}_B(t) + \alpha T_B(t) = \alpha T_E(t)$$

where $T_B(t)$ and $T_E(t)$ are the temperature of the beverage and the environment, respectively; and, we will assume that $\alpha = 6\times10^{-4}$ sec^{-1}.

a) Draw an I/O simulation diagram of this system.
b) Suppose the beverage has been in the refrigerator for a long time at 4 degrees Celsius and is then removed and placed in a room at 20 degrees Celsius. Write down an equation describing the temperature of the beverage as a function of time when the initial temperature is $T_B(0) = 4$ degrees Celsius and $T_E(t)$ is a 20 degree Celsius step input applied at time $t = 0$. Identify the natural and forced responses.
c) Assume that the beverage is removed from the refrigerator as in part b) at time $t = 0$ (4 degrees Celsius) and returned to the refrigerator at $t = 8$ minutes and you take it out again at $t=5$ minutes. What is the temperature of the drink when you take it out of the refrigerator for the second time.
d) Sketch the temperature as a function of time in parts b and c.