GENG-8030 Computational Methods and Modeling for Engineering Applications

Summer 2023

Tutorial 9

All questions were taken from the course textbook:

Title	MATLAB for engineering applications
Author	William J. Palm
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Chapter 10: Simulink

3. Draw a simulation diagram for the following equation.

$$3\dot{y} + 5 \sin y = f(t)$$

5. Draw a simulation diagram for the following model.

$$\dot{x} = -3x + 2y + f(t)$$
$$\dot{y} = 4x - 5y$$

8. Create a Simulink model to plot the solution of the following equation for $0 \leq t \leq 6$.

$$10\ddot{y} = 7 \sin 4t + 5 \cos 3t \quad y(0) = 3 \quad \dot{y}(0) = 2$$

10. The following equation has no analytical solution even though it is linear.

$$\dot{x} + x = \tan t \quad x(0) = 0$$

The approximate solution, which is less accurate for larger values of t, is

$$x(t) = \frac{1}{3}t^3 - t^2 + 3t - 3 + 3\,e^{-t}$$

13. Construct a Simulink model to plot the solution of the following equations for $0 \leq t \leq 2$

$$\begin{aligned} \dot{x}_1 &= -6x_1 + 4x_2 \\ \dot{x}_2 &= 5x_1 - 7x_2 + f(t) \end{aligned}$$

where $f(t) = 3t$. Use the Ramp block in the Sources library.

15. Construct a Simulink model to plot the solution of the following equations for $0 \leq t \leq 10$.

$$\begin{aligned} \dot{x} &= -5x + 3y + 5\sin 2t \qquad x(0) = 0 \\ \dot{y} &= 3x - 4y \qquad\qquad\quad y(0) = 0 \end{aligned}$$

18. Construct a Simulink model of the following problem.

$$5\dot{x} + \sin x = f(t) \quad x(0) = 0$$

The forcing function is

$$f(t) = \begin{cases} -5 & \text{if } g(t) \le -5 \\ g(t) & \text{if } -5 < g(t) < 5 \\ 5 & \text{if } g(t) \ge 5 \end{cases}$$

where $g(t) = 10 \sin 4t$.

25. Use Transfer Function blocks to construct a Simulink model to plot the solution of the following equations for $0 \le t \le 2$.

$$3\ddot{x} + 15\dot{x} + 18x = f(t) \quad x(0) = \dot{x}(0) = 0$$
$$2\ddot{y} + 16\dot{y} + 50y = x(t) \quad y(0) = \dot{y}(0) = 0$$

where $f(t) = 75u_s(t)$.

28. Create a Simulink model to plot the solution of the following equation for $0 \le t \le 1$.

$$\frac{Y(s)}{F(s)} = \frac{4}{s+5}$$

where

$$f(t) = u_s(t) - u_s(t-1)$$

33. The following model describes a mass supported by a nonlinear, hardening spring. The units are SI. Use $g = 9.81\ \text{m/s}^2$.

$$5\dot{y} = 5g - \left(900y + 1700y^3\right) \quad y(0) = 0.5 \quad \dot{y}(0) = 0$$

Create a Simulink model to plot the solution for $0 \le t \le 2$.

35. The equation describing the water height h in a spherical tank with a drain at the bottom is

$$\pi\left(2rh - h^2\right)\frac{dh}{dt} = -C_d A\sqrt{2gh}$$

Suppose that the tank's radius is $r = 3$ m and the circular drain hole of area A has a radius of 2 cm. Assume that $C_d = 0.5$ and that the initial water height is $h(0) = 5$ m. Use $g = 9.81\ \text{m/s}^2$. Use Simulink to solve the nonlinear equation, and plot the water height as a function of time until $h(t) = 0$.

45. Consider the system shown in **Figure P45**. The equations of motion are

$$m_1\ddot{x}_1 + (c_1 + c_2)\dot{x}_1 + (k_1 + k_2)x_1 - c_2\dot{x}_2 - k_2x_2 = 0$$
$$m_2\ddot{x}_2 + c_2\dot{x}_2 + k_2x_2 - c_2\dot{x}_1 - k_2x_1 = f(t)$$

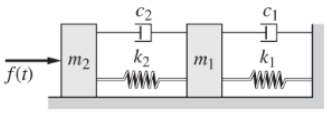

Figure P45

Suppose that $m_1 = m_2 = 1$, $c_1 = 3$, $c_2 = 1$, $k_1 = 1$, and $k_2 = 4$.

a. Develop a Simulink model of this system. In doing this, consider whether to use a state-variable representation or a transfer function representation of the model.

b. Use the Simulink model to plot the response $x_1(t)$ for the following input. The initial conditions are zero.

$$f(t) = \begin{cases} t & 0 \le t \le 1 \\ 2 - t & 1 < t < 2 \\ 0 & t \ge 2 \end{cases}$$