System Dynamics Exam 2 — Spring 2008

The FE reference book, a one-sided formula sheet, and MATLAB/Simulink may be used during this exam. Matlab/Simulink must be available to the student.

1. Solve the following for $x(t)$.
   (a) $5\dot{x} = 7t \qquad x(0) = 3$
   (b) $4\dot{x} = 3e^{-5t} \qquad x(0) = 4$
   (c) $7\ddot{x} = 4t \qquad x(0 = 3 \qquad \dot{x}(0) = 5$
   (d) $3\ddot{x} = 8e^{-4t} \qquad x(0) = 3 \qquad \dot{x}(0) = 5$

2. Use Matlab to plot the step response of the following systems:
   (a) $3\ddot{x} + 21\dot{x} + 30x = f(t)$
   (b) $5\ddot{x} + 2\dot{x} + 65x = f(t)$

3. Write the state space equation matrices A, B, C, and D for the following systems:
   (a) x_1 and x_2 are the outputs:
   $$\dot{x}_1 = -5x_1 + 3x_2$$
   $$\dot{x}_2 = x_1 - 4x_2 + 5u$$
   (b) $\dot{y}$ is the output:
   $$2\frac{d^3y}{dt^3} + 5\frac{d^2y}{dt^2} + 4\frac{dy}{dt} + 7y = f(t)$$
   (c) $y(t)$ and $\dot{y}(t)$ are the outputs:
   $$\frac{Y(s)}{F(s)} = \frac{6}{3s^3 + 63 + 10}$$

4. Create a Simulink model to solve for $\theta(t)$ and plot the solution for $0 < \theta < \pi/2$ given $\theta(0) = 0.1$ and $\dot{\theta}(0) = 0.0$ for the system defined by
   $$25,400\ddot{\theta} = -17,500\cos(\theta) + \frac{626,000}{Q}\sin(1.33 + \theta)$$
   where
   $$Q = \sqrt{2020 + 1650\cos(1.33 + \theta)}$$