EE452—Homework # 3

1. Consider the transfer function model \( G_5(s) \) for the double-mass spring system in Figure A.8 of your textbook with \( u \) as the input and \( y \) as the output. Set \( m = M = k = b = 1 \).

   (a) Draw an all-integrator block diagram for this system.

   (b) By labelling the output of each integrator as a state, obtain an state-space representation for this system.

   (c) Find a discrete-time state-space representation for the system below assuming that the sampling frequency is 1 Hz.

   (d) Find a discrete-time transfer function representation for the system below assuming that the sampling frequency is 1 Hz.

2. Repeat Problem 1 with \( G_5(s) = \frac{a-b}{(s-a)(s-b)} \). Do not assume particular values for the constants \( a \) and \( b \). (Hint: Expand \( G_5(s) \) to partial fractions first.)

3. Transform the discrete-time state-space representation you obtained in Problem 2 to a different one.

4. Obtain the control and observer canonical forms for \( \frac{2s^2+3s+1}{3s^3-2s^2-s-1} \).

5. (a) Consider the discrete-time state-space system you obtained in Problem 2 with \( a = -1 \), \( b = -2 \) and initial state vector \( x_0 = \begin{bmatrix} 1 \\ -2 \end{bmatrix} \). Find the response of this system due to a step input, i.e., \( u_k = 1 \), for all \( k \geq 0 \).

   (b) Verify your answer by solving the state-space equations recursively in MATLAB for \( 0 \leq k \leq 10 \). Attach your code and a single plot where the solution you obtained in the first part and the numerical solution you obtained in MATLAB are shown.