ESE 441 – Spring 2016 – Homework 8

1. For the following system

$$\dot{\mathbf{x}} = \begin{bmatrix} 2 & 5 \\ 0 & -1 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$$

   Design state feedback to move the poles to $-2 \pm 3j$.

2. Consider the following system

$$\dot{\mathbf{x}} = \begin{bmatrix} -4 & -3 \\ 1 & 0 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$$
$$y = \begin{bmatrix} 1 & 2 \end{bmatrix} \mathbf{x}$$

   If we design state feedback with gains $\mathbf{K} = [k_1 \;\; k_2]$:

   (a) Are there any values of k_1 and k_2 that make the system unreachable?

   (b) Are there any values of k_1 and k_2 that make the system unobservable?

3. Consider a system with transfer function

$$\frac{(s-1)(s+2)}{(s+1)(s-2)(s+3)}$$

   Is it possible to change the transfer function to

$$\frac{s-1}{(s+2)(s+3)}$$

   by state feedback? If yes, how?

4.

$$\dot{\mathbf{x}}(t) = \begin{bmatrix} 0 & 2 \\ 1 & 1 \end{bmatrix} \mathbf{x}(t) + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(t)$$
$$y(t) = \begin{bmatrix} 0 & 1 \end{bmatrix} \mathbf{x}(t)$$

   (a) Is it possible to arbitrarily place the poles using state feedback?

   (b) Is it possible to make the system stable using state feedback?

   (c) Is it possible to make the system stable with complex poles using state feedback?

5. For the inverted pendulum you modeled in Simulink for homework 4, design state feedback to stabilize the system at the unstable equilibrium point with 10% overshoot and 3 seconds settling time. Use the following parameters:

```
len = 1;
Jt = 0.1;
mg = 10;
gamma = 0.1;
theta0 = 0.1;
omega0 = 0;
```

   Model your design in Simulink and demonstrate that it meets specifications. Hand in your design work, a printout of the modified system, and a plot of the system output.