(40) 1. A negative unity feedback system has the following plant:

$$G(s) = \frac{K}{s(s+5)(s+20)}$$

Design a first order lead compensator such that the damping ratio zeta is equal to 0.5 for a unit step input, and the settling time is less than or equal to 2/3 second. Also determine the value of the error constant. Use the root locus method.

a) Due only one iteration.

b) Show all design steps by hand

c) Use MATLAB to plot the root locus for both the uncompensated and compensated systems

d) Use MATLAB to plot the step response for the compensated system. Check the resulting values for P.O. and T_s.

e) Include all MATLAB scripts.

(30) 2. Consider the system specified by:

$$\dot{\underline{x}}(t) = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \underline{x}(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} \underline{u}(t)$$

$$\underline{y}(t) = [1 \;\; 2]\, \underline{x}(t)$$

a) Determine the state controllability and observability.

b) Place the observer poles at $-2 \pm j4$. Use Ackermann's formula.

(30) 3. Determine the feedback gain $k > 1$ that minimizes the performance index

$$J = \int_0^\infty [x^2(t) + u^2(t)]\, dt$$

for

$$\dot{x}(t) = x(t) + u(t), \qquad x(0) = \sqrt{2}$$

where

$$u(t) = -k\, x(t).$$

Show all steps. What is the value of J_{min} ?