Midterm Exam: Engi. 0138 Advanced Control II

March 2, 2006.
8:30 AM to 10:00 AM, Room: AT2021
Closed Book exam.

Q-1 (8 marks)
Consider the following system

$$\dot{x} = Ax + Bu$$
$$y = Cx$$
$$A = \begin{bmatrix} 1 & 3 \\ 2 & 1 \end{bmatrix},\ B = \begin{bmatrix} 0 \\ 5 \end{bmatrix},\ C = [1 \quad 2]$$

a) Write the system in controllable canonical form, observable canonical form and diagonal canonical form or Jordan canonical form.

Q-2 (8 marks)
Consider the following matrices

$$A_1 = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix},\ A_2 = \begin{bmatrix} 3 & 1 & 0 & 0 \\ 0 & 3 & 1 & 0 \\ 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 6 \end{bmatrix}$$

Compute $e^{A_1 t}$ and $e^{A_2 t}$.

Q-3 (14 marks)
Consider the system defined by:

$$\dot{x} = Ax + Bu$$
$$y = Cx$$
$$A = \begin{bmatrix} 4 & 5 \\ 3 & 6 \end{bmatrix},\qquad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}\qquad C = [1 \quad 0]$$

a) Check the state controllability and observability of the system.
b) Using the state feedback control $u = -Kx + ly_d$, determine K and l such that the closed loop system will have zero-steady-state error for a unit-step input y_d, 5% overshoot and 2 seconds settling time.
c) Design a state observer with the poles at –2 and –4.

Percent overshoot: $\%\ OS = 100\exp(\frac{-\xi\pi}{\sqrt{1-\xi^2}})$. Settling time: $T_s \approx \frac{4}{\xi\omega_n}$