 Set No.1

III B.Tech. II Semester Regular Examinations, April/May -2005
ADVANCED CONTROL SYSTEMS
(Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. Define Minimum energy control. State the theorem and prove the same.

2. For the system $\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x$ find a suitable Lyapunov function V(x). Find an upper bound on time that it takes the system to get from the initial condition $x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ to within the area defined by $x_1^2 + x_2^2 = 0.1$.

3. (a) Draw the block diagram and deduce the expression of transfer function for the controller-observer.

   (b) Consider the system defined by

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

   Show that this system cannot be stabilized by the state feedback control $\mu = -kx$ whatever matrix k is chosen.

4. (a) What is meant by minimum energy control law.

   (b) Explain the factors to be considered for designing of an optimum controller.

5. (a) Derive the transversality condition in extermination of functions.

   (b) Prove that for the functional

   $$J(x) = \int_{t_0}^{t_1} A(x,t)\sqrt{1+\dot{x}^2}dt$$

   the transversality condition reduces to orthogonlity is $\dot{x}\,\dot{y} = -1$ where y(t) is the curve on which the movable right points lies.

6. (a) Derive the relations required for obtaining an observable realization algorithm of a given transfer matrix T(s).

   (b) Obtain state space controllable realization of a system with transfer matrix.

   $$T(s) = \begin{bmatrix} 2(s-1) & s+1 \\ 4 & -s \end{bmatrix} \begin{bmatrix} s+4 & 2(s+1) \\ 0 & s^2-s+4 \end{bmatrix}^{-1}$$

7. Write the MATLAB Programme for finding the error constants for

   (a) step

   (b) ramp

(c) parabolic inputs and steady state error of the system for all the inputs whose transfer function is given by

$$G(s)H(s) = \frac{10(s+4)}{(s+1)\,(s+3)\,(s+5)}$$

8. (a) How do you perform the following operations using MATLAB ?
   i. To find eigen values
   ii. Matrix multiplication

   Illustrate with examples.

   (b) Write short notes on:
   i. Relational and logic operations
   ii. Matrices operations and functions using MATLAB techniques

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1. Define Minimum energy control. State the theorem and prove the same.

2. State, prove and explain Lyapunovs stability theorm. Also explain what are the sufficient conditions of stability.

3. (a) Explain the linear system with full-order state observer with neat block diagram.
   (b) Design a full-order state observer for the given state model.

   $$Given\ A = \begin{bmatrix} 1 & -1 \\ -2 & 1 \end{bmatrix};\ C = [1,\ 0]$$

   and given values are $\mu_1 = -5, \ \mu_2 = -5$

4. (a) Discuss the nature of information about the plant supplied to the controller?
   (b) Write short notes on Design of optimum controllers?

5. (a) Find the condition to be satisfied by a trisections to extremise

   $J(x) = \int_{t_0}^{t_1} g(x, \dot{x}, t)dt$ and $x(t_0)$ and t_1 specified.

   (b) Find the curve with minimum arc length between the point $x(0) = 2$ and line $t_1 = 6$

6. Break up the following transfer matrices into R(s) and P(s).
   (a) $T(s) = R(s)P^{-1}(s)$
   (b) R(s) and P(s) are relatively right prime,
   (c) P(s) is column proper
      i. $T(s) = \begin{bmatrix} \frac{s+1}{s^2} & \frac{s+2}{s^2+1} \\ \frac{2}{s} & \frac{2s+3}{s^2+1} \end{bmatrix}$
      ii. $T(s) = \begin{bmatrix} \frac{(s-2)(s+1)}{s(s-1)^2} & \frac{1}{(s-1)^2} \\ -\frac{1}{s} & 0 \\ \frac{2}{s(s-1)} & \frac{1}{s-1} \end{bmatrix}$

7. Write a programme in MATLAB for drawing root locus plot for the following system whose transfer function

   $G(s)H(s) = \frac{K(s+6)}{s(s+4)\,(s^2+4s+8)}$

8. (a) Explain the following model conversion functions with examples
   i. C2d
   ii. SS2tf
   iii. tf22p
   iv. 2p 2 tf.

   (b) Discuss the Matrix and Math functions in MATLAB with examples.
   i. eye
   ii. det
   iii. cross
   iv. wiv

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1. Convert the system

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

$$y(t) = \begin{bmatrix} 1 & 1 \end{bmatrix} x(t)$$

   (a) Find, if possible, a control law, which will derive the system from $X(0) = 0 \; to \; x^1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ in 2 sec.

   (b) Find, if possible, the state x(0) when $y(t) = \frac{1}{2}e^{-2t} + \frac{3}{2} \;\; for \; u(t) = 1, \; t > 0$

2. Check the stability of the system described by

$$\dot{x}_1 = -x_1 + 2x_1^2 x_2$$

$$\dot{x}_2 = -x_2$$

by using the variable-gradient method.

3. (a) Find a three - dimensional observer with eigen values -2, -2, -3, for the system

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

y = [1 1 0] x

   (b) Show that the zero's of a scalar systems are invariant under linear state feedback to the input.

4. Consider a system described by the equation $\dot{X} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \; x_1(0) = x_2(0) = 1. Choose \; the \; feedback \; law \; u = -x_1 - kx_2.$

   (a) Find the value of K so that $J = 1/2 \int_0^{\alpha} (x_1^2 + x_2^2)\, dt$

   (b) Find Sensitivity of J with respect to K.

5. Illustrate with an example the problem with terminal time t_1 free and $x(t_1)$ fixed.

6. (a) Derive the transfer matrix relation from state space representation

(b) The state space triple (A, B, C,) of a system is given by

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 2 & 3 & 0 \\ 1 & 1 & 1 \end{bmatrix}; \mathrm{B} = \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix}; \mathrm{C} = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Calculate the input and output decoupling zeros, if any. Is the matrix A cyclic? Find out the transfer matrix T(s).

7. Write MATLAB commands for drawing Nyquist plot and obtaining the stability of he system whose transfer function is given by,

   $G(s)(H(s) = \frac{K(s+1)}{(s+1)(s+4)}$

8. Explain about control system tool box in connection with MATLAB commands giving examples.

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1. (a) Define and explain the principle of Duality.
   (b) Given the system

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

$$y(t) = \begin{bmatrix} 0 & 1 & 2 \\ 0 & 1 & 0 \end{bmatrix}$$

   What can we say about controllability and observability without making any further calculations?

2. (a) State and prove two Lyapunov stability and instability theorems.
   (b) Consider a system described by the following equations
   $\dot{x}_1 = -3x_1 + x_2$
   $\dot{x}_2 = x_1 - x_2 - x_2^3$
   Investigate the stability of equilibrium state.

3. (a) Find a three - dimensional observer with eigen values -2, -2, -3, for the system

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

   y = [1 1 0] x
   (b) Show that the zero's of a scalar systems are invariant under linear state feedback to the input.

4. (a) Explain Tracking Problem?
   (b) Explain Minimum fuel Problem?

5. Illustrate with an example the problem with terminal time t_1 free and $x(t_1)$ fixed.

6. Break up the following transfer matrices into R(s) and P(s).
   (a) $T(s) = R(s)P^{-1}(s)$
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i. $T(s) = \begin{bmatrix} \frac{s+1}{s^2} & \frac{s+2}{s^2+1} \\ \frac{2}{s} & \frac{2s+3}{s^2+1} \end{bmatrix}$

ii. $T(s) = \begin{bmatrix} \frac{(s-2)(s+1)}{s(s-1)^2} & \frac{1}{(s-1)^2} \\ -\frac{1}{s} & 0 \\ \frac{2}{s(s-1)} & \frac{1}{s-1} \end{bmatrix}$

7. Write the MATLAB commands for drawing root locus for the following system with,

$G(s)H(s) = \frac{K}{(s+1)\,(s+3)\,(s+4)}$

8. (a) How do you perform the following operations using MATLAB ?
   i. To find eigen values
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   Illustrate with examples.

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