Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. IST Semester–Remedial Examination – July- 2011

Subject code: 710703N

Subject Name: Modern Control System

Date:11/07/2011 **Time: 10:30 am – 01:00 pm**

Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** For the matrix Y given below,find its diagonalising (modal) matrix and hence, diagonalize the given matrix **07**

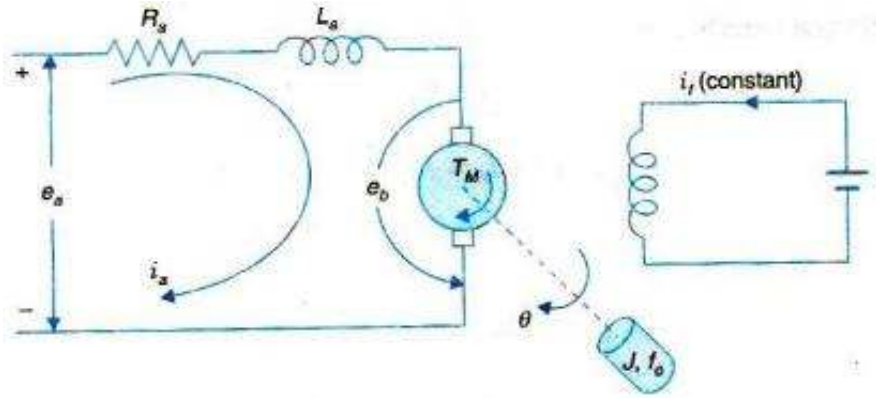
$$Y = \begin{bmatrix} 4 & 1 & -2 \\ 1 & 0 & 2 \\ 1 & -1 & 3 \end{bmatrix}$$

(b) Obtain the state space representation for the armature controlled d.c. motor shown in Fig. below, given **07**

Moment of inertia of motor and load = J

Coefficient of friction of motor and load = f

Back emf constant = K_b and motor torque constant = K_T



Q.2 **(a)** Consider a system represented in state space by the following equations **07**

$$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

Where u is unit step input and x_1 (0) = 1 and x_2 (0) = -1

Find x_1 (t) and x_2 (t)

(b) Explain eigenvalues and eigenvectors of a matrix. Hence, prove that the eigenvalues of a matrix are invariant under linear transformation **07**

OR

(b) Define state, state space and state transition matrix. **07**

Q.3 **(a)** A feedback system is characterized by the closed loop transfer function T **07**

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

Draw a suitable signal flow graph so that the system can be represented in controllable canonical state model ..

(b) Define 'State Controllability'. Hence, state Gilbert's method for testing state controllability. What are the limitations of this method. For a system represented in state space by $= \begin{bmatrix} -1 & -2 & -2 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \end{bmatrix}$, B = $\begin{bmatrix} 2 \\ 0 \\ 1 \end{bmatrix}$, C = $\begin{bmatrix} 1 & 1 & 0 \end{bmatrix}$ **07**

where A,B ,C carry usual meanings. Check whether the above system is completely controllable.

OR

Q.3 **(a)** A feedback system is characterized by closed loop transfer function T (*s*) = $\frac{5s+10}{s^3+6s^2+5s}$. Obtain the diagonal form of state space representation of the above system and therefrom draw its state diagram. **07**

(b) Obtain the solution of state equation $\dot{X} = A X + B U$ given $X(0) = X_0$ **07**

Q.4 **(a)** Consider the system $\dot{x_1} = -2x_1 + x_2 u$, $\dot{x_2} = -x_1 u$ where u is bounded Choose a suitable Lyapunov candidate and comment on the stability of the above system **07**

(b) Discuss the advantages of representing a dynamical system in state space form. How can the closed loop transfer function T(s) be derived from the state space representation **07**

OR

Q.4 **(a)** Define the following (support your answer with suitable figures) **07**

i. Asymptotic Stability in the sense of Lyapunov
ii. Exponential stability in the sense of Lyapunov
iii. Asymptotic stability in large

(b) Comment on the sign definiteness of the following energy functions V (x) **07**

i. $V(x) = x_1^2 + (x_2 + x_3)^2$
ii. $V(x) = x_1^2 + x_2^2 - (x_1^4 + x_2^4)$

Q.5 **(a)** Consider the system $\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \\ \dot{x_3} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & -3 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$ **07**

It is required that the system must have closed loop peak overshoot of 2 % and a settling time of 0.83 secs. The third pole can lie between s = - 6 and -10. Design a suitable control u = -**K**x to achieve the same using Bass Gura method of direct pole placement.

(b) Explain the pole placement method for SISO LTI system using Ackermann's method. **07**

OR

Q.5 **(a)** Discuss the necessary and sufficient condition for state observation and hence write the procedure for designing a full state observer. **07**

(b) Explain positive definite, positive semi definite and indefinite function **07**

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