9. (a) Consider a system having state and output equations as follows.

$$\dot{X} = \begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \text{ and } y = [1 \quad 0]X$$

Check the controllability and observability of the system.

(b) A system is described by,

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u \text{ and } y = [1 \quad 0 \quad 0]X$$

Using state feedback control, place the poles of the closed loop system to desired locations $s = -1 \pm j\sqrt{2}$ and $s = -5$. Determine the state feedback gain matrix.

5 + 7 = 12

CONTROL SYSTEM
(ELEC 3203)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The transfer function of a system is $G(s) = \frac{K}{s^2(1+s+2s^2)}$. The type and the order of the system are
(a) 1 and 4 (b) 4 and 4 (c) 2 and 4 (d) 4 and 2.

(ii) Which of the following has a closed loop configuration?
(a) Field controlled D.C servo motor
(b) Armature controlled D.C servo motor
(c) Both a and b
(d) D.C series motor.

(iii) A system has a dual pole at origin. Its impulse response will be
(a) constant amplitude (b) ramp
(c) decaying exponential (d) oscillatory.

(iv) The characteristics equation of a system is $s^2 + 10s + 25 = 0$. The values of natural frequency of oscillation and damping ratio are
(a) 50 rad/sec and 1 (b) 5 rad/sec and 0.5
(c) 5 rad/sec and 1 (d) 4 rad/sec and 1.5.

(v) The steady state error of a type-0 system due to unit parabolic input is
(a) zero (b) ∞ (c) constant (d) -∞.

(vi) The first column of the Routh's table contains the following integers 1, 7, 5, -3, 2. The system is
(a) Stable (b) Marginally stable
(c) Stability cannot be determined (d) Unstable.

(vii) A control system has $G(s)H(s) = \frac{K(s+1)}{s(s+3)(s+4)}$. Root locus of the system can lie on the real axis
(a) between $s = -1$ and $s = -3$ (b) between $s = 0$ and $s = -4$
(c) between $s = -3$ and $s = -4$ (d) towards left of $s = -4$.

(viii) The transfer function of a system is $G(s) = \frac{s+1}{s(0.5s+1)}$. The corner frequencies are
(a) 0.5 & 1 (b) 2 & 1 (c) 0 & 2 (d) 1 & 10.

(ix) If a system is described by, $A = \begin{bmatrix} -5 & 0 \\ 0 & -2 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ then
(a) system is controllable (b) system is uncontrollable
(c) cannot comment on controllability (d) system is undefined.

(x) The Eigen values of the matrix $A = \begin{bmatrix} 1 & 3 \\ 3 & 1 \end{bmatrix}$ are
(a) - 2 and 4 (b) -4 and 4
(c) -2 and -4 (d) 2 and -2.

Group - B

2. Find the transfer function of the system shown in Fig. (1) using block diagram reduction techniques. Apply Mason's gain formula to verify the result. Consider R(s) as input and C(s) as output of the system.

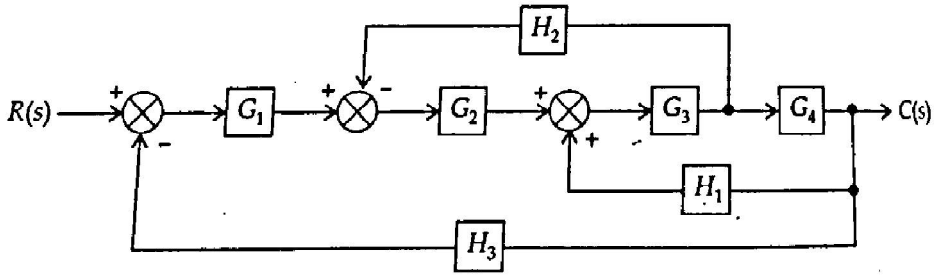

Fig. (1)

6 + 6 = 12

3. Write short notes on any three of the followings. **(3 × 4) = 12**
(i) Potentiometer
(ii) Servomotor
(iii) Synchro
(iv) Actuator.

Group - C

4. (a) The forward path transfer function of a unity feedback control system is given by $G(s) = \frac{5(s^2+2s+100)}{s^2(s+5)(s^2+3s+10)}$. Determine the step, ramp and parabolic error coefficients.

(b) Consider the system as shown in Fig. (2) and determine the value of 'a' such that the damping ratio of the overall system is 0.5. Also obtain the rise time and maximum overshoot in its step response.

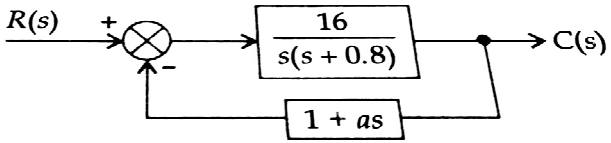

Fig. (2)

6 + (2 + 2 + 2) = 12

5. Sketch the complete root locus of a unity negative feedback system whose open loop transfer function is given by $G(s)H(s) = \frac{K}{s(s+1)(s^2+4s+5)}$.

12

Group - D

6. The open loop transfer function of a unity negative feedback system is $G(s)H(s) = \frac{10}{s^2(1+0.2s)(1+0.5s)}$. Draw the Nyquist diagram and comment on stability of the closed loop system.

12

7. A unity negative feedback control system has an open loop transfer function $G(s)H(s) = \frac{10(s+20)}{(s+1)(s+2)(s+10)}$. Draw the Bode plot and determine gain margin, phase margin, gain cross over and phase cross over frequency of the system. Also Comment on stability of the system.

(9 + 2 + 1) = 12

Group - E

8. (a) Discuss the effects on the performance of a system with introduction of lag and lead compensator.

(b) Find the controllable canonical form and draw the state diagram of the system whose transfer function is $G(s) = \frac{20(4s+2)}{s^3+5s^2+8s+2}$.

6 + (4 + 2) = 12