CONTROL SYSTEM
(ELEC 3103)

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) Which of the following has an open loop configuration?
(a) The respiratory system of human being
(b) Armature controlled D.C servo motor
(c) Field controlled D.C servo motor
(d) Both (a) and (b).

(ii) The characteristics equation of a system is given by $s^2 + 8s + 16 = 0$, the values of natural frequency of oscillation and damping ratio is
(a) 4rad/sec and 4 (b) 4 rad/sec and 1
(c) 1 rad/sec and 1 (d) 1 rad/sec and 4.

(iii) The first column of Routh table containing the following integers 1, -5, -5, 10, 4. The system has ____ number of poles on right half of s-plane.
(a) 2 (b) 5 (c) 1 (d) 0

(iv) The output of a linear system for a unit impulse input is given by $e^{-t}\cos(t)$. The transfer function is given by
(a) $\frac{1}{s^2+2s+2}$ (b) $\frac{s+1}{s^2+2s+2}$ (c) $\frac{s+1}{(s+1)^2+2}$ (d) $\frac{s+2}{(s+1)^2+1}$.

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

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

(vii) For a system having a transfer function $G(s) = \frac{K}{s(s^2+5s+20)}$ the angle of asymptotes will be
(a) 60°, 180°, 120° (b) 60°, 180°, 300°
(c) 60°, 180°, 200° (d) 60°, 150°, 300°

(viii) A system having a transfer function $G_c(s) = \frac{1+10s}{1+5s}$ is

(a) lag compensator (b) lead compensator
(c) lag-lead compensator (d) lead-lag compensator.

(ix) By the use of PI control to the second order system overshoot

(a) increases (b) decreases
(c) remains unaltered (d) can't be determined.

(x) If a system is described by, $A = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ then

(a) system is observable (b) system is not observable
(c) system is undefined (d) couldn't comment on observability.

Group- B

2. (a) Solve the block diagram shown in Fig.1 using block diagram reduction technique and determine the overall transfer function (C(s)/R(s)). [(CO1)(Analyse/IOCQ)]

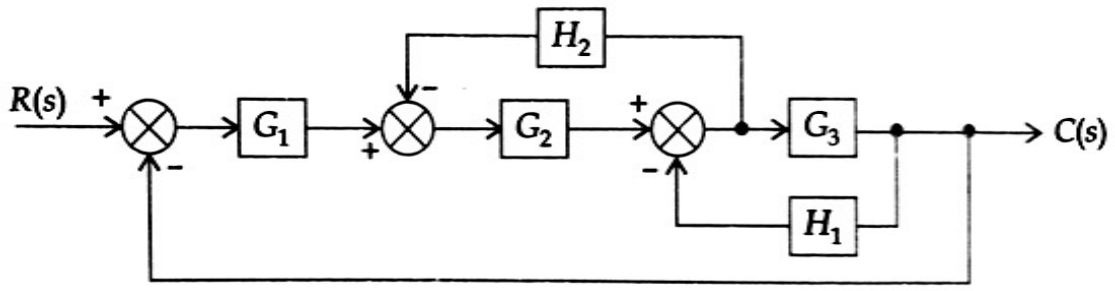

Fig.1

(b) Sketch the signal flow graph of the block diagram shown in Fig.1. From the signal flow graph identify the transfer function C/R using Masson's gain formula.
[(CO1)(Analyse/IOCQ)]

6 + (2 + 4) = 12

3. Describe any of the following three as short notes: **(3 × 4) = 12**

(i) Tacho generator
(ii) Actuator
(iii) Potentiometer
(iv) Servo motor. [(CO1)(Remember/LOCQ)]

Group – C

4. (a) What do you mean by steady state error? List down the factors which affects the steady state error. [(CO2)(Remember/LOCQ)]

(b) A unity negative feedback system has a forward path transfer function $G(s) = \frac{5(s^2+2s+100)}{s^2(s+5)(s^2+3s+10)}$. Determine the error coefficients for (i) step (ii) ramp and (iii) parabolic inputs. Also determine type and order of the system.
[(CO2) (Remember /LOCQ)]

(c) The open loop transfer function of a negative unity feedback control system is given by $G(s)H(s) = \frac{K(s+13)}{s(s+3)(s+7)}$. Determine (i) the range of K (K>0) for which the system is stable, (ii) the value of K for which system is marginally stable, (iii) frequency of sustained oscillation. [(CO2)(Evaluate/HOCQ)]

2 + 4 + 6 = 12

5. (a) What is 'Angle of Departure' and how to find it? [(CO2)(Understand/LOCQ)]
   (b) Sketch the root locus diagram of a negative unity feedback system whose open loop transfer function is given by $G(s)H(s) = \frac{K}{s(s+4)(s^2+4s+5)}$. Identify (i) the range of K for which system is stable, (ii) the intersection points between root locus and jω axis, (iii) break away points if any. [(CO2)(Analyze/IOCQ)]

2 + (4 + 6) = 12

Group – D

6. (a) What do you mean by 'Principle of Argument'? [(CO3) (Remember/LOCQ)]
   (b) State Nyquist Stability Criterion. [(CO3) (Remember/LOCQ)]
   (c) The open loop transfer function of a unity feedback system is given by,

$$G(s)H(s) = \frac{5}{s(1+2s)(1+s)}$$

Draw the Nyquist plot and evaluates the stability of the closed loop system. [(CO3)(Evaluate/HOCQ)]

2 + 2 + 8 = 12

7. The open loop transfer function of a unity feedback system is given by,

$$G(s)H(s) = \frac{K}{s(1+0.5s)(1+0.25s)}$$

Determine the value of K such that (a) Gain margin=20 dB and (b) phase margin=60°. [(CO3)(Analyze/IOCQ)]

(6 + 6) = 12

Group - E

8. (a) How PD control action improves various time domain indices of a 2nd order system? Explain with suitable example. [(CO4)(Remember/LOCQ)]
   (b) Determine the observable canonical form of the system whose transfer function is given by,

$$G(s) = \frac{s^3 + 6s^2 + 4s + 3}{s^4 + 4s^3 + 2s^2 + 5s + 6}$$

Hence draw the signal flow graph of the system realized in observable canonical form. [(CO4)(Analyse/IOCQ)]

4 + (6 + 2) = 12

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

$$\dot{X} = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -4 & 2 \\ 0 & 0 & -10 \end{bmatrix} X + \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix} u$$

and $y = [1 \quad 0 \quad 1]X$

Examine whether the system is state observable or not. [(CO4)(Analyse/IOCQ)]

(b) A system is described by,

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U \text{and } Y = [1 \quad 0 \quad 0]X$$

Using state feedback control place the pole of the close loop system to a desired locations $s = -1 \pm j$ and $s = -2$. Develop the state feedback gain matrix.

[(CO4)(Evaluate/HOCQ)]

4 + 8 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	29.17	47.92	22.91

Course Outcome (CO):

After the completion of the course students will be able to

CO1. Know the fundamental concepts of Control systems and mathematical modelling of the system

CO2. Analyze time response of a system and understand the concept of stability

CO3. Investigate frequency response of the system and examine the relative stability by various approach

CO4. Design and realize control systems using classical methods and state variable modeling technique

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question