CONTROL SYSTEM
(ELEC 3103)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) The transfer function of a system is $G(s) = \frac{4}{s^2(2s^2+4s+1)}$. The type and order of the system are
(a) 3 and 4 (b) 4 and 3 (c) 4 and 2 (d) 2 and 4.

(ii) By using feedback path, transient response
(a) Rises fast (b) Decays quickly
(c) Decays slowly (d) No decay.

(iii) The first column of Routh table containing the following integers 1, -4, -7, -6, 10. The system has _____ number of pole on right half of s-plane.
(a) 0 (b) 1 (c) 2 (d) 3

(iv) The steady state error of a type-2 system due to unit ramp input is
(a) Zero (b) ∞ (c) Constant (d) -∞.

(v) For a system, the open loop transfer function is given by $G(s)\mathrm{H(s)} = \frac{\mathrm{k}}{(\mathrm{s}^2+\mathrm{s}+1)}$. The angle of departure from the complex poles are
(a) 0° (b) $\pm 90^\circ$ (c) $\pm 180^\circ$ (d) $\pm 45^\circ$.

(vi) If the phase margin of a unity feedback control system is zero, then the Nyquist plot of the system passes through
(a) (-1,j0) point in the GH plane
(b) Left hand side of (-1,j0) point in the GH plane
(c) The origin in GH plane
(d) In between origin and (-1,j0) point in the GH plane.

(vii) A system having a transfer function $(s) = \frac{(1+0.1s)}{(1+0.2s)(1+0.01s)}$. The corner frequencies are
(a) 5, 10 and 100 rad/sec (b) 0.5, 10 and 100 rad/sec
(c) 0.2, 0.1 and 0.01 rad/sec (d) 1, 10 and 100 rad/sec.

(viii) A system having a transfer function $G(s) = \frac{(1+5s)}{(1+20s)}$ is a

(a) lead compensator (b) lag-lead compensator

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

(ix) By the use of PI control to a second order system the steady state error

(a) Decreases (b) Increases

(c) Can't be determined (d) Remains unaltered.

(x) If a system is described by, $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ then the roots of the characteristics equations are

(a) $s = -1$ and $s = -2$ (b) $s = -1$ and $s = -4$

(c) $s = -4$ and $s = -6$ (d) $s = 0$ and $s = -1$.

Fill in the blanks with the correct word

(xi) The forward path transfer function $G(s) = \frac{1}{(s+3)}$ and the feedback path transfer function $(s) = \frac{1}{(s+4)}$, then the close loop transfer function is _________.

(xii) The steady state error of a system $G(s) = \frac{1}{(s+10)}$ with unity negative feedback for a unit step input is _________.

(xiii) The breakaway point of a system whose loop transfer function $G(s)H(s) = \frac{1}{(s+3)(s+7)}$ is located at _________.

(xiv) The system whose loop transfer function $G(s)H(s) = \frac{10}{s^3+6s^2+11s+6}$ has _________ number of unstable open loop pole.

(xv) The system whose loop transfer function $(s)H(s) = \frac{1}{(s+1)(s+10)(s+100)}$, in Bode magnitude plot the slope will be _________ dB/decade after the corner frequency of 100 rad/sec.

Group - B

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

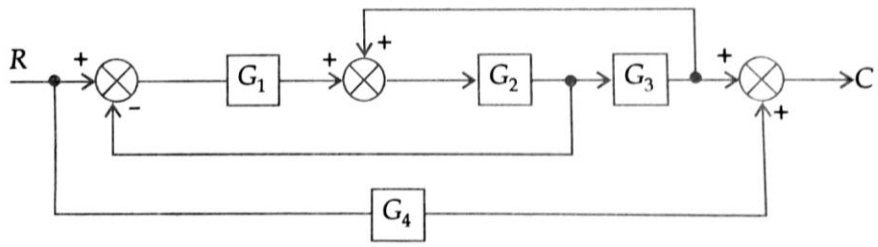

Fig. 1

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

6 + (2 + 4) = 12

3. Describe any of the following three as short notes:
(i) Potentiometer (ii) Servo motor
(iii) Tacho generator (iv) Actuator *[(CO1)(Remember/LOCQ)]*

(4 × 3) = 12

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 $G(s) = \frac{20}{s(s+5)}$. Determine (i) maximum overshoot, (ii) rise time, (iii) settling time and (iv) peak time of the system when the input to the system is unit step. *[(CO2)(Remember /LOCQ)]*

(c) The open loop transfer function of a negative unity feedback control system is given by $G(s)H(s) = \frac{K}{s(s^2+s+1)(s+4)}$. 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 'Asymptotes' and how to find the centroid of asymptotes. *[(CO2)(Understand/LOCQ)]*

(b) Sketch the root locus diagram of a negative unity feedback system whose open loop transfer function is given by $G(s)H(s) = \frac{K}{s(s+4)(s+7)}$. 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 $G(s)H(s) = \frac{10(s+2)}{(s+1)(s-1)}$. Develop the Nyquist plot and explain 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,

$$G(s)H(s) = \frac{10}{s(1+0.25s)(1+0.1s)}$$

Determine the gain margin, phase margin, gain crossover frequency and phase crossover frequency. *[(CO3)(Analyze/IOCQ)]*

(3 + 3 + 3 + 3) = 12

Group - E

8. (a) How PID 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, $G(s) = \frac{s^3+5s^2+2s+4}{s^4+3s^3+4s^2+6s+4}$. Hence draw the signal flow graph of the system realized in observable canonical form. *[(CO4)(Analyse /IOCQ)]*

4 + (6 + 2) = 12

9. (a) A system is described by,

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ 0 & -4 \end{bmatrix} X + \begin{bmatrix} 0 \\ 2 \end{bmatrix} U \quad \text{and} \quad Y = \begin{bmatrix} 0 & 2 \end{bmatrix} X$$

Examine the controllability and observability of the system. *[(CO4)(Analyse /IOCQ)]*

(b) Formulate the diagonalized form the following system.

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U \quad \text{and} \quad Y = \begin{bmatrix} 4 & 5 & 1 \end{bmatrix} X$$

[(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.*