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) By using feedback path, transient response
(a) rises fast (b) decays quickly (c) no decay (d) decays slowly.

(ii) The transfer function of a system is $G(s) = \frac{1}{s^2(3s^2+14s+1)}$. The type and order of the system are
(a) 3 and 4 (b) 4 and 3 (c) 4 and 2 (d) 2 and 4.

(iii) The first column of Routh table containing the following integers 1, -2, -4, -6, 12. The system has ____ number of pole on right half of s-plane.
(a) 0 (b) 3 (c) 2 (d) 4

(iv) For a system, the open loop transfer function is given by $G(s)\mathrm{H(s)} = \frac{\mathrm{k}}{(\mathrm{s}^2+6\mathrm{s}+13)}$. The angle of departure from the complex poles are
(a) 0° (b) $\pm 90^\circ$ (c) $\pm 180^\circ$ (d) $\pm 45^\circ$

(v) Consider a unity feedback control system with open-loop transfer function $G(s)H(s) = \frac{K(s+1)}{s(s+2)(s+3)}$. The steady state error of the system due to a unit step input is
(a) 0 (b) infinite (c) *K/6* (d) *6/K*.

(vi) If a Nyquist plot of $G(j\omega)H(j\omega)$ for a closed loop system passes through (-2, j0) point in GH plane, what would be the value of gain margin of the system in dB?
(a) 6.0205 dB (b) 2.0201 dB (c) -4 dB (d) -6.0205 Db.

(vii) The transfer function of a system is $G(s) = \frac{1000}{(0.1s+1)(0.01s+1)}$ the corner frequencies are
(a) 0.1& 0.01 (b) 0.001 & 0.0001 (c) 10 & 100 (d) 1 & 1000.

(viii) A system having a transfer function $G(s) = \frac{(1+20s)}{(1+s)}$ is a
(a) lead compensator (b) lag-lead compensator
(c) lead-lag compensator (d) lag compensator.

(ix) By the use of PD control to the second order system the rise time
(a) increases (b) decreases
(c) remains unaltered (d) can't be determined.

(x) If a system is described by, $A = [0\ 1\ -4\ -5]$, $B = [0\ 1]$ then the roots of the characteristics equations are

(a) $s = -1$ and $s = -5$ (b) $s = -1$ and $s = -4$

(c) $s = -4$ and $s = -5$ (d) $s = 0$ and $s = -1$.

Fill in the blanks with the correct word

(xi) The forward path transfer function $G_1(s) = \frac{1}{(s+5)}$ and another feed forward path transfer function $G_2(s) = \frac{1}{(s+2)}$ are connected in parallel, then the overall transfer function is _____.

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

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

(xiv) The system whose loop transfer function $(s)H(s) = \frac{4(s+5)^2}{(s+1)(s+2)}$, in Bode magnitude plot the slope will be _____ dB/decade after the corner frequency of 5 rad/sec.

(xv) In state variable analysis response due in initial condition is also known as_____.

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)]

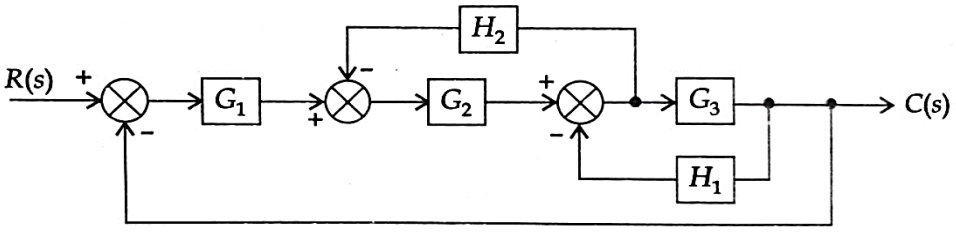

Fig. 1

(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. Consider the positional servo mechanism shown in Fig. 2. Assume that the input to the system is the reference shaft position θ_R and the system output is the load shaft position θ_L. Draw the block diagram of the system indicating transfer function of each block. Simplify the block diagram to obtain $\frac{\theta_L(s)}{\theta_R(s)}$. Parameters of the system are given below.

Sensitivity of the error detector K_p=10v/rad
Gain of the dc amplifier K_A=60volts/volt
Motor field resistance R_f=100Ω
Motor field inductance L_f=20H
Motor torque constant K_T=12Nm/A
Motor inertia load J_L=250Kgm^2
Coefficient of viscous friction of load f_L=2500Nm/(rad/sec)

Motor to load gear ratio = $\frac{1}{60}$
Load to potentiometer gear ratio = 1
Motor inertia and friction are negligible.

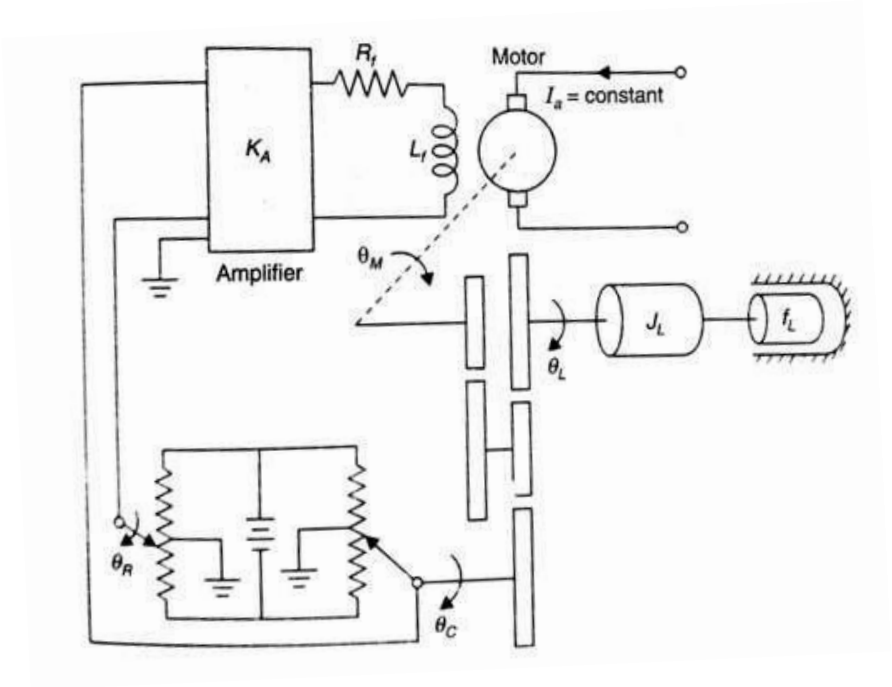

Fig. 2 *[(CO1)(Analyse/IOCQ)]*

12

Group - C

4. (a) Open loop transfer function of a unity feedback system is given by

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

Where K and T are positive constants. By what factor should the amplifier gain K be reduced so that the peak overshoot of unit step response of the system is reduced from 50% to 25%. *[(CO2)(Analyse/IOCQ)]*

(b) 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)(Analyse/IOCQ)]*

6 + (3 + 2 + 1) = 12

5. (a) What is centroid in root locus plot? *[(CO2)(Understand/LOCQ)]*

(b) Sketch the root locus diagram of a negative unity feedback system whose open loop transfer function is given by $G(s)H(s) = \frac{K}{s(s+4)(s^2+2s+2)}$. 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 + (5 + 2 + 1 + 2) = 12

Group - D

6. (a) State Nyquist Stability Criterion. *[(CO3)(Remember/LOCQ)]*

(b) What do you mean by 'Encirclement' and 'Enclosement'? *[(CO3)(Remember/LOCQ)]*

(c) The open loop transfer function of a unity feedback system is given by

$$G(s)H(s) = \frac{80}{(s+1)(s+2)(s+5)}$$

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,

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

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.

$$\dot{X} = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -4 & 2 \\ 0 & 0 & -10 \end{bmatrix} X + \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix} u \quad \text{and} \quad Y = [1 \quad 0 \quad 1]X$$

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

(b) A system is described by,

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

Using state feedback control place the pole of the close loop system to a desired locations $s = -2 \pm j2\sqrt{3}$ and $s = -10$. Develop the state feedback gain matrix.

[(CO4)(Evaluate/HOCQ)]

4 + 8 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	10	73	17