(vii) The first column of Routh table contains the following integers 1, -5, -4, 6, 3. The system has ____ number of poles in the right half of s-plane.
(a) 1 (b) 3 (c) 2 (d) 0.

(viii) Steady state error of a system does not depend on the
(a) nature of input (b) type of a system
(c) nonlinearities (d) order of a system.

(ix) A system having a transfer function $G(s) = \frac{(1+5s)}{(1+2s)}$ is a
(a) lag compensator (b) lead compensator
(c) lag-lead compensator (d) lead-lag compensator.

(x) By the use of PD control action to a second order system maximum overshoot
(a) increases (b) decreases
(c) remains unaltered (d) can't be determined.

Group – B

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

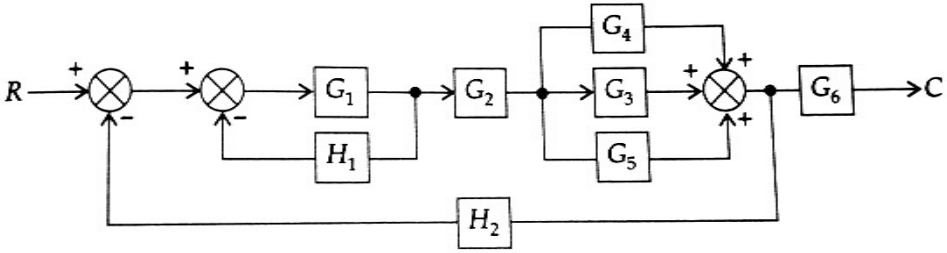

Figure 1

6 + 6=12

3. Consider the positional servo mechanism shown in Figure 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.

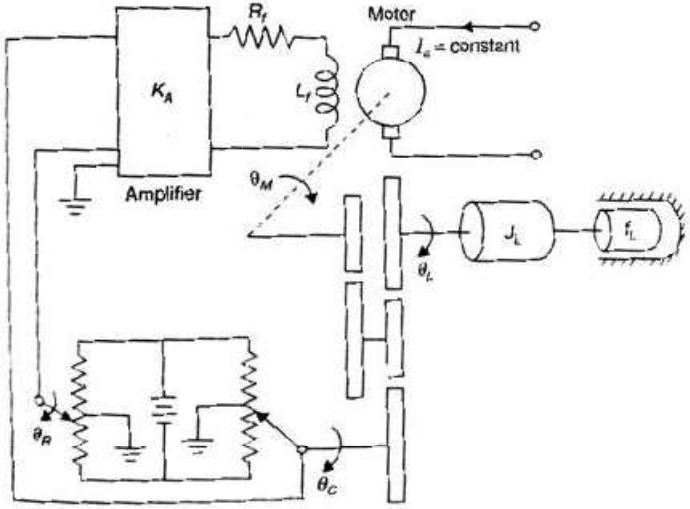

Figure 2

12

Group – C

4.(a) A unity negative feedback system has a forward path transfer function $G(s) = \frac{20}{s(s+5)}$. Determine (i) damping ratio, (ii) maximum overshoot, (iii) rise time, (iv) settling time and (v) peak time of the system when the input to the system is unit step.

(b) What do you mean by steady state error of a system?

(c) The open loop transfer function of a negative unity feedback control system is given by $G(s)H(s) = \frac{Ke^{-s}}{s(s^2+5s+9)}$. Determine the range of K (K>0) for which the system is stable.

5 + 1 + 6 =12

5. Sketch the complete root locus of the system whose open loop transfer function is given by

$$G(s)H(s) = \frac{K}{s(s+2)(s^2+4s+13)}$$

12

Group – D

6.(a) State "Nyquist stability criterion".

(b) The open loop transfer function of a unity negative feedback system is given by $G(s)H(s) = \frac{2(1-s)}{(s+2)(s+3)}$. Draw the Nyquist plot and hence comment on stability of the closed loop system.

2 + 10=12

7. The loop transfer of a unity negative feedback system is $G(s)H(s) = \frac{2000}{s(s+4)(s+10)}$. Draw the Bode plot. Hence find gain margin, phase margin, gain cross over and phase cross over frequency of the system. Comment on stability of the system.

7+4+1=12

Group – E

8. (a) Discuss the effects on the performances of a second order system with P-control, PD-control and PI-control action, respectively.

(b) Find the controllable canonical form of the system whose transfer function is

$$G(s) = \frac{s^2 + 2s + 1}{s^4 + 4s^3 + 6s^2 + 8s + 4}$$

6 + 6 = 12

9. (a) A system is described by

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

Check the controllability and observability of the system.

(b) A system is described by,

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

Using state feedback control, place the poles of the closed loop system to desired locations $s = -1 \pm j\sqrt{3}$ and $s = -10$.Determine the state feedback gain matrix.

4+8=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 $G(s) = \frac{K}{s^2(1+Ts)}$. The type and order of the system are
(a) 2 and 1 (b) 3 and 2 (c) 2 and 3 (d) 3 and 3.

(ii) The output of a linear system for a unit ramp input is given by te^{-t}. The transfer function is given by
(a) $\frac{s}{(s+1)^2}$ (b) $\frac{2s}{(s+1)^3}$ (c) $\frac{1}{s^2(s+1)}$ (d) $\frac{s^2}{(s+1)^2}$.

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

(iv) For a system the open loop transfer function is given by $G(s)\mathrm{H}(s) = \frac{\mathrm{k}(s+10)}{s(s+2)(s+5)}$. The centroid is located at
(a)-1.5 (b) 1.5 (c) -1 (d) 1.

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

(vi) The characteristics equation of a system is given by $s^2 + 2s + 4 = 0$, the values of natural frequency of oscillation and damping ratio are
(a) 0.5rad/sec and 2 (b) 2 rad/sec and 0.5
(c) 2 rad/sec and 1.2 (d) 4 rad/sec and 1