NEW SCHEME

EE43

USN

Fourth Semester B.E. Degree Examination, July/August 2004

BM/EC/EE/TE/ML/IT

Control Systems

Time: 3 hrs.] [Max.Marks : 100

Note: *Answer any FIVE full questions.*

1\. (a) The circuit of a bridged-T network is shown in the figure. Determine the transfer function $\frac{V_0(s)}{V_i(s)}$ of the network.

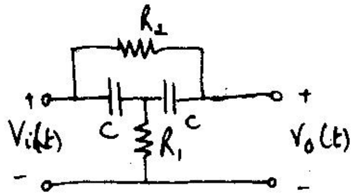


Fig. Q 1(a)

(8 Marks)

(b) Write the torque equations of the gear-train shown in the figure. The moment of inertias of the gears are lumped as J_1, J_2 and J_3, and the viscous-friction coefficients as B_1, B_2 and B_3. $T_m(t)$ is the applied torque. $N_1, N_2 N_3$ and N_4 are the number of gear teeth. Assume rigid shafts. Find the total inertia and the total viscous-friction which the motor sees.

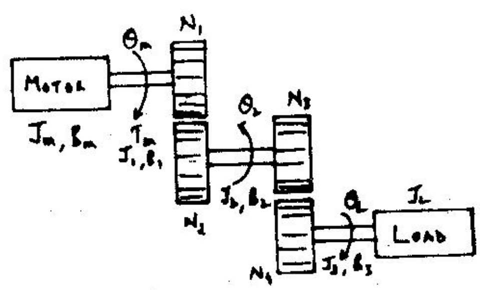


Fig. Q 1(b)

(12 Marks)

2\. (a) Using Mason's gain formula deduce the transfer function $\frac{Y(s)}{R(s)}$ for the signal flow graph shown in the figure. (12 Marks)

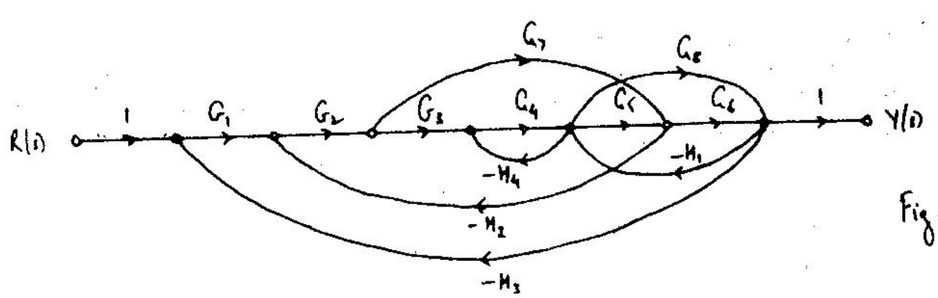


Fig. Q 2(a)

(b) The block diagram of a mechanical system is as shown in the figure. Obtain the transfer function $\frac{Y(s)}{R(s)}$ using block diagram reduction rules.

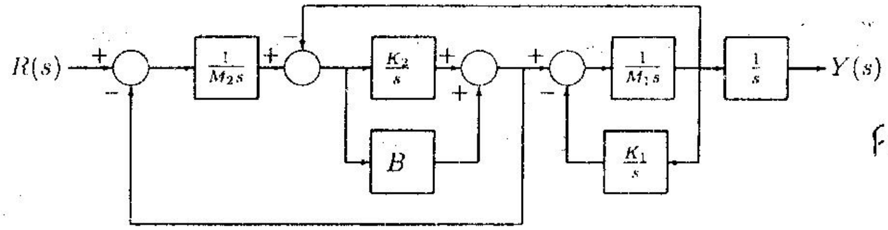


Fig. Q2(b)

(8 Marks)

3. (a) A submersible vehicle has a depth-control system as illustrated in the figure. (i) Determine the sensitivity of the closed-loop transfer function with respect to the parameter K_1. ii) Calculate the response y(t) for a unit step input, when $K = K_2 = 1$ and $1 < K_1 < 10$. Select the gain K_1 for the fastest response.

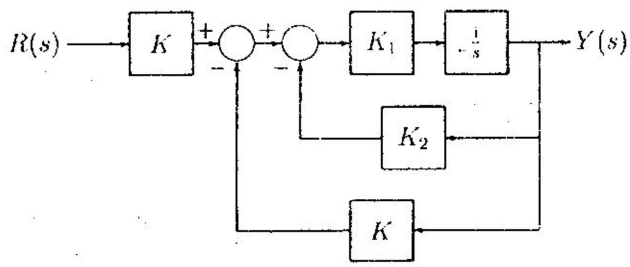


Fig. Q3(a)

(8 Marks)

(b) For the system shown in the figure, calculate the sensitivity of the closed loop system with respect to the function $G(s)$. Does the sensitivity depend on $U(s)$ or $M(s)$?

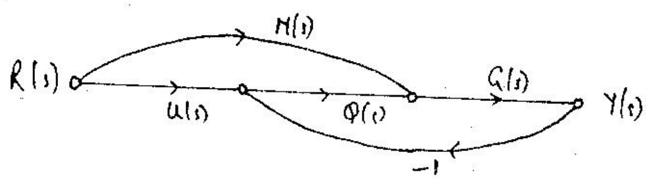


Fig. Q3(b)

(6 Marks)

(c) A negative feed back system with unity feedback has a plant $G(s) = \frac{2(s+8)}{s(s+4)}$. i) Find the response of the system for a unit step input. ii) Using the final value theorem, determine the steady-state value of the response for the same step input.

(6 Marks)

4. (a) Derive the transfer function from the applied armature voltage $e_a(t)$ to the rotor displacement $\theta_m(t)$ of an armature controlled DC motor. (6 Marks)

(b) For a system with characteristic equation $s^4 + Ks^3 + s^2 + s + 1 = 0$, determine the range of K for stability. (6 Marks)

(c) A plotter may be represented by the block diagram shown in the figure. i) Determine the value of the gain K that gives a peak overshoot of 4.32%. ii) For this value of K, determine the steady - state error for a unit ramp input. iii) For what range of K is the 2% settling time less than 1 sec. (8 Marks)

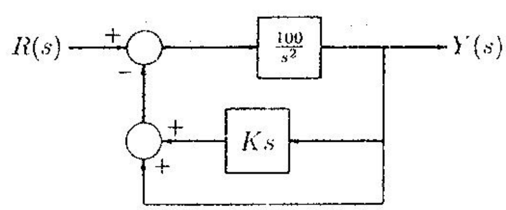


Fig. Q4(c)

5. (a) A feedback control system has a characteristic equation $s^6 + 2s^5 + 9s^4 + 16s^3 + 24s^2 + 32s + 16 = 0$. How many poles are i) in the left half of s-plane, ii) on the imaginary axis, and iii) on the right half of s-plane? **(6 Marks)**

(b) The control system for a wheelchair, designed for people paralyzed below the neck, may be represented by the block diagram illustrated in the figure. Typical values for the time constants are $\tau_1 = 0.5s, \tau_2 = 1s$, and $\tau_3 = 0.25s$. Determine the range of the gain $K = K_1K_2K_3$ for a stable system.

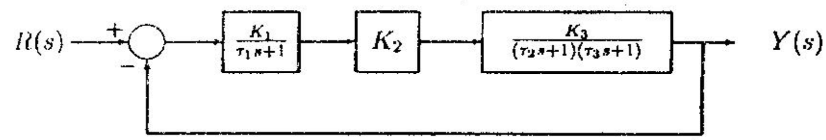


Fig: 5(b)

(6 Marks)

(c) Derive the condition on the impulse response so that the system is bounded-input bounded output (BIBO) stable. Show that for BIBO stability, the roots of the characteristic equation must all lie in the left half of s-plane. **(8 Marks)**

6. The open-loop transfer function of negative feedback system is given by

$$GH(s) = \frac{k(s+1)}{s(s-1)(s^2+4s+16)}$$

Sketch the root locus for $0 < k < \infty$ indicating all the relevant points. What do you call such systems? **(20 Marks)**

7. (a) The position control system is made up of components as shown in the figure. The polar plot of $G_1(s)$, and the magnitude plots of $G_2(s)$ are also as indicated. Sketch the Bode plot of the overall system

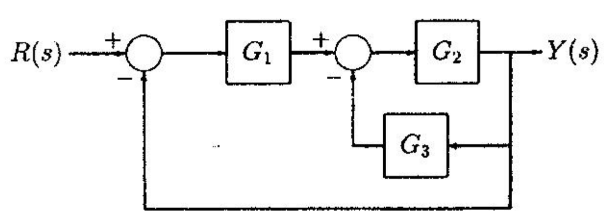
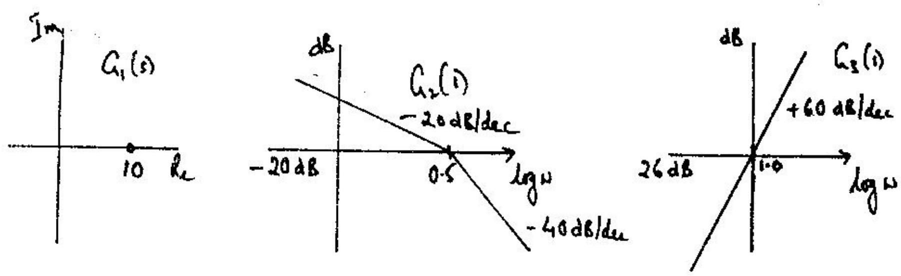


Fig. Q7(a)



(12 Marks)

(b) The polar plot of the open loop transfer function of a unity feedback control system is as shown in the figure. Assuming that the Nyquist path in the s plane encloses the entire right-half s plane, draw the complete Nyqist plot. i) If the open-loop transfer function has no poles in the right-half s plane, is the closed -loop system stable? ii) If the open-loop transfer function has one pole and no zeros in the right-half s plane, is the closed-loop system stable? iii) If the open-loop transfer function has one zero and no poles in the right-half s plane, is the closed-loop system stable?

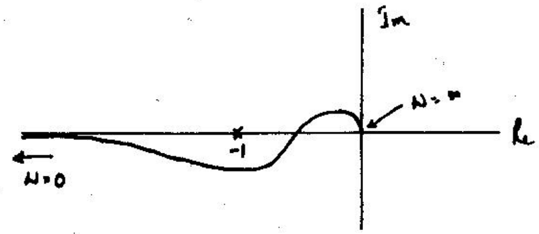


Fig. Q7(b)

(8 Marks)

8. (a) The figure shows a block diagram of a vehicle control system. Determine the gain K such that the phase margin is 50^0. What is the gain margin in this case? (5 Marks)

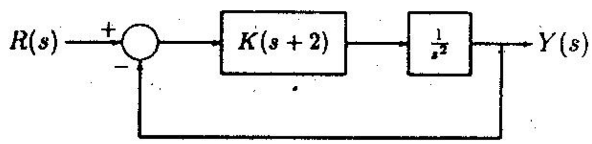


Fig. Q8(a)

(b) The open loop transfer function is $\frac{(s+2)(s+8)}{s^3}$. Is the closed loop system stable? If not, deduce the number of unstable poles. Use the Nyquist criterion to arrive at your answers. (11 Marks)

(c) Derive the condition used to determine the trajectories of the root loci in the s-plane. (4 Marks)

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