NEW SCHEME

ME55

USN

~~Fifth~~ 4th Semester B.E. Degree Examination, July/August 2005

Common to ME/IP/IM/MA/AU

Control Engineering

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

Note: *Answer any FIVE full questions.*
All questions carry equal marks.

1. (a) Distinguish between open loop and closed loop systems with examples. **(8 Marks)**

(b) Explain the requirements of a control system. **(4 Marks)**

(c) An electromechanical position control system is as shown in fig.1. The error signal is proportional to $(G-\infty)$. The rotating potentio meter constant is k. The output of the servo amplifier is proportional to the error signal. Amplifier constant is G. The torque produced by the servo motor is proportional to field current which is the output of the amplifier. This torque is required to accelerate the motor shaft, load shaft and to resist the viscous friction damping. J be the moment of inertia of the system and f be the coefficient of friction of the damper, 'n' is the gear ratio. Derive the equation for the positional control system and state the order of the system.

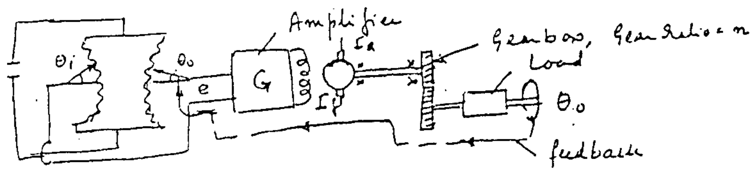

Fig. 1

(8 Marks)

2. (a) A second order control system is defined by a differential equation

$$\frac{d^2c(t)}{dt^2} + 6\frac{dc(t)}{dt} + 16c(t) = 16\,r(t)$$

It is supplied with a step input of 10mm

Find i) Transfer function ii) Damping factor iii) Natural frequency iv) Damped natural frequency v) Response of the system **(12 Marks)**

(b) Investigate the stability of the system. Using Routh Harwith Criterion - having the following characteristic equation.

$$s^5 = 4s^4 + 12s^3 + 20s^2 + 30s + 100 = 0$$ **(8 Marks)**

3. (a) Reduce the given block diagram and write the over all transfer ...nction of the system shown in fig 2.

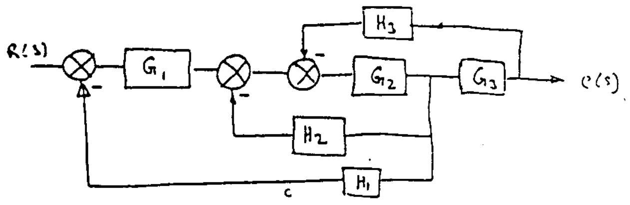

Fig. 2

(8 Marks)

(b) Obtain the overall transfer function $\frac{C}{R}$ from the signal flow graph shown in Fig 3.

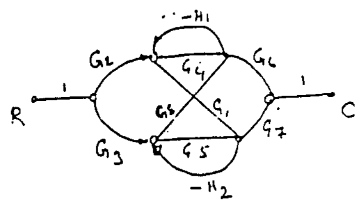

Fig. 3

(10 Marks)

4. (a) Explain integral control and show how integral control action can eliminate or reduce the steady state error in control system. (10 Marks)

(b) Explain proportional + Integral + differential controller and explain the effect on stability. (10 Marks)

5. (a) Define the terms peak resonance and resonant frequency. (4 Marks)

(b) Determine the peak resonance and resonant frequency for a second order control system represented by a closed loop transfer function.

$$\frac{C(s)}{R(s)} = \frac{25}{s^2+6s+25}$$ (6 Marks)

(c) The open loop turns for formation of a unity feed bach system in

$$G(s)H(s) = \frac{(3s+1)}{s^2(s+1)\,(2s+1)}$$

Sketch the Nyquist plot and asertain the stability. (10 Marks)

6. (a) Sketch Bode plots for the following transfeer function and obtain the phase and gain margins.

$G(s) = \frac{10}{s(s+1)(s+5)}$ and $1 + (s) = 1$ (10 Marks)

Contd.... 3

(b) Sketch t... ...rt locus diagram of the control system with an open loop transfer function.

$G(s)\ H(s) = \frac{k(s+1)}{s^2(s+10)}$ and find the maximum value of k for stability. (10 Marks)

7. (a) Write a brief note on system compensation. (6 Marks)

(b) The system shown below has to be modified by adding the compensation element $\frac{5\left(1+Q.\frac{s}{30}\right)}{\left(1+\frac{3}{200}\right)}$ tri series will at make the system stable.

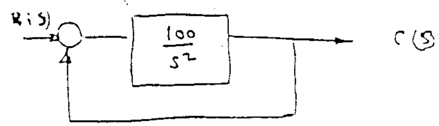

Fig. 4.

8. (a) Define the following :

i) Canonical state model

ii) Controllability

iii) Observability

(b) A feed back system has a closed loop trnsfer function.

$$\frac{C(s)}{R(s)} = \frac{10(s+4)}{S(s+1)\,(s+3)}$$

Construct any two different state models for the system and give block diagrams represented for each state models. (14 Marks)

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NEW SCHEME

ME55

USN

~~Fifth~~ 4th Semester B.E. Degree Examination, January/February 2005

Common to ME/IP/IM/MA/AU

Control Engineering

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

Note: *Answer any FIVE full questions.*

1. (a) Explain the terms:

   i) System ii) Disturbances
   iii) Transfer function iv) Open loop control system
   v) Block diagram

   (10 Marks)

   (b) Obtain the equivalent spring constant for the system shown in fig. Q.1(b) by writing equilibrium equation. (5 Marks)

   (c) Derive the transfer function of electrical circuit shown in fig. Q. 1. c. (5 Marks)

2. (a) Consider a liquid level system shown in fig. Q 2a. At steady state, the inflow rate and out flow rate are both $\overline{Q}$. The head of the tank is $\overline{H}$, at $t = 0$. The inflow rate is changed to $\overline{Q} + q$, where, q is small change in inflow rate. The resulting head changes by h_1 and outflow rate increases by q_1.

   The capacitance of tank is C_1. The resistance of the valve is R_1. Write down the governing differential equation. (5 Marks)

   (b) The open loop transfer function of a unity negative feedback control system is

   $$G(s) = \frac{25}{s(s+5)}$$

   Obtain maximum over shoot, peak time, rise time and settling time. (10 Marks)

   (c) Obtain an expression for time response of the first order system subjected to unit step input. (5 Marks)

3. (a) Find the range of K so that the system with following characteristic equation will be stable.

   $$s^4 + 5s^3 + 5s^2 + 4s + K = 0$$ (10 Marks)

   (b) Obtain the overall transfer function of the block diagram shown in Fig. 3(b) by reduction technique. (10 Marks)

Contd.... 2

4. (a) Write the Manson's gain formula for signal flow graph. Indicate what each term represents. (5 Marks)

(b) An integral controller is shown in fig. Q4 (b). Obtain steady state error for

i) unit step input

ii) unit ramp input (10 Marks)

(c) What is polar plot? Sketch a typical polar plot and indicate phase cross over frequency and gain cross over frequency. (5 Marks)

5. (a) State the Nyquist stability criterion. Write down the three possibilities that can occur while examining the stability of linear system using Nyquist stability criterion. (10 Marks)

(b) A unity negative feed back control system has

$$G(s) = \frac{80}{s(s+2)(s+20)}$$

i) Draw the bode plot (magnitude plot only)

ii) If phase cross over occurs at $\omega = 6.35$ find the correspoing gain margin. (10 Marks)

6. Sketch the root locus for the system having

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

For what value of K the system is stable. Comment on stability. (20 Marks)

7. Write notes on :

i) Lead compensator

ii) Lag compensator (20 Marks)

8. Consider the mechanical system shown in fig. Q 8. For shown displacement and velocities, obtain state model in standard form. (20 Marks)

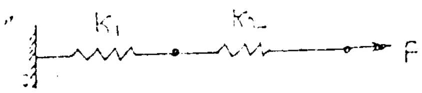

Fig. Q1. b

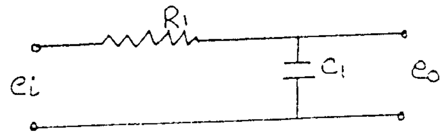

Fig. Q1. c.

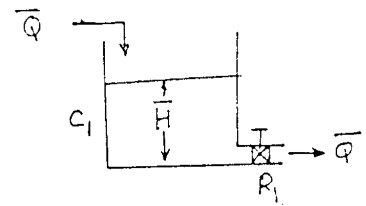

Fig. Q2. a.

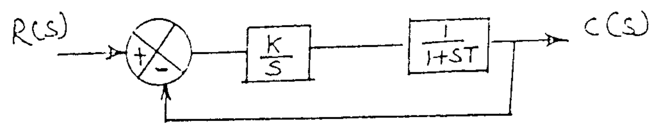

Fig. Q4. b

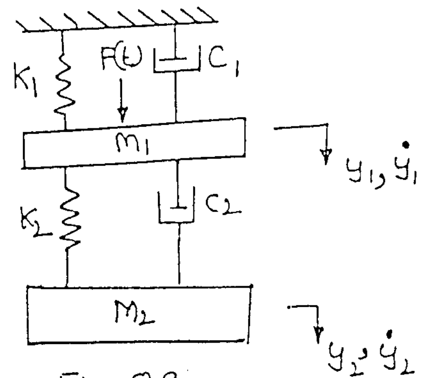

Fig. Q8

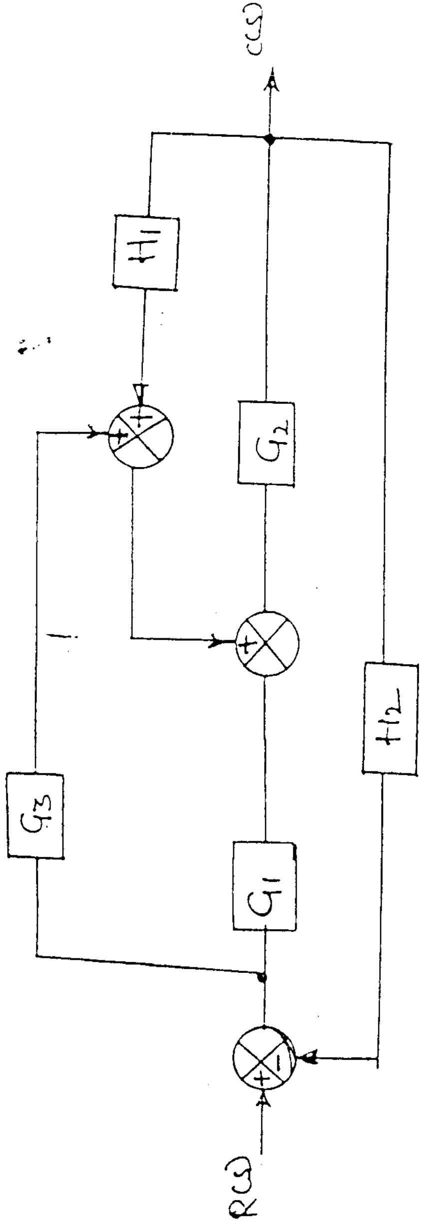

Fig. Q3.b.

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NEW SCHEME

ME55

Reg. No. [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

~~Fifth~~ 4th Semester B.E. Degree Examination, January/February 2006

Mechanical Engineering

Control Engineering

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

Note: *Answer any FIVE full questions.*

1. (a) What are the requirements of an ideal control system? Can they be met with (i) open loop system (ii) feed back system? Give a comparison between the two. **(10 Marks)**

   (b) Obtain the transfer functions of the mechanical and electrical systems shown in fig 1(a) and 1(b) and show that they are identical. **(10 Marks)**

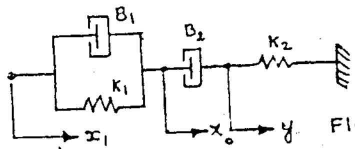

FIG 1(a)

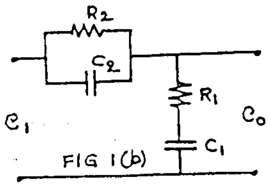

FIG 1(b)

2. (a) A simple system is defined by

   $T_m D^2 \theta_0 + D\theta_o = k_v e$ where $e = \theta_i - \theta_0$ in which T_m is the motor time constant and K_v is the velocity constant. When the system is subjected to a step input $\theta_i u(t)$, the response is found to be

   $$\theta_o = \theta_i\{1 + 0.207\, e^{-60.6t} - 1.2\, e^{-10.4t}\}$$

   i) Determine the damping ratio δ, K_v and T_m.

   ii) If K_v is increased until $\delta = 0.707$ find the new values of w_n and K_v. **(10 Marks)**

   (b) A unity feed back control system is as shown in Fig.2. Find the range of K as a function of T such that the system is stable. Comment on the effect of decreasing T on K for stability. Use R-H criterion. **(10 Marks)**

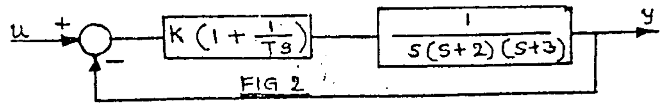

FIG 2

3. (a) Illustrate how to perform the following n connection with block diagram reduction techniques:

   i) moving a summing point ahead of a block and behind a block

   ii) moving a take off point ahead of a block and behind a block

   iii) transforming a non unity feed back to a unity feed back. **(10 Marks)**

Contd.... 2

(b) Explain Mason's gain formula. Use it to determine the transmitt[illegible] of the flow graph shown in fig.3. Given $A = B = \frac{1}{s+1}$. (10 Marks)

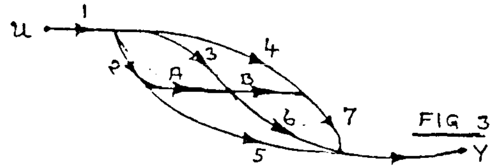

FIG 3

4. (a) Give a classification of automatic controllers. Draw a block diagram of an industrial control system and mention the function of each block in it. (10 Marks)

(b) Explain, giving equations, the functions of

i) integral control

ii) proportional plus derivative control and

iii) proportional plus integral plus derivative control with respect to system performance.

(10 Marks)

5. (a) Draw the Bode plot for the system shown in fig. 4. Determine the phase margin and the gain margin. (10 Marks)

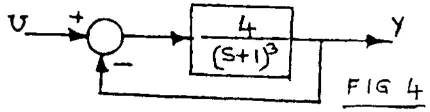

FIG 4

(b) For the polar plot shown in fig. 5,

i) determine the gain margins in dB and the phase margins if $OA = -0.5$, $OB = -1$, $OC = -2$, $OD = -2.5$, $OE = -0.866 + J0.5$ and $OF = -0.643 - J0.766$.

ii) Complete the Nyquist plot and determine whether the system is stable if all the poles are in LH of S plane. (10 Marks)

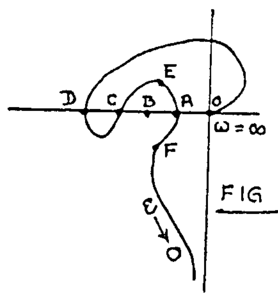

FIG 5.

6. (a) As applied to root locus, explain how to

i) determine the angle of departure from a complex pole

ii) determine the breakaway points if they are present

iii) calculate k on a given point on the root locus. (10 Marks)

Contd.... 3

(b) The loc[illegible]nsfer function of a unit feedback control system is

$$G(s) = \frac{k}{s^3 + 3s^2 + 2s - 7}$$

Draw the root locus diagram, mark the salient points and determine the range of k for a closed loop system to be stable. (10 Marks)

7. (a) What is compensation in control systems? Distinguish between series compensation and feedback compensation. Explain the basic principle for designing a parallel compensated system. (10 Marks)

(b) Give a summary of the characteristics of the phase-lead and phase-lag compensation networks with reference to

i) approach ii) relative merits ii) end results and iv) applications. (10 Marks)

8. (a) Obtain matrix state and output equations in

i) phase variable and

ii) diagonal forms of a mechanical system with transfer function

$$T(s) = \frac{s^3 + 8s^2 + 17s + 8}{s^3 + 6s^2 + 11s + 6}$$

(10 Marks)

(b) Use controllability and observability matrices to determine whether the system represented by the following flow graph is completely controllable and completely observable (fig. 6) (10 Marks)

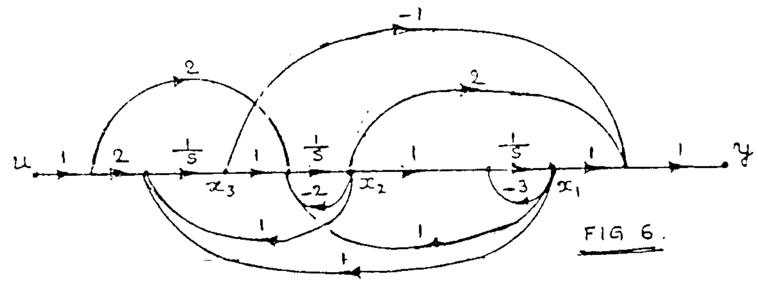

FIG 6.

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USN

NEW SCHEME

Fifth Semester B.E. Degree Examination, Dec.06 / Jan.07

ME / IP / MA / AU

Control Engineering

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

Note: *1. Answer any FIVE full questions.*

1 a. What are the requirements of an ideal control system? **(05 Marks)**

b. Differentiate between open loop system and closed loop system. **(05 Marks)**

c. Derive the transfer function for an armature controlled DC motor. The field current is maintained constant during operation. Assume that the armature coil has back emf $e_b = K_b \frac{d\theta}{dt}$ and the coil current produces a torque $T = K_m I$ on the rotor. K_b and K_m are the back emf constant and motor torque constant respectively. **(10 Marks)**

2 a. Figure Q2 (a) shows a mechanical vibratory system. When 1 kN force is applied to the system, the mass oscillates as shown. Determine the mass M, damping coefficient B and the spring stiffness K of the system from this response curve. **(10 Marks)**

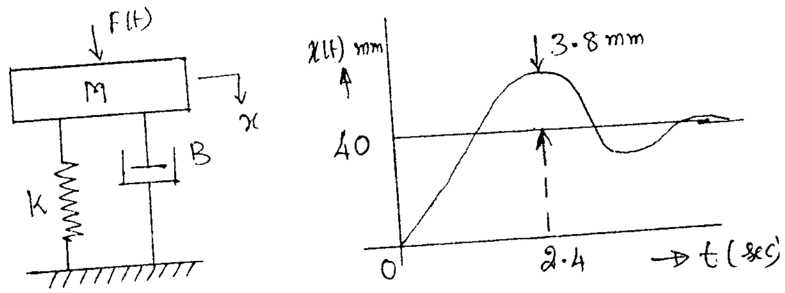

Fig. Q2 (a)

b. By applying Routh criterion, discuss the stability of the closed loop system as a function of K for the following open loop transfer function. **(10 Marks)**

$$G(S)H(S) = \frac{K(S+1)}{S(S-1)(S^2+4S+16)}.$$

3 a. Reduce the block diagram shown in figure Q3 (a) to canonical form and determine its control ratio. **(10 Marks)**

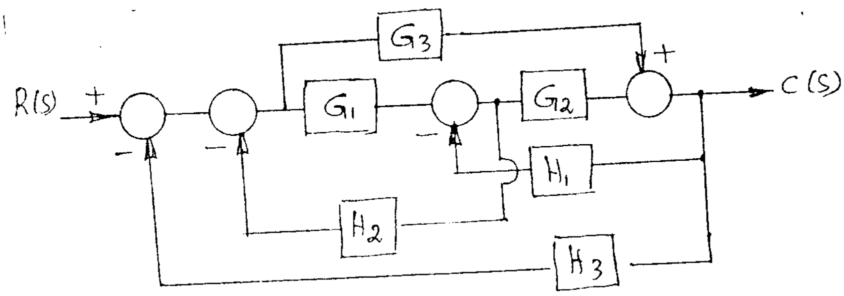

Fig. Q3 (a), Q3 (b)

b. Draw the signal flow graph for the block diagram shown in figure Q3 (b) and find its control ratio using Mason's formula. **(10 Marks)**

Contd... 2

4 a. Describe an integral controller with suitable example. What are the characteristics of integral controller? **(08 Marks)**

b. Prove that in an integral controller the steady state error is zero. **(06 Marks)**

c. Describe a controller which will improve the transient behavior of the system. **(06 Marks)**

5 a. The open loop transfer function of a unity feedback system is

$$G(S) = \frac{Ke^{-0.1S}}{S(1+0.1S)(1+S)}.$$

By drawing Bode attenuation plot, determine the value of K so that the gain margin of the system is 20 db. **(10 Marks)**

b. Define phase margin and gain margin using Nyquist plots. **(05 Marks)**

c. Write a note on M and N circles. **(05 Marks)**

6 Draw the complete root-locus diagram for the system with open loop transfer function.

$$G(S)H(S) = \frac{K(S+1)}{S^2(S+3)(S+5)}$$

Hence determine the range of variation of K over which the system remains stable. **(20 Marks)**

7 a. What is compensation? How are compensators classified? **(05 Marks)**

b. Derive the transfer function of the lead network and find the frequency at which the phase lead of a lead network is maximum. What are the characteristics of lead compensator? **(15 Marks)**

8 a. Choosing suitable state variable, construct a state model for a spring, mass and damper system. **(05 Marks)**

b. Is the system completely state controllable and completely observable? Use Kalman's method.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

(15 Marks)

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ME55

USN

NEW SCHEME

~~Fifth~~ Semester B.E. Degree Examination, July 2007
ME / IP / IM / MA / AU
Control Engineering

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

Note : ***Answer any FIVE full questions.***

1 a. Explain the concept of feed back control system and the requirements of an ideal control system. **(10 Marks)**

b. Explain the working principle of an automatic electric iron with temperature control using block diagram. List the advantages of this system with conventional non automatic electric iron. **(10 Marks)**

2 a. Derive an expression for the translational response of a mechanical Mass-Spring-Damper system with a small damping for a step input. Sketch the response of this system. **(10 Marks)**

b. Explain Routh-Hurwitz criterion for stability of a control system and examine the stability of $S^4 + 2S^3 + 3S^2 + 8S + 2 = 0$ using the same. **(10 Marks)**

3 a. Reduce the given block diagram shown in figure Q3 (a) and then obtain the transfer function of the system if $G_1 = G_2 = 1$, $G_3 = G_4 = 2$ and $H_1 = H_2 = 1$, $H_3 = 2$. **(10 Marks)**

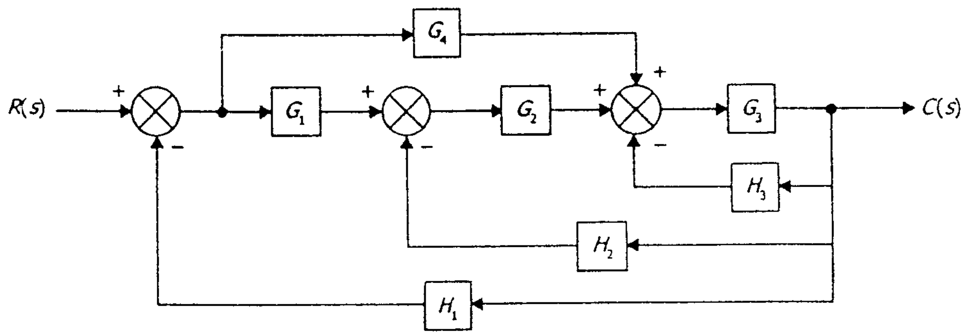

Fig. Q3(a)

b. Find the transfer function of the system shown in figure Q3 (b) using Mason's gain formula. **(10 Marks)**

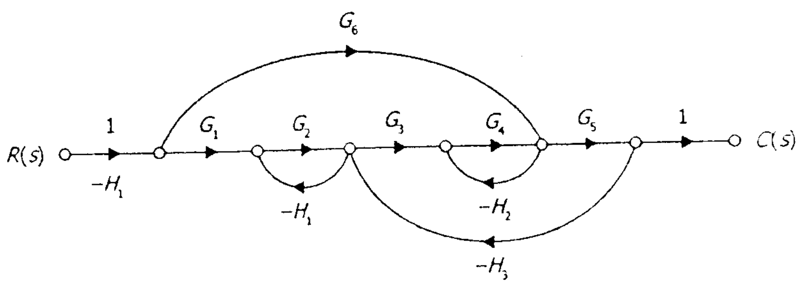

Fig. Q3 (b)

Contd....2

4 a. Explain integral control and show how integral control action can eliminate or reduce the steady state error in control system. **(10 Marks)**

b. Explain proportional + integral + differential controller and their effect on stability. **(10 Marks)**

5 a. The open loop transfer function of a control system is

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

Sketch the Nyquist plot, path and ascertain the stability. **(10 Marks)**

b. A unity feed back control system has

$$G(s)H(s) = \frac{K}{s(s+4)(s+10)}$$ **(10 Marks)**

Draw the Bode plot and find the value of K for which the system is marginally stable.

6 Construct a Root-locus plot for the open loop transfer function

$$G(s)H(s) = \frac{K(s+2)}{s(s+1)(s+8)}$$ **(20 Marks)**

7 a. Write short note on series and feedback compensation. **(10 Marks)**

b. Explain any one physical device for Lag-lead system compensation. **(10 Marks)**

8 a. Explain controllability and observability with suitable examples. **(10 Marks)**

b. A feed back control system has a closed loop transfer function,

$$\frac{C(s)}{R(s)} = \frac{10(s+4)}{s(s+1)(s+2)}$$

construct any two different state models for the system and suggest the block diagrams represented for each state variable. **(10 Marks)**

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USN

06ME71

Seventh Semester B.E. Degree Examination, Dec.09/Jan.10
Control Engineering

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. Explain open loop and closed loop control systems, with block diagrams. What are the advantages and disadvantages of a closed loop system over an open loop system? **(10 Marks)**

b. What are the requirements of a control system? Briefly explain. **(05 Marks)**

c. Draw the block diagram of proportional integral controller and explain. **(05 Marks)**

2 a. Obtain the differential equations for the mechanical system shown in Fig.2(a). **(10 Marks)**

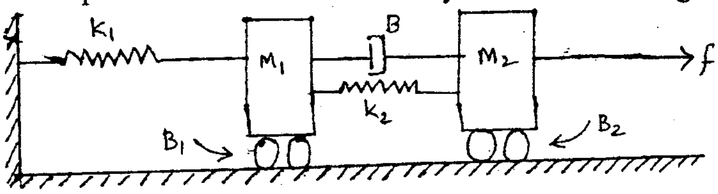

Fig.2(a)

b. A thermometer is dipped in a vessel containing liquid at a constant temperature of $\theta_i(t)$. The thermometer has a thermal capacitance for storing heat as C and thermal resistance to limit heat flow as R. If the temperature indicated by the thermometer is $\theta_o(t)$, obtain the transfer function of the system. **(10 Marks)**

3 a. Reduce the block diagram shown in Fig.3(a) to its simplest possible form and find its closed loop transfer function. **(10 Marks)**

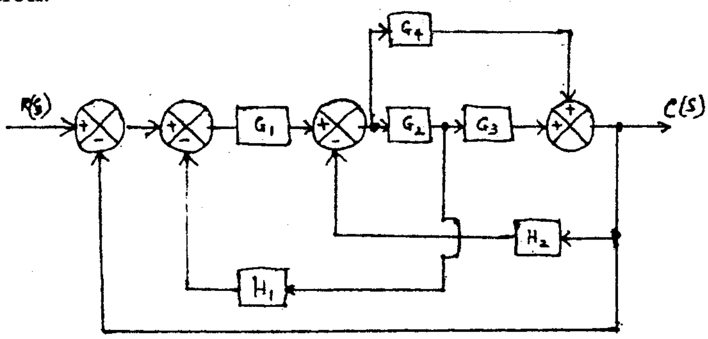

Fig.3(a)

b. For the system shown in Fig.3(b) determine $\dfrac{C(s)}{R(s)}$ using Mason's gain formula. **(10 Marks)**

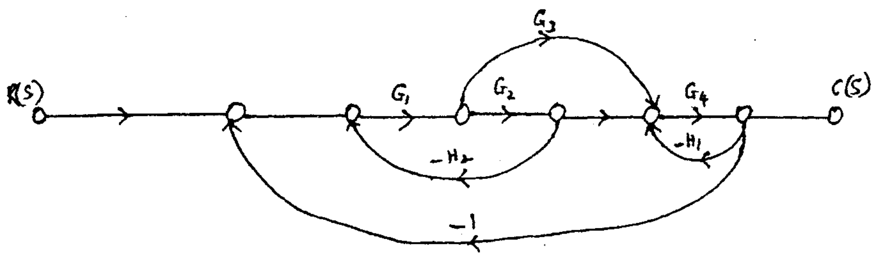

Fig.3(b).

4 a. Aunity feedback system is characterized by an open loop transfer function $G(S) = \frac{10}{S^2 + 5S + 6}$

Determine the following, when the system is subjected to a unit step input.

i) Undamped natural frequency
ii) Dampimg ratio
iii) Peak overshoot
iv) Peak time
v) Setting time. **(12 Marks)**

b. Ascertain the stability of the system given by the characteristic equation, $S^6 + 3S^5 + 5S^4 + 9S^3 + 8S^2 + 6S + 4 = 0$, by Routh Hurwitz criterion. **(08 Marks)**

PART – B

5 a. Sketch the polar plot for the transfer function $G(S) = \frac{10}{S(S+1)(S+2)}$. **(08 Marks)**

b. Apply Nyquist stability criterion to the system with transfer function $G(s)H(s) = \frac{4S+1}{S^2(1+S)(1+2S)}$ and ascertain its stability. **(12 Marks)**

6 Sketch the Bode plot for $G(s)H(s) = \frac{2}{S(S+1)(1+0.2S)}$. Also obtain gain margin and phase margin and crossover frequencies. **(20 Marks)**

7 Sketch the root locus plot for the system, whose open loop transfer function is given by $G(s)H(s) = \frac{K}{S(S+2)(S^2+8S+20)}$. **(20 Marks)**

8 a. Explain the need for system compensation. List the types of compensators used. **(10 Marks)**

b. Explain the following systems, with block diagrams.

i) Series compensated system
ii) Feedback compensated system. **(10 Marks)**

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