BITS, PILANI – DUBAI CAMPUS

Knowledge Village, Dubai

Year III – Semester I 2004 – 2005

TEST I (Closed Book)

Course No.: AAOC UC321 Course Title: Control Systems

Date: October 10, 2004 Time: 50 Minutes M.M. = 20 (20 %)

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1. *- EACH PART OF THIS QUESTION CARRIES 1 MARK EACH.*

(a) What is the analogous quantity of spring stiffness in electrical system using Force-Voltage analogy?

(b) In a closed loop control system
(i) input signal controls the output
(ii) error signal does not change
(iii) feedback signal controls the output
(iv) actuating signal controls the output

(c) If the forward path gain of a unity negative feedback control system is G(s), Then the closed loop transfer function of the system will be ....

(d) Inertia and friction parameters are referred from one shaft of the gear train to the other in the direct ratio of ....

(e) In the following pick up the linear systems

(A) $\frac{d^2y(t)}{dt^2} + a_1\frac{dy(t)}{dt} + a_2y(t) = u(t)$ (B) $y\frac{dy(t)}{dt} + a_1y(t) = a_2u(t)$

(C) $2\frac{d^2y}{dt^2} + t\frac{dy}{dt} + t^2y(t) = 5$

(i) (A) and (B) (ii) (A) only
(iii) (A) and (C) (iv) (B) and (C)

2. Derive the transfer function of an armature controlled DC motor and draw the corresponding block diagram. (5)

3. Write the differential equation of the mechanical system shown in figure (1) and obtain its transfer function. (5)

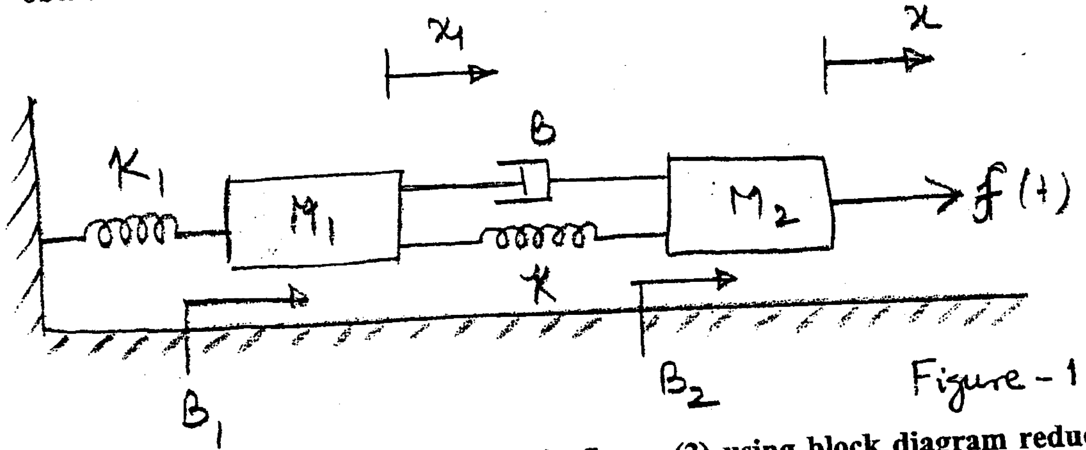

Figure - 1

4. Simplify the block diagram shown in figure (2) using block diagram reduction technique and obtain the closed-loop transfer function $C(s)/R(s)$. (5)

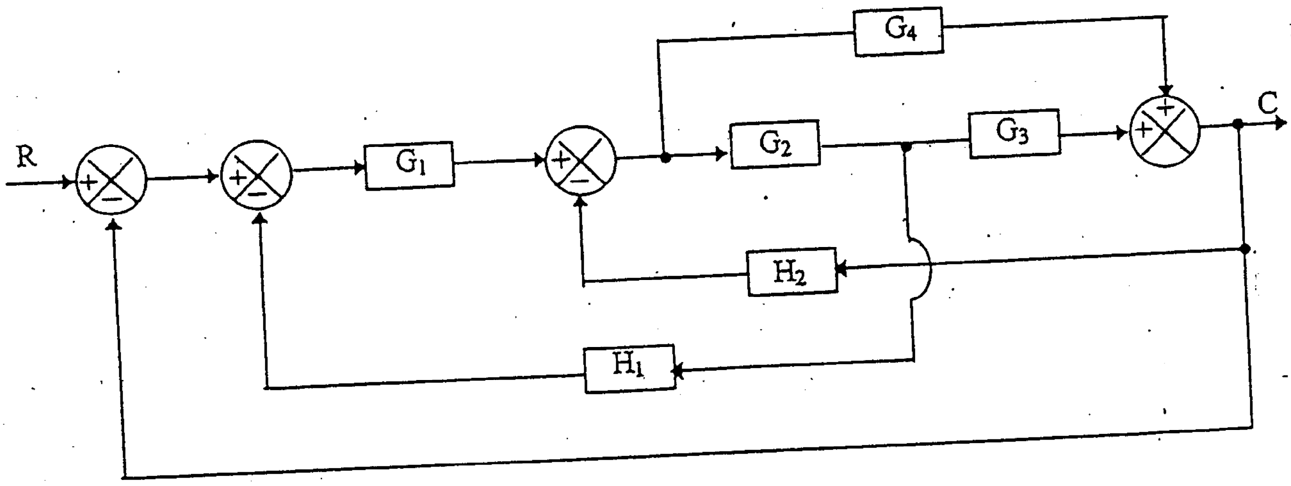

Figure - 2

BITS, PILANI – DUBAI CAMPUS

Knowledge Village, Dubai

Year III – Semester I 2004 – 2005

TEST I [Make up](Closed Book)

Course No.: AAOC UC321 **Course Title: Control Systems**

Date: **Time: 50 Minutes** **M.M. = 20 (20 %)**

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1. *EACH PART OF THIS QUESTION CARRIES 1 MARK EACH.*

(a) The feed back loop of a control system can drive the system to instability. True / False.

(b) The transfer function of a linear time –invariant system is defined as……………

(c) In case of mechanical rotational elements, the through variable is……….. and across variable is…………..

(d) In a linear control system

(i) the input signal follows the output

(ii) the input signal linearly follows the output

(iii) the input signal does not follow the output

(iv) the output linearly follows the input

(e) Friction may be introduced internally in a system by use of ………………

2. Derive the transfer function of Gear train system with respect to motor shaft.

(5)

3. Write the differential equations for the mechanical rotational system shown in figure (1). Obtain the transfer function of this system. (5)

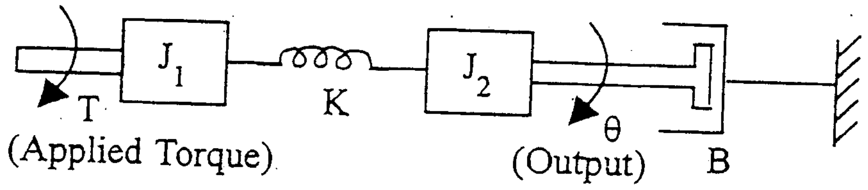

Figure 1

4. Determine the overall transfer function C(s) / R(s) for the system shown below. (5)

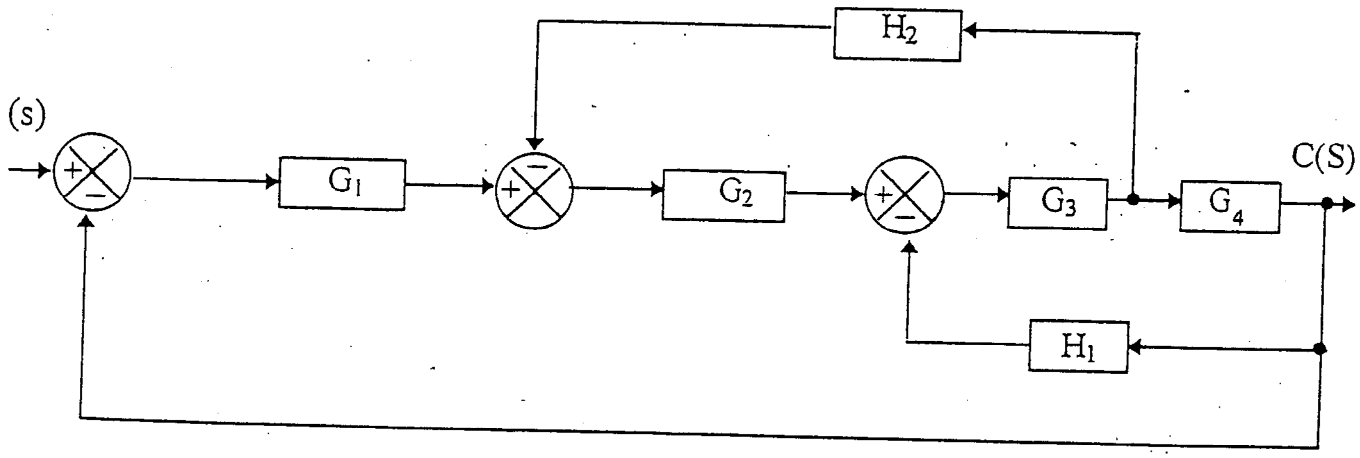

Figure 2

BITS, PILANI – DUBAI CAMPUS

Knowledge Village, Dubai

Year III – Semester I 2004 – 2005

TEST II (Open Book)

Course No.: AAOC UC321 Course Title: Control Systems

Date: December 01, 2004 Time: 50 Minutes M.M. = 20 (20 %)

NOTE: Only Text Book is allowed for answering questions.

1. Draw the signal flow graph of the block diagram given in figure (1). Use the Mason's gain formula to find the transfer function of the system.

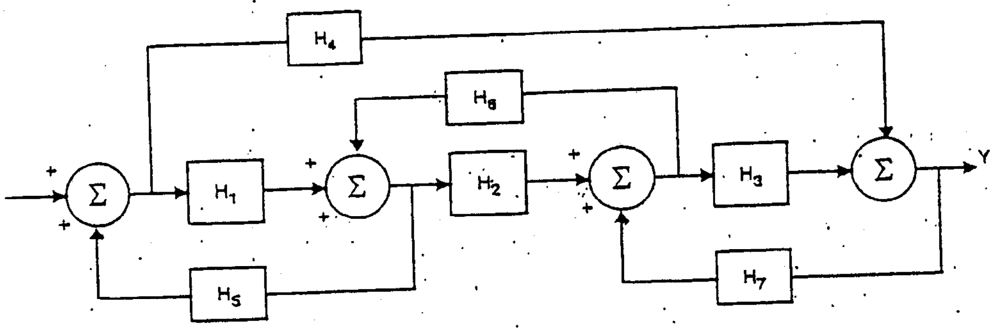

Figure (1)

2. The SFG of figure (2) describes a speed control system using an armature controlled d.c. motor. The output of the system is speed ω(s) while the input is voltage $V_1(s)$. Determine the sensitivity of the system $S_K^{M_d}$ and $S_{K_b}^{M_d}$. (Here $M_d(s) = \frac{\omega(s)}{T_d(s)}$.

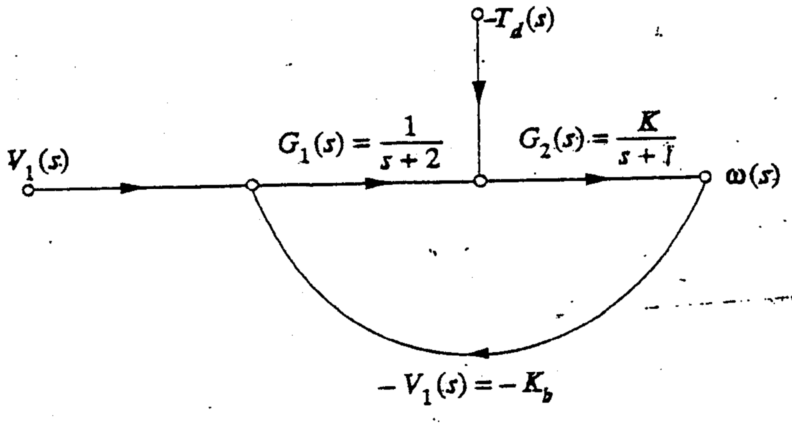

Figure (2)

3. A feedback system which employs output-rate damping is shown in figure (3).

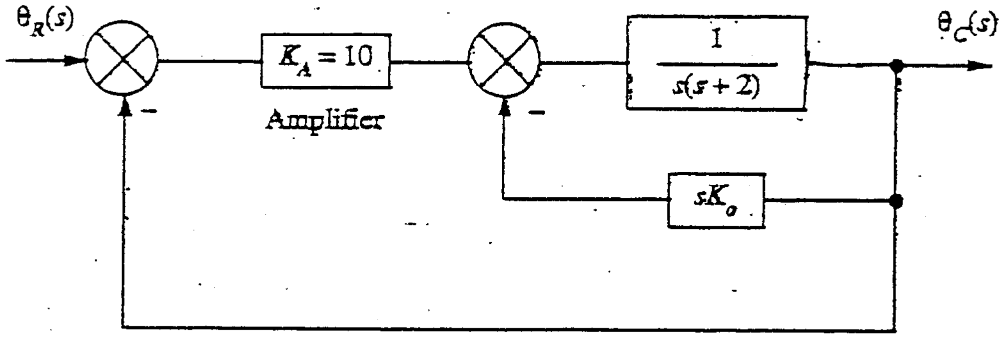

Figure (3)

(a) In the absence of derivative feedback ($K_o = 0$), determine the damping factor and natural frequency of the system. What is the steady state error resulting from unit ramp input?

(b) Determine the derivative feedback constant K_o, which will increase the damping factor of the system to 0.6. What is the steady-state error to unit ramp input with this setting of the derivative feedback constant?

4. A positional control system with velocity feedback is shown in figure (4). For damping ratio (ξ) = 0.5, obtain the expression for the response c(t) to the unit step input?

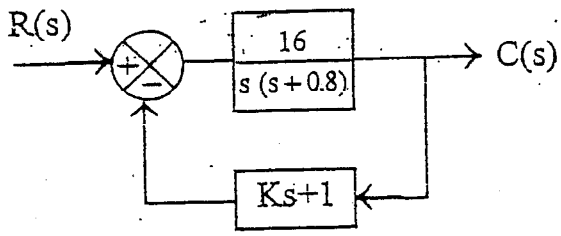

Figure (4)

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BITS, PILANI – DUBAI CAMPUS

Knowledge Village, Dubai

Year III – Semester I   2004 – 2005

QUIZ I (Closed Book)

Course No.: AAOC UC321   **Course Title: Control Systems**

Date: October 25, 2004   **Time: 30 Minutes**   **M.M. = 20 (10 %)**

NOTE: Tick the appropriate one of the given options, fill-up the blanks and draw the diagrams in the question paper itself. Each question carries equal mark. All the symbols carry their usual meanings, unless otherwise stated.

1. **By the use of feedback, the system gain is ...... (increased/decreased).** ✓

2. **One of the ideal element used in the fluid systems is the fluid capacitance, which is defined as**

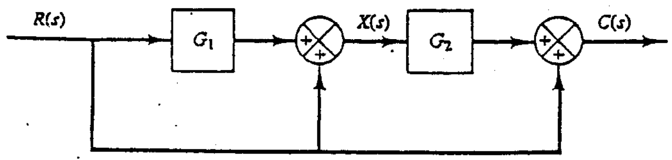
   ✓ (i) $\frac{A}{\rho g}$ $\left(\frac{m^3}{N/m^2}\right)$

   (ii) $\frac{\rho l}{A}$ $\left(\frac{Ns^2}{m^5}\right)$

   (iii) $\rho g H$ $\left(\frac{N}{m^2}\right)$

   (iv) None of the above

3. **The overall transfer function $\frac{C(s)}{R(s)}$ of the following block diagram will be ....**



$X(s) = G_1 R(s) + R(s)$

$C(s) = X(s) G_2 + R(s)$

$= (G_1 R(s) + R(s)) G_2 + R(s)$

$= G_1 G_2 R(s) + G_2 R(s) + R(s)$

$\frac{C(s)}{R(s)} = G_1 G_2 + G_2 + 1$

4. The force of sliding friction between dry surfaces is called COULOMB FRICTION FORCE

5. In the signal flow graph terminology a node with only out going branches is referred as INPUT NODE (or) SOURCE; whereas a node with only incoming branches is called OUTPUT NODE (or) SINK.

6. In the Mason's gain rule; Δ_k is stands for

(i) Δ for that part of the graph not touching the k^{th} forward path.

(ii) Δ for that part of the graph touching the k^{th} forward path.

(iii) Δ for that part of the graph not touching the k^{th} loop.

(iv) Δ for that part of the graph not touching the k^{th} loop.

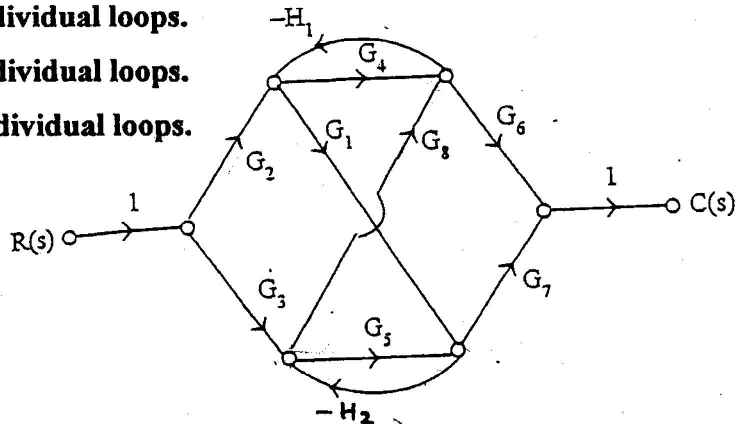
7. In the following signal flow graph, in order to use the Mason's gain rule, count the number of forward paths and number of individual loops.

(i) Six forward paths and three individual loops.

(ii) Four forward paths and three individual loops.

(iii) Five forward paths and three individual loops.

(v) Six forward paths and two individual loops.



8. According to Reynols experiments, pipe flow will be laminar for Re

(a) less than 2,000.

(b) more than 3,000.

(c) between 2,000 and 3,000.

(d) can't tell by simply knowing the Re.

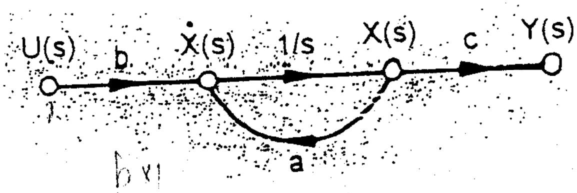
9. Transfer function $\frac{Y(s)}{U(s)}$ of the following signal flow graph is

(a) $\frac{bc}{s-a}$

(b) $\frac{s-a}{s}$

(c) $\frac{bc}{s}$

(d) $\frac{bc}{as}$



BITS, PILANI – DUBAI CAMPUS

Knowledge Village, Dubai

Year III – Semester I 2004 – 2005

COMPREHENSIVE EXAMINATION (Closed Book)

Course No.: AAOC UC321 **Course Title: Control Systems**

Date: January 4, 2005 **Time: 3 Hours** **M.M. = 80 (40 %)**

NOTE:

1. *ANSWER ALL QUESTIONS FROM PART A AND ANY SIX QUESTIONS FROM PART B.*
2. *IF YOU ARE USING GRAPH OR SEMIGRAPH SHEETS, FIRST GET IT SIGNED BY THE INVIGILATOR THEN ONLY USE IT. GRAPH SHEETS USED WITHOUT INVIGILATOR'S SIGNATURE WILL NOT BE ACCEPTED.*
3. *ALL THE SYMBOLS CARRY THEIR USUAL MEANINGS UNLESS OTHRWISE INDICATED.*
4. *ANY MISSING DATA CAN BE ASSUMED, BUT NEED TO BE MENTIONED.*

PART - A

(2 x 10 = 20)

1. (a) The transfer function is $\frac{K}{(s+1)(s+2)(s+3)}$. The break point will be between

(i) 0 and -1 (ii) -1 and -2 (iii) -2 and -3 (iv) beyond -3

(b) The root- locus plot is shown in Figure (1). What is the transfer function?

(i) $\frac{4}{s+1}$

(ii) $\frac{4}{(s+1)^2}$

(iii) $\frac{4}{(s+1)^3}$

(iv) $\frac{4}{(s+1)^4}$

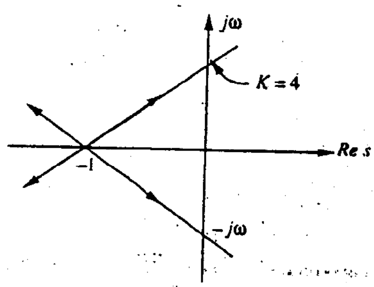


Figure 1

(c) A minimum-phase function has m finite poles and n finite zeros. Its phase angle at $\omega = \infty$ is

(i) 0 radians (ii) $(m-n)\frac{\pi}{2}$ *radians*

(iii) $(n-m)\frac{\pi}{2}$ *radians* (iv) π radians

(d) The open-loop transfer function of a feedback system is $G(s)H(s) = \frac{K(s+1)(s+2)}{s(s+3)(s+4)}$. The real axis segments of the root locus lies between

(i) 0 and -1; -2 and -3; -4 and -∞

(ii) -1 and -2; -3 and -4

(iii) -1 and -1.5; -.5 and -4

(iv 0 and -1; -2 and -∞

(e) Figure (2) below gives two equivalent block diagrams

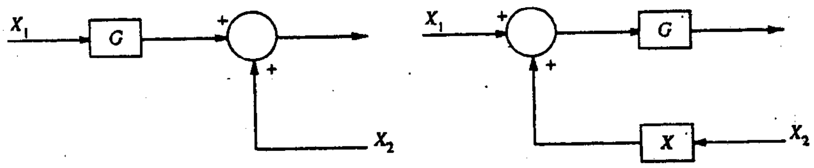


Figure (2)

The value of transfer function of block marked 'X' is given by

(i) G(s) (ii) $\frac{1}{G(s)}$ (iii) 1 (iv) 1 + G(s)

(f) Using Routh's criterion, Find whether the system, having characteristic equation as $S^4 + 8S^3 + 18s^2 + 16s + 5 = 0$, is stable or not.

(g) In a series RLC circuit, the transfer function of the output voltage across the capacitor in terms of supply voltage is

(i) $\dfrac{sC}{R+sL}$ (ii) $\dfrac{sC}{s^2+sR+1}$

(iii) $\dfrac{sC}{s^2+sR+1/LC}$ (iv) $\dfrac{1}{s^2LC+sRC+1}$

(h) In the gear train shown in Figure (3), the ratio $\dfrac{\theta_1}{\theta_2}$ is equal to

(i) $\dfrac{N_1}{N_2}$

(ii) $\dfrac{N_2}{N_1}$

(iii) 1

(iv) $\left(\dfrac{N_1}{N_2}\right)^2$

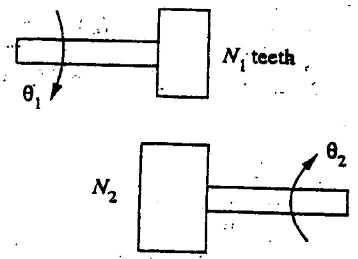


Figure (3)

(i) What is the gain (i.e., $\dfrac{output}{input}$) of the system, whose block diagram is given below in Figure (4):

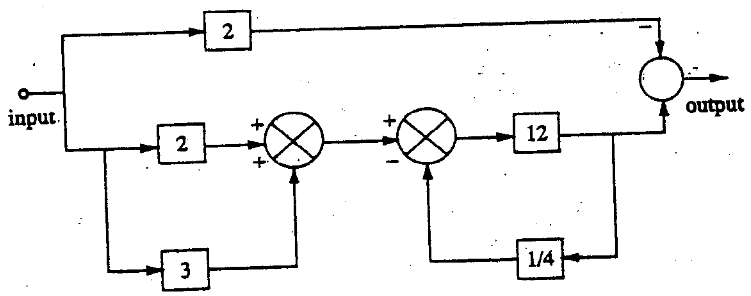


Figure (4)

(i) 36 (ii) 13 (iii) 90 (iv) -10

(j) What is Nyquist criterion?

PART - B (6 x 10 = 60)

2. Draw the force voltage analogous circuits of the mechanical system shown in Figure (5). Write down mesh equations of the obtained electrical circuit and convert them into differential equations governing the mechanical system.

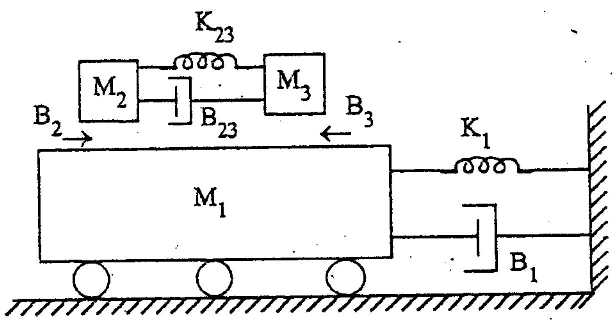


Figure (5)

3. The block diagram of a feedback control system is shown in Figure (6) below:

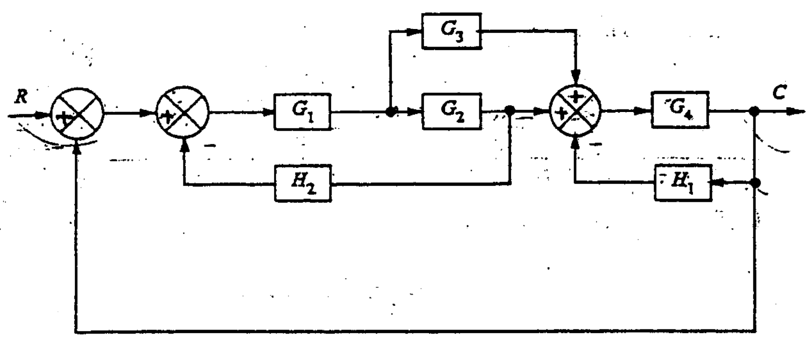


Figure (6)

(a) Draw the signal flow graph of the system.

(b) Find the overall transfer function of the system $\frac{C(s)}{R(s)}$ by applying Mason's gain formula.

4. A unity feedback system has $G(s)=\frac{K_1}{s(s+1)(0.5s+1)}$ and $r(t)=5t$

(a) If $K_1 = 1.5\ sec^{-1}$ determine $e(t)_{ss}$

(b) Find the minimum value of K_1 for $e_{ss} \leq 0.1$ for a unit ramp input.

5. Sketch the root locus for $0 < K < \infty$, for the system with open- loop transfer function

$$G(s)\cdot H(s)=\frac{K}{s(s+3)(s^2+2s+2)}$$

6. Plot the Bode curves for the following transfer function and obtain the gain and phase cross over frequencies.

$$G(s)=\frac{10}{s(1+0.4s)(1+0.1s))}$$

7. Draw the Nyquist plot for the system whose open loop transfer function is

$$G(s)H(s)=\frac{K}{s(s+2)(s+10)}$$

Determine the range of K for which closed loop system is stable.