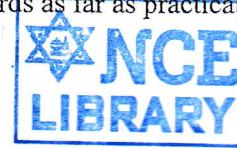


TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
**Examination Control
Division**
2080 Baishakh

Exam. Level	BE	Back	Full Marks	80
Programme	BEL,BEX,BIE,BME,BAM	Pass Marks	32	
Year / Part	III / I	Time	3 hrs	

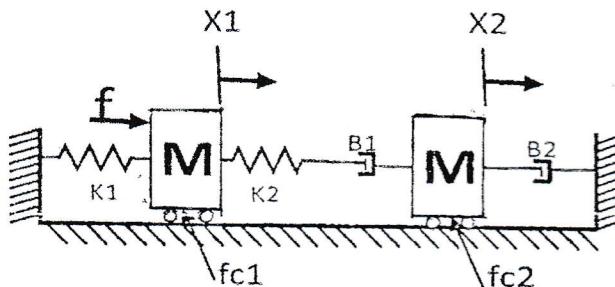
Subject: - Control System (EE 602)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks
- ✓ Semi-log graph paper will be provided.
- ✓ Assume suitable data if necessary.

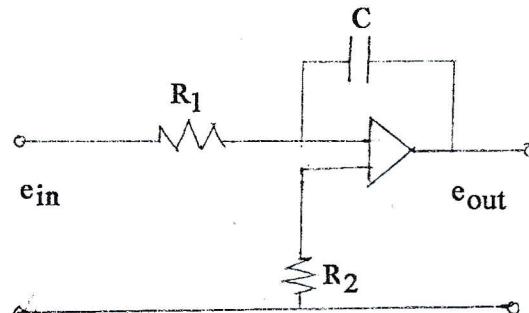


1. a) System response is faster in closed loop control system than in open loop control system. Justify. [4]

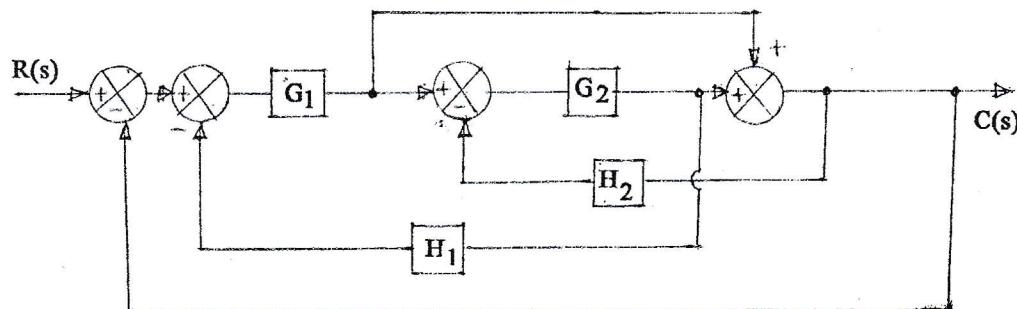
- b) Find the transfer $\frac{X_2(s)}{F(s)}$ for the given mechanical system. Also develop F-I analogy circuit. [8]



- c) Find transfer function, [4]



2. a) Obtain the overall transfer function of given system by block diagram reduction techniques. [8]



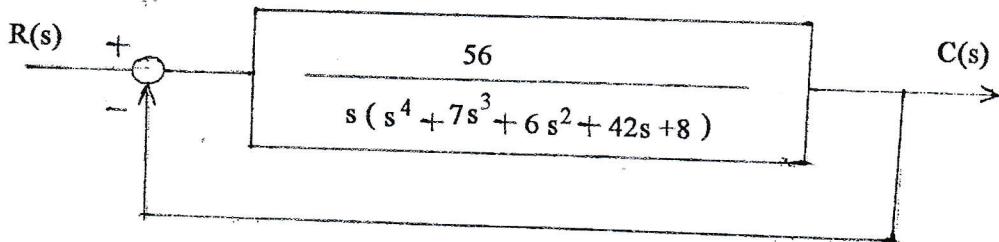
- b) For a mechanical system with closed loop transfer function $\frac{\theta(s)}{T(s)} = \frac{1}{aS^2 + bS + c}$;

Where $\theta(s)$ is the output of step input $T(t) = 10\text{Nm}$. Determine values of a , b , and c ; if maximum overshoot is 6%, peak time(t_p) = 1 Sec, and $e_{ss} = 0.5$.

[8]

3. a) Check stability of the system as given below in block diagram.

[6]



- b) Draw Bode plot for given open loop transfer function $G(s)H(s) = \frac{50(s+10)}{(s+1)(s+100)}$.
Also comment on stability from the plot.

[10]

4. a) What is Nyquist Contour? Map the Nyquist contour of open loop transfer function $G(s) = \frac{200}{(s+3)(s+1)(s+2)}$ into $G(s)$ plane and apply Nyquist criterion to check the stability of closed loop system.

[8]

- b) The system equation is given by $X(t) = \begin{bmatrix} 0 & 1 \\ -5 & -6 \end{bmatrix} X(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U(t)$ and $y(t) = [1 \ 0] x(t)$. Find transfer function of the system and check stability.

[8]

5. a) For a unity feedback system with open loop transfer function $G(s) = \frac{4}{s(s+2)}$

Design a Lead compensator such that settling time would become 2 seconds without change in maximum overshoot of the system.

[12]

- b) What is derivative feedback controller? Draw block diagram and find the transfer function and hence show its effect on transient performance of the system.

[4]

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Examination Control Division

2079 Bhadra

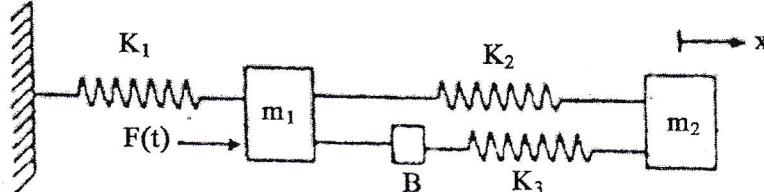
Exam. Level	BE	Regular	80
Programme	BEL, BEX, BME, BAM, BIE	Full Marks	32
Year / Part	III / I	Pass Marks	3 hrs.
		Time	

Subject: - Control System (EE 602)

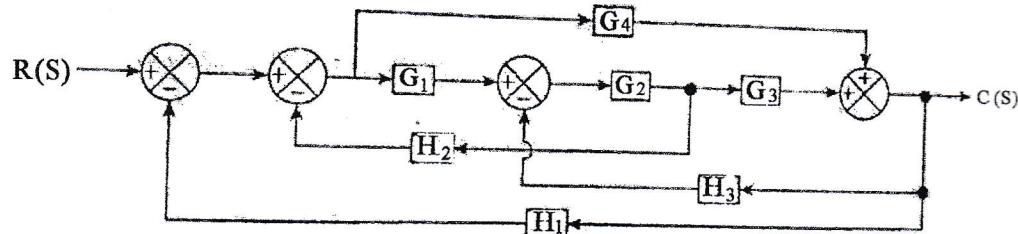
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.



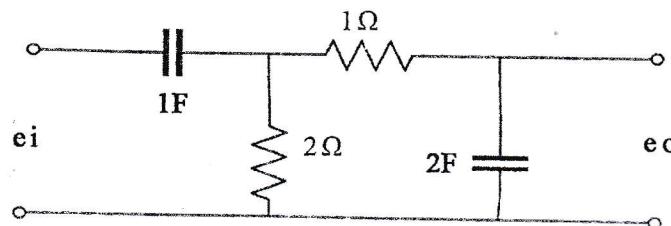
1. a) Mention any two advantages of closed loop system in comparison to open loop system. You must justify them with any mathematical support. [6]
- b) Find the transfer function, $\frac{X(S)}{F(S)}$, for the mechanical system of figure below. Also draw F-V analogy circuit of the system. [8+2]



2. a) From the given block diagram, draw the signal flow graph and find the transfer ratio $C(S)/R(S)$ using Mason gain's formula. [8]



- b) Find the impulse response of the given circuit. [8]

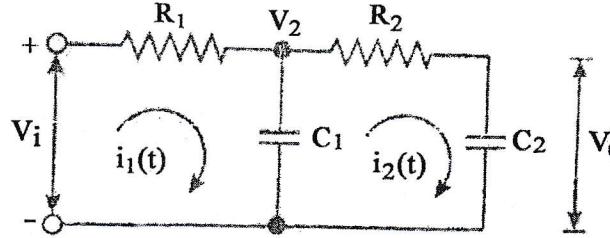


3. a) Using R-H criteria, tell how many roots of polynomial is in right half s-plane, in left half s-plane and on jw axis. Comment on stability. [8]
- $S^6 + 3S^5 + 4S^4 + 6S^3 + 5S^2 + 3S + 2 = 0$
- b) Draw Bode plot for system with open loop transfer function.

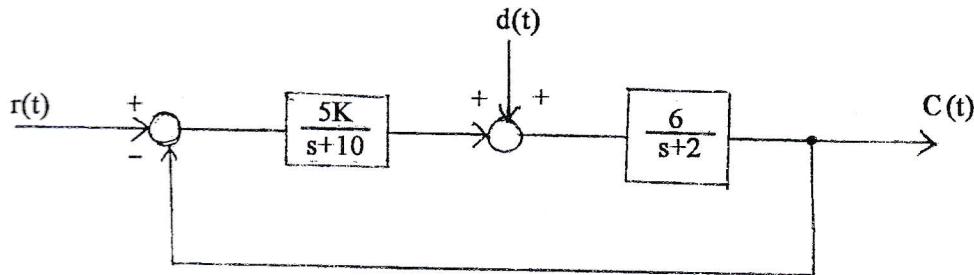
$$G(S) H(S) = \frac{60}{s(s+2)(s+6)}$$

Also find GM and comment on stability. [8]

4. a) Examine the closed-loop stability of a system applying Nyquist criterion whose open-loop transfer function is given by $G(s) H(s) = \frac{50}{(s+1)(s+2)}$. Also find phase margin. [8+2]
- b) Find state space model of given circuits. Consider V_0 as output. [6]



5. a) For a unity feedback system with open loop transfer function $G(s) = \frac{1.06}{s(s+1)(s+2)}$, design a log compensator such that steady state error for ramp input would be less than 0.2 without significant change in transients. [12]
- b) The system below shows a potential tracking problems with the reference input $r(t)$ and disturbance $d(t)$. [4]



What value of K will limit the steady state component of $c(t)$ due to $d(t)$ to 2% of $d(t)$?

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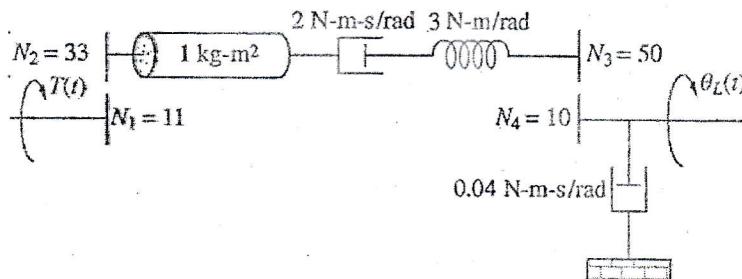
Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BAM, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System (EE 602)

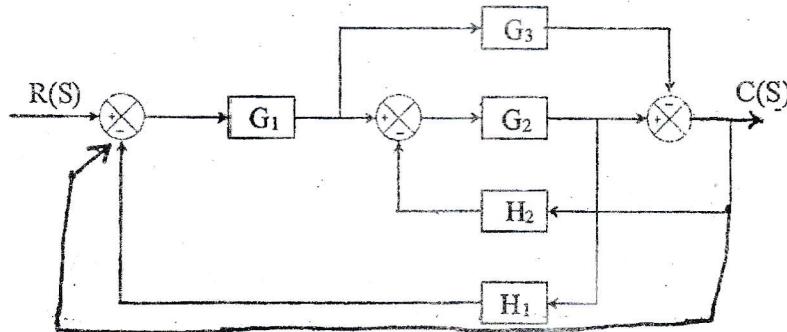
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.



1. a) State whether the following statements are true or false and justify them: [2x4]
 - (i) An air conditioning system is an example of closed loop control system.
 - (ii) System response is faster in closed loop control system than in open loop control system.
- b) Find the transfer function $\frac{\theta_L(s)}{T(s)}$ the mechanical rotational system shown below: [8]



2. a) Determine the transfer function of the given system by block reduction technique. [8]



- b) The open loop transfer function of unity feedback system is given by [8]

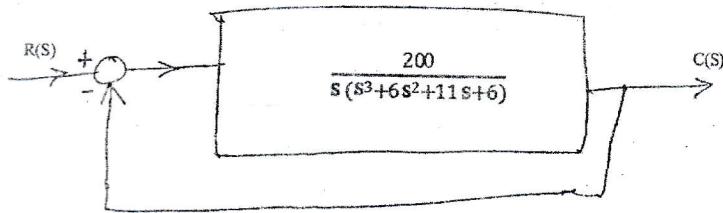
$$G(s) = \frac{108}{s^2(s+4)(s^2 + 3s + 12)}$$

Find the static error coefficients and steady state error of the system when subjected to an input given by

$$r(t) = 2 + 5t + 2t^2$$

3. a) Use RH criterion to determine number of roots on right side, left side and on the imaginary axis itself of s-plane for the system as below.

[6]



- b) Consider a unity feedback system having forward transfer function given below. Determine the value of 'K' such that the damping ratio ξ of the dominant closed poles is 0.5 using root locus technique.

[8+2]

$$G(s) = \frac{K(s+1)}{(s+2)(s+4)(s+6)}$$

4. a) Using Nyquist criteria, determine the stability of the closed loop system whose open loop transfer function is given by:

$$G(s)H(s) = \frac{1}{s(1+2s)(1+s)} ; \text{ also find the gain margin.}$$

[6+2]

- b) For state equation as

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} X + \begin{bmatrix} 10 \\ 0 \\ 0 \end{bmatrix} u \text{ and } y = [1 \ 0 \ 0] X$$

Find transfer function and check its stability.

[6+2]

5. a) Discuss criteria for a point on s-plane that may lie on a root locus.

[4]

- b) Design a suitable phase lead compensating network for $G(s) = \frac{4}{s(s+2)}$ to meet the following specification.

[12]

$$K_v = 20 \text{ Sec}^{-1}$$

$$P.M \geq 50^\circ$$

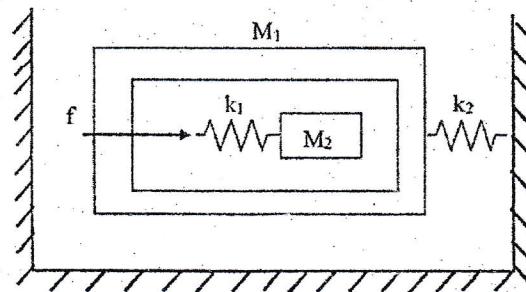
Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BAM, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System (EE 602)

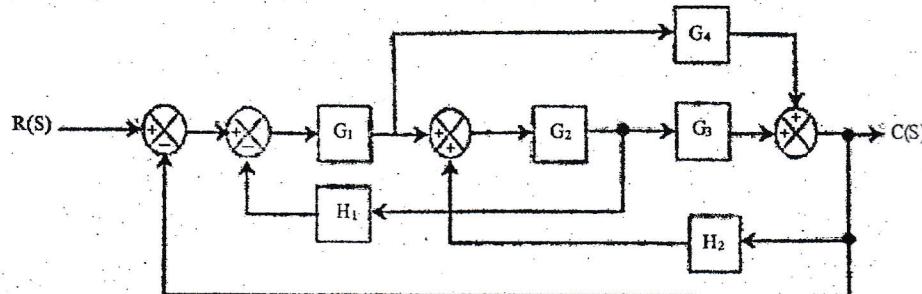
- ✓ Candidates are required to give their answers in their own words as far as practicable.
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1. a) Why do you think traffic light system in Kathmandu is an open loop control system? [4]
- b) What is the affect of feedback on system gain and speed of response and how? [4]
- c) Consider displacement of mass M_2 as output and find transfer function of the mechanical system as in figure. Also find F – I analogous circuit. [6+2]



2. a) From the given block diagram, draw the signal flow graph and find the transfer ratio $C(S)/R(S)$ using Mason gain's formula. [8]



- b) For the system as in figure (a), the unit step response is as in figure (b), determine M, B and K. [8]

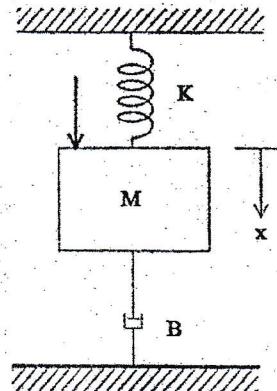


Fig (a)

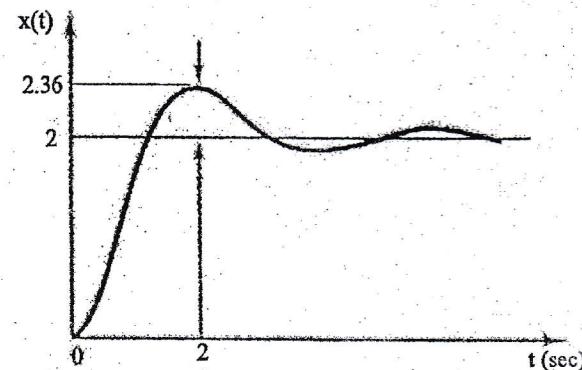
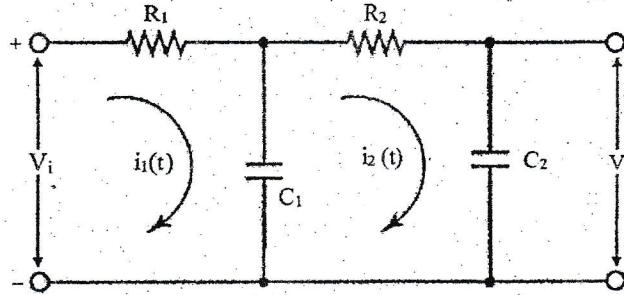


Fig (b)

3. a) Draw the block diagram of circuit shown below:

[4]



b) The characteristic equation of a feedback control system is given by,

[4]

$$s^4 + 20s^3 + 15s^2 + 2s + K = 0$$

(i) Determine the range of K for the system to be stable.

(ii) What value of K will make the system marginally stable? Also, find the frequency of sustained oscillation.

c) Draw the root locus for the system with open loop transfer function as

$$G(S)H(S) = \frac{K}{s(s^2 + 10s + 24)}$$

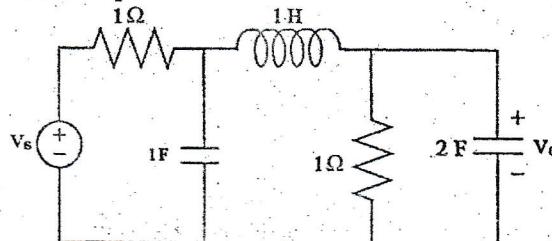
and hence from the root locus, find the gain(k) and

corresponding natural frequency of oscillation when the damping ration is 0.7.

[8]

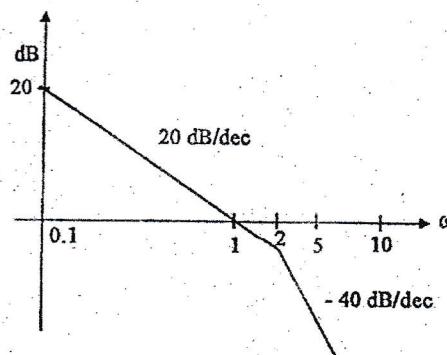
4. a) Write the state space equation for the electrical network shown below. Take voltage across 2F capacitor as output.

[5]



b) Find the open loop transfer function with the help of following Bode plot.

[3]



c) For open loop transfer with unity feedback $G(S) = \frac{s+2}{(s+1)(s-1)}$. Sketch Nyquist plot, determine gain margin and comment on stability.

[8]

5. a) What kind of controller would you recommend to bring changes in transient properties of a system and how?

[4]

b) The open loop transfer function of a unity feedback control system is given by

$$G(s) = \frac{K}{s(1 + 0.2s)}$$

Design a lead compensator such that the velocity error constant, $K_v = 10 \text{ sec}^{-1}$ and phase margin = 50° . Also draw the bode diagram for compensated system.

[12]

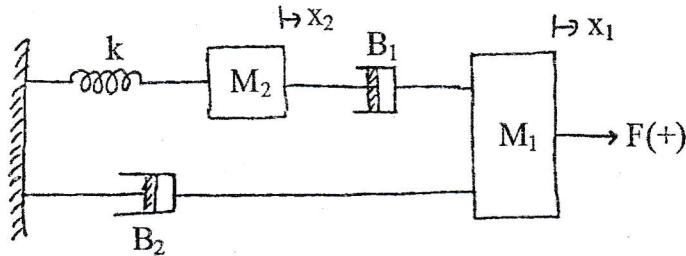
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Examination Control Division
2076 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BAM, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

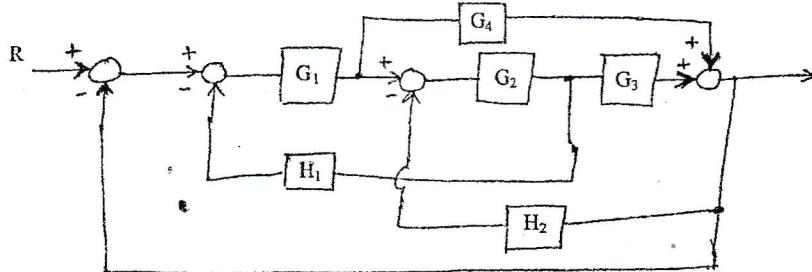
Subject: - Control System (EE 602)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Define control system. Why closed loop control system is more pronounced in modern complex systems rather than open loop control systems. Justify. [6]
- b) The given mechanical system has force, $f(t)$ as input and x_1 and x_2 as displacement outputs. Draw equivalent f-v and f-I analogous electrical circuit and determine the transfer function with x_2 as output. [10]

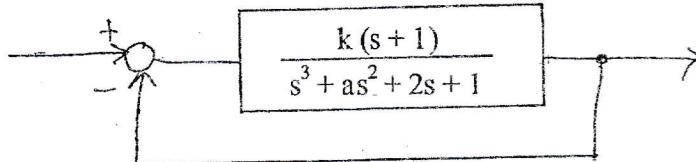


2. a) Reduce the following block diagram and find transfer function. [8]



- b) For a unity feedback system, the open loop transfer function is $G(s) = \frac{50}{s(s+2)}$. With unit step input find maximum overshoot and settling time. Also determine static error coefficients and steady state error if the input to the system is $r(t) = 2 + 4t + 6t^2$, $t \geq 0$. [8]

3. a) In the following system, determine K if the system just oscillates at a frequency 2 rad/sec. [6]



- b) Draw Bode plot for unity feedback system with open loop transfer function $G(s) = \frac{40(s+2)}{(2+s+25s^2)(1+2s)s}$. Find GM and comment on stability. [10]

4. a) Obtain the transfer function from the following system equations given by,

[4]

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -K/M & -R/M \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1/M \end{bmatrix} u$$

$$y = [1 \ 0] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

- b) Sketch the Nyquist contour and plot of unity feedback system having open loop

$$\text{transfer function: } G(S)H(S) = \frac{s+10}{(S-3)(S+3)}$$

- (i) Comment on stability.
(ii) Determine gain margin.

[5+1+2]

- c) Discuss briefly about PD controller.

[4]

5. a) How does the location of poles affect the stability in control system?

[2]

- b) For a unity feedback system with feed forward transfer function $G(s) = \frac{10}{s(s+1)}$,

design a lead compensator such that the settling time of the system will become 2sec and maximum percent overshoot 5%.

[12]

- c) Describe angle criteria for a point in s-plane such that the root locus would cross through the point.

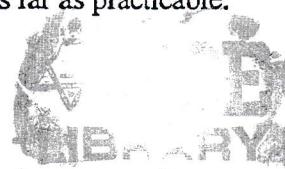
[2]

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2076 Ashwin

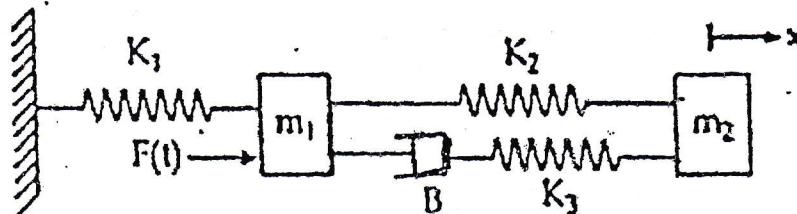
Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BAM, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System (EE 602)

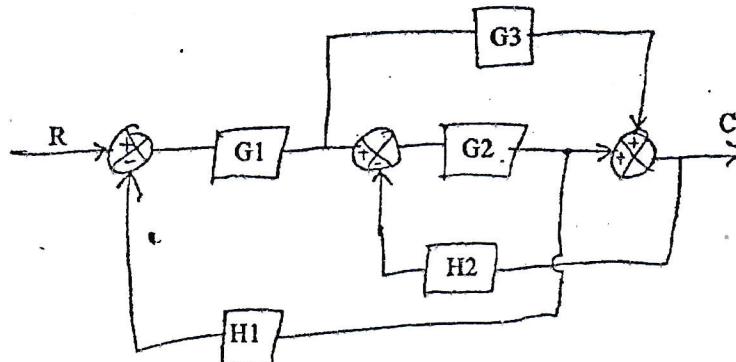
- ✓ Candidates are required to give their answers in their own words as far as practicable.
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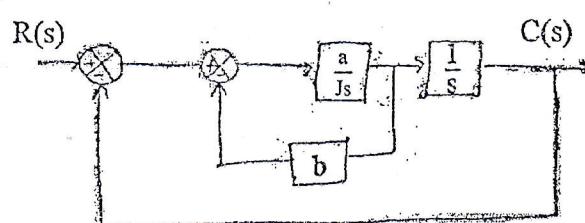
1. a) What is control system? Draw the block diagram of a closed loop control system and briefly explain the function of each block. [6]
- b) Find the transfer function. $\frac{X(S)}{F(S)}$, for the mechanical system of figure below. Also draw the F-V and F-I analogy circuit of the system. [10]



2. a) Develop Signal Flow graph for the block diagram model below and find transfer function using Mason's gain formula. [2+6]

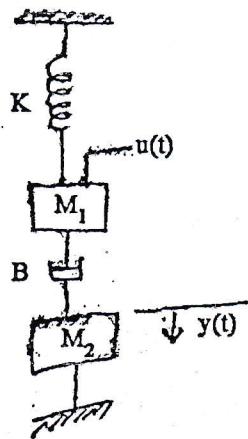


- b) Check stability for the system with open loop transfer function $G(S)H(S)=\frac{2}{2s^5+3s^4+2s^3+s^2+2s}$ using R-H criterion. [4]
- c) What is derivative controller? How and why it can be useful? [4]
3. a) Determine values of a and b of the closed loop control system shown below, so that maximum overshoot for unit step input is 25% and the peak time is 2 sec. Assume that $J=1 \text{ kg/m}^3$. [6]



- b) Sketch Root locus plot for the system open loop transfer function $G(s)H(s) = \frac{k(s+2)}{s((s+1)(s^2 + 8s + 64))}$. Discuss the region for stability, instability and marginal stability. What is frequency of oscillation at the point of marginal stability? [10]

4. a) the open loop transfer function of closed loop system is $G(s) = \frac{2}{s(s+1)(2s+1)}$. Using Niquist Criterion, determine closed loop stability of this system. [8]
- b) Consider a mechanical system shown in figure below. The external force $u(t)$ is input to the system and displacement $y(t)$ of the mass is the output. Obtain the state space representation of the system. [8]



5. Why lead compensator is required? Design a suitable lead compensating network for $G(S) = \frac{k}{s^2(1 + 0.25s)}$ to meet the following specification $K_a=10 \text{ sec}^{-1}$ P.M $\geq 35^\circ$. [2+14]

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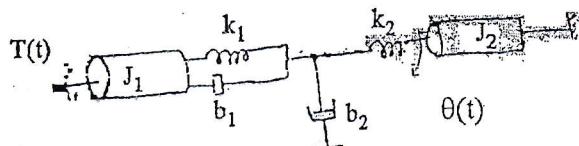
Exam.	Regular / Back	Full Marks	80
Level	BE	Pass Marks	32
Programme	BEL, BEX, BME, BAM, BIE		
Year / Part	III / I	Time	3 hrs.

Subject: - Control System (EE 602)

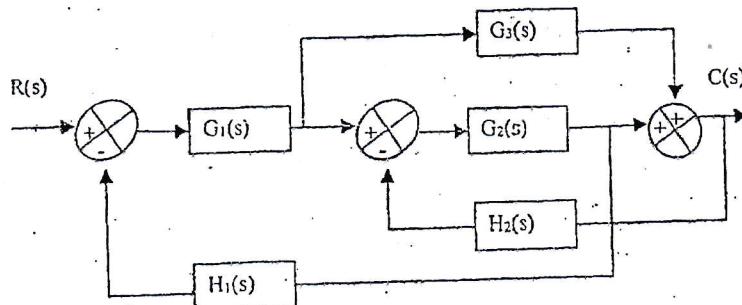
- ✓ Candidates are required to give their answers in their own words as far as practicable.
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1. a) Which of the system is more sensitive to the disturbance and prove it how? Also discuss effect of gain on response of the system. [4+4]
- b) Find the transfer function $\frac{\theta(s)}{T(s)}$ for the mechanical system rotational system shown below: Also develop T-I analysis circuit. [8]



2. a) Using block diagram reduction technique, find the tr. Function $\frac{C(S)}{R(S)}$ of the figure given below. [8]

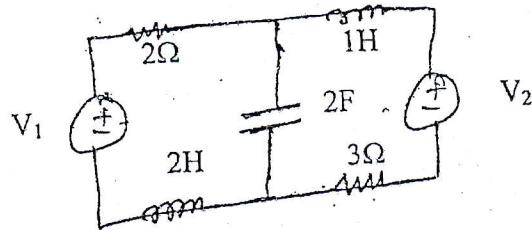


- b) A system has 40% overshoot and requires a settling time of 4 seconds when given a step input. Find peak time and rise time. [8]
3. a) Using R-H criteria fin the range of K for system having characteristics equation shown below, to be stable. [6]
- b) Sketch Rout locus plot for the system with open loop transfer function. [6]
- c) What sort of measures would you apply to track a reference from the actual output of the system? [4]

$$S^4 + 2S^3 + (4+K)S^2 + 9S + 25 = 0$$

$$G(s)H(s) = \frac{k(s-1)}{s(s-1)}$$

4. a) Using Nyquist criterion determine the stability of the feedback system whose open loop transfer function is given by $G(s) H(s) = \frac{1}{s(1+2s)(1+s)}$ and what is its gain margin? [10]
- b) Develop state space model for circuit below. [6]



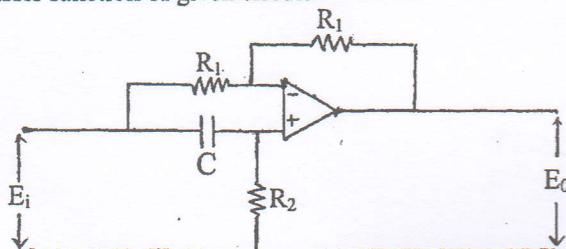
5. a) Consider a system shown below. The open loop transfer function is given by:
 $G(s)H(s) = \frac{2}{s(s+1)(s+2)}$. It is desired to compensate the system, so that the static velocity error constant K_v is 5 per second. The phase margin is at least 40° and gain margin is at least 10dB. Determine transfer function of appropriate lag compensator. [12]
- b) Consider a point P in s-plane which actually indicate dominant closed loop pole of the system. How would you recognize that the root locus passes through the point P? [4]

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BAME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

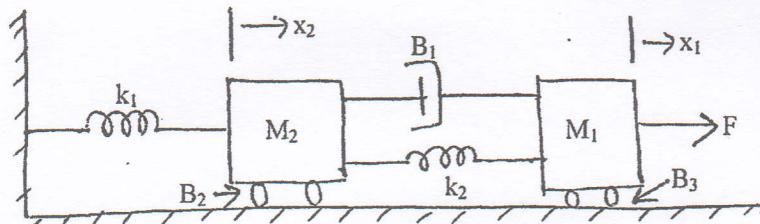
Subject: - Control System (EE602)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
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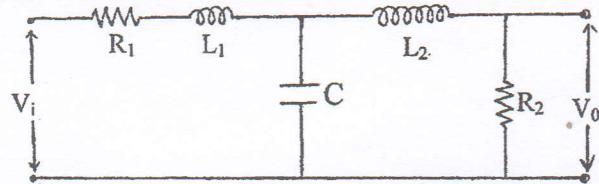
1. a) Inspite of cost and complicated design, closed loop control system are widely preferred over open loop control system. Justify the statement with some examples. [4]
- b) Find the transfer function of given circuit. [4]



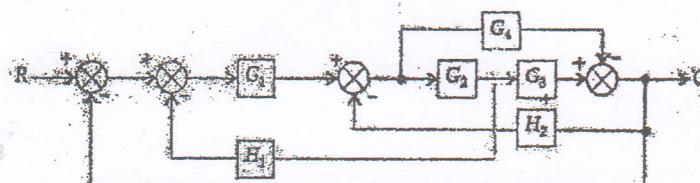
- c) For the mechanical system shown below find the transfer function $M_2(s)/F(s)$. Draw the force voltage analogy. [6+2]



2. a) Develop block diagram model for the circuit shown in figure below. [4]



- b) Using Mason's gain formula, find the tr. Function $\frac{C(S)}{R(S)}$ of the fig given below. [8]



- c) Using R-H criteria, tell how many roots of polynomial is in right half s-plane. [4]
- $$S^5 + 4S^4 + 2S^3 + 8S^2 + S + 4 = 0$$

3. a) Fig (ii) is step response of system as in fig (i) find K and P.

[6]

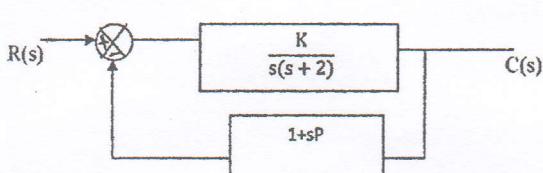


Fig. (i)

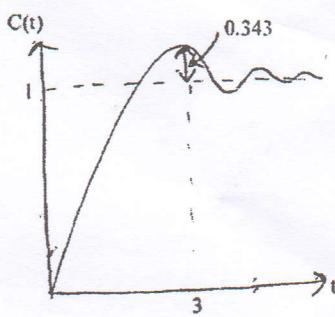


Fig. (ii)

- b) Sketch the root locus for unity feedback the system having the forward path transfer

$$\text{function } G(S) = \frac{K}{(s^2 + 2s + 2)(s^2 + 2s + 5)} \quad [10]$$

4. a) Using Nyquist criterion determine the stability of the feedback system whose open loop transfer function is given by

$$G(S)H(S) = \frac{(S+5)}{(S-2)(S+2)}$$

Also find GM.

[8]

- b) A system is characterized by the equation

$$\frac{Y(S)}{U(S)} = \frac{20(4s+2)}{s^3 + 5s^2 + 8s + 2}$$

Find its state and output equation and express in matrix form. Then using your matrix, how do you get characteristic equation?

[8]

5. a) Discuss effect of addition of a zero to a system.

[4]

- b) The open loop transfer function of a system is given by:

$$G(S) = \frac{1}{S(S+1)(0.5S+1)}$$

Compensate the system, such that, $K_v = 5 \text{ sec}^{-1}$ and phase margin is at least 40° and the gain margin is at least 10 dB with a lag compensator.

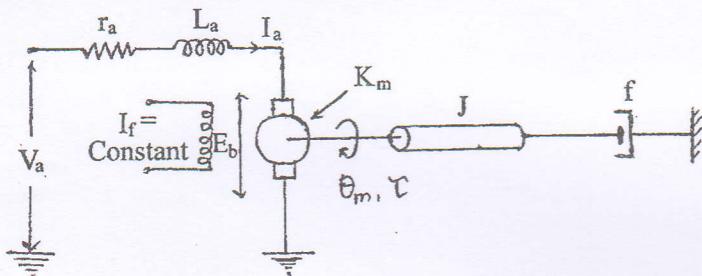
[12]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BAME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

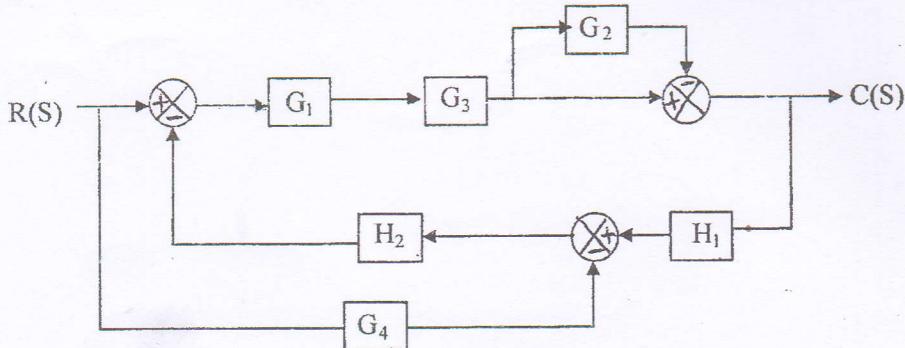
Subject: - Control System (EE602)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) What is control system? Draw the block diagram of a closed loop control system and briefly explain the function of each block. [5]
- b) Show that the speed of response increases with the increase of the gain of the system. [3]
- c) Find the transfer function $\frac{\theta_m(S)}{V_a(S)}$ of the system below by constructing the block diagram. [8]



2. a) Determine the transfer function of the given system by reducing blocks. [8]



- b) Consider a unity feedback control system with the closed loop transfer function

$$\frac{C(S)}{R(S)} = \frac{Ks + b}{(s^2 + as + b)}$$

Determine the open loop transfer function. Show that the steady state error in the unit ramp input response is given by

$$e_{ss} = \frac{a - k}{b}$$

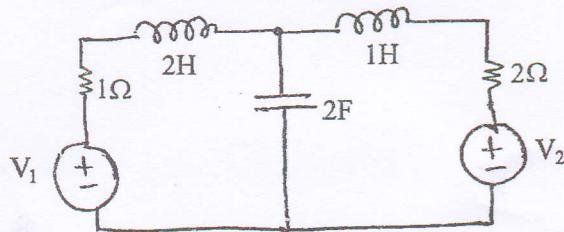
- c) How we can perform relative stability analysis using RH-Criteria? [3]

3. a) For a unity feedback system the open loop transfer function of a control system is given by [10]

$$G(S) = \frac{k}{s(s+4)(s^2 + 4s + 20)}$$

Sketch the root locus for $0 \leq K \leq \infty$ and determine the breakaway point, the angle of departure from complex poles and the stability conditions.

- b) Write the state equation for the circuit shown below. Also write output equation. [6]



4. a) Discuss working of PI controller. [4]

- b) Suppose that the step response of a first order system is $C(t) = 5(1 - e^{-\frac{t}{5}})$. What are impulse and ramp responses? [4]

- c) Sketch the Nyquist Plot of Unity feedback system having open loop transfer function and $G(S)H(S) = \frac{s+10}{(s-3)(s+3)}$. Comment on stability. What is gain margin? [8]

5. a) Discuss the purpose of lead and lag compensators. [4]

- b) Design a suitable phase lag compensating network for $G(S) = \frac{k}{S(1+0.1s)(1+0.2s)}$ to

meet the following specification [12]

$$K_v = 30 \text{ Sec}^{-1}$$

$$P.M \geq 40^\circ$$

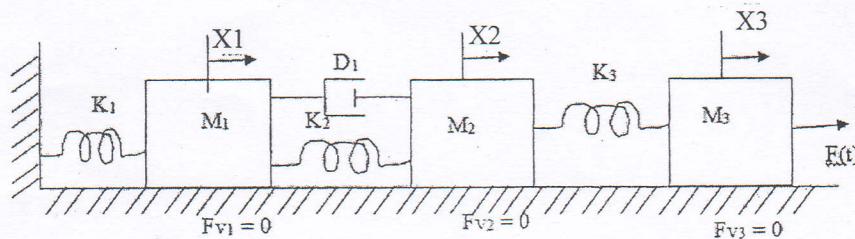
Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System (EE602)

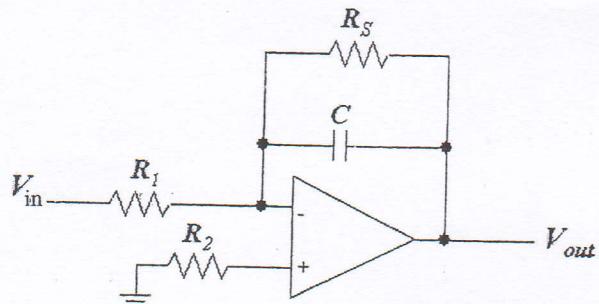
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) How would a closed loop system differ from open loop one on its steps response?
Give analytical explanation. [6]

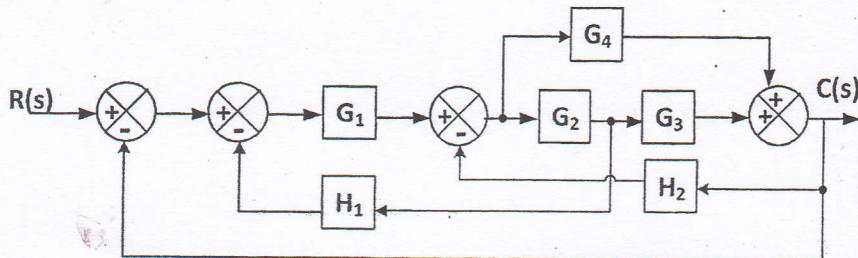
b) Find the transfer function, $\frac{X_2(S)}{F(S)}$, for the mechanical system of figure below. Also draw the E-V and F-I analogy circuit of the system. [6]



c) Find transfer function of an op-amp model as below. [4]



2. a) Determine the overall transfer functions $C(s)/R(s)$ of the given system by block diagram reduction technique. [8]



b) Using R-H criteria, tell how many roots of polynomial given below is in right half s-plane, in left half s-plane and on jw axis. Comment on stability. [8]

$$s^6 + 3s^5 + 4s^4 + 6s^3 + 5s^2 + 3s + 2 = 0$$

3. a) The open loop transfer function of a control system is

[8]

$$G(s)H(s) = \frac{(4s+1)}{s^2(s+1)(2s+1)}$$

Using Nyquist criterion, determine the open loop and closed loop stability of this system.

- b) The open loop transfer function of a unity feedback system is given by

[8]

$$G(S) = \frac{108}{S^2(s+4)(s^2 + 3s + 12)}$$

Find the static error coefficients and steady state error of the system when subjected to an input given by $r(t) = 2 + 5t + 8t^2$

4. a) Draw Bode Plot for the system with transfer function $G(s) = \frac{20s + 200}{(s^2 + 4s + 25)(s^2 + 40s)}$

Determine gain margin, phase margin and comment on stability of the system according to your plot.

[8]

- b) Given state equation and output equation, find transfer function $\frac{Y(S)}{U(S)}$ and determine the poles and zeros.

[8]

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

5. a) State whether the statement "Derivative controllers are always used with other controllers" is true or false and justify your answer.

[1+3]

- b) Design a lead compensator for a system having open loop transfer function

$$G(s)H(s) = \frac{k}{s(1+0.1s)(1+0.001s)}$$

$$K_v = 1000 \text{ sec}^{-1}$$

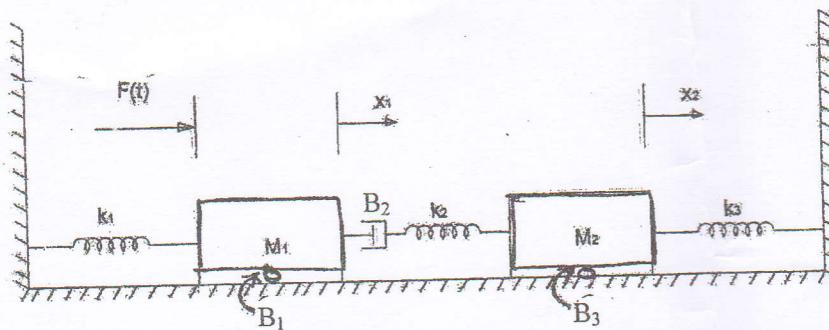
[12]

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

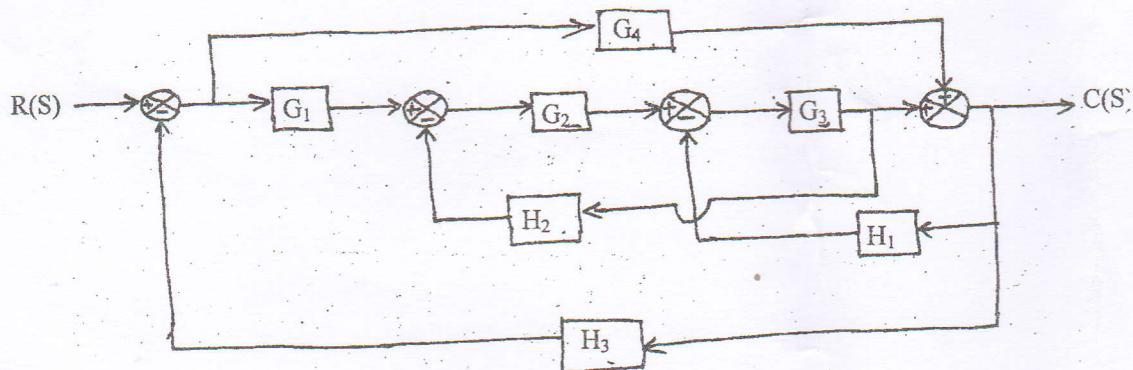
Subject: - Control System (EE602)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) What kind of control system could have been in the following? Illustrate with necessary blocks and variables. [4×2]
- i) Governer system of Hydropower Station
 - ii) Traffic light system of Kathmandu
- b) Find transfer function (consider displacement of mass M_2 as output) for the given mechanical system. Also develop force-current analogous circuit. [8]



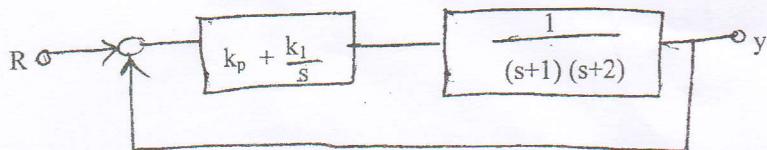
2. a) Determine the overall transfer functions $C(S) / R(S)$ of the given system by block diagram reduction technique. [8]



- b) The system equations are given by: $\dot{x}(t) = \begin{bmatrix} 0 & 1 \\ -5 & -6 \end{bmatrix}x(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix}u(t)$; and $y(t) = [1 \ 0]x(t)$; Find transfer function of the system and also check stability. [8]

3. a) For a closed loop system presented by

[4]



Determine the range of controller gain (K_p, K_I) so that the PI controller provides the stable output.

b) A unity feedback control system has an open loop transfer function

$$G(S) = \frac{K(S+9)}{S(S^2 + 4S + 11)}. \text{ Sketch the root locus and determine:} \quad [8]$$

- i) The range of 'K' for system to be stable
- ii) Undamped natural frequency of oscillation

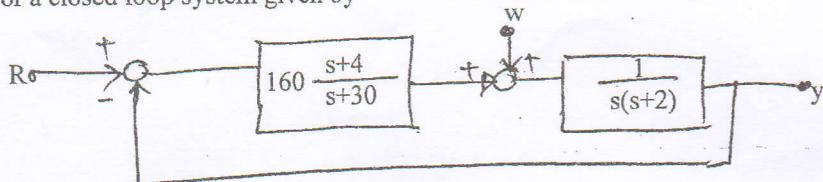
c) A closed loop servo is represented by the differential equation $\frac{d^2y}{dt^2} + 8\frac{dy}{dt} = 64z$ where

'y' is the displacement of the output shaft and 'u' is the displacement of the input shaft and $z = u - y$. Determine frequency of sustained oscillation, damping ratio and percentage maximum overshoot for unit step input. [4]

4. a) Draw the region in S-plane that satisfies following requirements. [4]

i) $S > 0.707$ (ii) $t_s < 2 S$

b) For a closed loop system given by [8]



- i) Can the system track a step reference input 'r' with zero steady state error
- ii) Can the system reject a step disturbance ' ω ' with zero steady state error?
- iii) Compute the sensitivity of closed loop transfer function to change in the plant pole at '-2'

c) How a controller with transfer function $G_c(S) = \frac{1+aTS}{1+TS}$ can be used as lead or lag compensator, explain. [4]

5. a) Design a suitable lead compensator for a system whose open loop transfer function is

$$\text{given by } G(S) = \frac{K}{s(1+0.2s)} \quad [10]$$

The system should meet the following criteria

- i) $K_v \geq 20 \text{ sec}^{-1}$
- ii) P.M. $\geq 44^\circ$

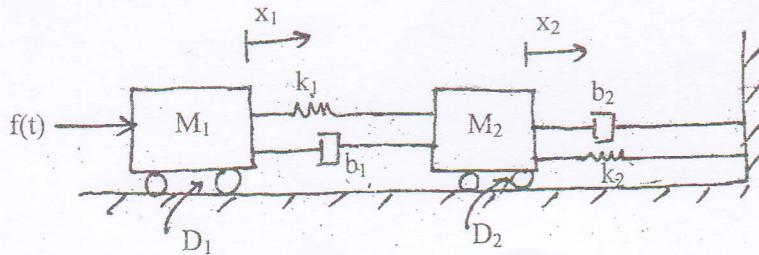
b) The differential equations related to a system are $\frac{dx_1}{dt} = -3x_1 + x_2$ and $\frac{dx_2}{dt} = -2x_1 + u$ for $t > 0$. Its output equation is given by $y = x_1$. Derive the transfer function of the system with these differential equation and output equation. [6]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

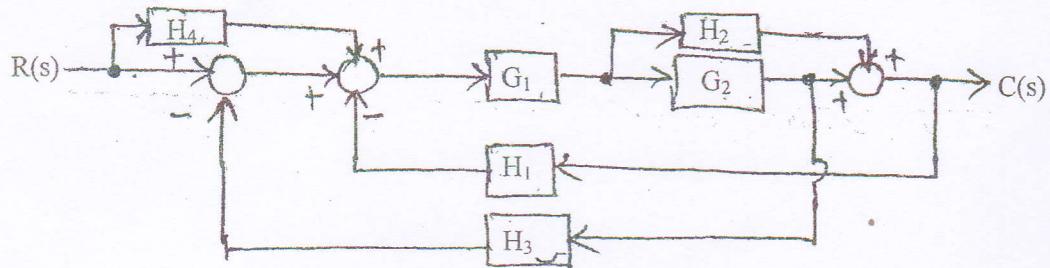
Subject: - Control System (EE602)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

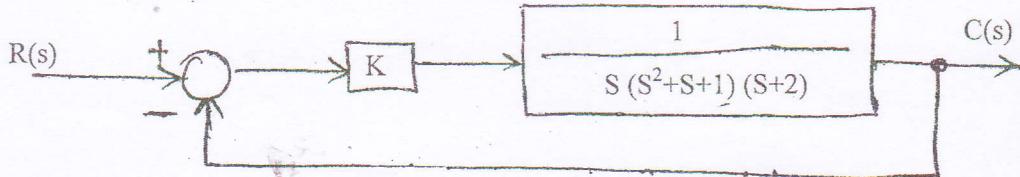
1. a) Define linear time invariant system. Justify the statement "modern complex systems are more pronounced with closed loop control system". [4]
- b) The given mechanical system has force $f(t)$ as input and x_1 and x_2 as displacement outputs. Draw equivalent F-V analogous circuit and determine the transfer functions $X_1(S)/F(S)$ and $X_2(S)/F(S)$. [8]



- c) Discuss, how a closed loop system has better disturbance rejection and command input tracking capabilities in comparision to an open loop system. [4]
2. a) Find Transfer function of the following system. [8]

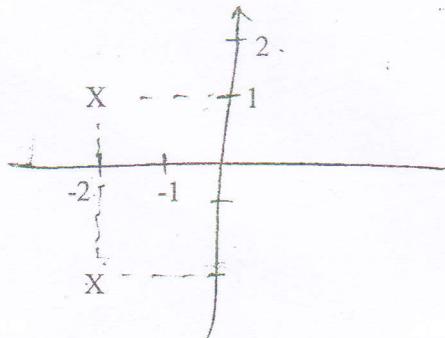


- b) Find the range of 'K' for stable operation using R-H criteria. [4]

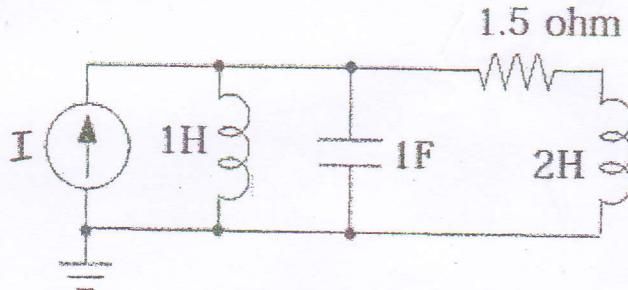


- c) Explain how RH (Routh Hurwitz) method is used for determining relative stability. [4]

3. a) Open loop pole/zero plot of a unity feedback system are shown in figure below. Determine maximum overshoot and setting time for its step response. [6]



- b) If desired damping ratio is '1', which controller do you suggest, explain. [4]
- c) Determine value of 'K' and 'b' so that the unity feedback system with open loop transfer function; $G(s) = \frac{K(s+1)}{s^3 + bs^2 + 3s + 1}$ [6]
4. a) Develop state space equations for the following circuit considering voltage of 2H inductor as output. I is input to the system. [6]



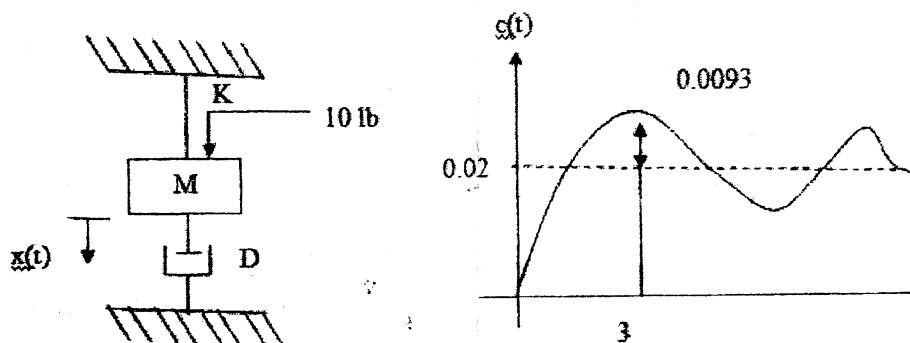
- b) Draw Bode plot for the system with transfer function $G(s) = \frac{4s + 40}{(s^2 + 4s + 25)(s^2 + 50s)}$. Determine gain margin, phase margin and comment on stability of the system according to your plot. [10]
5. a) Compare the Lag and Lead compensator applications in control system. [4]
- b) Design a suitable compensator for a unity feedback system with its feed forward transfer function as $G(s) = \frac{4}{s(s+2)}$ such that its maximum percent overshoot 16.3% and settling time 2 sec. for its step response. Also velocity error constant should not be less than 2 per sec. [12]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

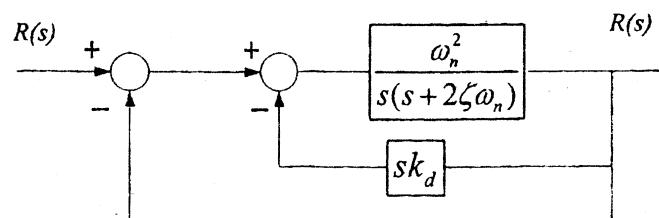
Subject: - Control System (EE602)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

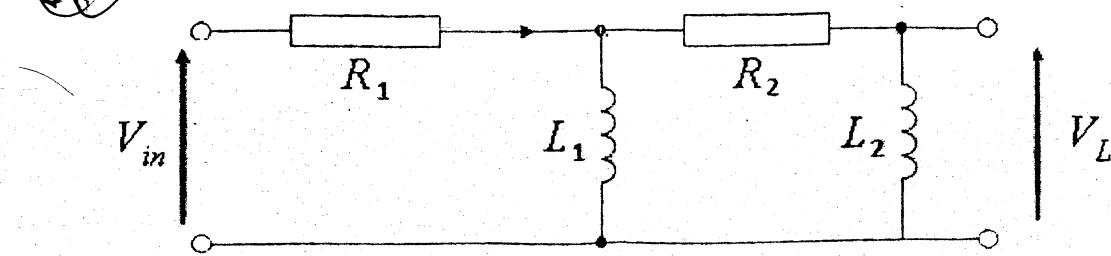
1. a) Construct a general block diagram of a control system showing the different blocks, variables and hence briefly point out their meaning. [4]
- b) Effect of disturbance in case of feedback control system can be suppressed by increasing the gain G(S) and / or H(S). [4]
- c) Following figure shows a mechanical vibratory system and the response when 10 lb of force is applied to the system. Determine the transfer function and value of M, D and K. The displacement x is measured from the equilibrium position. [8]



2. a) Show that using the velocity feedback techniques shown figure below damping ratio and steady state error are both increased. [8]



- b) Develop block diagram model for the system below. [6]



c) Using R-H criteria, tell how many roots of polynomial is in right half s-plane, in left half s-plane and on jw axis and also comment on stability. [4]

$$S^6 + 3S^5 + 4S^4 + 6S^3 + 5S^2 + 3S + 2 = 0$$

3. a) For the unity feedback system with open loop transfer function (OLTF)

$$G(s) = \frac{k}{(s+1)(s+3)}, \text{ use angle criteria to check whether the root locus passes from point}$$

$s_d = -2 + j3.5$. If yes, use magnitude criteria to select the appropriate value of gain parameter. [4]

b) For a system given by $\frac{d}{dt} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} -5 & -6 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u; y = \begin{bmatrix} 1 & 2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$, determine the zeros and the poles of the system. [4]

c) The open loop transfer function of a control system is given by [8]

$$G(s)H(s) = K \frac{s^2 - 2s + 5}{s^2 + 1.5s - 1}$$

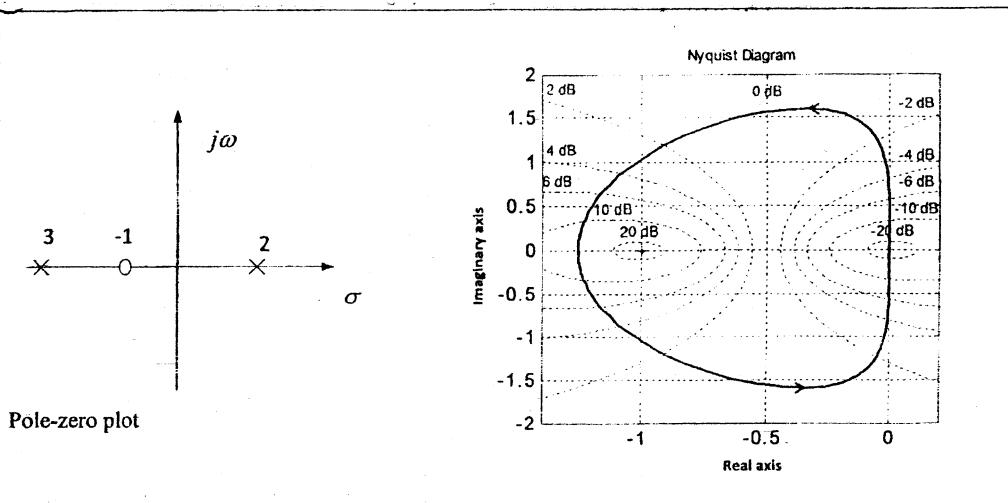
Sketch the root locus for $0 \leq K \leq \infty$ and determine the breakaway point, the angle of departure from complex poles and the stability conditions. Also find value of K that gives poles at $(-0.35 \pm j0.6)$

4. a) Design a suitable compensator for a unity feedback system with open loop transfer

$$G(s) = \frac{4}{s(s+2)} \text{ such that the settling time will become 2 seconds without change in overshoot and velocity time constant will be } 2 \text{ s}^{-1}. [12]$$

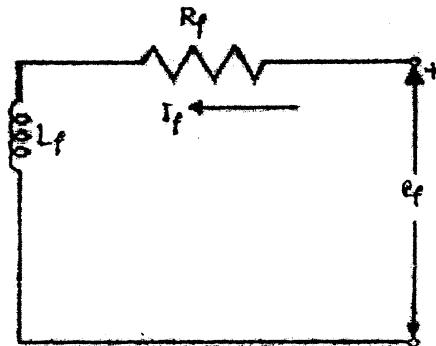
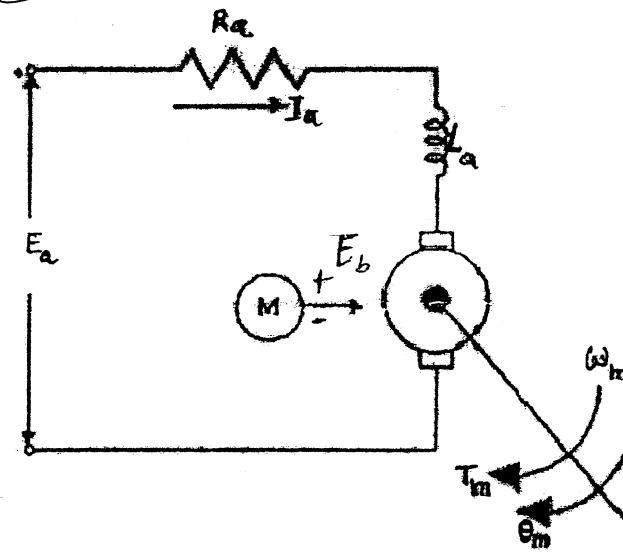
b) For a compensator transfer function given by $G_c(s) = \frac{s+\tau}{s+a\tau}$, give the condition of lead compensator. For the given value of 'a' what is the frequency that leads to maximum phase angle lead. [4]

5. a) State the Nyquist stability criteria for negative feedback control system. Using this concept determine whether the following system represented by figure below is stable. [4]



b) Discuss how bode plot can be used to determine transfer function of the system. [5]

c) Develop state equation for motor circuit at below. [5]



J_m = Inertia

B_m = Friction

2071 chaitra

control system

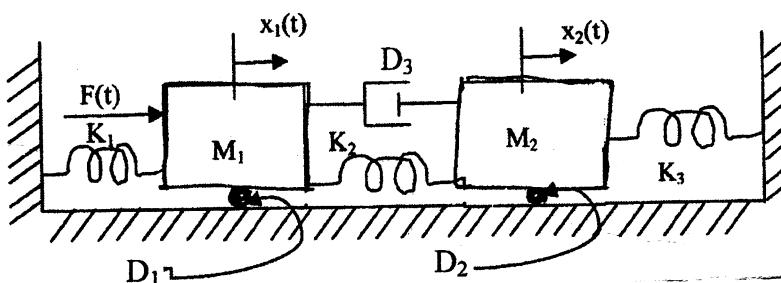
Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	30
Programme	BEL, BEX, BME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System (EE602)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) What is control system? Draw the block diagram of a closed loop control system and briefly explain the function of each block. Mention also advantages of closed loop system over open loop system. [8]

b) Find the transfer function, $\frac{X_2(S)}{F(S)}$, for the mechanical system of figure below. Also draw the F-V and F-I analogy circuit of the system. [8]



2. a) Discuss how the dynamic responses of control system are affected by a feed back. [6]

b) For an open loop transfer function with unity feedback $G(S) = \frac{\omega_n^2}{s(s + 2\xi\omega_n)}$ where $\xi < 1$, derive an expression for output when unit step input is applied. [4]

c) Using R-H criteria, tell how many roots of polynomial is right half s-plane, in left half s-plane and on jw axis. [6]

$$S^6 + 2S^5 + 8S^4 + 12S^3 + 20S^2 + 16S + 16 = 0$$

3. a) The open loop transfer function of a control system is given by

$$G(S)H(S) = \frac{K}{s(s+6)(s^2 + 4s + 13)}$$

Sketch the root locus for $0 \leq K \leq \infty$ and determine the breakaway point, the angle of departure from complex poles and the stability conditions. [10]

b) Discuss how a Bode plot can be used to determine transfer function of the system. Explain with an example. [6]

4. a) Construct the polar plot of unity feedback system with $G(S) = \frac{K}{S(S+1)(0.1S+1)}$. Then, upgrade the plot to make it Nyquist plot. Hence find range of k for stable operation. [3+3+2]

b) For given state equation and output equation, find transfer function $\frac{Y(S)}{U(S)}$ [8]

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} X + \begin{bmatrix} 10 \\ 0 \\ 0 \end{bmatrix} u \quad \text{and} \quad y = [1 \ 0 \ 0] X$$

Design a suitable lead compensating network for $G(S) = \frac{k}{s^2(1+0.25s)}$ to meet the following specification $K_a = 10 \text{ sec}^{-1}$ [16]

$$P.M \geq 35^\circ$$

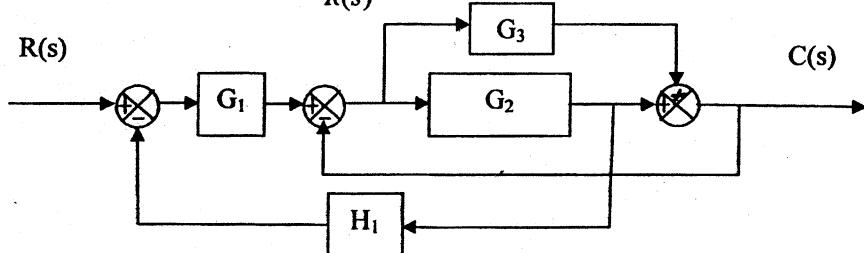
Exam.	Old Back (2065 & Earlier Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System (EG 648EE)

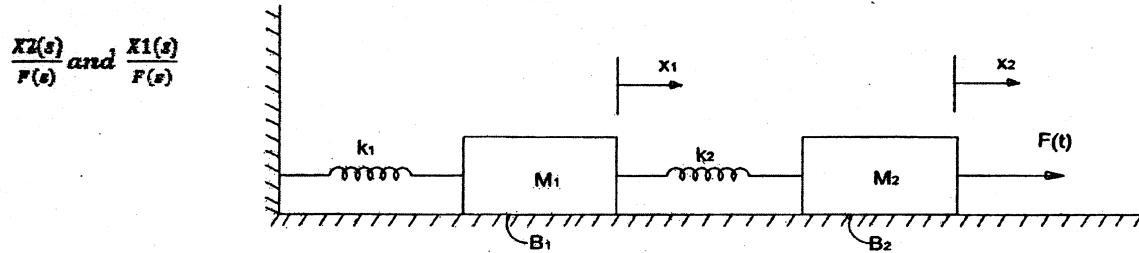
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt any Five questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) For armature controlled separately excited DC motor, identify the necessary differential equations governing its behaviors and hence derive the dynamic model of such motor. [8]

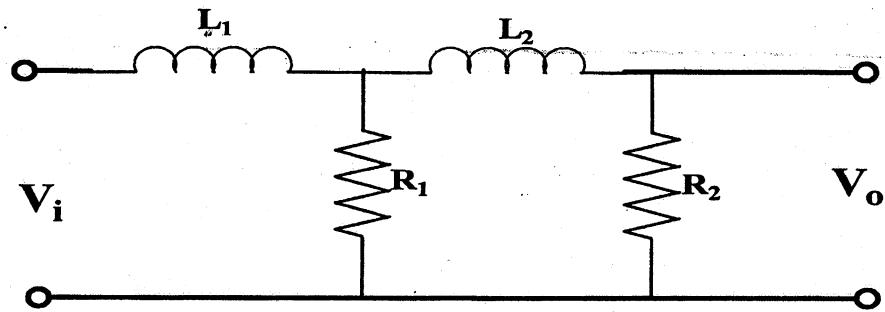
b) Determine the transfer function $\frac{C(s)}{R(s)}$ for the following system. [8]



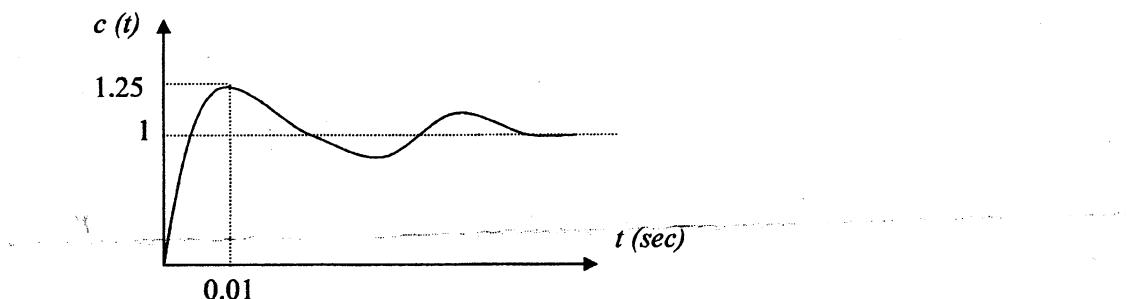
2. a) Draw the free body diagram, write the differential equations and find the mentioned transfer function of the below [10]



b) Draw the block diagram and reduce it to calculate $\frac{V_o(s)}{V_i(s)}$ for the following network. [6]



3. a) The unit step response of a linear control system is shown in figure below. Find the transfer function of a second order system to model the system. [8]



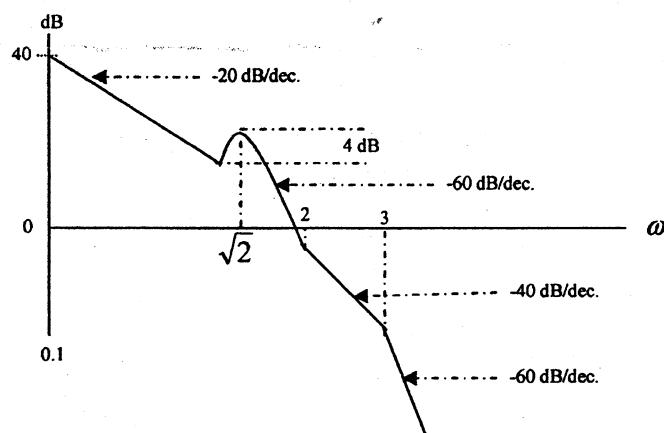
- b) Check the stability of the system represented by the following characteristic equation given below using R-H criteria. [8]

$$s^4 + 8s^3 + 18s^2 + 16s + 50 = 0$$

4. a) Find the Gain Margin and Phase Margin using Bode plots for the following transfer

function: $G(s) = \frac{1}{s(0.1s+1)(0.2s+1)}$ [8]

- b) An engineer is called in to consult on a control system in a piece of equipment in the field. No one can find the design report or test results from the original design of control system. The engineer therefore decided to take a frequency response of the system. The resulting asymptotic frequency response is obtained as below. Determine the transfer function. [8]



5. a) Draw the Nyquist plot for the following open loop transfer function [10]

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

- b) Discuss in brief the use of PID controllers in control system. [6]

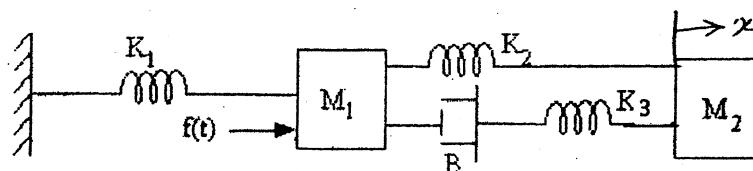
6. A system of which open loop transfer function $G_f(s) = \frac{4}{s(s+2)}$. It is desired to design a compensator so that the static velocity error constant K_v is 20sec^{-1} , Phase margin is at least 50° and gain margin is at least 10db. [16]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

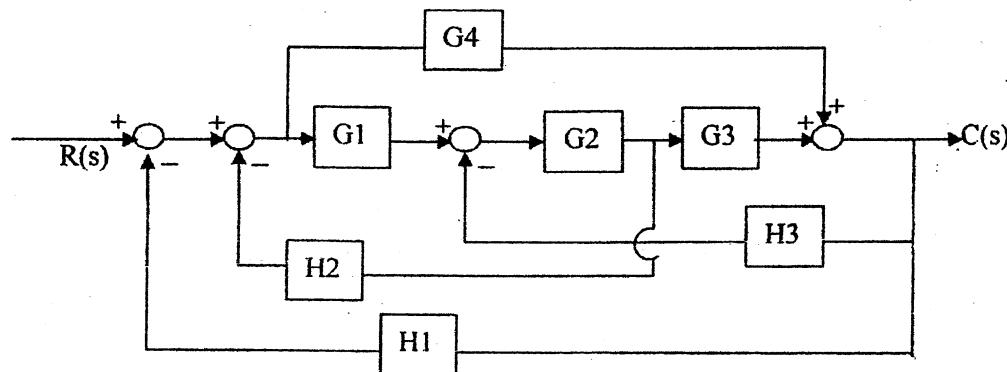
Subject: - Control System (EE602)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. (a) Find transfer function for the following mechanical system considering displacement of mass M_2 as output of the system. Also develop force current analogous circuit. [6]

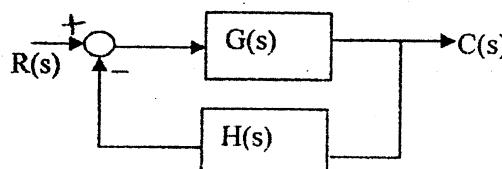


(b) Reduce the following block diagram model to obtain its overall transfer function. [6]



(c) How can you characterize a control system in term of (i) Speed (ii) accuracy (iii) Stability explain. [4]

2. (a) For a second order system as below $G(s) = \frac{w_n^2}{s(s+2\xi w_n)}$ and $H(s) = 1$, find expression for maximum overshoot on its unit step response where w_n is natural frequency of oscillation and ξ is damping ratio at underdamped situation. [7]



(b) Discuss how a feed back control system reject the disturbance input. [3]

(c) Find all static error constant for a unity feedback system with feedforward transfer function $G(s) = \frac{1000}{s(s+10)(s+100)}$. Evaluate steady state error if system is excited with $r(t) = 2+t$. [6]

3. (a) Obtain Nyquist plot and comment on stability using Nyquist Criterion for a unity feedback system with feedforward transfer function $(s) = \frac{(s+2)}{(s+1)(s-1)}$. [8]

(b) Discuss how Bode plot is used for determining relative stability. [4]

(c) Discuss the application of a PI controller with suitable example. [4]

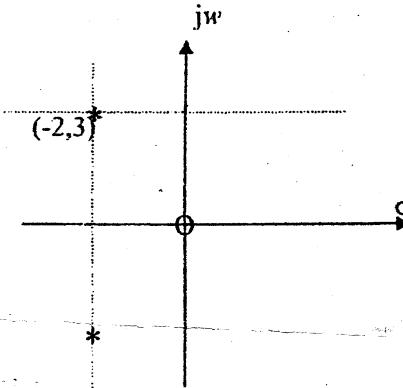
4. (a) Obtain characteristic equation for the system having given state model. [4]

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -5 & -1 \\ 3 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 2 \\ 5 \end{bmatrix} u$$

$$Y = [1 \quad 2] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

(b) Design series lag compensator for the unity feedback system with feedforward transfer function $G(s) = \frac{K}{s(s+4)(s+80)}$. The velocity error constant is $30s^{-1}$ and phase margin at least 33° . [12]

5. (a) Draw Root Locus for the system that has open-loop pole/zero plot in s-plane as below in figure. Also estimate the system gain at the point where the system exhibits critical damping. [8]



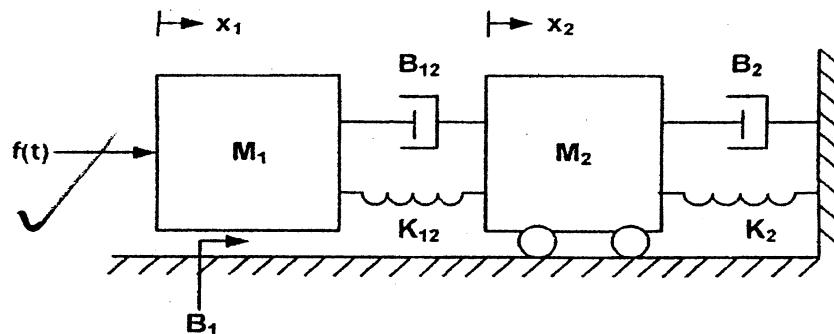
(b) The open loop transfer function of a closed loop system is $(s) = \frac{K(s+1)}{s(s+2)(s+3)}$, find maximum possible K for which the poles lie on left of point -0.5. [8]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System (EE602)

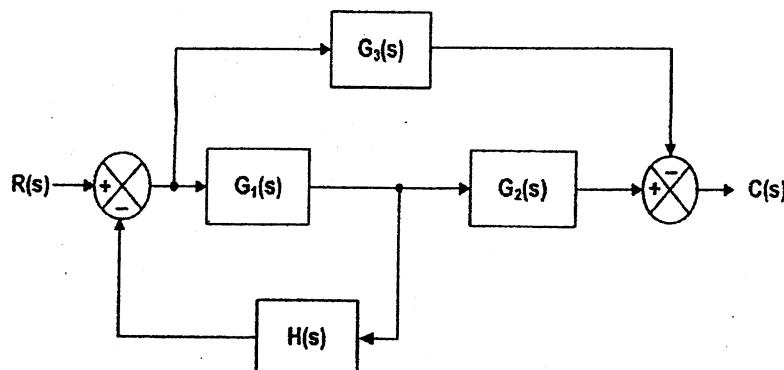
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Bode plot and normal graph paper would be provided.
- ✓ Assume suitable data if necessary.

1. Stating an example of a system that you see in everyday life, explain what do you understand by closed loop system and the importance of feedback in it. [4]
2. Write the differential equations governing the mechanical system shown in figure below and find $\frac{X_2(s)}{F(s)}$. [8+4]



Also tabulating the necessary analogies draw the Force-Current and Force-Voltage electrical analogous circuit.

3. a) Convert the given block diagram to signal flow graph and determine the overall transfer function using Masson's Gain Formula. [6]



- b) Consider a unity feedback system with a closed loop transfer function

$$\frac{C(s)}{R(S)} = \frac{Ks + b}{s^2 + as + b}$$

[6]

Determine the open loop transfer function G(S). Also compute the steady state error with unit ramp input.

4. The characteristics equation of a system is given by $S^6 + 3S^5 + 4S^4 + 6S^3 + 5S^2 + 3S + 2 = 0$. Comment on the stability. [6]

5. Plot the root loci for closed loop system with $G(S) = \frac{K}{S(S+1)(S^2 + 4S + 5)}$, $H(S) = 1$. Also determine the dominant closed loop pole with $\xi = 0.5$. [12]

6. Draw the bode plot for transfer function $G(S) = \frac{48(1+s)}{(s^2)(1+3s)(1+0.5s)(2+02.s)}$, from the graph determine (i) Phase crossover frequency (ii) Gain crossover frequency (iii) P.M (iv) G.M (v) Stability of the system. [10]

7. Design a suitable cascade lag compensator network for the given system
 $G(s) = \frac{50K}{s(s+5)(s+10)}$ [16]

Such that the requirement of velocity error constant of 30 sec^{-1} and phase margin of $\geq 45^\circ$ are met.

8. A system has the transfer function $\frac{Y(s)}{U(s)} = \frac{2}{s^3 + 6s^2 + 11s + 6}$ [8]

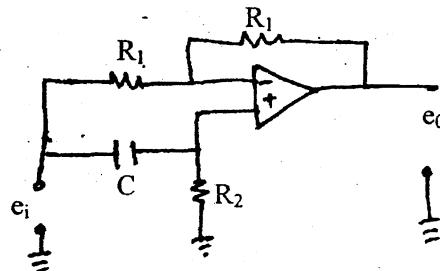
Find the state and output equation in matrix form and test the controllability and observability of the system.

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System (EE 602)

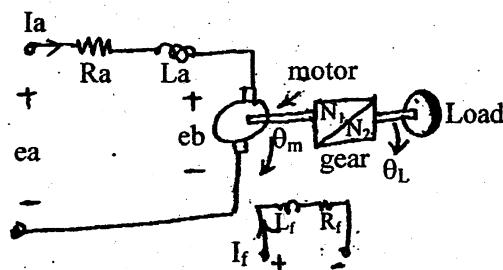
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Find the transfer function $e_o(S)/e_i(s)$ of the given circuit. [6]

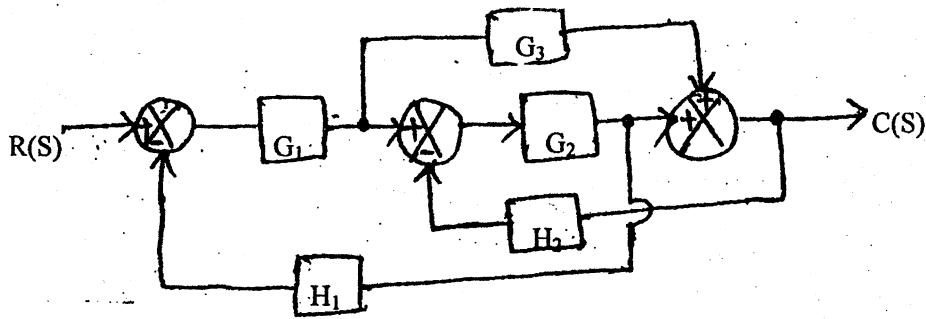


b) For an electromechanical system shown below, derive an expression for $V_L(S)$ considering it as armature controlled dc motor. [10]

Motor: i) Moment of inertia = J_m (ii) Frictional coefficient = D_m (iii) Torsional Load: i) Moment of inertia = J_L (ii) Frictional coefficient = D_L (iii) Torsional



2. a) Determine overall transfer function $\frac{C(S)}{R(S)}$ by block diagram reduction technique. [8]

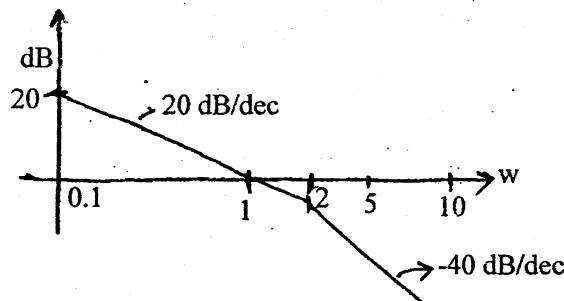


b) Apply RH criteria to determine the range of 'K' for a unity feedback system with

$$G(S) = \frac{K(S+13)}{S(S+3)(S+7)}$$
 will be stable. [8]

3. a) Sketch the root locus for the system having $G(S) = \frac{K(S+1)}{(S^2 + 2S + 2)(S^2 + 2S + 5)}$. [10]

b) Estimate transfer function with the help of following Bode plot. [6]



4. a) Write short notes on following: [4x2]

- i) Gain margin and phase margin
- ii) PD and PI controller

b) Determine TF for the system whose state space representation is given by: [8]

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & -1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u$$

$$y = [1 \quad 0] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

5. Design a suitable lead compensator for a system having open loop TF

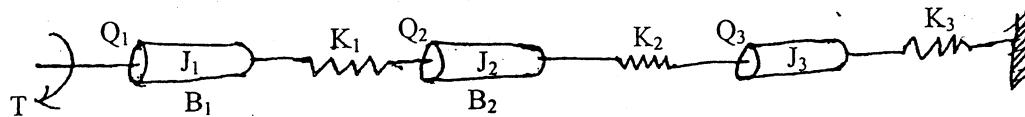
$$G(S) = \frac{K}{S(1+0.1S)(1+0.001S)}$$
 such that the compensated system should have phase margin of at least 45° and static velocity error constant of at least 1000. [16]

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

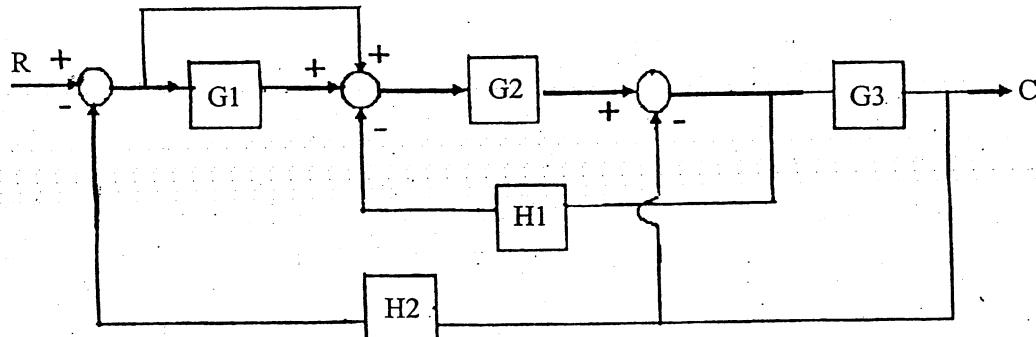
Subject: - Control System

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Semilog graph paper will be provided.

1. State whether the following statements are true or false and justify them. [1+3]x4]
 - a) Introduction of feedback on the system makes the system response faster.
 - b) Effect of disturbances can be reduced by increasing the gain of forward path TF.
 - c) Proportional controller makes the steady state error zero.
 - d) Derivative controllers are always used with other controllers.
2. a) Write differential equation and obtain transfer function of the mechanical system as shown below considering θ_3 as output. Also draw torque voltage analogy network. [6+2]



- b) Find overall transfer function of the system as shown below by block diagram reduction technique. [8]

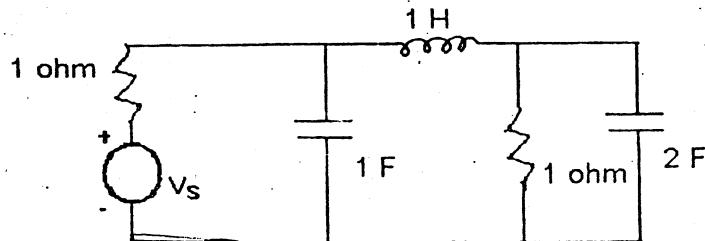


- a) The open loop TF of a unity feedback control system is given as: [8]

$$G(s) = \frac{K}{(s+2)(s+4)(s^2 + 6s + 25)}$$

Determine the range of gain K for the system to be stable. Also determine the value of K which will cause the sustained oscillation and corresponding oscillation frequency.

- b) Write state equation for the system as below shown. Consider voltage across $2F$ capacitor as output. [8]



4. a) Sketch approximate polar plot for a unity feedback system with feed forward transfer function $G(s) = \frac{10}{s(s+1)^2}$ and obtain gain margin. [8]
- b) Draw bode plot of a system having open loop transfer function, $G(s) = \frac{4(s+4)}{(s+2)(s^2 + 2s + 4)}$. Also analyze the stability. [8]
5. Design a lead compensator for a system having open loop transfer function as $\frac{4}{s(s+2)}$, such that the designed system should have $\%M_p \leq 16.3\%$ and settling time (t_s) ≤ 2 sec. [16]

Exam.	Regular/Back	
Level	BE	Full Marks
Programme	BEL, BEX, BCT	Pass Marks
Year / Part	III / I	Time

Subject: - Control System

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Semi-log and normal graph paper will be provided.
- ✓ Assume suitable data if necessary.

1. a) Find the transfer function $X_1(S)/F(S)$ of the mechanical system shown in figure 1.
 Also find the force-voltage analogy of the same system. [8]

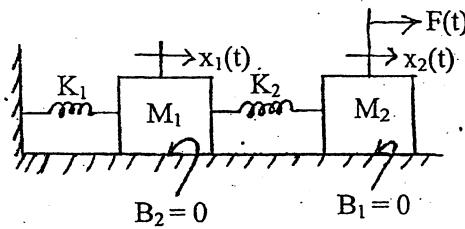
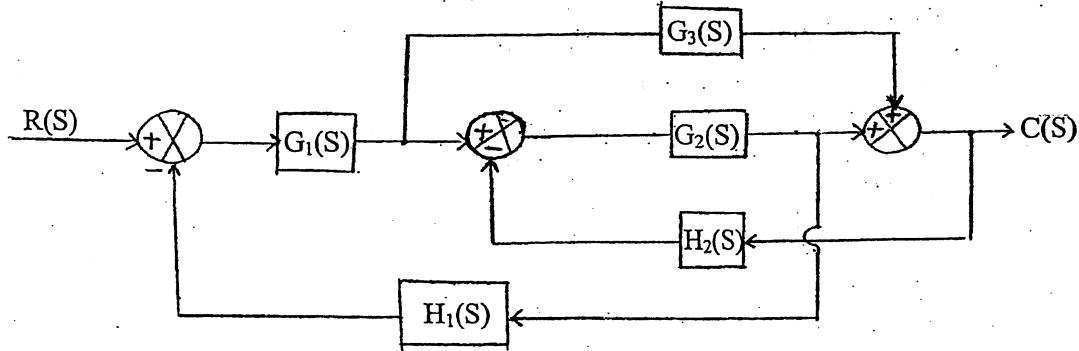
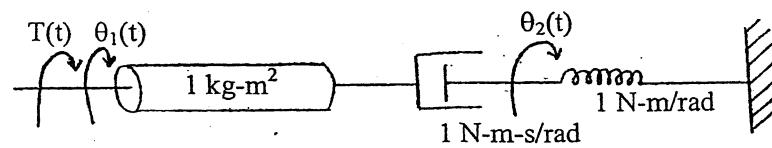


Figure 1

- b) Represent the mechanical system of figure 1 with state equation and output equation, if output is $x_2(t)$ in the figure. [8]
2. a) Draw signal flow graph for a system whose block diagram is shown in figure below and determine $C(S)/R(S)$. [8]



- b) A step torque $T(t)$ is applied in a system shown in figure below. Find the percent overshoot, settling time and peak time for output $\theta_2(t)$. [8]



3. a) The open loop transfer function of a unity feedback system is given by $G(S) = \frac{K}{S(1+ST)}$; where 'K' is the gain constant and 'T' is time constants. With the gain multiplied by a factor K_1 the maximum overshoot of the system is increased from 25% to 50%. Determine K_1 . [8]
- b) The open loop transfer function of a unity feedback system is given by $G(S) = \frac{5}{S(S+2)(S^2+2S+8)}$. Find the static error coefficients and steady state error of the system when subjected to an input given by $r(t) = 2 + 5t + 2t^2$. [8]
4. a) For a unity feedback system that has the forward transfer function $G(S) = \frac{K(S+2)}{(S^2 - 4S + 13)}$. [8]
- Sketch the root locus.
 - Find the imaginary axis crossing.
 - Find the gain K, at the jw axis crossing.
 - Find the break-in point.
- b) Examine the closed-loop stability of a system applying nyquist criterion whose open-loop transfer function is given by $G(S)H(S) = \frac{50}{(S+1)(S+2)}$. [8]
5. The open loop transfer function of a unity feedback is $G(S) = \frac{K}{S(1+0.2S)}$. It is required that $K_v \geq 20 \text{ sec}^{-1}$ and phase margin (ϕ_m) = 44° . Design a lead compensating network to satisfy the required specifications. [16]

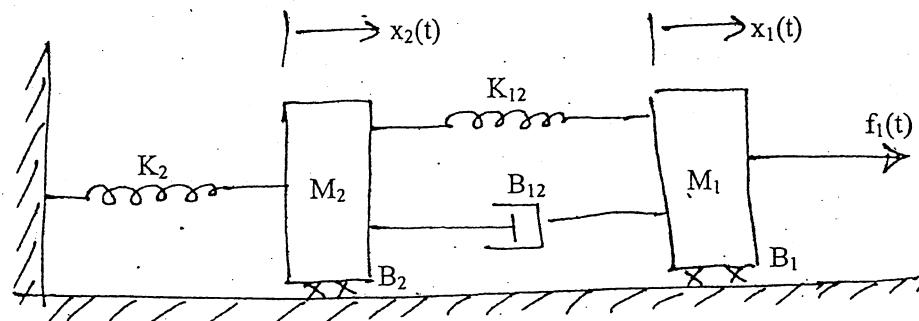
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Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

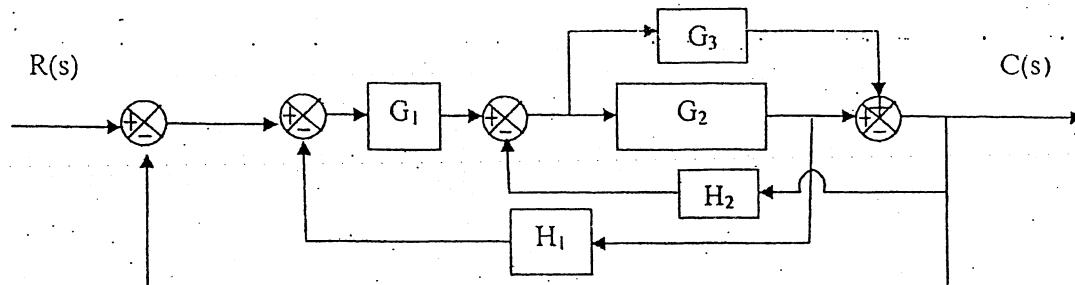
Subject: - Control System

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt any Five questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

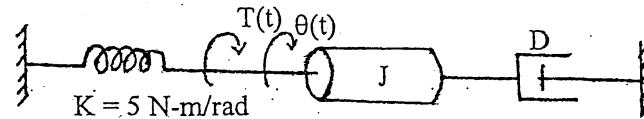
1. a) What is open loop and close loop control systems? Draw the block diagram of closed loop control system and explain the role of each block. [8]
- b) For the mechanical system shown in fig.1(b), draw body diagram, write complete differential equations and identify the transfer function $X_1(s)/F_1(s)$. [8]

**Fig.1(b)**

2. a) Reduce the block diagram of fig.2(a) and find the overall transfer function $C(s)/R(s)$. [8]

**Fig.2(a)**

- b) For the system shown in Fig.2(b), find J and D to yield 20% overshoot and a settling time of 2 seconds for a step input of torque $T(t)$. In the figure $\theta(t)$ is the output. [8]

**Fig.2(b)**

3. a) Using R-H criteria, tell how many roots of polynomial is in right half plane, in left half plane and on jw-axis. $P(S) = S^5 + 3S^4 + 5S^3 + 4S^2 + S + 3$. [8]
- b) Sketch the root locus of a unity feedback control system with open loop transfer function. $G(s) = \frac{k(s+4)}{s(s^2 + 2s + 2)}$ and find the range of k for which the system will be stable. [8]
4. a) Use Nyquist stability criteria to evaluate the stability of the system with open loop transfer function, $G(s) = \frac{10}{s(s^2 + 2s + 4)}$. Identify phase cross-over frequency and gain margin from the Nyquist plot. [8]
- b) The open loop transfer function of a unity negative feedback system is given by $G(s) = \frac{20}{s(0.5s + 1)(s + 2)}$. Calculate the static error constants for this system. Also calculate the steady state error due to input $r(t) = 10 + 5t$. [8]
5. a) Mention P, I and D controllers. Also explain the role of PI and PP controllers on transient and steady state performance specification. [8]
- b) Evaluate the percentage overshoot and peak time for the unity feedback system with open loop transfer function, $G(s) = \frac{5}{s(s + 4)}$. [8]
6. The open-loop transfer function of a unity feedback control system is given by $G(S) = \frac{K}{S(1 + 0.2S)}$. Design a lead compensator such that velocity error constant, $K_v = 10$ and phase margin = 50° . [16]

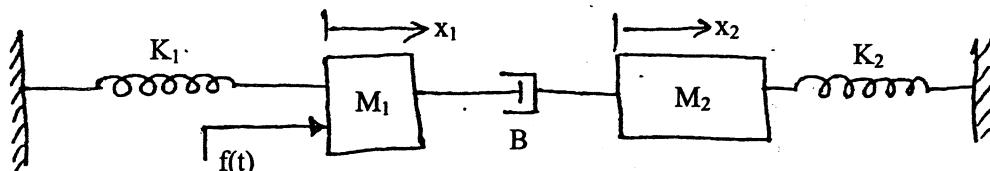
22 TRIBHUVAN UNIVERSITY
 INSTITUTE OF ENGINEERING
Examination Control Division
 2066 **Jestha**

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Semilog graph paper will be provided.
- ✓ Assume suitable data if necessary.

1. a) Draw free body diagram, write complete differential equations and find the transfer function $X_1(S)/F(S)$ for the dynamic system shown below. [8]

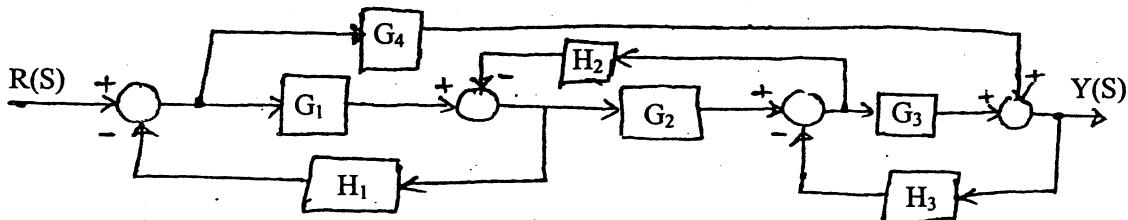


- b) The open loop transfer function of a unity feedback system is given by: [8]

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

Calculate the static error constants for this system and find the range of K if static error is less than 0.5 for input $r(t) = 10 + 50t$. [8]

2. a) Evaluate the transfer function $Y(S)/R(S)$ for the system represented by following block diagram. [6]



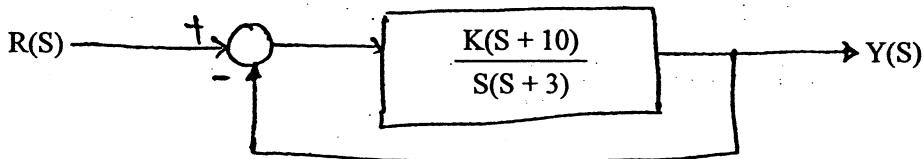
- b) Discuss the advantages and limitations of state-space analysis of control systems. Find the transfer function for the system represented by following state-space model. [10]

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -4 & -1 \\ 10 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} [u]$$

$$[y] = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Also evaluate the stability of this system.

3. a) For a process control system shown below, find the range of K for which the roots of characteristics equation are more -ve than $S = -2$. [6]



- b) Draw root locus for a unity feedback system with open loop transfer function $G(S) = \frac{K(S+1)}{S^2(S+3.6)}$. Also determine the range of K for (i) overdamped response and (ii) unstable system. [10]

4. a) Draw the asymptotic Bode magnitude plot of the unity feedback system whose open loop transfer function is given by: [6]

$$G(S) = \frac{125}{S(S^2 + 10S + 25)}$$

- b) Use Nyquist stability criterion to find the range of K for which the unity feedback system represented by open loop transfer function $G(S) = \frac{K}{S(S+1)(S+2)}$ is stable. [10]

5. a) Discuss in brief the use of PID controllers in control system. [6]

- b) The open loop transfer function of a unity feedback system is given by [10]

$$G(S) = \frac{K}{S^2(0.2S+1)}$$

Design a lead compensator to meet the following specifications.

Acceleration error constant = 10

Phase margin = 35°

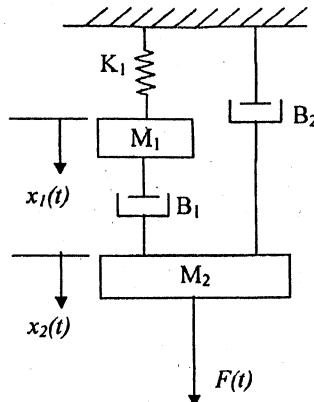
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Semi-log graph paper will be provided.
- ✓ Assume suitable data if necessary.

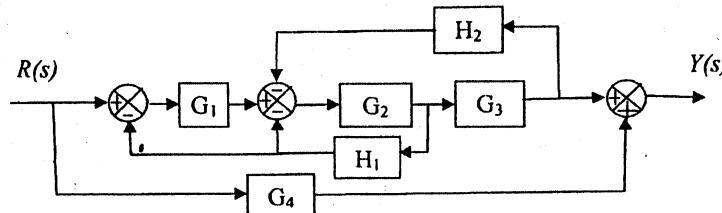
1. a) Draw the close loop control system configurations showing major components.
Discuss the advantage and disadvantage of closed loop systems. [8]

b) Derive the transfer function $X_1(s)/F(s)$ for the system shown below. [8]



2. a) Find the unit step response of a unity feedback system whose open loop transfer function is given by $G(s)H(s) = \frac{4}{s(s+2)}$. [8]

b) Derive the overall transfer function $Y(s)/R(s)$ for the system shown below using block reduction technique. [8]



3. a) The open loop transfer function of a unity feedback system is given by: [6]

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

Find the static error constants and calculate error due to input $r(t) = 4t + 1$.

b) Draw the root locus for the system with open loop transfer function: [10]

$$G(s)H(s) = \frac{k}{s(s^2 + 10s + 24)}$$

From the root locus, find the gain (k) and corresponding natural frequency of oscillation when the damping ratio is 0.7.

4. a) Draw the Nyquist plot for the following open loop transfer function. [8]

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

b) Discuss the advantages of state space representation. Find the state equation and output equation of state space form for the system represented by transfer function. [8]

$$G(s) = \frac{2s^2 + 3s + 1}{s^3 + 5s^2 + 6s + 7}$$

5. Design a lead compensator for a system with open loop transfer function $G(s) = \frac{k}{s^2(s+5)}$ for the specifications of phase margin = 30° and acceleration error constant, $K_a = 5 \text{ sec}^{-2}$. Also draw the bode magnitude and phase plots after compensation. [16]