11 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Ashwin

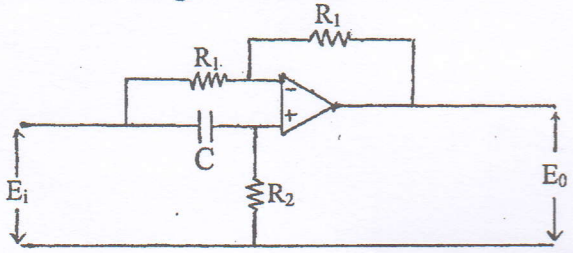
Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BAME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System *(EE602)*

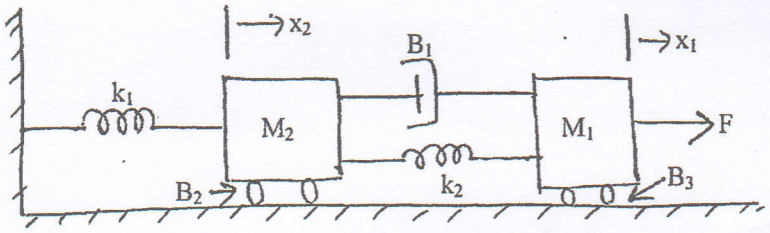
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Inspite of cost and complicated design, closed loop control system are widely preffered over open loop control system. Justify the statement with some examples. [4]

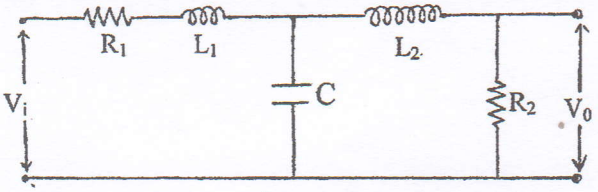
   b) Find the transfer function of given circuit. [4]



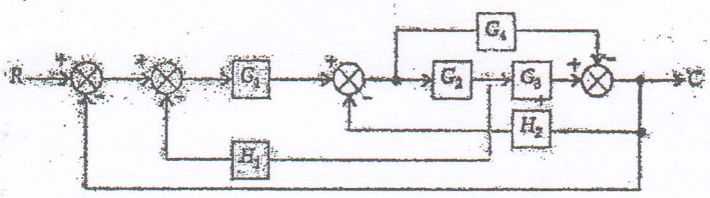
   c) For the mechanical system shown below find the transfer function $M_2(s)/F(s)$. Draw the force voltage analogy. [6+2]



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



   b) Using Masons 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]

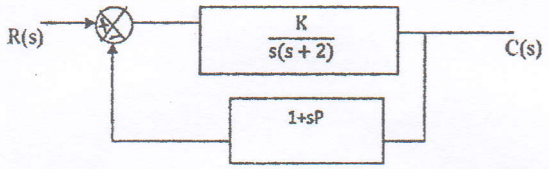


Fig. (i)

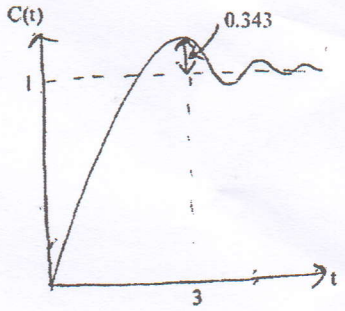


Fig. (ii)

b) Sketch the root locus for unity feedback the system having the forward path transfer function $G(S)=\frac{K}{(s^2+2s+2)(s^2+2s+5)}$ [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, $K_v = 5\ sec^{-1}$ and phase margin is at least 40° and the gain margin is at least 10 dB with a lag compensator. [12]

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11 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Chaitra

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

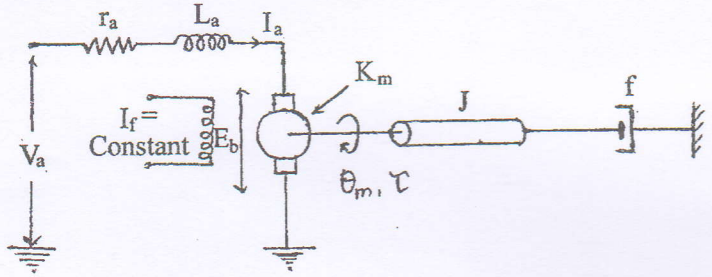
Subject: - Control System *(EE602)*

- ✓ 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.*

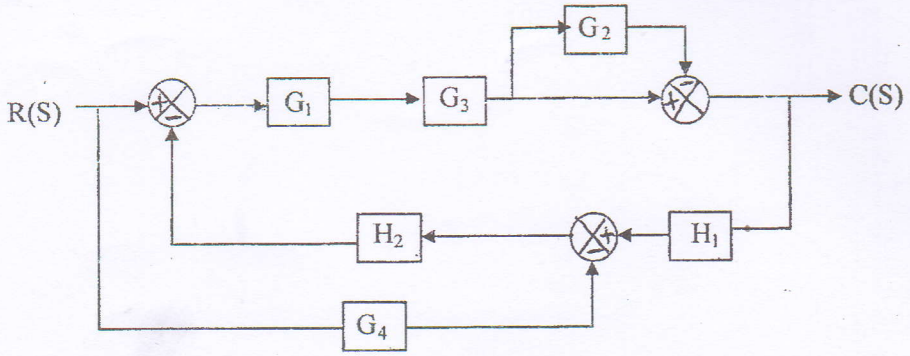
1. a) What is control system? Draw the block diagram of a closed loop control system and briefly explain the function of each block. [5]

   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 [5]

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

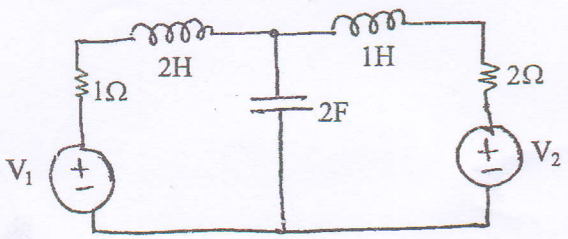
   c) How we can perform relative stability analysis using RH-Criteria? [3]

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 $0 \le K \le \infty$ 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 $C(t)=5(1-e^{-t/5})$. 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]

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

$P.M \ge 40°$

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21 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division

2074 Ashwin

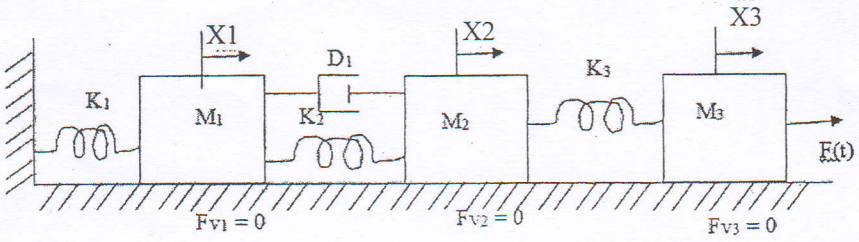
Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BME, BIE	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System *(EE602)*

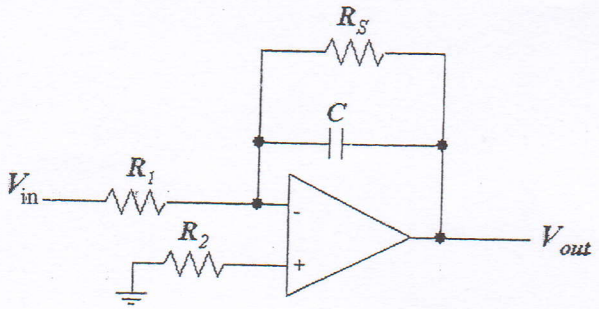
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

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

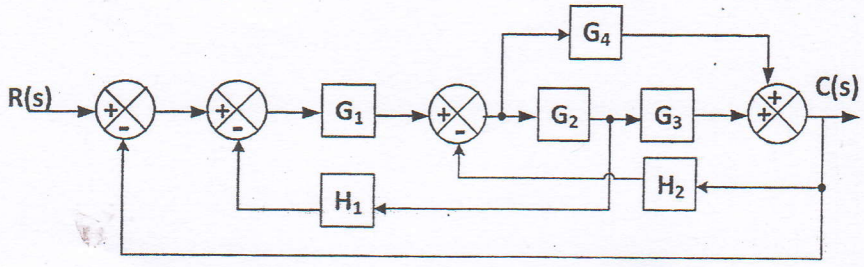
   b) Find the transfer function, $\frac{X2(S)}{F(S)}$, for the mechanical system of figure below. Also draw the F-V and F-I analogy circuit of the system. [6]



   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 $G(s)=\frac{20s+200}{(s^2+5s+25)(s^2+40s)}$.

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 $G(s)H(s)=\frac{k}{s(1+0.1s)(1+0.001s)}$ so that the designed system should have PM $\geq 45°$, $K_v=1000\ \sec^{-1}$ [12]

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Shrawan

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.

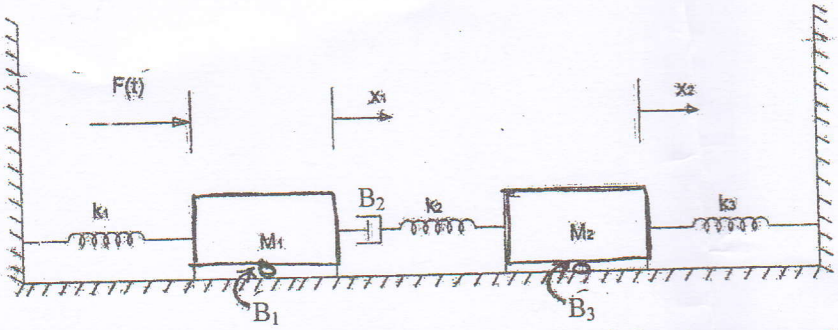
Subject: - Control System *(EE602)*

- ✓ 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.*

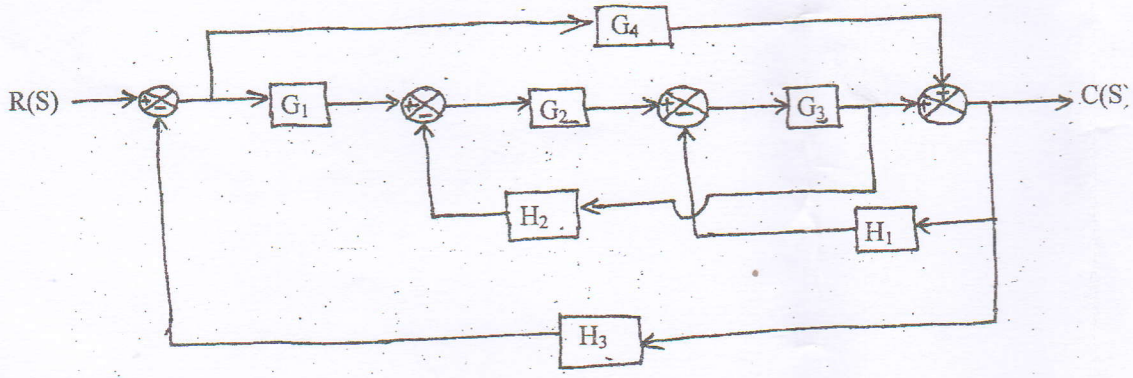
1. a) What kind of control system could have been in the following? Illustrate with necessary blocks and variables. [4×2]

   i) Governer system of Hydropower Station
   ii) Traffic light system of Kathmandu

   b) Find transfer function (consider displacement of mass M2 as output) for the given mechanical system. Also develop force-current analogous circuit. [8]



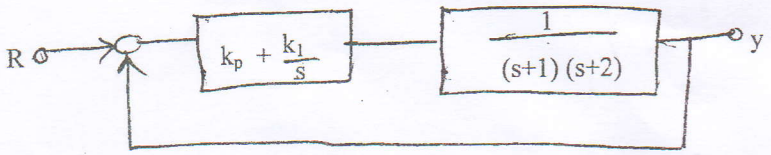
2. a) Determine the overall transfer functions C(S) / R(S) of the given system by block diagram reduction technique. [8]



   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

   $y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} x(t)$; 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 $G(S) = \frac{K(S+9)}{S(S^2+4S+11)}$. Sketch the root locus and determine: [8]

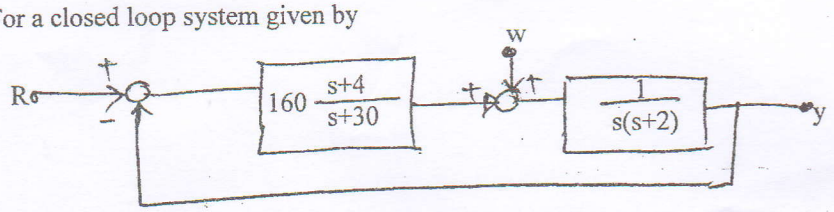
i) The range of 'K' for system to be stable
ii) Undamped natural frequency of oscillation

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

The system should meet the following criteria

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

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]

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21 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Chaitra

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.*
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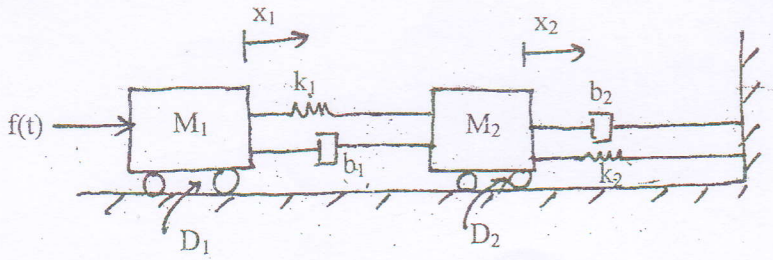
- ✓ *Assume suitable data if necessary.*

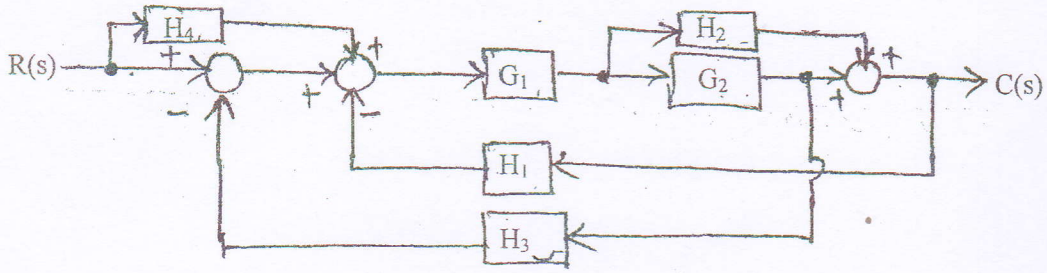
1. a) Define linear time invariant system. Justify the statement "modern complex systems are more pronounced with closed loop control system". [4]

   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]

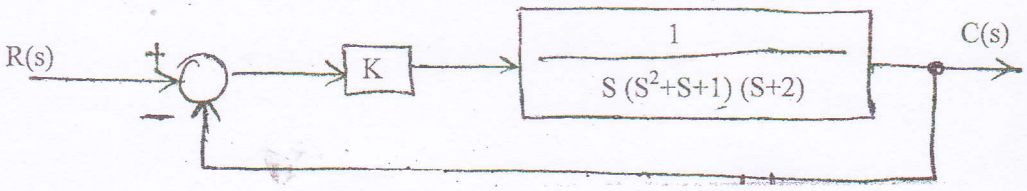


   c) Discuss, how a closed loop system has better disturbance rejection and command input tracking capabilities in comparision to an open loop system. [4]

2. a) Find Transfer function of the following system. [8]

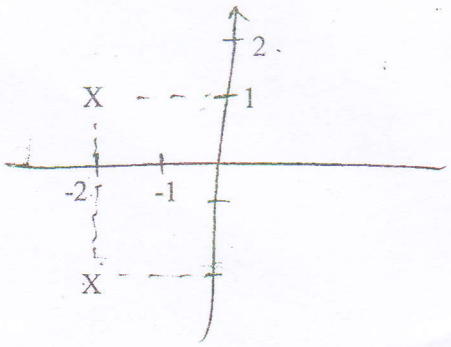


   b) Find the range of 'K' for stable operation using R-H criteria. [4]



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

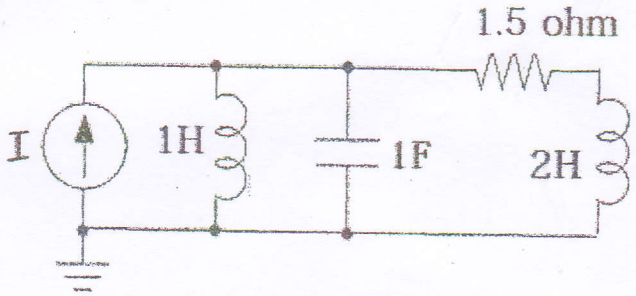
3. a) Open loop pole/zero plot of a unity feedback system are shown in figure below. Determine maximum overshoot and setting time for its step response. [6]



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]

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21 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Chaitra

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.*
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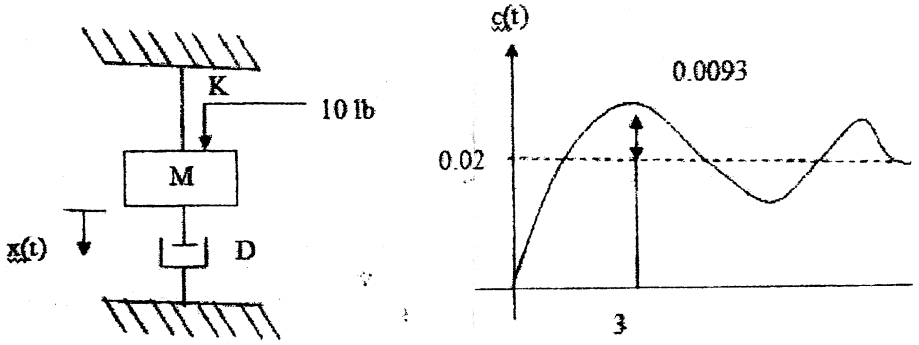
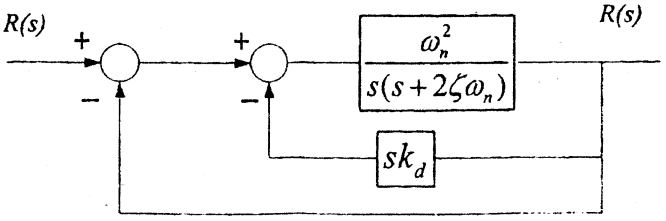
1. a) Construct a general block diagram of a control system showing the different blocks, variables and hence briefly point out their meaning. [4]

   b) Effect of disturbance in case of feedback control system can be suppressed by increasing the gain G(S) and / or H(S). [4]

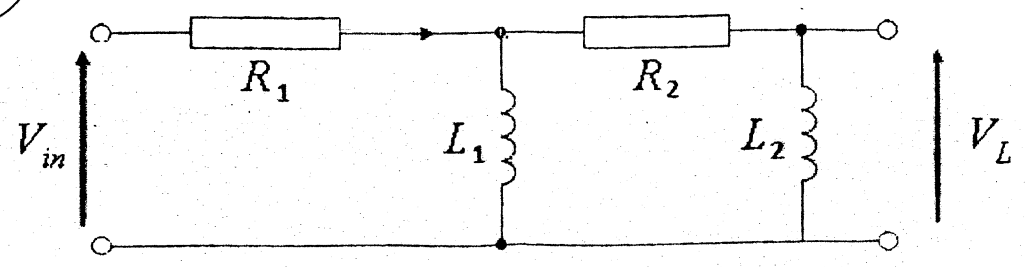
   c) Following figure shows a mechanical vibratory system and the response when 10 lb of force is applied to the system. Determine the transfer function and value of M, D and K. The displacement x is measured from the equilibrium position. [8]



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) $G(s) = \frac{k}{(s+1)(s+3)}$, 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]

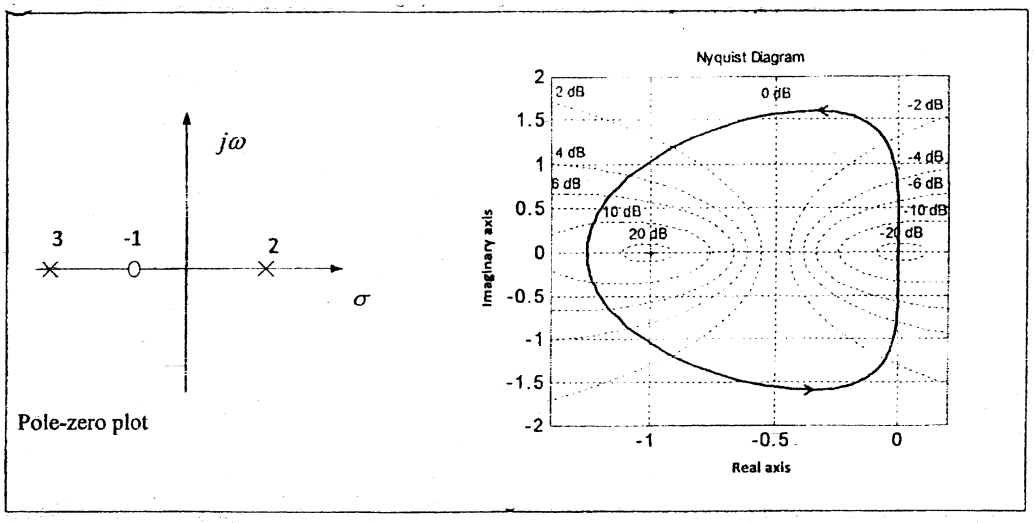
$$G(s)H(s) = K\frac{s^2 - 2s + 5}{s^2 + 1.5s - 1}$$

Sketch the root locus for $0 \le K \le \infty$ 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±j0.6)

4. a) Design a suitable compensator for a unity feedback system with open loop transfer $G(s) = \frac{4}{s(s+2)}$ such that the settling time will become 2 seconds without change in overshoot and velocity time constant will be $2\ s^{-1}$. [12]

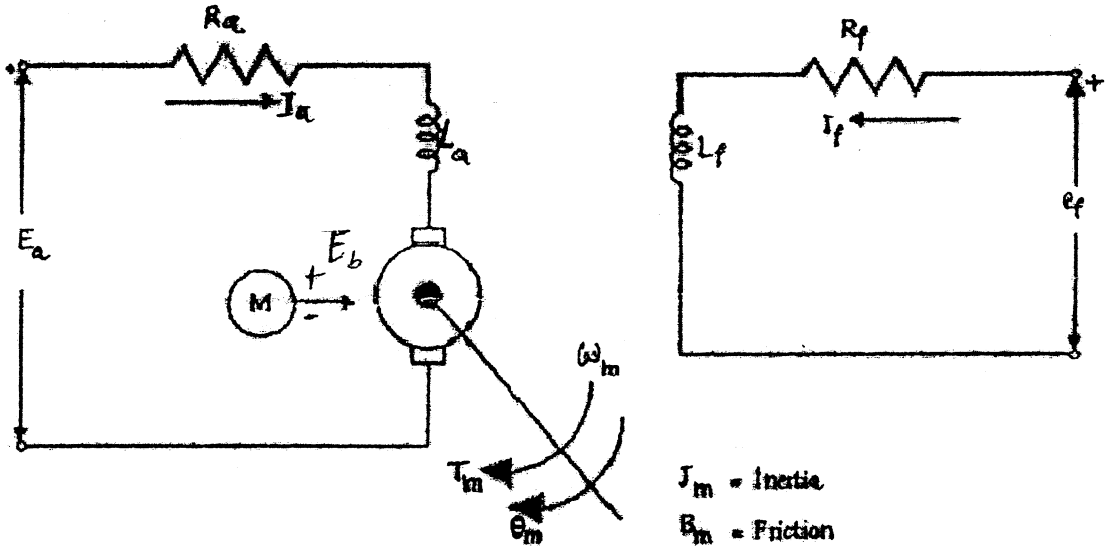
b) For a compensator transfer function given by $G_c(s) = \frac{s+\tau}{s+a\tau}$, give the condition of lead compensator. For the given value of 'a' what is the frequency that leads to maximum phase angle lead. [4]

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]



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2071 chaitra

control system

22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Shawan

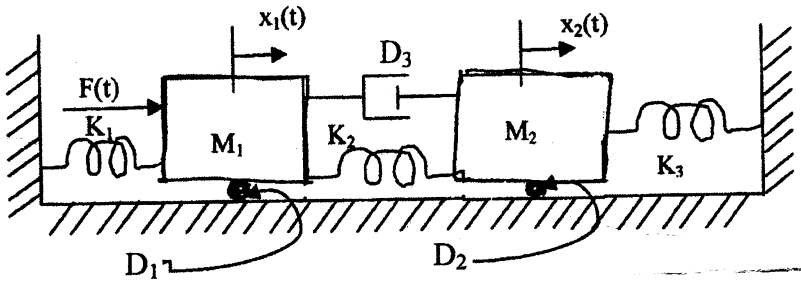
Exam.	New Back (2066 & Later Batch)		
Level	BE	**Full Marks**	80
Programme	BEL, BEX, BME, BIE	**Pass Marks**	32
Year / Part	III / I	**Time**	3 hrs.

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 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, $\frac{X2(S)}{F(S)}$, 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 $0 \le K \le \infty$ 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]

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

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

$P.M \ge 35°$ [16]

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21 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2070 Chaitra

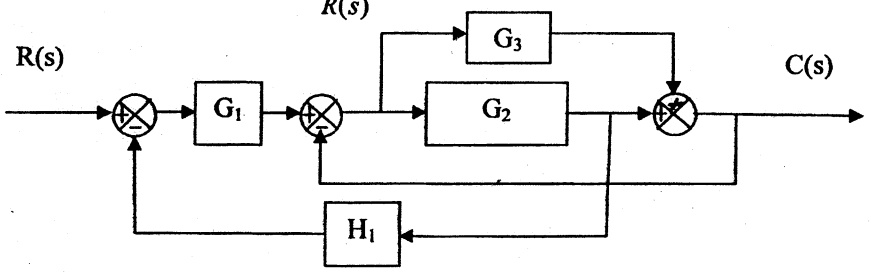
Exam.	Old Back (2065 & Earlier Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

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.*

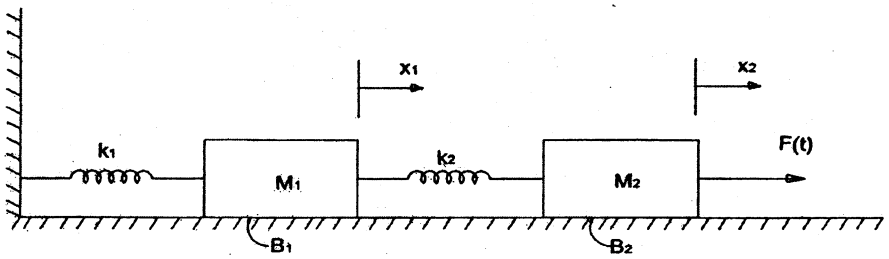
1. a) For armature controlled separately excited DC motor, identify the necessary differential equations governing its behaviors and hence derive the dynamic model of such motor. **[8]**

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

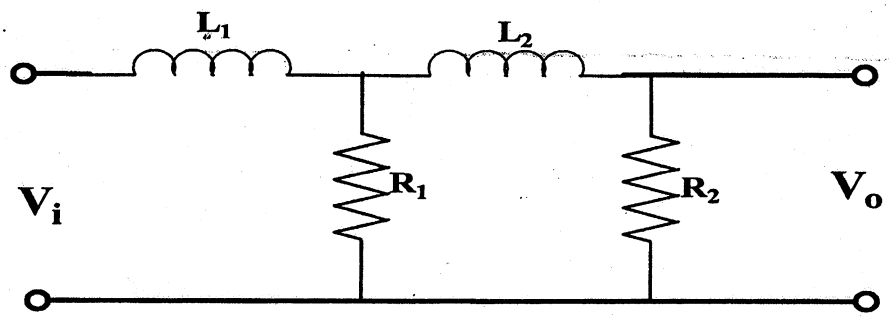


2. a) Draw the free body diagram, write the differential equations and find the mentioned transfer function of the below **[10]**

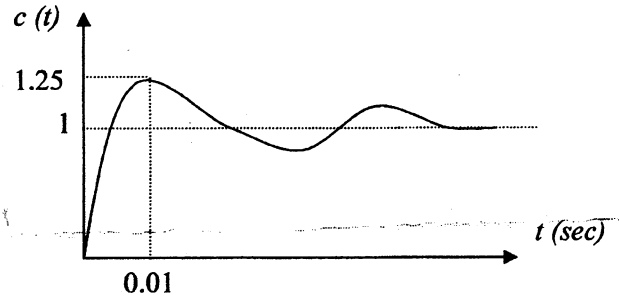
$\frac{X2(s)}{F(s)}$ and $\frac{X1(s)}{F(s)}$



b) Draw the block diagram and reduce it to calculate $\frac{V_0(s)}{V_i(s)}$ for the following network. **[6]**



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

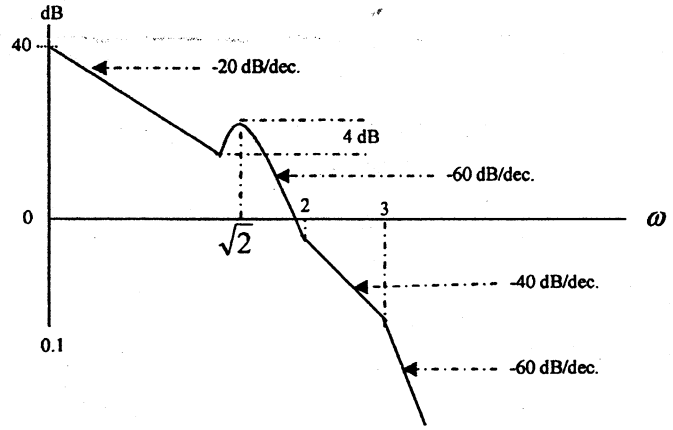


b) Check the stability of the system represented by the following characteristic equation given below using R-H criteria. [8]

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

4. **a)** Find the Gain Margin and Phase Margin using Bode plots for the following transfer function: $G(s)=\dfrac{1}{s(0.1s+1)(0.2s+1)}$ [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]

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

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

6. A system of which open loop transfer function $G_f(s)=\dfrac{4}{s(s+2)}$. 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]

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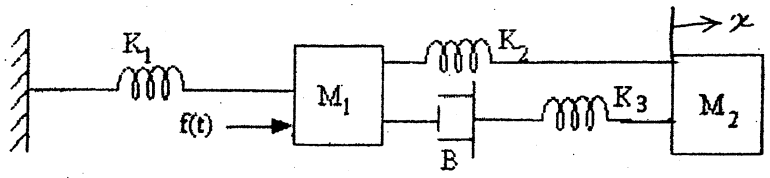
21 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Chaitra

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

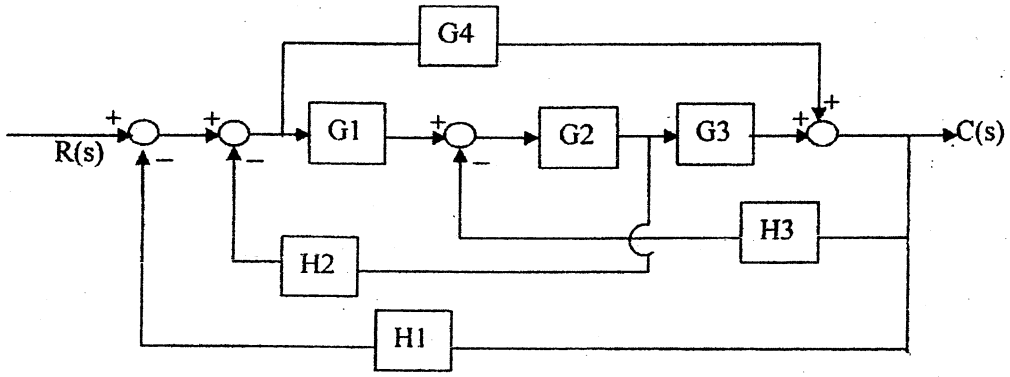
Subject: - Control System *(EE602)*

- ✓ 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]

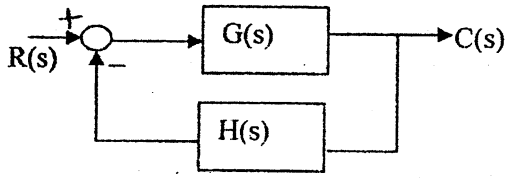


(b) Reduce the following block diagram model to obtain its overall transfer function. [6]



(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]

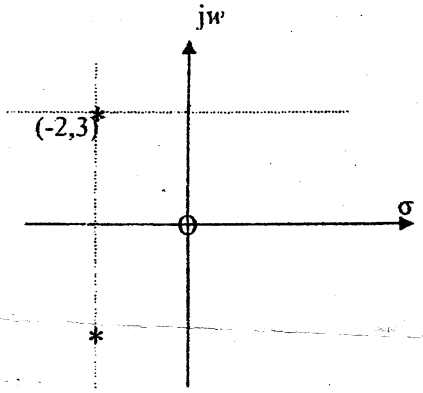
4. (a) Obtain characteristic equation for the system having given state model. [4]

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

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

(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 33^0. [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]

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division

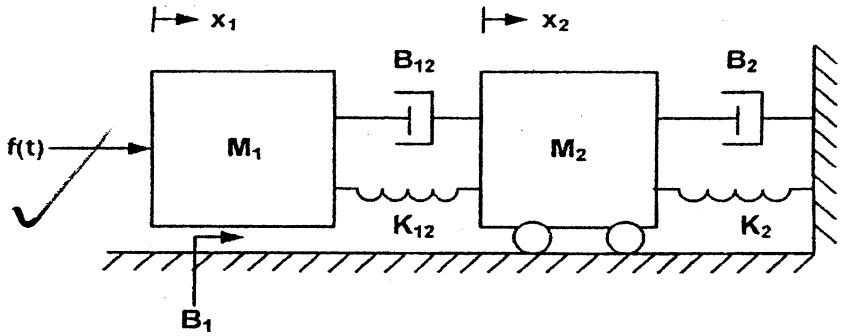
2069 Chaitra

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)*

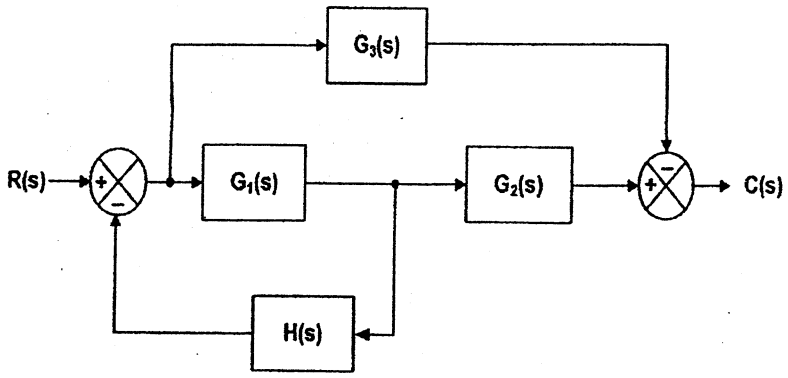
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Bode plot and normal graph paper would be provided.*
- ✓ *Assume suitable data if necessary.*

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 $\geq 45°$ 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.

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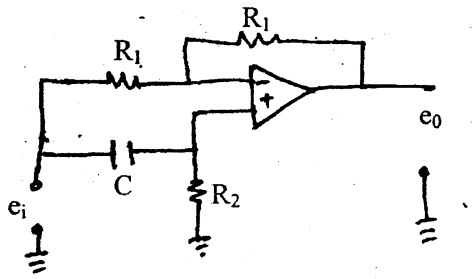
22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Chaitra

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)***

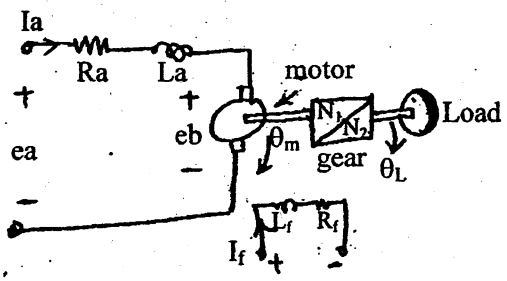
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

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

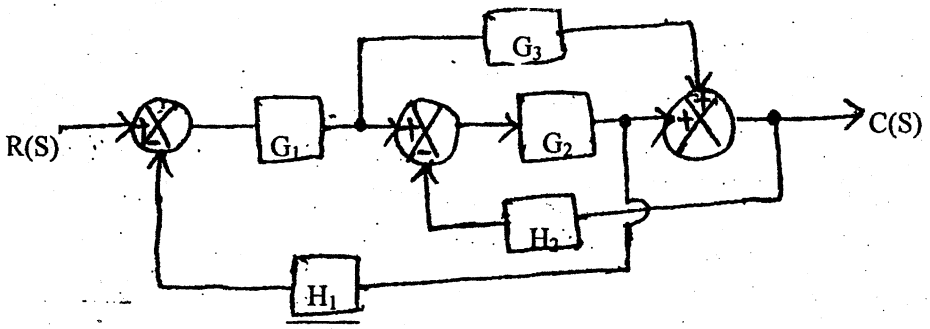


b) For an electromechanical system shown below, derive an expression for $V_L(S)$ considering it as armature controlled dc motor. [10]

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



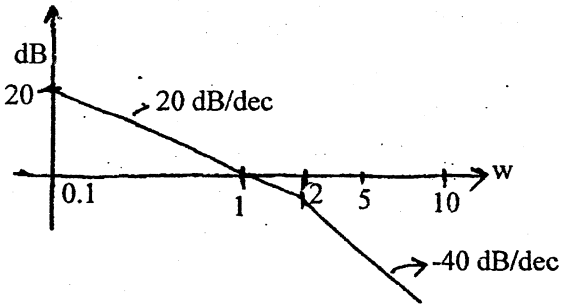
2. a) Determine overall transfer function $\frac{C(S)}{R(S)}$ by block diagram reduction technique. [8]



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: [4×2]

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]

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Baishakh

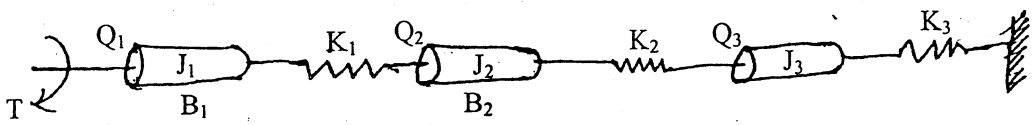
Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Control System

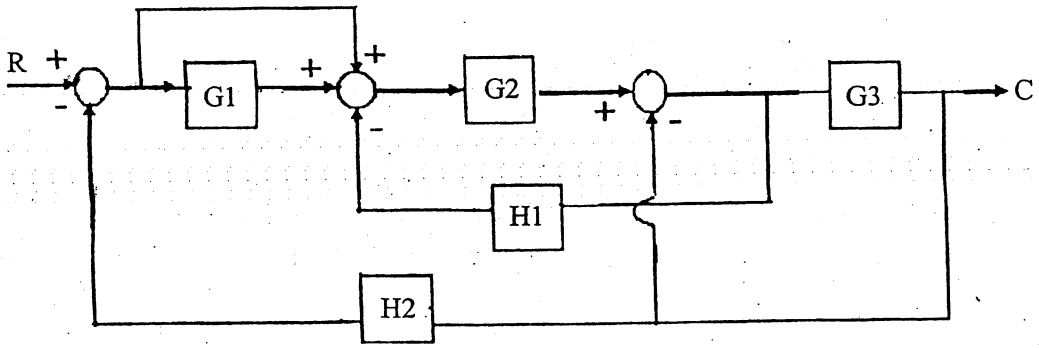
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Semilog graph paper will be provided.***

1. State whether the following statements are true or false and justify them. [(1+3)×4]
   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]

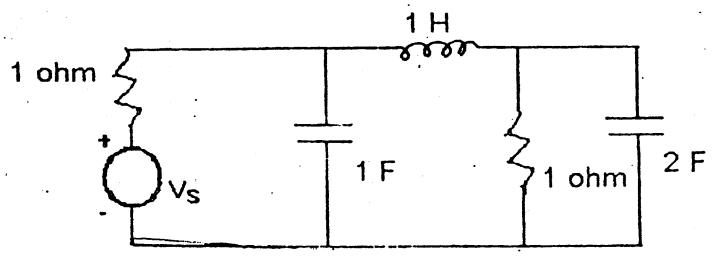


3. a) The open loop TF of a unity feedback control system is given as: [8]

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

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 %Mp ≤ 16.3% and settling time (t_s) ≤ 2 sec. [16]

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2067 Ashadh

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**.*
- ✓ ***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]

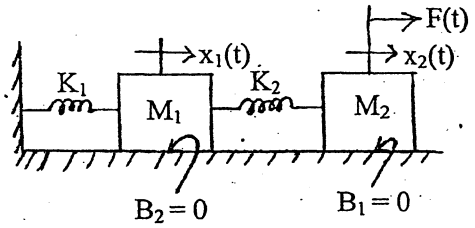
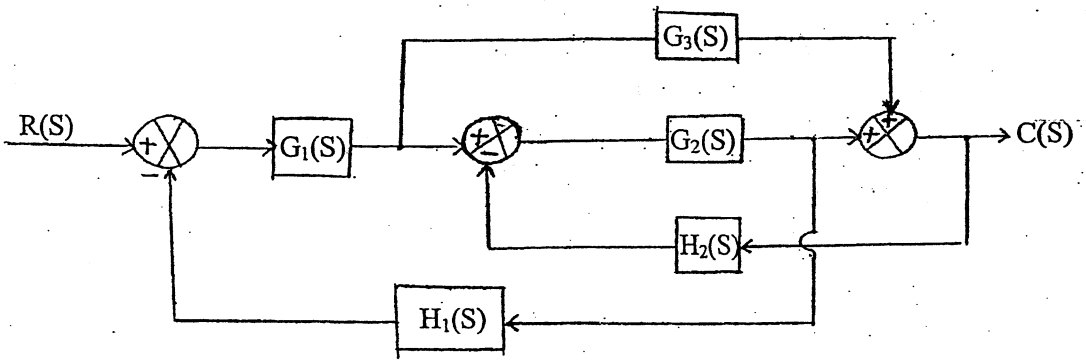


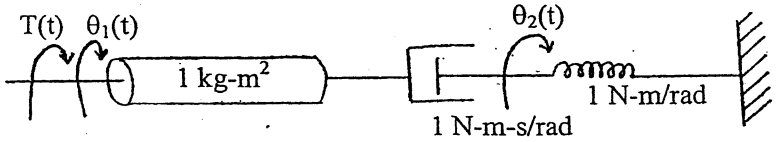
Figure 1

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 unify 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 unify 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]

i) Sketch the root locus.
ii) Find the imaginary axis crossing.
iii) Find the gain K, at the jw axis crossing.
iv) 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 unify feedback is $G(S) = \frac{K}{S(1+0.2S)}$. It is required that $K_v \geq 20\ sec^{-1}$ and phase margin (ϕ_m) = 44°. Design a lead compensating network to satisfy the required specifications. [16]

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2066 Bhadra

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 identity the transfer function $X_1(s)/F_1(s)$. [8]

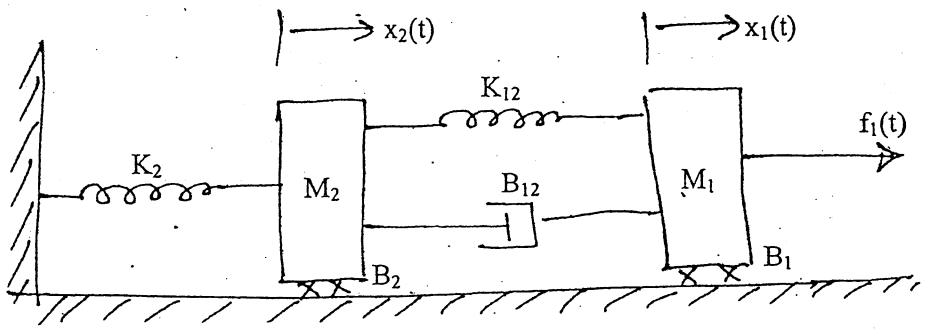

Fig.1(b)

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

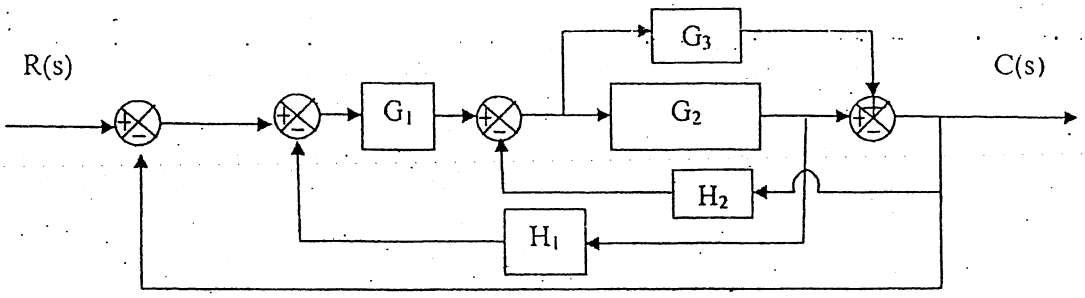

Fig.2(a)

   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 θ(t) is the output. [8]

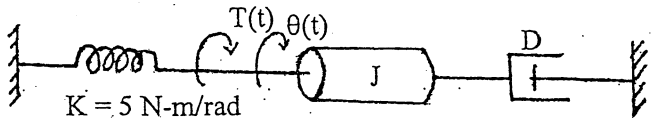

Fig.2(b)

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]

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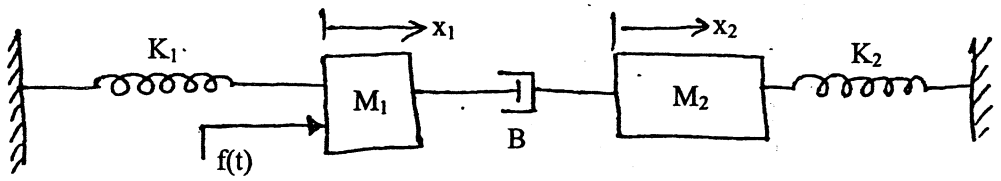
22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2066 Jestha

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]

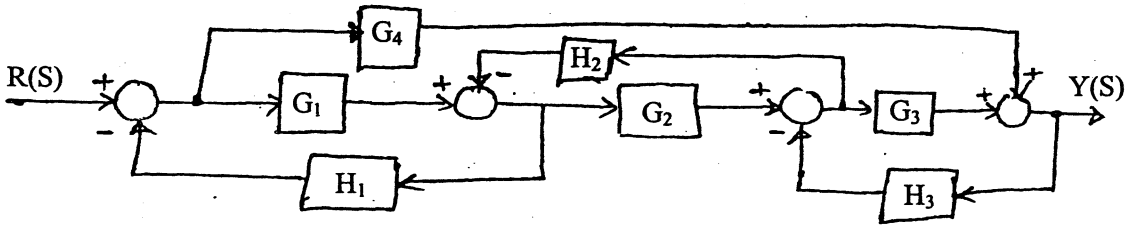


b) The open loop transfer function of a unity feedback system is given by: [8]

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

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]



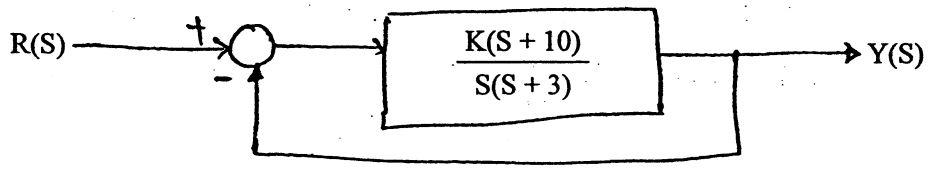
b) Discuss the advantages and limitations of state-space analysis of control systems. Find the transfer function for the system represented by following state-space model. [10]

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

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

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 assymptotic 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°

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division

2065 Shrawan

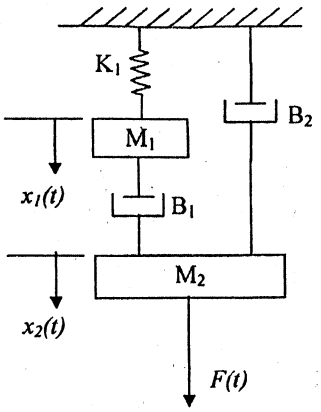
Exam.			
Level	BE	**Full Marks**	80
Programme	BEL, BEX, BCT	**Pass Marks**	32
Year / Part	III / I	**Time**	3 hrs.

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.*

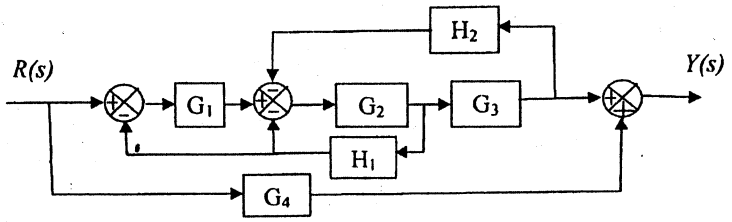
1. a) Draw the close loop control system configurations showing major components. Discuss the advantage and disadvantage of closed loop systems. [8]

   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 ration 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]

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