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.

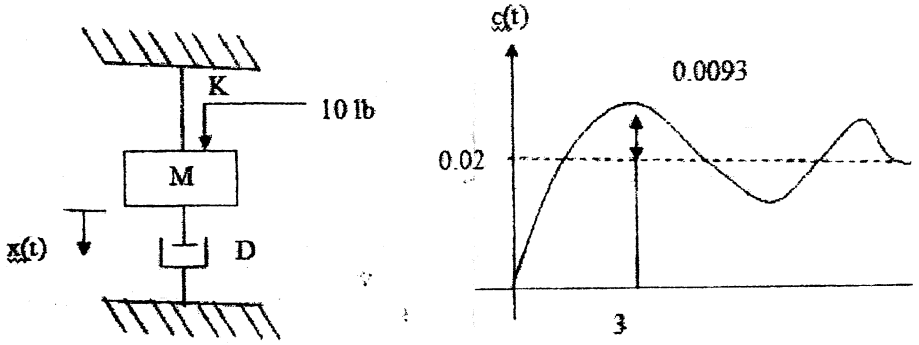
Subject: - Control System *(EE602)*

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

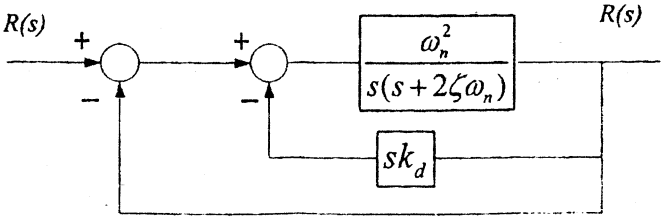
1. a) Construct a general block diagram of a control system showing the different blocks, variables and hence briefly point out their meaning. [4]

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

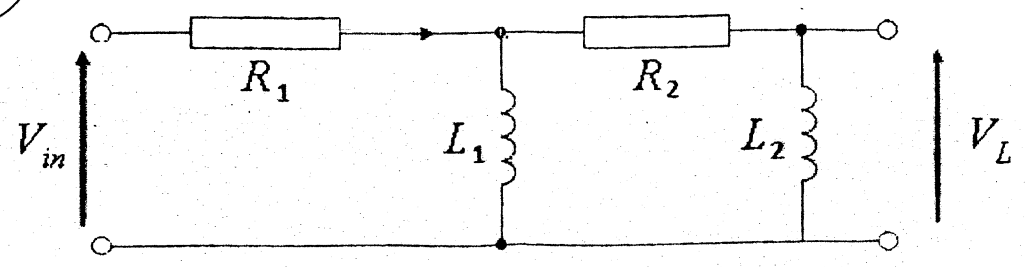
   c) Following figure shows a mechanical vibratory system and the response when 10 lb of force is applied to the system. Determine the transfer function and value of M, D and K. The displacement x is measured from the equilibrium position. [8]



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

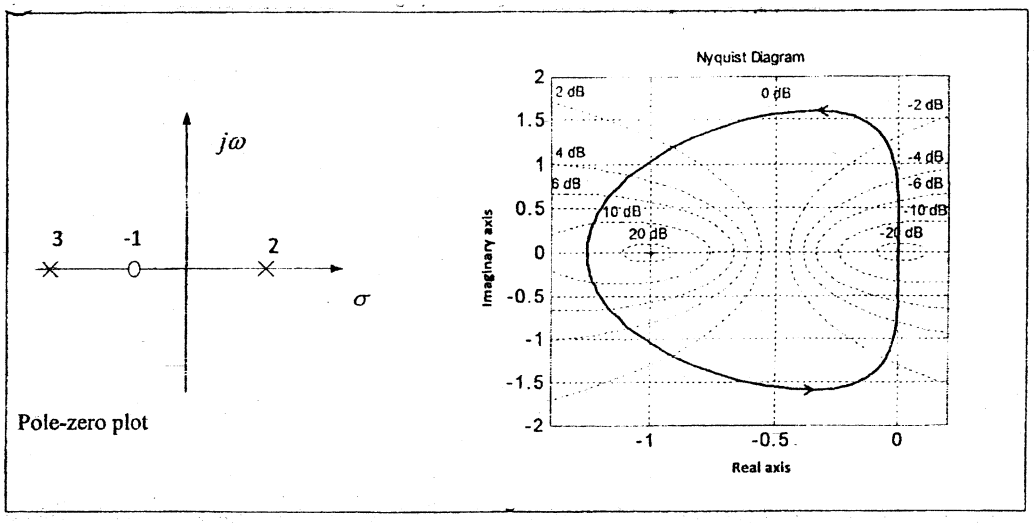
$$G(s)H(s) = K\frac{s^2 - 2s + 5}{s^2 + 1.5s - 1}$$

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]

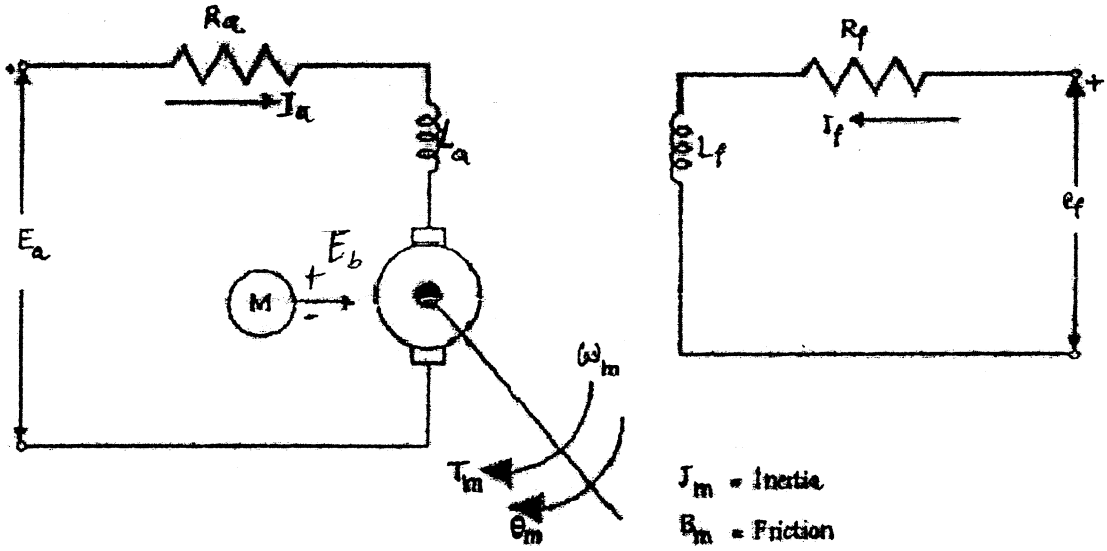
b) For a compensator transfer function given by $G_c(s) = \frac{s+\tau}{s+a\tau}$, give the condition of lead compensator. For the given value of 'a' what is the frequency that leads to maximum phase angle lead. [4]

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

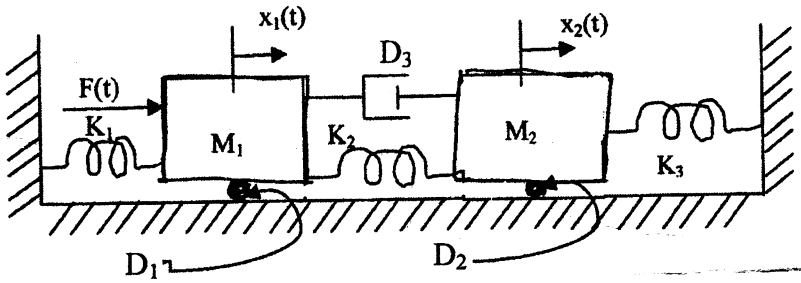
Exam.	New Back (2066 & Later Batch)		
Level	BE	**Full Marks**	80
Programme	BEL, BEX, BME, BIE	**Pass Marks**	32
Year / Part	III / I	**Time**	3 hrs.

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

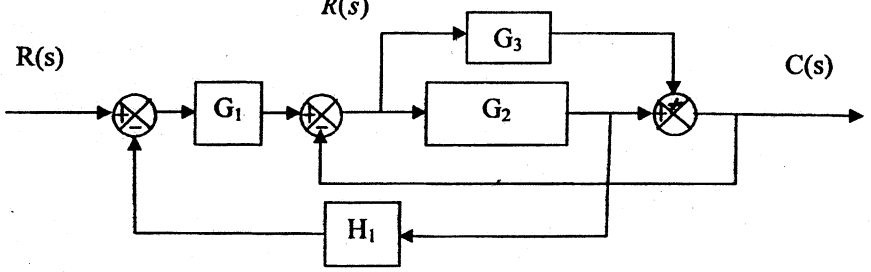
Exam.	Old Back (2065 & Earlier Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

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.*

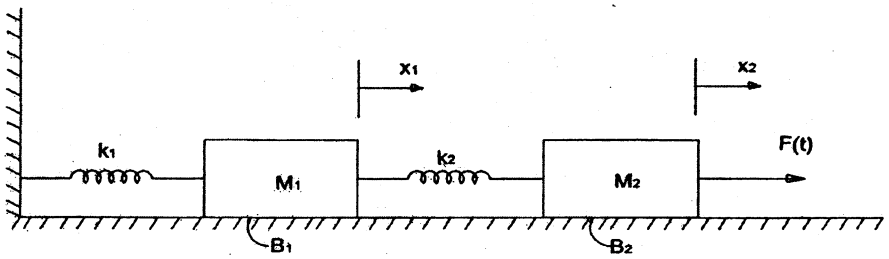
1. a) For armature controlled separately excited DC motor, identify the necessary differential equations governing its behaviors and hence derive the dynamic model of such motor. **[8]**

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

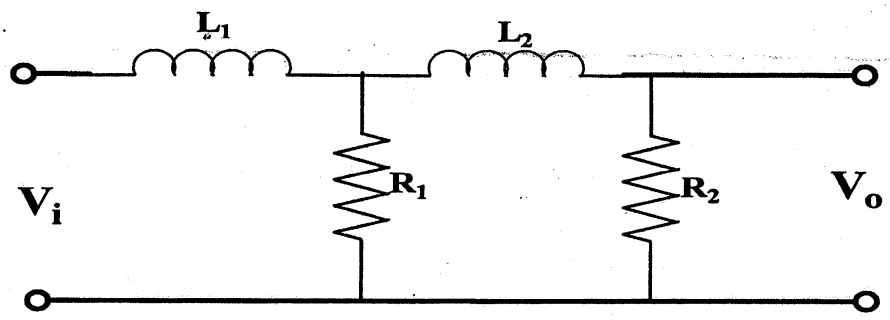


2. a) Draw the free body diagram, write the differential equations and find the mentioned transfer function of the below **[10]**

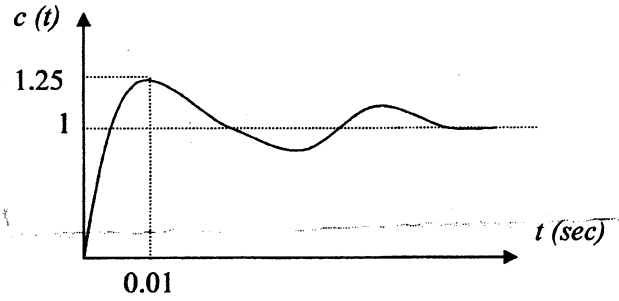
$\frac{X2(s)}{F(s)}$ and $\frac{X1(s)}{F(s)}$



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]

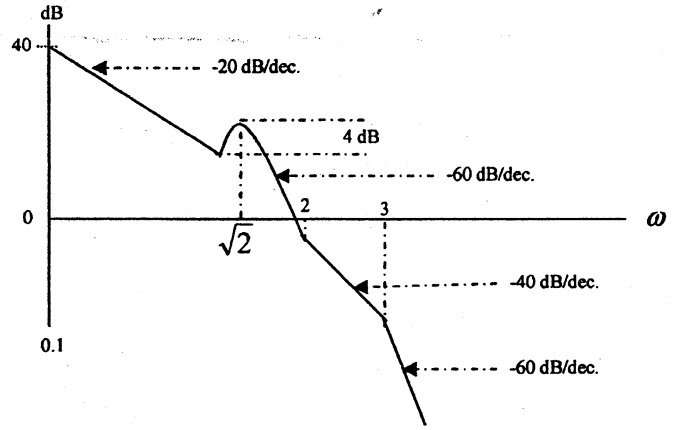


b) Check the stability of the system represented by the following characteristic equation given below using R-H criteria. [8]

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

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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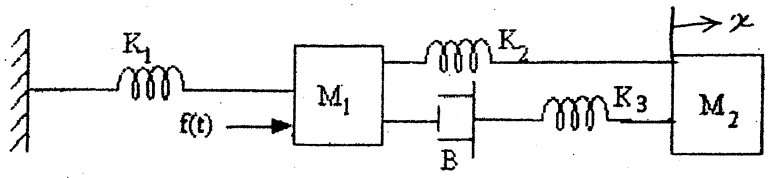
2070 Chaitra

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

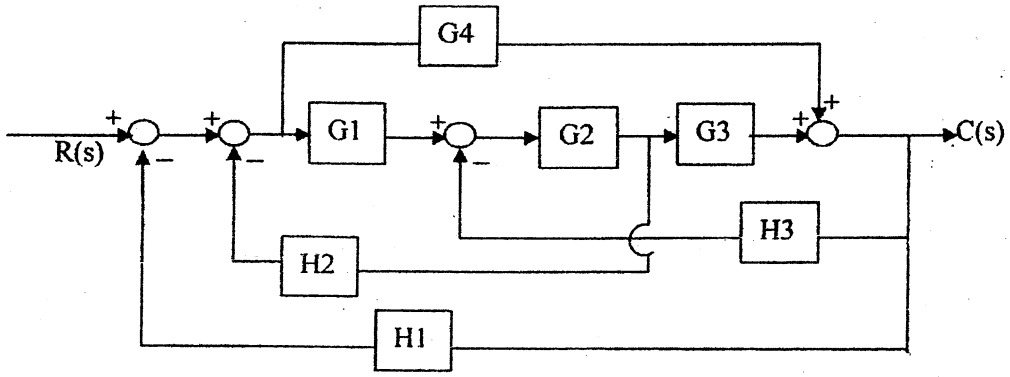
Subject: - Control System *(EE602)*

- ✓ 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]

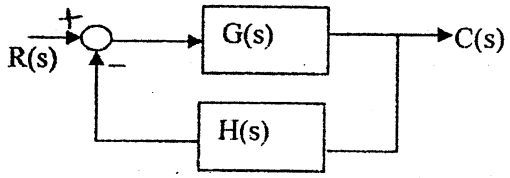


(b) Reduce the following block diagram model to obtain its overall transfer function. [6]



(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]

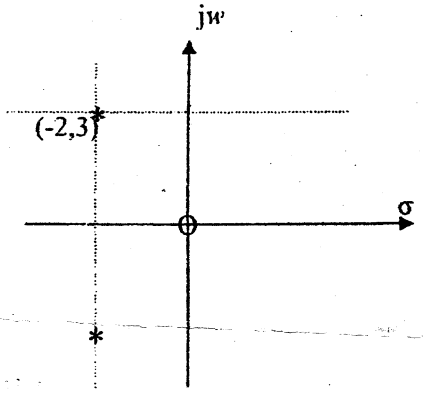
4. (a) Obtain characteristic equation for the system having given state model. [4]

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

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

(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

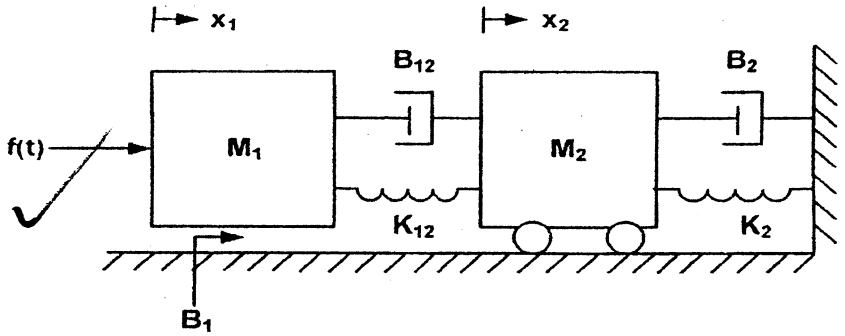
2069 Chaitra

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)*

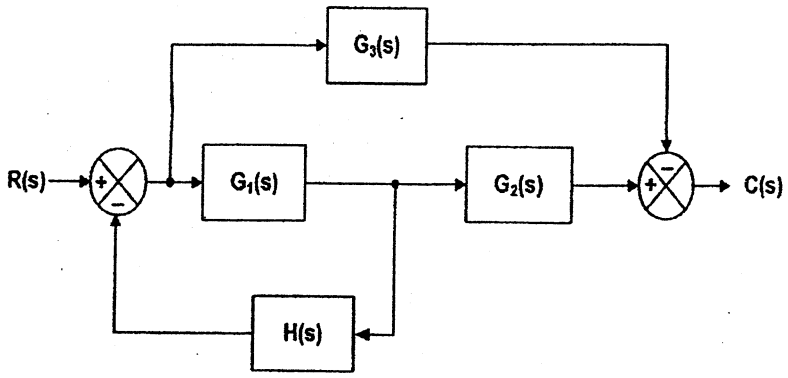
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Bode plot and normal graph paper would be provided.*
- ✓ *Assume suitable data if necessary.*

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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