ANJUMAN COLLEGE OF ENGINEERING AND TECHNOLOGY

SADAR , NAGPUR

Academic Monitoring Cell

Staff Teaching Plan

Date : 01/01/2018

Academic Year : 2017-2018

Course : BE

Year : 3RD YEAR

Branch : MECHANICAL ENGG.

Sub Code : 187

Semester : 6TH SEM

Section : B

Subject : CONTROL SYSTEM ENGINEERING

Subject Type : THEORY

Emp ID : 202

Emp Name : KIRTI KHANDELWAL

Sr.No.	Unit	Topic Code	Expected Date	Topic Description
1	1	1.1	26/12/2017	1. CONTROL SYSTEM CONTROLS: STUDY OF CONTROL SYSTEM COMPONENTS SUCH AS HYDRAULIC ACTUATORS,
2	1	1.2	28/12/2017	2. SERVOMECHANISM D.C. AND A.C. MOTOR, LIQUID LEVEL CONTROL, AUTOMOBILE POWER STEERING CONTROL, SPEED CONTROL, POSITION CONTROL OF ROBOTIC MANIPULATOR ETC
3	1	1.3	01/01/2018	3. STUDY AND ANALYSIS OF PERFORMANCE CHARACTERISTICS, THE CONCEPT OF VARIOUS TYPES OF SYSTEM LIKE MACHINE TOOLS,
4	1	1.4	03/01/2018	4. PRIME MOVERS, SYSTEM GENERATORS, ETC. MODELING OF MECHANICAL SYSTEM:
5	1	1.5	04/01/2018	5. BASIC ELEMENTS OF CONTROL SYSTEM – OPEN LOOP AND CLOSED LOOP SYSTEMS –
6	1	1.7	05/01/2018	6. DIFFERENTIAL EQUATION – LAPLACE TRANSFORM –TRANSFER FUNCTION, MODELING OF PHYSICAL SYSTEM LIKE TRANSLATIONAL,
7	1	1.7	08/01/2018	7. ROTATIONAL MECHANICAL SYSTEMS, ELECTRIC SYSTEMS, ELECTRONIC SYSTEM AND ELECTROMECHANICAL SYSTEM.
8	1	1.8	10/01/2018	8. CONCEPT OF TRANSFER FUNCTION & ITS DETERMINATION FOR PHYSICAL SYSTEMS
9	2	2.1	11/01/2018	1. TRANSFER FUNCTION SYSTEM REPRESENTATION THROUGH BLOCK DIAGRAM AND SIGNAL
10	2	2.2	12/01/2018	2. FLOW GRAPH: BLOCK DIAGRAM REPRESENTATION
11	2	2.3	15/01/2018	3. REDUCTION TECHNIQUES FOR SINGLE AND MULTIPLE INPUT/OUTPUT
12	2	2.4	17/01/2018	4. CONVERSION OF BLOCK DIAGRAM INTO SIGNAL FLOW GRAPH,
13	2	2.5	18/01/2018	5. CONVERSION OF BLOCK DIAGRAM INTO SIGNAL FLOW GRAPH
14	2	2.6	19/01/2018	6. CONVERSION OF ALGEBRAIC EQUATION INTO BLOCK DIAGRAM AND SIGNAL FLOW GRAPH.
15	2	2.7	29/01/2018	7. CONVERSION OF ALGEBRAIC EQUATION INTO BLOCK DIAGRAM AND SIGNAL FLOW GRAPH
16	2	2.8	31/01/2018	8. TRANSFER FUNCTION THROUGH BLOCK DIAGRAM SIMPLIFICATION USING MASONS GAIN FORMULA.
17	3	3.1	01/02/2018	1. SYSTEM RESPONSE & TIME DOMAIN RESPONSE ANALYSIS
18	3	3.2	02/02/2018	2. FIRST AND SECOND ORDER SYSTEMS RESPONSE TO IMPULSE, RAMP AND SINUSOIDAL INPUTS,
19	3	3.3	05/02/2018	3. PROPERTIES OF UNIT STEP RESPONSE OF SECOND ORDER SYSTEM, SYSTEMS WITH VELOCITY LAG, STEADY STATE ERRORS AND ERROR CONSTANTS.
20	3	3.4	07/02/2018	4. SIGNALS: STEP, RAMP, IMPULSE, PARABOLIC AND PERIODIC SIGNALS WITH THEIR MATHEMATICAL REPRESENTATION AND CHARACTERISTICS.
21	3	3.5	08/02/2018	5. MODE OF CONTROLS: BASIC CONTROL ACTIONS AND INDUSTRIAL CONTROLLERS, INTRODUCTION TO P, PI AND PID CONTROLLERS THEIR CHARACTERISTICS, REPRESENTATION AND APPLICATIONS

Question Bank

22	3	3.6	09/02/2018	6. CLASSIFICATION OF INDUSTRIAL AUTOMATIC CONTROLLERS, CONTROL ACTIONS, PROPORTIONAL CONTROLLERS,
23	3	3.7	12/02/2018	7. OBTAINING DERIVATIVE AND INTEGRAL CONTROL ACTION, EFFECTS OF INTEGRAL AND DERIVATIVE CONTROL ACTION ON SYSTEM PERFORMANCE.
24	3	3.8	14/02/2018	8. CONTROLLER MECHANISMS: PNEUMATIC, HYDRAULIC AND ELECTRIC CONTROLLERS, GENERAL PRINCIPLES FOR GENERATING VARIOUS CONTROL ACTIONS.
25	4	4.1	15/02/2018	1. CONTROL SYSTEM ANALYSIS: CONCEPT AND TYPES OF STABILITY,
26	4	4.2	16/02/2018	2. ROUTH-HURWITZ CRITERION AND ITS APPLICATION FOR DETERMINATION OF STABILITY, LIMITATIONS.
27	4	4.3	19/02/2018	3. ROUTH-HURWITZ CRITERION AND ITS APPLICATION FOR DETERMINATION OF STABILITY, LIMITATIONS
28	4	4.4	21/02/2018	4. ROOT LOCUS PLOT: SIMPLE TRANSFER FUNCTIONS TRANSIENT RESPONSE FROM ROOT LOCUS.
29	4	4.5	22/02/2018	5. ROOT LOCUS PLOT: SIMPLE TRANSFER FUNCTIONS TRANSIENT RESPONSE FROM ROOT LOCUS
30	4	4.6	23/02/2018	6. CONCEPT OF STABILITY, NECESSARY CONDITION FOR STABILITY
31	4	4.7	26/02/2018	7. CONCEPT OF STABILITY, NECESSARY CONDITION FOR STABILITY,
32	4	4.8	28/02/2018	8. ROOT LOCUS CONCEPT, CONSTRUCTION OF ROOT LOCI.
33	5	5.1	02/03/2018	1. FREQUENCY DOMAIN ANALYSIS –
34	5	5.2	05/03/2018	2. CORRELATION BETWEEN TIME AND FREQUENCY RESPONSES OF A SECOND ORDER SYSTEM
35	5	5.3	07/03/2018	3. CORRELATION BETWEEN TIME AND FREQUENCY RESPONSES OF A SECOND ORDER SYSTEM
36	5	5.4	08/03/2018	BODE & POLAR PLOT: DETERMINATION OF GAIN MARGIN,
37	5	5.5	09/03/2018	5. PHASE MARGIN AND THEIR STABILITY FROM BODE AND POLAR PLOTS.
38	5	5.6	12/03/2018	6. INVERSE BODE PLOT, TRANSPORTATION LAG,
39	5	5.7	14/03/2018	7. INVERSE BODE PLOT, TRANSPORTATION LAG,
40	5	5.8	15/03/2018	8. SYSTEM IDENTIFICATION FROM BODE PLOT
41	6	6.1	16/03/2018	1. STATE SPACE REPRESENTATION OF CONTINUOUS
42	6	6.2	19/03/2018	2. TIME SYSTEMS: STATE EQUATIONS,
43	6	6.3	21/03/2018	3. TRANSFER FUNCTION FROM STATE VARIABLE REPRESENTATION – SOLUTIONS OF THE STATE EQUATIONS,
44	6	6.4	22/03/2018	4. CONCEPTS OF CONTROLLABILITY AND OBSERVABILITY
45	6	6.5	23/03/2018	5. STATE SPACE REPRESENTATION FOR DISCRETE TIME SYSTEMS
46	6	6.6	26/03/2018	6. STABILITY CRITERION: INTRODUCTION TO CONTROL SYSTEM
47	6	6.7	28/03/2018	7. DESIGN LAG LEAD COMPENSATION
48	6	6.8	29/03/2018	8. FEED BACK COMPENSATION AND POLE -ZERO PLACEMENT.

Total Topics: 48

Programme: Mechanical Engineering (Theory)

Course: CONTROL SYSTEM ENGINEERING

Course Code: COBEME602T

Upon completion of this course, students will be able to:

C0602T.1	Identify the type of control system, their applications, limitations, Concepts of feedback, Types of controllers and also arrive at the transfer functions of the given physical system (i.e. Mechanical, Electrical, Thermal, Hydraulic) models by writing Differential Equations using Laplace Transformation
C0602T.2	Produce the Transfer Function by Block Reduction Technique and also using Mason's Formula for Signal Flow Graph and also Interpret the S-plane with the terms like settling time, rise-time and overshoot to step-response. Apply Routh-Hurwitz criterion to determine the stability of time- invariant systems.
C0602T.3	Apply frequency domain analysis techniques, and design control systems to achieve specific dynamic characteristics, Possess knowledge of stability and controls, Determine the stability of control systems using Nyquist methods and also by using Bode Attenuation diagrams
C0602T.4	Determine the stability of control systems using Root-Locus Technique and feedback control systems using frequency domain and state-variable methods. Possess knowledge of stability and controls
C0602T.5	Determine stability of the control system from bode plot, polar plot.
C0602T.6	Identify the transfer function from state variable representation method

Mapping of COs with POs

COs\ Pos→	1	2	3	4	5	6	7	8	9	10	11	12
BEME505T.1	3	3		2	2							
BEME505T.2	3	3	2	2	2							
BEME505T.3	3			2	2							
BEME505T.4	2		3	2	2							
BEME505T.5	2		2	2	2							
BEME505T.6	2		2	2	2							
AVERAGE	2.5	3	2.5	2	2							

1, 2, Apply 3, Analyze, Explain, Evaluate

Question Bank

BEME602T: CONTROL SYSTEMS ENGINEERING (Theory)

Teaching Scheme Examination Scheme Lectures: 3 Hours/Week Duration of Paper: 03 Hours
Tutorial: 1 Hour/Week University Assessment: 80 Marks
College Assessment: 20 Marks

Course Objectives and Expected Outcomes: This course is formulated to familiarize the students with concepts related to the operation, analysis and stabilization of control systems. The main objective of this course is to make understanding of various control systems and its stability analysis using analytical and graphical techniques, to understand the concepts of Time Domain and Frequency Domain analysis of control system, Mathematical modeling and Transfer function of engineering systems. At the end of this course, student will be able to understand various control systems & their stability analysis.

UNIT – I [8 Hrs.]

Control System controls: Study of Control System components such as hydraulic actuators, Servomechanism D.C. and A.C. motor, liquid level control, Automobile Power Steering Control, Speed Control, Position control of Robotic Manipulator etc. Study and Analysis of performance characteristics, the concept of various types of system like machine tools, Prime movers, system generators, etc.
Modeling of Mechanical System: Basic Elements of Control System – Open loop and Closed loop systems – Differential equation – Laplace Transform –Transfer function, Modeling of physical system like Translational, rotational mechanical systems, Electric systems, Electronic system and Electro-mechanical system. Concept of transfer function & its determination for physical systems.

UNIT – II [8 Hrs.]

Transfer Function system Representation through Block Diagram and Signal Flow Graph: Block Diagram representation, Reduction Techniques for single and multiple input/output, Conversion of Block Diagram into Signal Flow Graph, Conversion of algebraic equation into Block Diagram and Signal Flow Graph. Transfer function through Block Diagram Simplification using Masons Gain Formula.

UNIT – III [8 Hrs.]

System Response & Time Domain Response Analysis: First and second order systems response to impulse, ramp and sinusoidal inputs, properties of unit step response of second order system, systems with velocity lag, Steady state errors and Error constants. Signals: Step, Ramp, Impulse, Parabolic and Periodic signals with their mathematical representation and characteristics.
Mode of Controls: Basic control actions and Industrial controllers, Introduction to P, PI and PID controllers their characteristics, representation and applications. Classification of industrial automatic controllers, control actions, proportional controllers, obtaining derivative and integral control action, effects of integral and derivative control action on system performance.
Controller Mechanisms: Pneumatic, hydraulic and electric controllers, general principles for generating various control actions.

UNIT – IV [8 Hrs.]

Control system analysis: Concept and types of stability, Routh-Hurwitz Criterion and its application for determination of stability, limitations.
Root locus plot: Simple transfer functions transient response from root locus. Concept of stability, necessary condition for stability, Root locus concept, construction of Root loci. .

UNIT – V [8 Hrs.]

Frequency Domain analysis - Correlation between time and frequency responses of a second order System.
Bode & Polar plot: Determination of Gain Margin, Phase Margin and their Stability from Bode and Polar plots.
Inverse Bode Plot, Transportation lag, System Identification from Bode plot.

UNIT – VI [8 Hrs.]

State space representation of Continuous Time systems: State equations, Transfer function from State Variable Representation – Solutions of the state equations, Concepts of Controllability and Observability, State space representation for Discrete time systems.
Stability criterion: Introduction to control system design lag lead compensation, Feed Back Compensation and Pole -Zero placement.

LIST OF TUTORIALS:

1) Mathematical Modeling of Mechanical and Electrical System.
2) Numerical examples of Block Diagram Reduction Technique and Signal Flow Graph.
3) Numerical of Time response analysis.
4) Numerical of Frequency Domain analysis.
5) Numerical of Routh's Criteria.

Anjuman College of Engg & Technology, Nagpur

Academic Schedule

Programme Name / Event Name / Activities	UG 4th, 6th & 8th (Semesters)	PG 2nd & 4th (Semesters)	First year BE 2nd (Semester)
DECEMBER 2016			
Commencement of Even Semester(Saturday)	19th Dec 16	19th Dec 16	19th Dec 16
JANUARY 2017			
First Unit Test	23rd to 31st Jan 17		23rd to 31st Jan 17
Republic Day(Thursday)	26th Jan 17		
FEBRUARY 2017			
Parent Meet(Saturday)	04th Feb 17		
Techsaga & Celestial 2017	17th to 20th Feb 17		
Mahashivratri(Friday)	24 Feb 17		
MARCH 2017			
Objective Test			01st Mar 17
First sessional S & H			03rd to 09 Mar 17
Holi(Second Day)(Monday)	13th Mar 17		
Gudipadwa(Tuesday)	28th Mar 17		
APRIL 2017			
Last Teaching Day	7th Apr 17		
Seasonal exam	10th to 17th Apr 17		10th Apr 17(Onwards) Pre-university exam S&H
Submission of Continues Assessment	20th Apr 17		
Make Up Classes	18th to 30th Apr 17		20th to 30th Apr 17
May 2017			
University Exams	2nd May Onwards		

 # Above dates are subject to change if university schedule changes

Programme: Mechanical Engineering (Theory)

Course: CONTROL SYSTEM ENGINEERING

Course Code: COBEME602T

Course Outcome:

The students would be able to:

CO602T.1	Identify the type of control system, their applications, limitations, Concepts of feedback, Types of controllers and also arrive at the transfer functions of the given physical system (i.e. Mechanical, Electrical, Thermal, Hydraulic) models by writing Differential Equations using Laplace Transformation
CO602T.2	Produce the Transfer Function by Block Reduction Technique and also using Mason's Formula for Signal Flow Graph and also Interpret the S-plane with the terms like settling time, rise-time and overshoot to step-response. Apply Routh-Hurwitz criterion to determine the stability of time- invariant systems.
CO602T.3	Apply frequency domain analysis techniques, and design control systems to achieve specific dynamic characteristics, Possess knowledge of stability and controls, Determine the stability of control systems using Nyquist methods and also by using Bode Attenuation diagrams
CO602T.4	Determine the stability of control systems using Root-Locus Technique and feedback control systems using frequency domain and state-variable methods. Possess knowledge of stability and controls
CO602T.5	Determine stability of the control system from bode plot, polar plot.
CO602T.6	Identify the transfer function from state variable representation method

Question Bank

BEME602T: CONTROL SYSTEMS ENGINEERING (Theory)

CREDITS: 04

Teaching Scheme
Lectures: 3 Hours/Week
Tutorial: 1 Hour/Week

Examination Scheme
Duration of Paper: 03 Hours
University Assessment: 80 Marks
College Assessment: 20 Marks

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UNIT – I

[8 Hrs.]

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UNIT – II

[8 Hrs.]

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UNIT – III

[8 Hrs.]

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Signals: Step, Ramp, Impulse, Parabolic and Periodic signals with their mathematical representation and characteristics.

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UNIT – IV [8 Hrs.]

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UNIT – VI [8 Hrs.]

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Stability criterion: Introduction to control system design lag lead compensation, Feed Back Compensation and Pole -Zero placement.

LIST OF TUTORIALS:

1) Mathematical Modeling of Mechanical and Electrical System.
2) Numerical examples of Block Diagram Reduction Technique and Signal Flow Graph.
3) Numerical of Time response analysis.
4) Numerical of Frequency Domain analysis.
5) Numerical of Routh's Criteria.
6) Numerical of Polar Plot.
7) Numerical of Root Locus.
8) Numerical of Bode plot.
9) Numerical of State space representations.
10) Numerical of Root Locus using MATLAB.

At least **six** exercises are expected.

TEXT BOOKS:

1. Control System Engineering, J. Nagrath and M.Gopal, New Age International Publishers, 5th Edition, 2007
2. Control System – Principles and Design, M. Gopal, Tata McGraw Hill, 2nd Edition, 2002.
3. Control Systems Engineering, S. K. Bhattacharya, Pearson.
4. Control System Engineering, Baxi and Goyal, Technical Publication, Pune.
5. Control Systems, Dhanesh N. Manik, Cengage Learning.
6. Control Systems -Theory & Application, Smarajit Ghosh, Pearson.
7. Control Systems, Anand Kumar, PHI.

B.E. (Mechanical Engineering) Sixth Semester (C.B.S.)

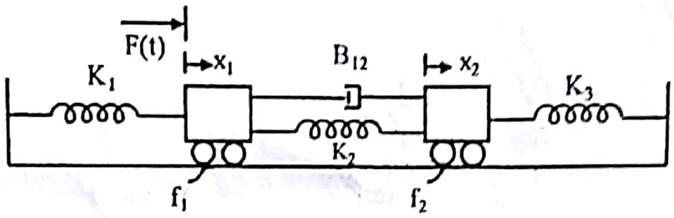
Control System Engineering

P. Pages : 3 NRJ/KW/17/4535

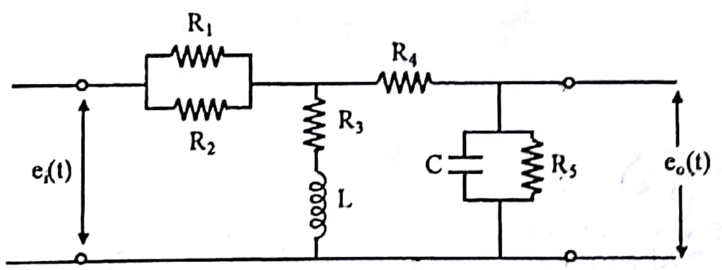
Time : Three Hours Max. Marks : 80

Notes :
1. All questions carry marks as indicated.
2. Solve Question 1 OR Questions No. 2.
3. Solve Question 3 OR Questions No. 4.
4. Solve Question 5 OR Questions No. 6.
5. Solve Question 7 OR Questions No. 8.
6. Solve Question 9 OR Questions No. 10.
7. Solve Question 11 OR Questions No. 12.
8. Due credit will be given to neatness and adequate dimensions.
9. Illustrate your answers whenever necessary with the help of neat sketches.
10. Use of non programmable calculator is permitted.

1. a) Find $\frac{X_2(s)}{F(s)}$ 7



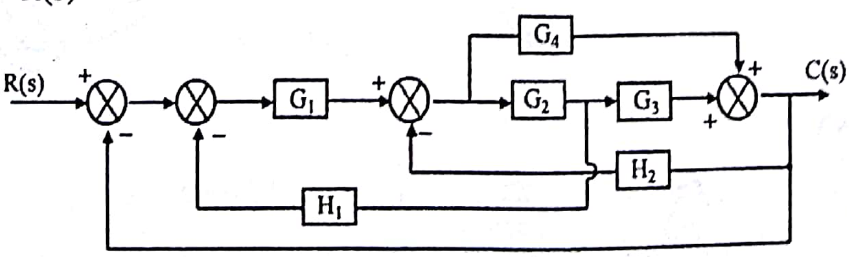
b) Find $\frac{E_o(s)}{E_i(s)}$ 7



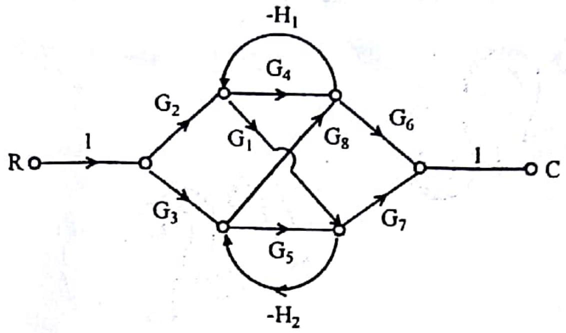
2. a) Give comparision of open and closed loop control system. 6

b) Explain servo motors. Give its application. 8

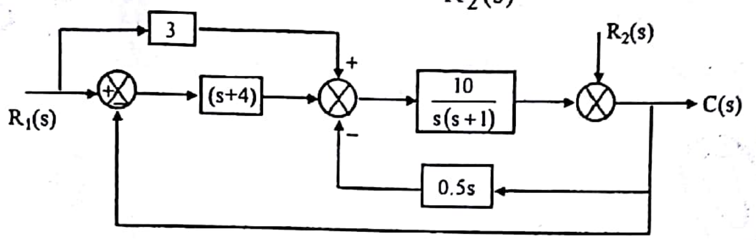
3. a) Determine $\frac{C(s)}{R(s)}$ for the block diagram shown. 7



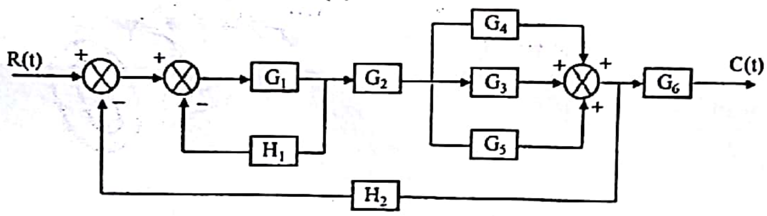
b) Obtain the transfer function $\frac{C(s)}{R(s)}$ from the signal flow graph show in fig. 6



4. a) The system block diagram is show in fig. find the $\frac{C(s)}{R_2(s)}$ if $R_1(s) = 0$ 7



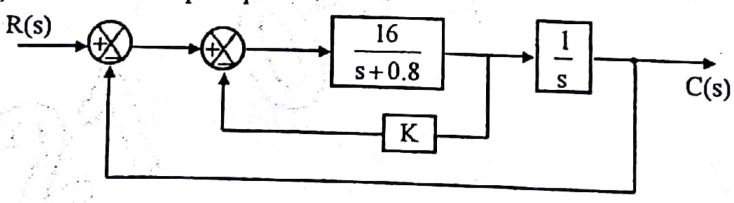
b) Obtain signal flow graph representation for a system whose block diagram in given below and using Mason's gain formula find $\frac{C(s)}{R(s)}$ 6



5. a) Explain the role of PID Controller in a feedback system. 6

b) Derive an expression for response of the first order system with unit step input. 8

6. a) Consider the system shown in figure Determine the value of 'K' such that the damping ratio ζ is 0.5. Then obtain the rise time (t_r), Peak time (t_p), maximum overshoot (mP) and settling time (t_s) in the unit step response. 8

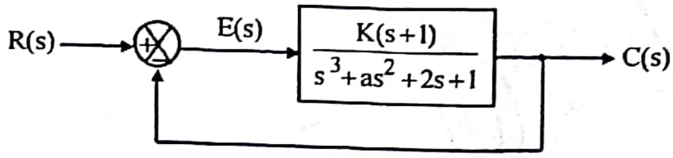


b) For a unity feedback control system the forward path transfer function is given by 6

$$G(s)=\frac{20}{s(s+2)\left(s^2+2s+20\right)}$$

Determine the steady state error of the system. When the inputs are (i) 5 (ii) 5t (iii) $\frac{3t^2}{2}$

7. a) A system oscillates with frequency 'ω' if it has poles at $s = \pm j\omega$ and n poles in the right half s-plane. Determine the values of K and a so that the system shown in fig. oscillates at a frequency 2 rad / sec. **7**



b) Investigate the stability using Routh's criterion $s^5 + s^4 + 2s^3 + 2s^2 + 3s + 5 = 0$ **6**

8. For a unity feedback system the open loop transfer function is given by **13**

$$G(s) = \frac{k}{s(s+2)\,(s^2+6s+25)}$$

a) Sketch the root locus for $0 \le k \le \infty$

b) At what value of 'k' the system becomes unstable.

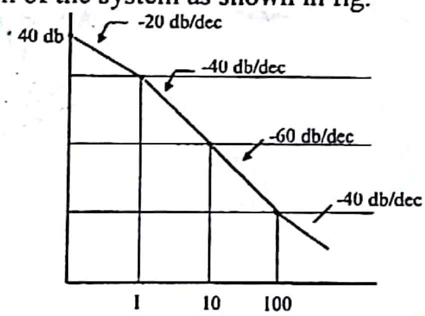
c) At this point of instability determine the frequency of oscillation of the system.

9. **14**

Given $$G(s) = \frac{170\left(\frac{s}{10}+1\right)}{s\left(1+\frac{s}{1.75}\right)\left(1+\frac{s}{60}\right)}$$

Draw the open loop Bode diagram. Determine the gain crossover frequency, phase cross over frequency, gain margin, phase margin, Determine the stability.

10. a) Determine transfer function of the system as shown in fig. **7**



b) Draw polar plot of $G(s)\,H(s) = \dfrac{100}{(s+2)\,(s+4)\,(s+8)}$ **7**

11. a) Explain the term controllability and observability. **7**

b) Give the state space representation for the system whose transfer function is given by **6**

$$\frac{Y(s)}{U(s)} = \frac{2}{s^3+6s^2+11s+6}$$

12. a) A single input single output system is given as **8**

$$\dot{x}(t) = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 & 2 \end{bmatrix} x(t)$$

Test for controllability and observability.

b) Explain lag-lead compensation and pole zero placement in details. **5**

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B.E. (Mechanical Engineering) Sixth Semester (C.B.S.)

Control System Engineering

P. Pages : 3 NRJ/KW/17/4535

Time : Three Hours Max. Marks : 80

Notes :
1. All questions carry marks as indicated.
2. Solve Question 1 OR Questions No. 2.
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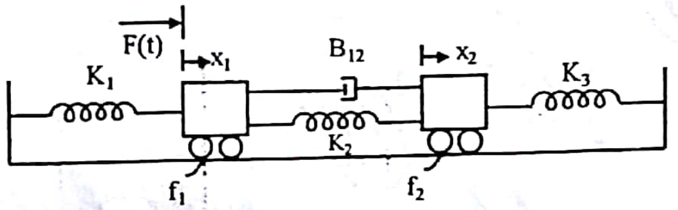
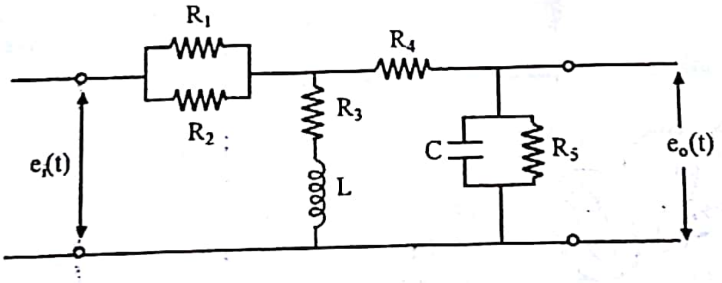
5. Solve Question 7 OR Questions No. 8.
6. Solve Question 9 OR Questions No. 10.
7. Solve Question 11 OR Questions No. 12.
8. Due credit will be given to neatness and adequate dimensions.
9. Illustrate your answers whenever necessary with the help of neat sketches.
10. Use of non programmable calculator is permitted.

1. a) Find $\frac{X_2(s)}{F(s)}$ **7**



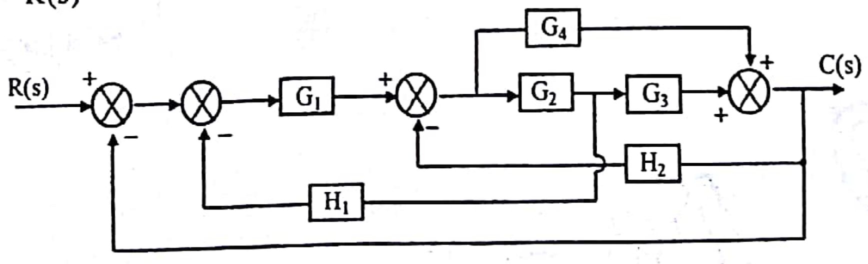
b) Find $\frac{E_o(s)}{E_i(s)}$ **7**



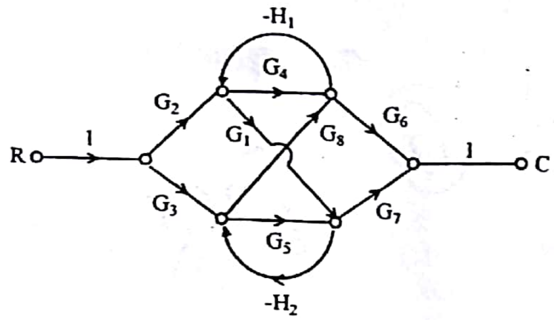
2. a) Give comparision of open and closed loop control system. **6**

b) Explain servo motors. Give its application. **8**

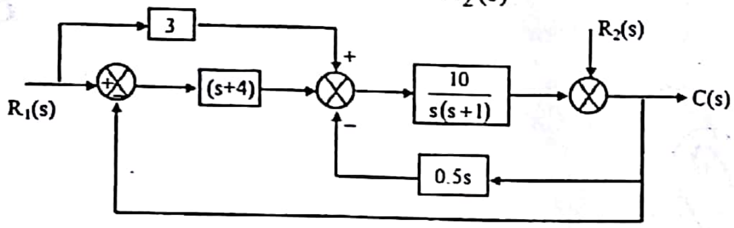
3. a) Determine $\frac{C(s)}{R(s)}$ for the block diagram shown. **7**



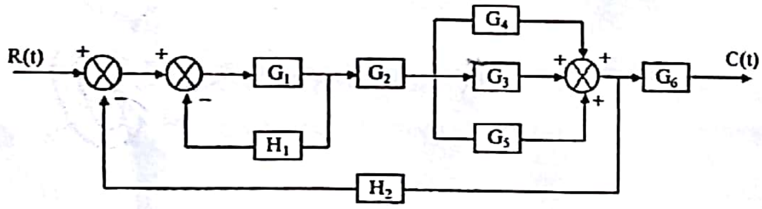
b) Obtain the transfer function $\frac{C(s)}{R(s)}$ from the signal flow graph show in fig. 6



4. a) The system block diagram is show in fig. find the $\frac{C(s)}{R_2(s)}$ if $R_1(s)=0$ 7



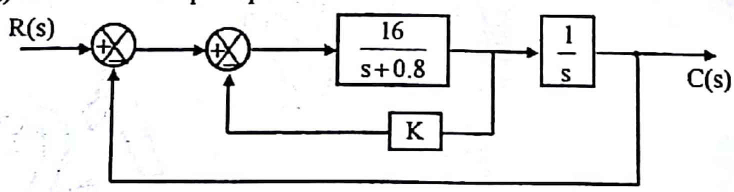
b) Obtain signal flow graph representation for a system whose block diagram in given below and using Mason's gain formula find $\frac{C(s)}{R(s)}$. 6



5. a) Explain the role of PID Controller in a feedback system. 6

b) Derive an expression for response of the first order system with unit step input. 8

6. a) Consider the system shown in figure Determine the value of 'K' such that the damping ratio ζ is 0.5. Then obtain the rise time (t_r), Peak time (t_p), maximum overshoot (mP) and settling time (t_s) in the unit step response. 8

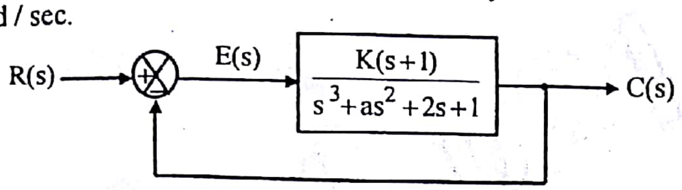


b) For a unity feedback control system the forward path transfer function is given by 6

$$G(s)=\frac{20}{s(s+2)\left(s^2+2s+20\right)}$$

Determine the steady state error of the system. When the inputs are (i) 5 (ii) 5t (iii) $\frac{3t^2}{2}$

7. a) A system oscillates with frequency 'ω' if it has poles at $s = \pm j\omega$ and n poles in the right half s-plane. Determine the values of K and a so that the system shown in fig. oscillates at a frequency 2 rad / sec. 7



b) Investigate the stability using Routh's criterion $s^5 + s^4 + 2s^3 + 2s^2 + 3s + 5 = 0$ 6

8. For a unity feedback system the open loop transfer function is given by 13

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

a) Sketch the root locus for $0 \le k \le \infty$

b) At what value of 'k' the system becomes unstable.

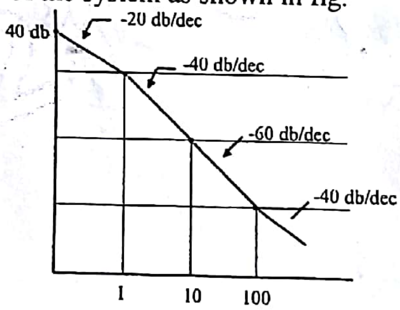
c) At this point of instability determine the frequency of oscillation of the system.

9. 14

$$\text{Given } G(s) = \frac{170\left(\frac{s}{10}+1\right)}{s\left(1+\frac{s}{1.75}\right)\left(1+\frac{s}{60}\right)}$$

Draw the open loop Bode diagram. Determine the gain crossover frequency, phase cross over frequency, gain margin, phase margin, Determine the stability.

10. a) Determine transfer function of the system as shown in fig. 7



b) Draw polar plot of $G(s)\,H(s) = \dfrac{100}{(s+2)\,(s+4)\,(s+8)}$ 7

11. a) Explain the term controllability and observability. 7

b) Give the state space representation for the system whose transfer function is given by 6

$$\frac{Y(s)}{U(s)} = \frac{2}{s^3+6s^2+11s+6}$$

12. a) A single input single output system is given as 8

$$\dot{x}(t) = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} u$$

$$y = [1 \quad 0 \quad 2]\, x(t)$$

Test for controllability and observability.

b) Explain lag-lead compensation and pole zero placement in details. 5

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B.E. Sixth Semester (Mechanical Engineering) (C.B.S.)

Control System Engineering

P. Pages : 4
Time : Three Hours

KNT/KW/16/7396
Max. Marks : 80

Notes :
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6. Solve Question 9 OR Questions No. 10.
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8. Due credit will be given to neatness and adequate dimensions.
9. Assume suitable data whenever necessary.
10. Diagrams and chemical equations should be given whenever necessary.
11. Illustrate your answers whenever necessary with the help of neat sketches.
12. Use of non programmable calculator is permitted.

1. a) Find T. F. $\frac{Y_2(s)}{Y_1(s)}$ **7**

CO – I

PO – II

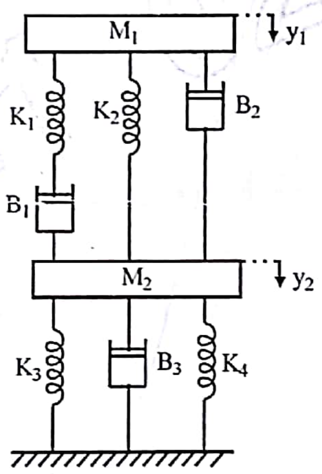


Fig. 1 (a)

b) Find T. F. $\frac{E_o(s)}{E_i(s)}$ **7**

CO – I

PO – II

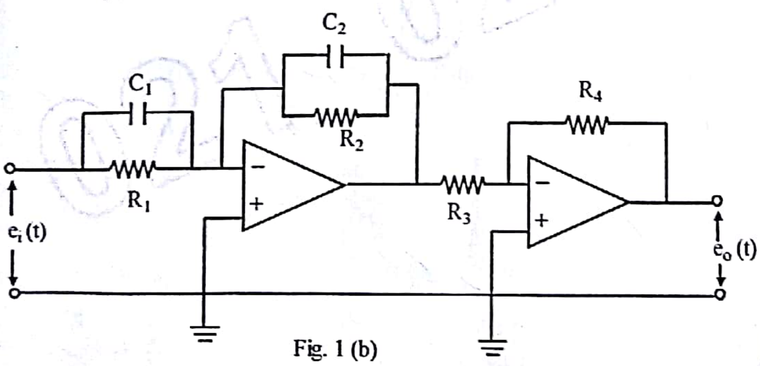


Fig. 1 (b)

OR

2. a) Explain open loop and close loop control system with advantages and disadvantages. 6

b) Find T. F. $\frac{X(s)}{E_i(s)}$ 8

CO-I PO-II

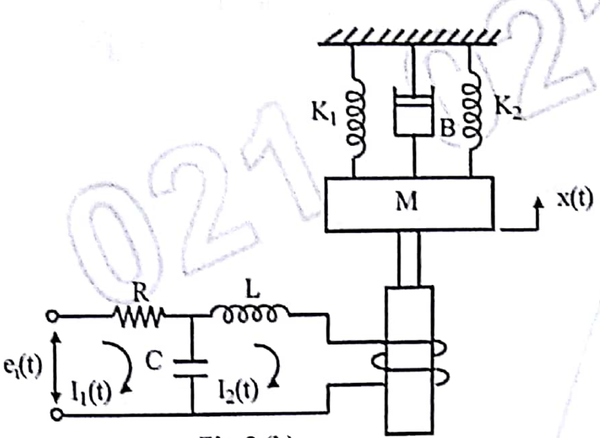


Fig. 2 (b)

3. a) Find $\frac{C(s)}{R(s)}$ by using Block Reduction Technique. 6

CO-I PO-II

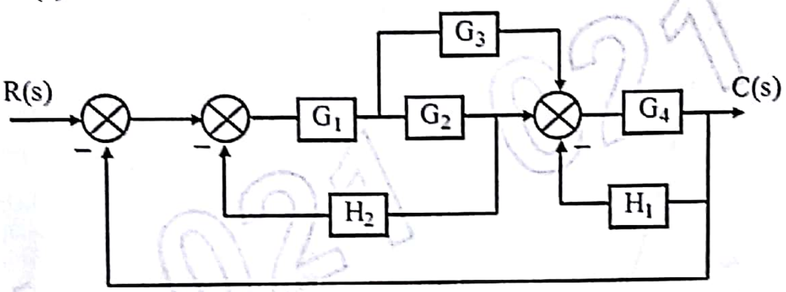


Fig. 3 (a)

b) Convert the given algebric equations into signal flow graph and find its transfer function. 7

CO-II

$$Y_2 = G_1Y_1 + G_3Y_3$$
$$Y_3 = G_4Y_1 + G_2Y_2 + G_5Y_3$$
$$Y_4 = G_6Y_2 + G_7Y_3$$

Where Y_4 is output and Y_1 is input.

OR

4. a) Obtain $\frac{C(s)}{R(s)}$ using block reduction technique. 6

CO-II PO-II

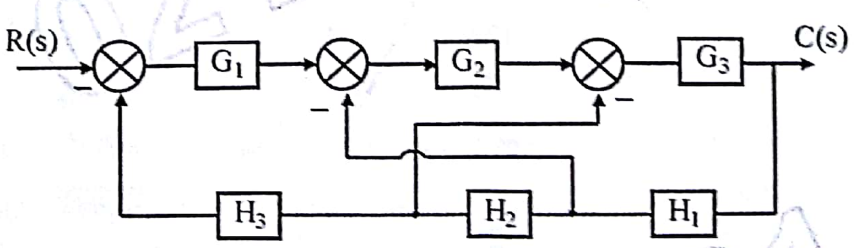


Fig. 4 (a)

b) Convert the given block diagram into SFG & find T. F. **7**

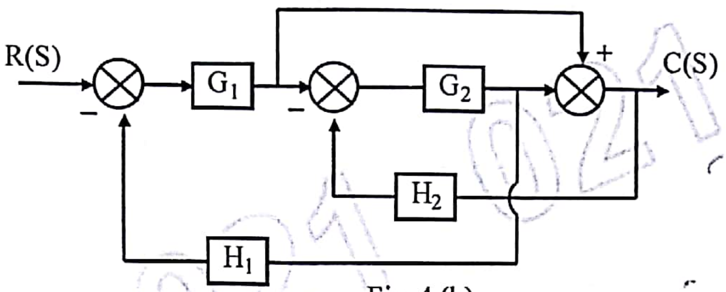


Fig. 4 (b)

5. a) Derive the transfer function of field controlled DC motor. **7**

b) Derive an expression for unit ramp response of first order system. **7**

OR

6. a) Find response of a given system for time of 0.5 sec when OLTF is $G(s)\,H(s) = \dfrac{36}{s(s+8)}$ with step input of 2.5 units. Also find maximum output; peak time; rise time; settling time. **7**

b) A system is described as – **7**

$$\frac{d^2y}{dt^2} + 10\frac{dy}{dt} + 49y = 100x$$

Find response, maximum output and all time domain specifications for a step input of 2.85 units.

7. a) Explain PID controller with its applications. **5**

b) For unity feedback system – **8**

$$G(s) = \frac{K}{s(1+0.4s)(1+0.25s)}$$

Find Range of value of K, K_{mas} and frequency of sustained oscillation. Also check the stability of the system.

OR

8. For a control system having $G(s) = \dfrac{K(s+1)}{(s^2+4s+5)}$ and feedback H(s) = 1/s. Sketch the root locus when the gain K varies upto ∞. **13**

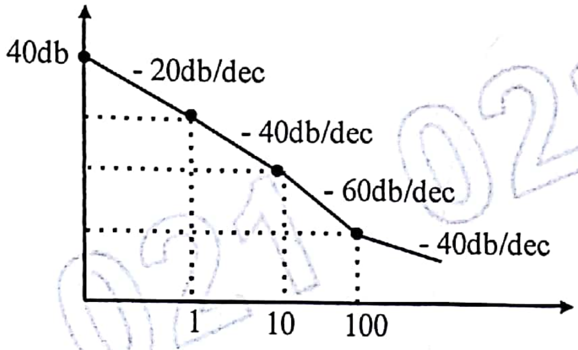
9. Draw bode plot for following function **14**

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

Find gain margin and phase margin for the stability of given system.

OR

. a) Determine T. F. of the system as shown in fig. 7



b) Draw polar plot & find GM and PM 7

$$G(s)\,H(s) = \frac{40}{s(s+4)(s+8)}$$

Co - V

11. a) Explain the term controllability and observability. 6

b) Give the state space representation for the system whose T. F. is given by – 7

$$\frac{Y(s)}{U(s)} = \frac{2}{s^4 + 1.5s^3 + 2.5s + 1}$$

Co-4

OR

12. a) Find T. F. of the system. Check whether the system is observable and controllable or not 8

CO - VI

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

$$Y = [1 \quad 0 \quad 0] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

b) Explain lag-lead compensation and pole-zero placement in detail. 5

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B.E. Sixth Semester (Mechanical Engineering) (C.B.S.)

Control System Engineering

P. Pages : 4

Time : Three Hours

NKT/KS/17/7396

Max. Marks : 80

* 0 5 6 2 *

Notes :
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9. Assume suitable data whenever necessary.
10. Illustrate your answers whenever necessary with the help of neat sketches.
11. Use of non programmable calculator is permitted.

1. a) Differentiate between hydraulic and pneumatic actuators. **4**

b) Write equation of motion of translational mechanical system shown in fig. 1(b) and determine Transfer function. **9**

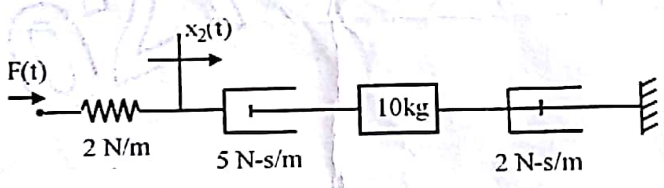

Fig. 1(b)

OR

2. a) Explain in brief classification of control system. **4**

b) Determine Transfer function of rotational mechanical system shown in fig. 2 (b) **9**

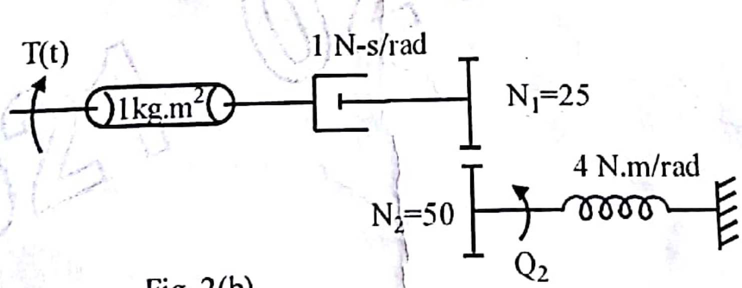

Fig. 2(b)

3. a) Simplify the following system shown in fig. 3 (a) using block diagram algebra and determine transfer function C(s) / R(s) 8

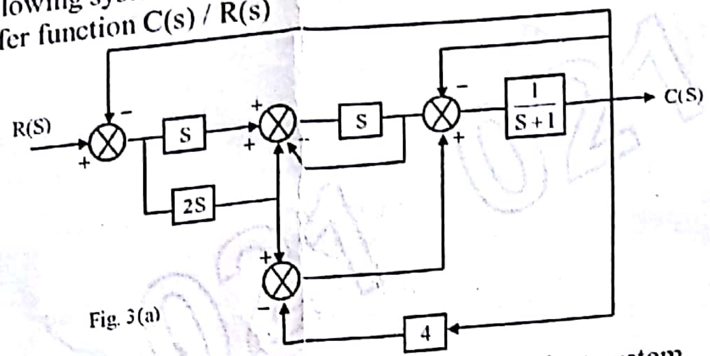

Fig. 3(a)

b) Name four components of block diagram for liner time invariant system. 5

OR

4. a) Explain following terms w.r.to signal flow graph.

i) Forward path ii) Feed back path. iii) Source and sink node.

b) Determine transfer function C(s) / R(s) of signal flow graph show in fig. 4 (b) using Mason's gain formula. 8

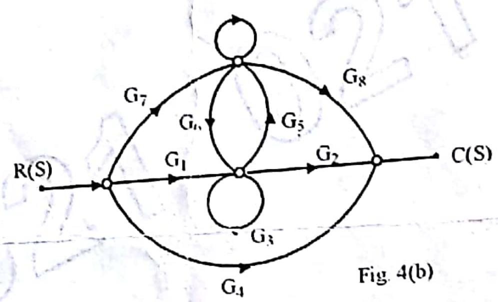

Fig. 4(b)

5. a) Explain PID controllers and there characteristics. 6

b) A unity feed back system has $G(s) = \dfrac{K}{S(S+2)(S^2+2S+5)}$ 8

i) Determine limiting value of gain 'K' for unit ramp input so that $e_{ss} \leq 0.2$

ii) Determine e_{ss} for input $r(t) = 2 + 4t + t^2/2$

OR

6. a) Explain general principles for generating control action. 5

b) Determine transient response specifications of mechanical system shown in fig. 6 (b) 9

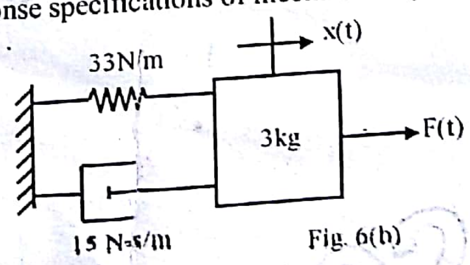

Fig. 6(b)

7. For the transfer function having characteristic equation 13

$$1 + G(s)H(s) = s^8 + s^7 + 12s^6 + 22s^5 + 39s^4 + 59s^3 + 48s^2 + 38s + 20$$

comment on system stability using Routh's criterion.
Also, tell how many poles lies in RH, in LH and on Jw axis.

OR

8. Sketch the root locus for a system represented by block diagram as below. 13

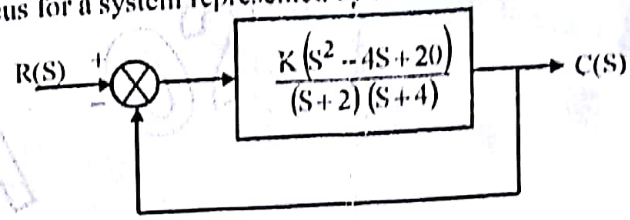

Fig. 8

i) determine gain 'K' for $\xi = 0.45$

ii) determine marginal value of gain 'K'

iii) find range of 'K' within which system is stable.

9. Draw the Bode log-magnitude and phase plots for 14

$$GH(s) = \frac{(s+3)}{(s+2)(s^2+2s+25)}$$

Determine

i) Gain margin (Gm)

ii) Phase margin (Pm)

iii) Comment on stability

OR

10. a) Draw polar plot for system having 8

$$GH(s) = \frac{12}{s(s+1)(s+2)}$$

state whether system is stable or not.

b) Find open loop transfer function of system having Bode magnitude plot as shown in fig. 10 (b) 6

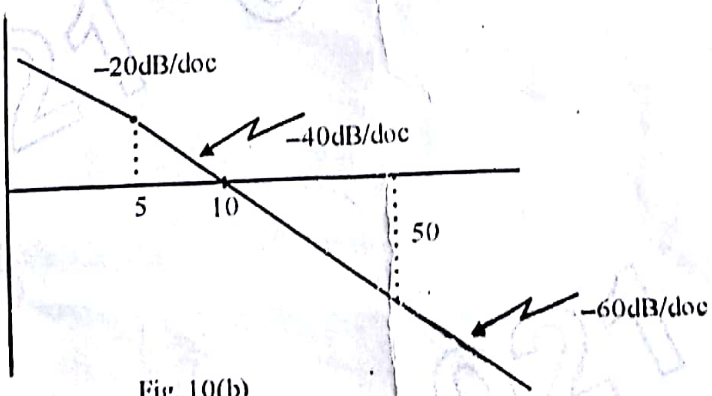

Fig. 10(b)

11. a) Determine whether the system given below is completely controllable and observable or not. **8**

$$\{\dot{x}\} = \begin{bmatrix} -6 & -18 & -6 \\ 2 & 3 & 1 \\ -4 & -8 & -3 \end{bmatrix} \{x\} + \begin{bmatrix} 2 \\ -3 \\ 7 \end{bmatrix} U$$

$$y = [1 \quad 3 \quad 1]\{x\}$$

b) Explain controllability and observability of the system. **5**

OR

12. a) Explain phase Lead-Lag compensation. **5**

b) Construct the state model for the system given by the differential eq^n.

$$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y = \mu$$ give block diagram representation of the state model.

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B.E. Sixth Semester (Mechanical Engineering) (C.B.S.)

Control System Engineering

P. Pages : 4 | NKT/KS/17/7396
Time : Three Hours | Max. Marks : 80

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b) Write equation of motion of translational mechanical system shown in fig. 1(b) and determine Transfer function. 9

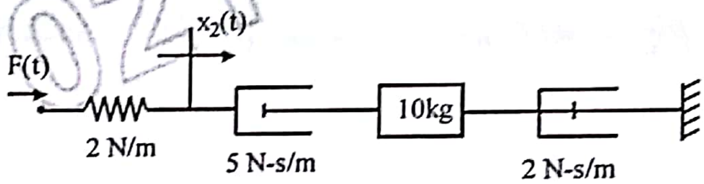

Fig. 1(b)

OR

2. a) Explain in brief classification of control system. 4

b) Determine Transfer function of rotational mechanical system shown in fig. 2 (b) 9

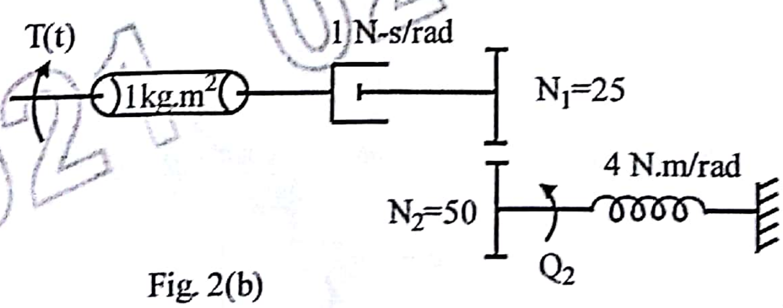

Fig. 2(b)

3\. a) Simplify the following system shown in fig. 3 (a) using block diagram algebra and determine transfer function C(s) / R(s)

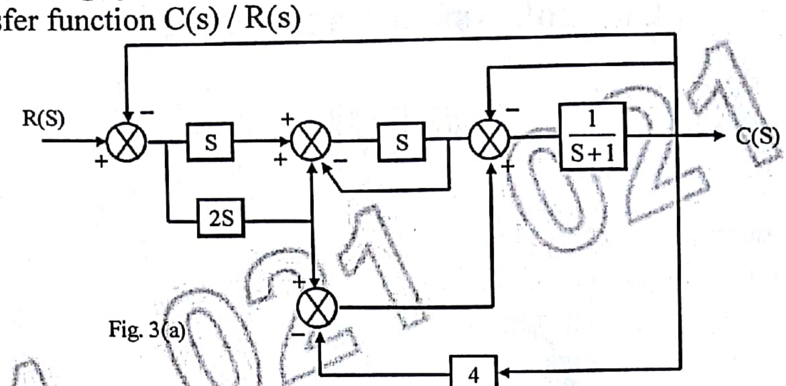

Fig. 3(a)

b) Name four components of block diagram for liner time invariant system. 5

OR

4\. a) Explain following terms w.r.to signal flow graph. 5

i) Forward path ii) Feed back path. iii) Source and sink node.

b) Determine transfer function C(s) / R(s) of signal flow graph show in fig. 4 (b) using Mason's gain formula. 8

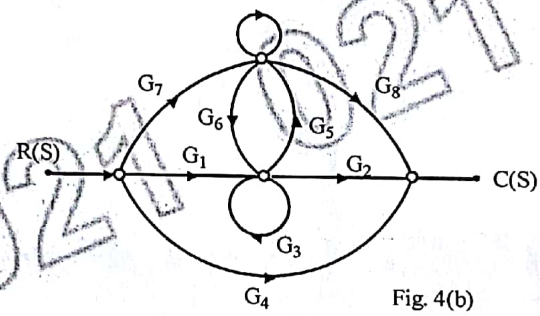

Fig. 4(b)

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b) A unity feed back system has $G(s) = \dfrac{K}{S(S+2)(S^2+2S+5)}$ 8

i) Determine limiting value of gain 'K' for unit ramp input so that $e_{ss} \le 0.2$

ii) Determine e_{ss} for input $r(t) = 2 + 4t + t^2/2$

OR

6\. a) Explain general principles for generating control action. 5

b) Determine transient response specifications of mechanical system shown in fig. 6 (b) 9

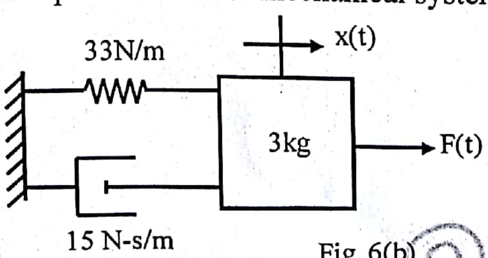

Fig. 6(b)

7. For the transfer function having characteristic equation 13

$$1+G(s)H(s) = s^8 + s^7 + 12s^6 + 22s^5 + 39s^4 + 59s^3 + 48s^2 + 38s + 20$$

comment on system stability using Routh's criterion.
Also, tell how many poles lies in RH, in LH and on Jw axis.

OR

8. Sketch the root locus for a system represented by block diagram as below. 13

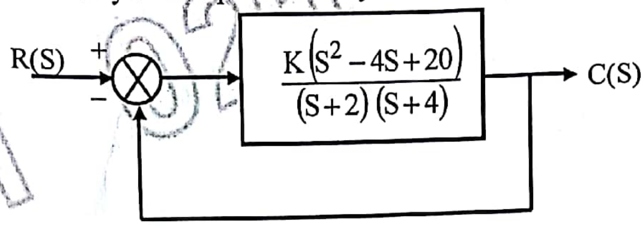

Fig. 8

i) determine gain 'K' for $\xi = 0.45$

ii) determine marginal value of gain 'K'

iii) find range of 'K' within which system is stable.

9. Draw the Bode log-magnitude and phase plots for 14

$$GH(s) = \frac{(s+3)}{(s+2)\,(s^2+2s+25)}$$

Determine

i) Gain margin (Gm)

ii) Phase margin (Pm)

iii) Comment on stability

OR

10. a) Draw polar plot for system having 8

$$GH(s) = \frac{12}{s(s+1)\,(s+2)}$$

state whether system is stable or not.

b) Find open loop transfer function of system having Bode magnitude plot as shown in fig. 10 (b) 6

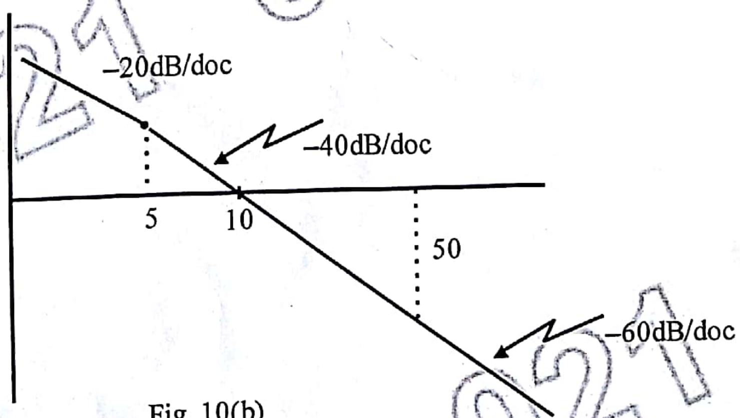

Fig. 10(b)

11. a) Determine whether the system given below is completely controllable and observable or not. 8

$$\{\dot{x}\} = \begin{bmatrix} -6 & -18 & -6 \\ 2 & 3 & 1 \\ -4 & -8 & -3 \end{bmatrix} \{x\} + \begin{bmatrix} 2 \\ -3 \\ 7 \end{bmatrix} U$$

$$y = [1 \quad 3 \quad 1]\{x\}$$

b) Explain controllability and observability of the system. 5

OR

12. a) Explain phase Lead-Lag compensation. 5

b) Construct the state model for the system given by the differential eq^n. 8

$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y = \mu$ give block diagram representation of the state model.

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B.E. (Mechanical Engineering) Sixth Semester (C.B.S.)

Control System Engineering

P. Pages : 4

Time : Three Hours

TKN/KS/16/7483-A

Max. Marks : 80

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5. Solve Question 7 OR Questions No. 8.
6. Solve Question 9 OR Questions No. 10.
7. Solve Question 11 OR Questions No. 12.
8. Assume suitable data whenever necessary.
9. Diagrams should be given whenever necessary.
10. Illustrate your answers whenever necessary with the help of neat sketches.

1. a) Compare merits and demerits of A.C. Servomotor over D.C. Servomotor. 6

b) Find T.F, $G(s)=\frac{x_2(S)}{F(s)}$ for mechanical system shown in fig 1 (b) 8

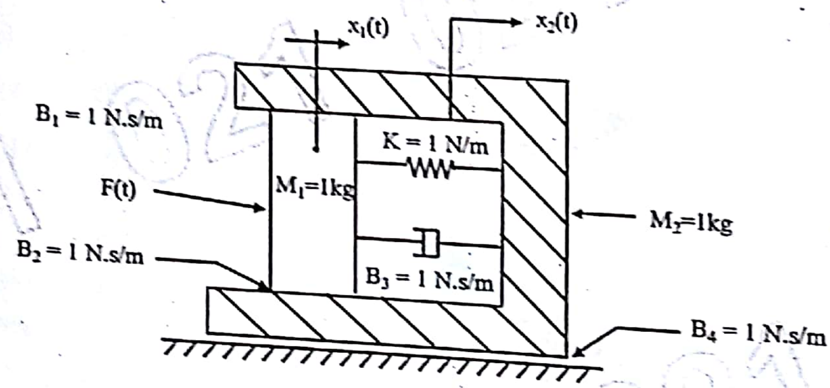


Fig. 1 (b)

OR

a) State different types of actuators used in control system. Explain any one type of actuator with neat sketch. 6

b) Find T.F. of rotational mechanical system shown in fig 2 (b). 8

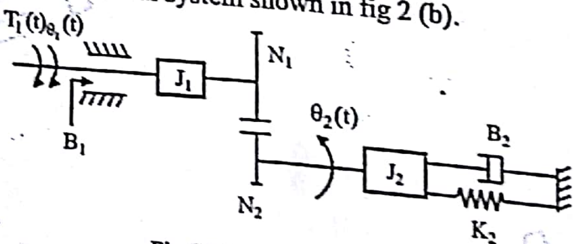


Fig. 2 (b)

3. a) Determine T.F., C (s) / R(s) of a system shown in fig 3(a) by using block diagram algebra. 7

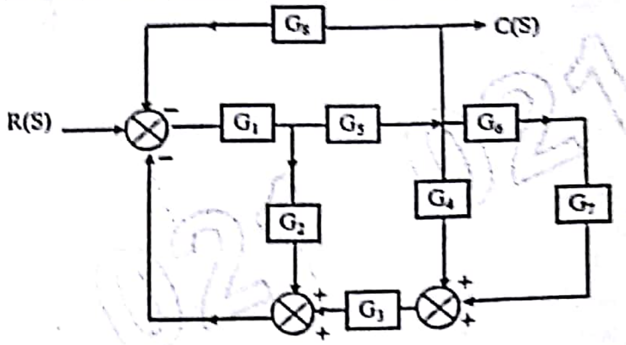


Fig. 3 (a)

b) Draw close loop block diagram of voltage divider network shown in fig 3 (b). 6

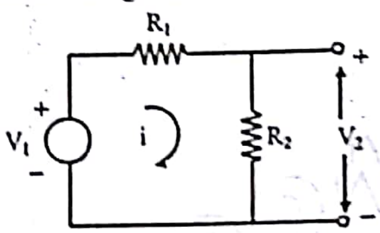


Fig. 3 (b)

OR

4. a) Using Mason's gain formula rule determine T.F. $\frac{C(s)}{R(s)}$ of a system represented by fig 4(a). 6

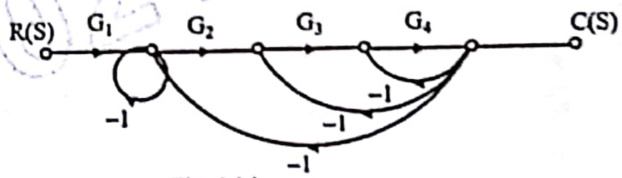


Fig. 4 (a)

b) Construct signal flow graph for the following equations. 7

$x_2 + 3x_3 - 3x_1 = 0$

$x_3 + 4x_4 - 4x_2 = 0$

$x_4 - 5x_3 = 0$

5. a) Determine T.F. $\frac{X(S)}{F(S)}$ for the system shown in fig 5 (a) and find domain specifications

(i) w_n, ξ, % M_p, T_s, T_p, and T_ξ

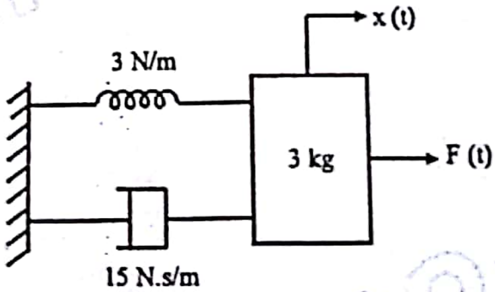


Fig. 5 (a)

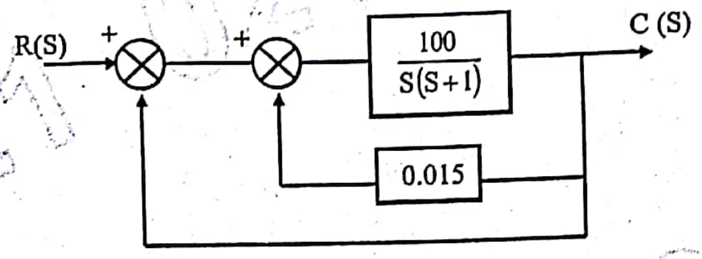
b) Explain the role of P.I.D. Controller in a feedback system. 6

OR

6. a) A position control system is damped with velocity feedback as shown in fig 6 (a) 7

i) For unit step input, what is the steady state error

ii) Determine system static error co-efficients.



b) How do you modify proportional hydraulic system to obtain proportional & derivative control. Explain with help of a neat sketch. 6

7. a) A feedback system has an open loop T.F. 7

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

Determine the value of 'K' for the close loop system to be stable, using Routh's criterion.

b) How many poles of the system having following characteristic equation lie in Right-half, left half and jw-Axis of S-plane. 6

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

OR

8. Sketch root locus for a system having open loop transfer function. 13

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

9. Draw an asymptotic Bode plot for the unity feedback system having. 13

$$G(S)\,H(S) = \frac{(S+3)}{(S+2)\left(S^2+2S+25\right)}$$

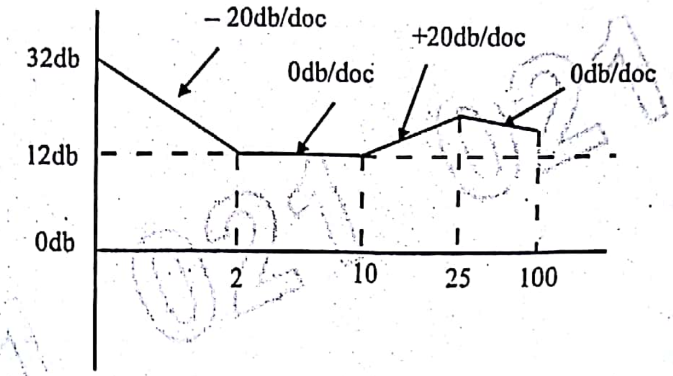
Determine G.M, P.M and comment on stability.

OR

10. a) Draw a polar plot for system having. 6

$$G(S)\,H(S) = \frac{100}{(S+2)(S+4)(S+8)}$$

b) Determine OLTF of a system represented by the following Gain curve on Bode diagram. 7



11. Consider the following plan of state-space representation. Examine controllability and observability. Also convert state space equation into transfer function. 14

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \quad B = \begin{bmatrix} -2 \\ -2 \end{bmatrix}$$

$$C = [-2, \quad -2]$$

OR

12. Write short notes on: 14

a) Stability criterion.

b) Lead-Lag compensation.

c) Effect of pole-zero placement on system stability.

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W-15

5

NTK/KW/15/7483-A

Faculty of Engineering & Technology

Sixth Semester B.E. (Mechanical Engg.) (C.B.S.) Examination

CONTROL SYSTEM ENGINEERING

Time—Three Hours] [Maximum Marks—80

INSTRUCTIONS TO CANDIDATES

(1) All questions carry marks as indicated.

(2) Solve Question No. **1** OR Question No. **2**.

(3) Solve Question No. **3** OR Question No. **4**.

(4) Solve Question No. **5** OR Question No. **6**.

(5) Solve Question No. **7** OR Question No. **8**.

(6) Solve Question No. **9** OR Question No. **10**.

(7) Solve Question No. **11** OR Question No. **12**.

(8) Due credit will be given to neatness and adequate dimensions.

(9) Assume suitable data wherever necessary.

(10) Diagrams and Chemical equations should be given wherever necessary.

(11) Illustrate your answers wherever necessary with the help of neat sketches.

(12) Use of Non-programmable calculator is permitted.

1. (a) Using appropriate diagram, give the constructional and operational features of a hydraulic linear actuator. 5

(b) Determine T.F. $\frac{n_2(s)}{f(s)}$ for the translational mechanical system shown in Fig. 1(b). 8

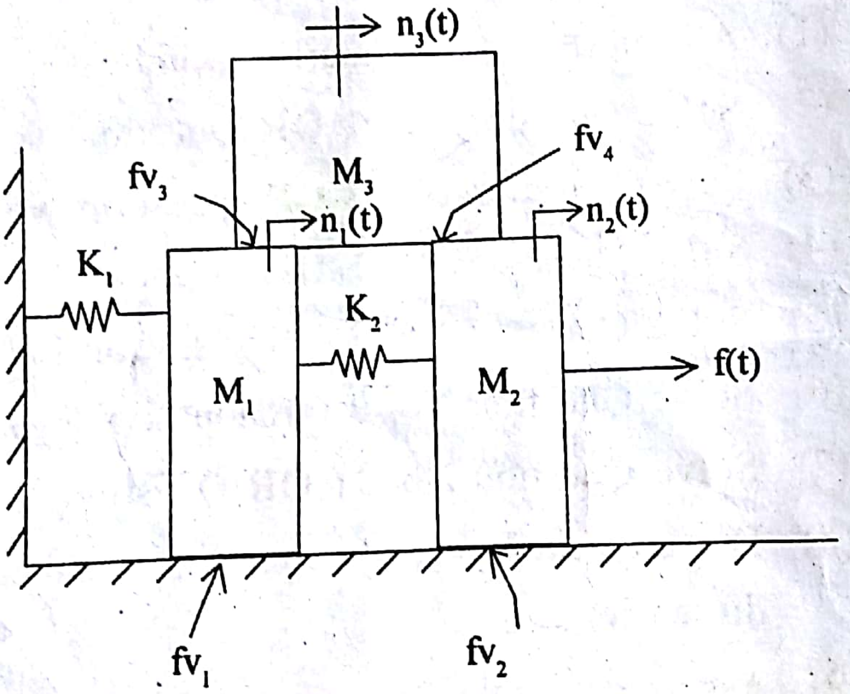


Fig. 1(b)

OR

2. (a) Explain with neat sketch basic structure of position control system. 5

(b) Find transfer function $\frac{Q_2(s)}{T(s)}$ for the rotational mechanical system shown in Fig. 2(b). 8

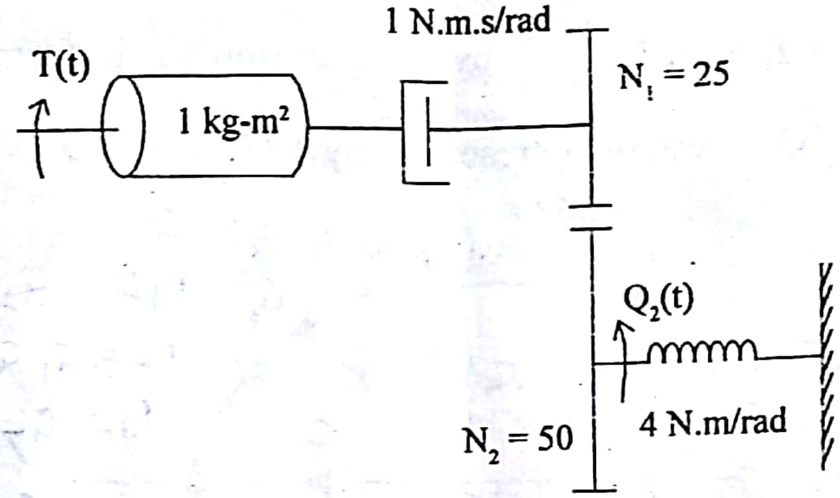


Fig. 2(b)

3. (a) Determine T.F. $\frac{C(s)}{R(s)}$ of a system shown in Fig. 3(a) by block diagram algebra. 8

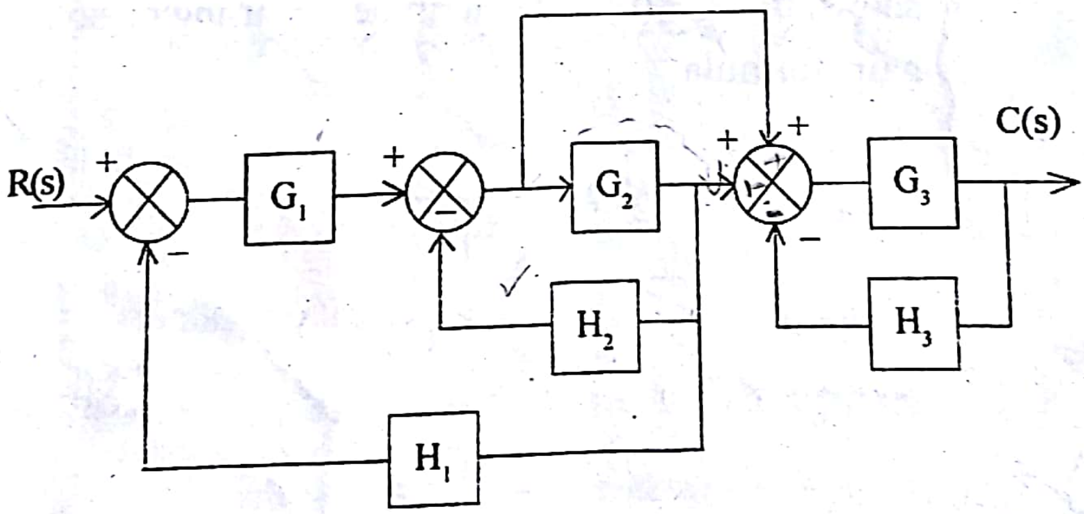


Fig. 3(a)

(b) State advantages and disadvantages of closed loop control system. 5

OR

4. (a) Obtain T.F. $\frac{C(s)}{R(s)}$ by using mason's gain formula of a system represented by SFG Fig. 4(a). 8

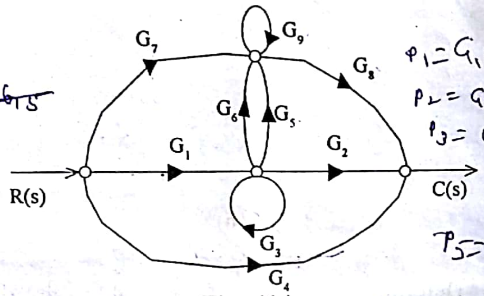


Fig. 4(a)

(b) Draw signal flow graph for the electrical network shown in Fig. 4(b) and determine T.F. using masons gain formula. 5

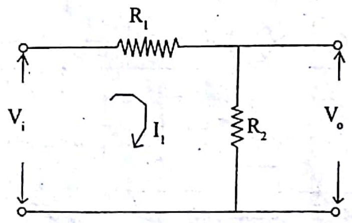


Fig. 4(b)

5. (a) Determine various transient response specifications of the translational mechanical system represented in Fig. 5(a). 8

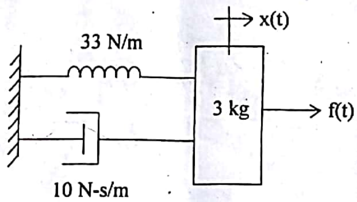


Fig. 5(a)

(b) For a unity feed-back system having :

$$G(s) = \frac{10(s+1)}{s(s+4)(s+7)}$$

determine static error coefficients. 6

OR

6. (a) The block diagram in Fig. 6(a) represents a radar antenna drive.

(i) If 'R' is ramp input of 0.1 t rad/sec then what is steady state error.

(ii) If R = 0 the system is at stand still. Considering that wind-blows applies a load torque of T_L = 0.2. What is steady state error ? 9

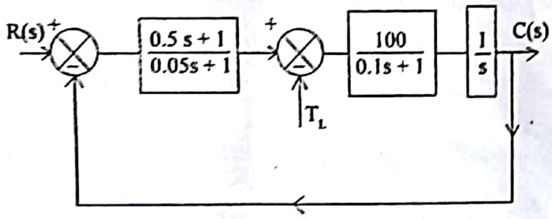


Fig. 6(a)

(b) Explain effect of adding poles on output response of a system. 5

7. (a) Using Routh's criterion determine range of gain 'K' for stability of system having :

$$G(s)\,H(s) = \frac{K}{(s+1)^3 + (s+4)}.$$

Also, find frequency of oscillation when the system is marginally stable. 8

(b) Explain stable, unstable and marginally stable system. 5

OR

8. Draw root-locus plot for a unity feed-back system having :

$$G(s) = \frac{K}{s(s+6)(s+9)}.$$

Obtain value of 'K' for ξ = 0.6 from root locus. 13

9. Draw the asymptotic Bode-Plot for a feed-back control system having :

$$G(s)\,H(s) = \frac{K}{s\left(1+\frac{s}{4}\right)\left(1+\frac{s}{40}\right)}.$$

Determine value of gain 'K' for :

(i) Gain margin = 20 dB

(ii) Phase margin = 30°. 14

OR

10. (a) Sketch a polar plot for a system having :

$$G(s)\,H(s) = \frac{1}{s(s+2)(s+4)}.$$ 9

(b) Obtain transfer function of system from bode gain plot. 5

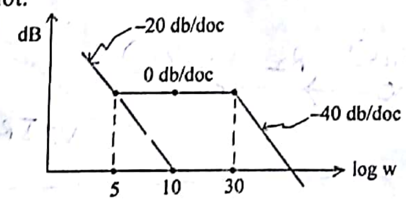


Fig. 10(b)

11. Find the state-space representation in matrix form for the T.F.

$$\frac{C(s)}{R(s)} = \frac{24}{(s^3 + 9s^2 + 26s + 24)}.$$

Also, test for controllability and observability. 13

OR

12. (a) Find the transfer function for the system given as :

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

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

8

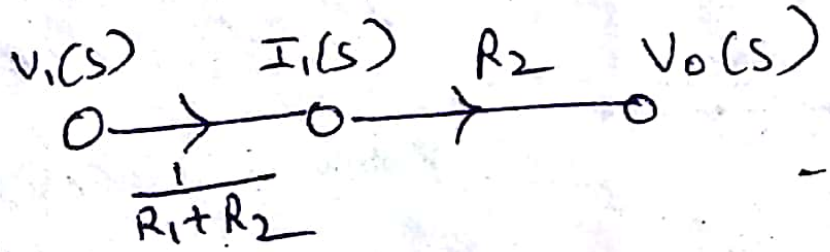
Q.4 (b)

(b) Explain lead-lag compensation. 5

$V_1 = I_1 (R_1 + R_2)$

$V_1(s) = I_1(s)[R_1 + R_2]$ — (1)

$V_o(s) = I_1(s) R_2$ — (2)



$\because V = IR$