DEPARTMENT OF

ELECTRONICS & COMMUNICATION

Session [2019-2020]

Course File of Control System

For

Bachelor of Engineering

In

Electronics & Communication

Prepared

By

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Content

Course Title	**CONTROL SYSTEMS**			
Course Code	**EC 404**			
University	**Rajiv Gandhi Technical University, Bhopal, M.P.**			
Course Scheme	Lectures	Tutorials	Practical's	Credits
	3	1	2	5
Course Coordinator	Dr. Mehajabeen Fatima, Dr. Jyoti Jain			

1. VISION OF THE DEPARTMENT

To produce globally competitive, socially sensitized Engineering graduates and to establish the department as a center of excellence by bringing out the professional competence in the core areas of Electronics and Communication Engineering.

2. MISSION OF THE DEPARTMENT

1. To Provide Quality Education in the domain of Electronics and Communication Engineering and motivate students for life long learning.
2. To Achieve Excellence in Technical Education through effective teaching-learning process and impart managerial skills to the students to make them suitable for technical industries.
3. To prepare students for higher studies and make them capable to design and develop innovative ideas by adopting IT based knowledge for benefit of society.

3. PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

PEO-1: To prepare the students for achieving the excellence in their professional career.
PEO-2: To develop social and ethical values within the students in today's technology drive society.
PEO-3: To inculcate communication skill, managerial skill and leadership quality in students to make them successful entrepreneur.
PEO-4: To provide the Engineering solutions using latest tools to enhance Research and development activities in Electronics, Communication and IT industries.

4. PROGRAM OUTCOMES (POs)

1. **Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics iences and Engineering sciences.
/Development of solutions: Design solutions for complex engineering problems and stem components or processes that meet the specified needs with appropriate

consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**:Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6.**The engineer and society**:Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7.**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8.**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9.**Individual and team work**: Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.

10.**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

5. PROGRAMME SPECIFIC OUTCOMES (PSOs)

A graduate of the Electronics and Communication Engineering Program will have:

PSO-1: An ability to comprehend the fundamental concepts of electronic devices, circuits and digital systems for designing of application oriented Engineering problems.

PSO-2: An ability to clearly understand the technological advancements in the field of Analog and Digital communication/ networking, Antenna and Signal processing systems.

PSO-3 An ability to apply acquired knowledge to implement solutions in real life problems relating to Microprocessor based, Control systems, VLSI and Embedded systems.

: OVERVIEW

This course is aimed to introduce the students about the principles of control systems in everyday life. The basic concepts of block diagram reduction, time analysis solutions to time invariant systems and different aspects of stability analysis of systems in time domain and frequency domain. Also dynamic system modeling is discussed.

7. PREREQUISITE(S)

Level	Credits	Periods/ Week	Prerequisites
UG	4	4	Knowledge of laplace transform

8. MARKS DISTRIBUTION

Mid Semester Test

There shall be 2 midterm examinations. Each midterm examination consists of subjective type. 1st Mid semester exam is conducted for 10 marks, with duration of 2 and 3 hour. IInd Mid semester exam is conducted for 10 marks, with duration of 3 hours. Mid Semester test of each subject shall contain 4 to 5 questions. The student has to answer 3 to 4 questions. First midterm examination shall be conducted for the first 21/2 unit of syllabus and second midterm examination shall be conducted for the remaining portion.

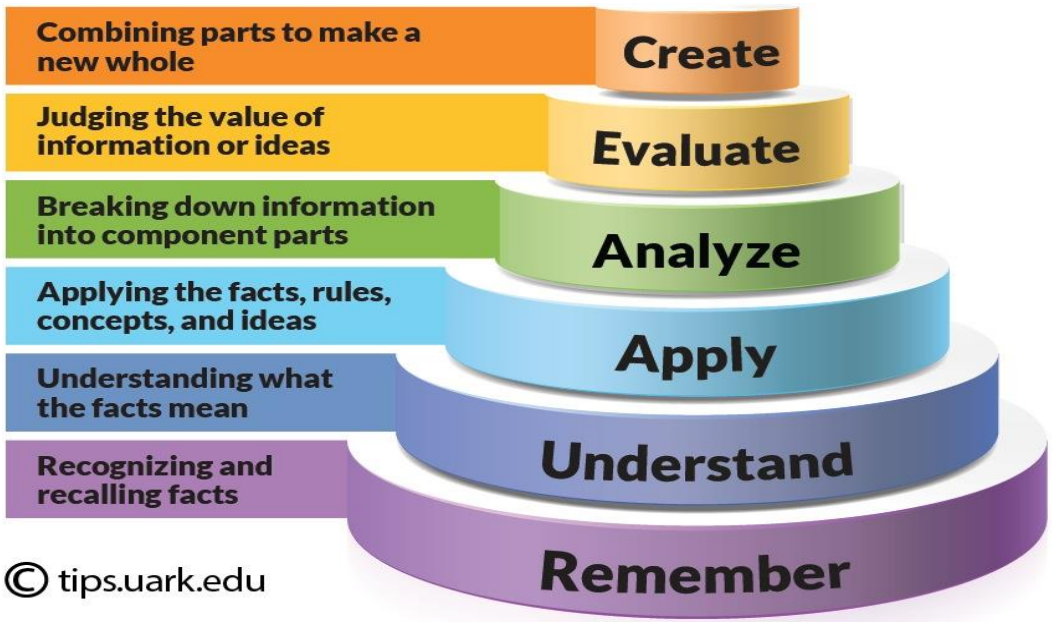
Five marks are earmarked for assignments.

There shall be five unit wise assignments in every theory course. Marks shall be awarded considering the average of two assignments in each course. The total marks secured by the student in each mid-term examination are evaluated for 20 marks, and the best of the two mid-term examinations shall be taken as the final marks secured by each candidate.

9. EVALUATION SCHEME

S. No	Component	Duration	Marks
1.	I Mid Examination	120 minutes	10
2.	I Assignment/Quiz	-	5
3.	II Mid Examination	180 minutes	10
4.	II Assignment	-	5
5.	Lab Work/ Sessional	-	20
6.	External practical Examination	3 hours	30
7.	Theory Exam	3 hours	70
	Total		150

10. BLOOMS TAXONOMY



11. COURSE OUTCOMES

After completing this course the student must demonstrate the knowledge and ability to

CO	COURSE OUTCOME	LEVEL
CO 1	Relate previous knowledge to basic concepts and transfer function of control system.	1
CO2	Understanding the time domain, frequency domain, stability, static and dynamic control system	2
CO3	Solve the problems of time domain, frequency domain, stability, static and dynamic control system	3
CO4	Analyze the static and dynamic system stability	4

12. SYLLABUS

UNIT-I

Introduction to Control system: Terminology and classification of control system, examples of control system, mathematical modeling of mechanical and electrical systems, differential equations, transfer function, block diagram representation and reduction, signal flow graph techniques.

Feedback characteristics of control systems Open loop and closed loop systems, effect of feedback on control system and on external disturbances, linearization effect of feedback, regenerative feedback

UNIT-II

Time response analysis Standard test signals, time response of 1st order system, time response of 2nd order system, steady-state errors and error constants, effects of additions of poles and zeros to open loop and closed loop system.

Time domain stability analysis Concept of stability of linear systems, effects of location of poles on stability, necessary conditions for stability, Routh-Hurwitz stability criteria, relative stability analysis, Root Locus concept, guidelines for sketching Root-Locus.

UNIT-III

Frequency response analysis Correlation between time and frequency response, Polar plots, Bode Plots, all- pass and minimum-phase systems, log-magnitude versus Phase-Plots, closed-loop frequency response.

Frequency domain stability analysis : Nyquist stability criterion, assessment of relative stability using Nyquist plot and Bode plot (phase margin, gain margin and stability).

UNIT-IV

Approaches to system design Design problem, types of compensation techniques, design of phase-lag, phase lead and phase lead-lag compensators in time and frequency domain, proportional, derivative, integral and Composite Controllers.

UNIT-V

State space analysis of continuous system: State space representation of systems, block diagram for state equation, transfer function decomposition, solution of state equation, transfer matrix, relationship between state equation and transfer function, controllability and observability.

Text books:

1. Control systems by Nagoorkani by RBApublication
2. Control System by B.S. Manke
3. Control System by Pankaj Swarnkar
4. Modern control engineering by K.Ogata,prenticehall

books:

Control system engineering by I.J.nagarath and M.Gopal ,newage

2. Control System by Hasan Saeed
3. Control system by A.AnandKumar

13. COURSE PLAN

At the end of the course, the students are able to achieve the following course outcomes

Lecture no.	Learning objectives	Topics to be covered	Relevant COs
1	Subject Introduction	To learn and remember the control system	CO1
2	Introduction to control systems	To learn and remember the Concepts of Control Systems, Open Loop and Closed loop control systems and their differences	CO1
3	Differential equations, Impulse Response and transfer function	To learn and remember the Differential equations, Impulse Response and transfer function of a Control Systems.	CO1
4-5	Block diagram representation of systems	To learn and remember the Block diagram representation of systems considering electrical systems as examples	CO1
6-9	Block diagram algebra	To understand and analyze the Problems on Block diagram algebra	CO2
10-14	Representation by Signal flow graph - Reduction using Mason's gain formula.	To understand and solve the problems related to Signal flow graph - Reduction using Mason's gain formula.	CO2
15-20	translational and rotational electrical, mechanical system	To understand and solve the problems related to translational and rotational mechanical system	CO2
21	Introduction	To understand the Time response analysis of system	CO2
22	Time response of first order systems	To understand the Time response of first order	CO2

		systems	
23-24	Characteristic Equation of Feedback control systems	To understand the Characteristic Equation of Feedback control systems	CO2
25-27	Transient response of second order systems - Time domain specifications	To understand the Transient response of second order systems - Time domain specifications	CO2
28-29	Numerical on First order systems and second order systems	Apply the above concepts to solve different problems of First order systems and second order systems	CO3
30	Steady state response - Steady state errors and error constants	Apply the concepts to solve different problems of the Steady state response - Steady state errors and error constants	CO3
31-33	Effects of proportional derivative, proportional integral systems.	To understand the Effects of proportional derivative, proportional integral systems.	CO2
34	Introduction	To understand The concept of stability	CO2
35-36	Routh's stability criterion – qualitative stability and conditional stability	Routh's stability Routh's stability criterion	CO2
37	limitations of Routh's stability and numericals	Apply knowledge of routh Hurwitz to solve various problem.	CO3
38	Introduction	To understand The root locus concept	CO2
39-41	Construction of root loci-effects of adding poles and zeros to G(s) H(s) on the root loci.	Construction of Root locus for different problems And analyze it	CO3, CO4
42	Introduction	To understand the frequency response analysis	CO2
43	Frequency domain specifications	To understand the Frequency domain specifications expressions	CO2
-48	polar plots-nyquits plots-stability analysis	To understand polar ,nyqits plots	CO2

49-52	Determination of Frequency domain specifications and transfer function from the Bode Diagram-Phase margin and Gain margin stability Analysis from Bode Plots.	Analyze stability from the Bode Diagram, Determine Phase margin and Gain margin and different problems	CO4
53	concept of state, state variables and state model	To understand concept of state variable	CO2
54	derivation of state models from block diagrams	To understand state model	CO2
55	state transition matrix and its properties – concept of controllability and observability.	Analyze whether the system is controllable or observable	CO4
56-57	compensation technique –lag, lead and lead-lag controllers design in frequency domain	To analyse compensation technique	CO2
58-59	PID controllers	To understand PID controller	CO2

14. HOW PROGRAM OUTCOMES ARE ASSESSED

Program Outcomes		Level	Proficiencyassessed by
PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.	H	Assignments, mid sem exam
PO2	**Problem analysis**: Identify, formulate, review research literature, basic and analyze complex engineering problems reaching substantiatedconclusions using first principles of mathematics, natural sciences, and engineering sciences.	H	Assignments, Tutorial

PO3	**Design/development of solutions**: Design solutions for basic and complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	H	Excercise
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	H	utorial, iscussions
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	M	Seminar
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	N	------
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	S	Excercise
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineeringpractice.	S	iscussion, eminars
PO9	**Individual and team work**: Function effectively as an individual, and asame mberorleaderindiverseteams,and in multidisciplinary settings.	S	Discussions, Seminar
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	S	Discussions, Assignments

PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	N	----------
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	S	esearch paper

N - None **S - Supportive** **H - Highly Related**

15. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

	Program Specific Outcomes	Level	Proficiency assessed by
PSO1	**Professional Skills:** An ability to comprehend the fundamental concepts of mathematics, electronic devices, circuits and digital systems for designing of application oriented Engineering problems.	S	Lectures, Assignments
PSO2	**Problem-Solving Skills: U**nderstand the technological advancements in the field of Analog and Digital communication/ networking, Antenna and Signal processing systems.	H	**Tutorial Lab Work** Mid Sem Exam
PSO3	**Successful Career and Entrepreneurship: U**nderstanding of technologies like PLC, PMC, process controllers, transducers , Control System, Microprocessor, VLSI.	S	Projects

N - None **S - Supportive** **H - Highly Related**

16. CO- PO MAPPING

CO		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC- 404	1	3	-	-	-	-	-	-	-	1	1	-	-
EC- 404	2	1	3	3	-	-	-	-	-	2	2	-	-
EC- 404	3	1	1	3	-	-	-	-	-	2	1	-	-
EC- 404	4	1	1	1	3	-	-	-	-	1	1	-	1
		or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium)3: Substantial (High) and It there is no correlation, put "-"											

17. MAPPING CO LEADING TO THE ACHIEVEMENT OF PO AND PSO

Course Objectives	Program Outcomes												gram Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	-	-	-	-	-	-	-	1	1	-	-	3	2	1
2	1	3	3	-	-	-	-	-	2	2	-	-	3	2	-
3	1	1	3	-	-	-	-	-	2	1	-	-	1	3	-
4	1	1	1	3	-	-	-	-	1	1	-	1	-	3	-

1–Supportive 2-Medium 3 – Highly Related

18. TUTORIALS

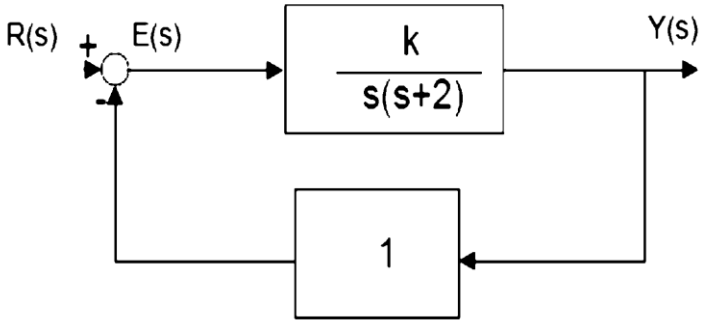
SUBJECT NAME & CODE: Control System & EC-404
SESSION: 2019-20

TUTORIAL SHEET NO.: 1

1. Differentite between open loop and closed loop control system. (CO1, PO1, 9, 10)

2. Enlist laplace transform of important function. (CO1, PO1, 9, 10)

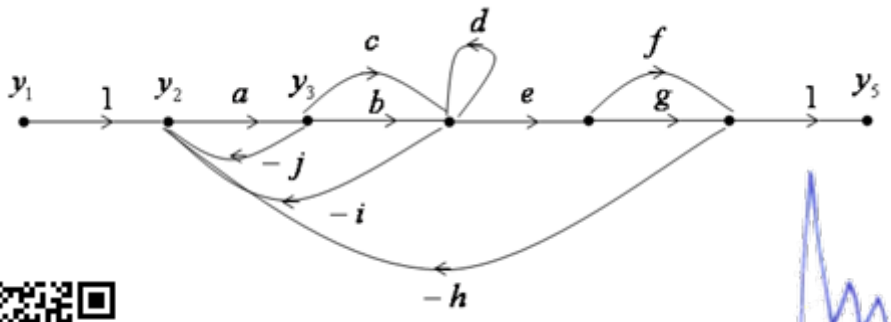
3. Calculate transfer function of given block diagram (CO3, PO1, 2, 3, 9, 10)



TUTORIAL SHEET NO.: 2

1. Write Mason's Gain Formula. (CO1, PO1, 9, 10)

2. Determine transfer function of following signal flow graph. (CO3, PO1, 2, 3, 9, 10)



TUTORIAL SHEET NO.:3

1. **Explain absolute and relative stability. (CO2, PO1, 2, 3, 9, 10)**

2. **Find out whether the closed loop system is stable or not using Routh Herwithz criteria. The open loop transfer function is given below** (CO3, PO1, 2, 3, 9, 10)

$$\hat{G}(s) = \frac{s^2 + s + 1}{s^4 + 2s^3 + 3s^2 + s + 1}$$

TUTORIAL SHEET NO.: 4

$$G(s) = \frac{K(s+5)}{(s+2)(s+6)(s+10)}$$

Q The unity feedback system with
is operating with 20% overshoot.

a. Find the settling time, Kp, phase margin and the gain crossover frequency **(CO2, PO1, 2, 3, 9, 10)**

d. Using frequency response techniques, design a compensator that will yield a threefold improvement in Kp and a twofold reduction in settling time while keeping the overshoot at 20%.(CO4, PO4)

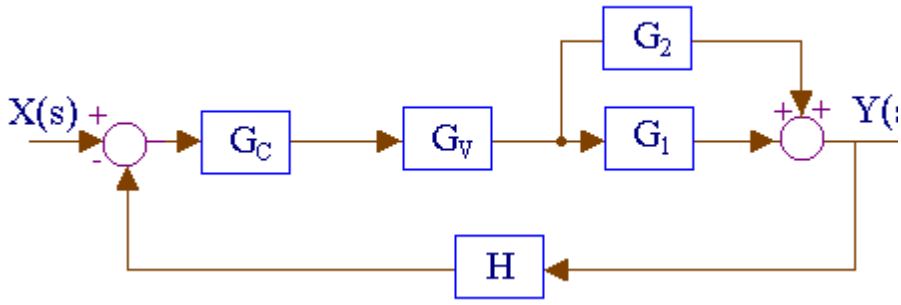
TUTORIAL SHEET NO.: 5

1. Draw root locus for following transfer function and analyze the results.. (CO4, PO4)

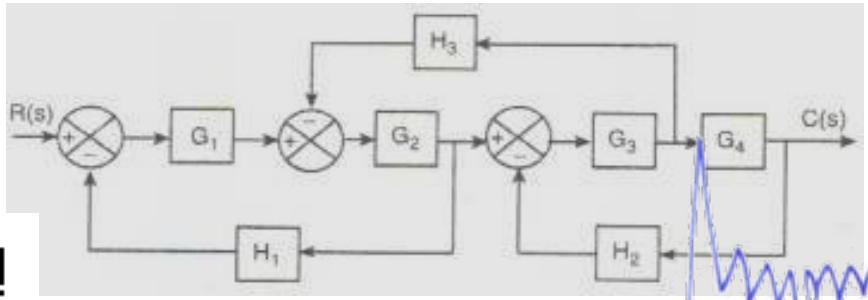
$$kG(s)C(s) = \frac{k(s+4)}{(s+2)s}$$

19.ASSIGNMENT

S. No	Question	Blooms Taxonomy Level	Course Outcome
	UNIT – I		
1.	What is control system? Define open loop and closed loop control system. Define transfer function.	1	1
2.	Explain the advantages of systems with feedback? What are the effects of feedback On the performance of a system? Briefly explain? Also give at least three applications of feedback control systems?	2	2
3.	What is block diagram? What is the basis for framing the rules of block diagram reduction technique?	2	2
4.	Obtain transfer function of given block diagram using block diagram reduction technique.	3	3

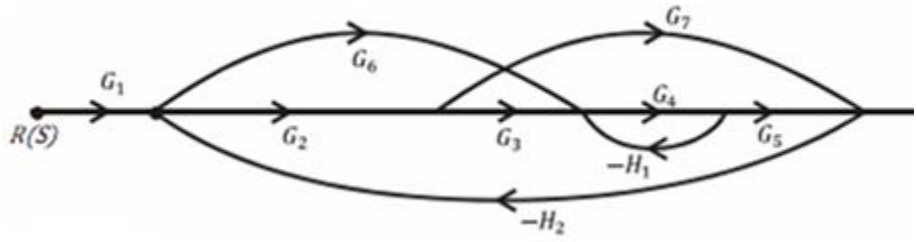


5.	Determine the transfer function C(S)/R(S) of the system shown below using block diagram reduction method	3	3

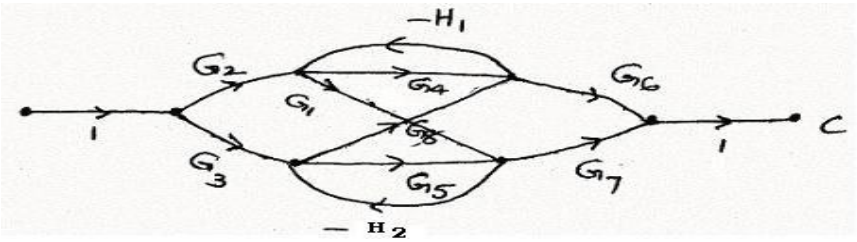


6. What is a signal flow graph? Write Masons Gain formula. 2 2

7. Obtain closed loop transfer function of given diagram using Mason's gain formula. 3 3



8. Obtain the overall transfer function C/R from the signal flow graph shown. 3 3



UNIT – II

1. What is the time response of the first and second order system? 1, 2 1, 2
2. Define Damping ratio. Classify the system depending on the value of damping? 2 2
3. Draw transient response and show underdamp, overdamp, critical damping and its value. 2 2
4. For a unity feedback system whose open loop transfer function is G(s) = 50/(1+0.1s)(1+2s) , Determine the position, velocity & acceleration error Constants. 4 4
5. A unity feed-back system is characterized by the open-loop transfer function: $G(s) = 1/(s(0.5s + 1)(0.2 s + 1))$ 3 3
   termine the steady-state errors for unity-step, input. Also find the
   mping ratio and natural frequency of the dominant roots.

6.	Define BIBO Stability. What is the essential condition for stability?	2	2
7.	What is characteristic equation? Explain how the roots of characteristic equation are related to stability?	2	2
8.	Define the terms (i) Absolute stability (ii) marginal stability (iii) conditional stability (iv) stable system (v) Critically stable system (vi) conditionally stable system?	2	2
9.	Check the stability of the given characteristic equation using Routh's Hurwitz method $S^6 + 2S^5 + 8S^4 + 12S^3 + 20S^2 + 16S + 16 = 0$	3	3
10	**Determine the value of K for which the system is stable whose transfer function of closed loop system is given below** $G_o(s) = \frac{k_o(s+1)}{s(s+2)(s^2+12s+40)}$	4	4

UNIT – III

1.	Sketch the Bode plot for the open loop transfer function and analyse the results **10/ (s+10)**	4	4
2.	Sketch bode phase angle plot of a systemG(s)= 1/ ((1+S)(1+2S))	3	3

UNIT – IV

1.	What is Proportional controller and what are its advantages? What is the drawback in P-controller? What is PI, PD, PID controller?	2	2
2.	What are the polar plots?	2	2

UNIT – V

1.	What is state, state variable and state vector?	2	2
2.	Draw state space diagram for G(s)= 1/ ((1+S)(1+2S))	3	3
3.	State and explain controllability and observability?	4	4

20. MID SEMESTER EXAMINATIONS PAPER

SEMESTER: IV **BRANCH: EC**

Subject Code / Name: EC-404 / Control System

Time: 2:00 Hrs. **Max. Marks: 42**

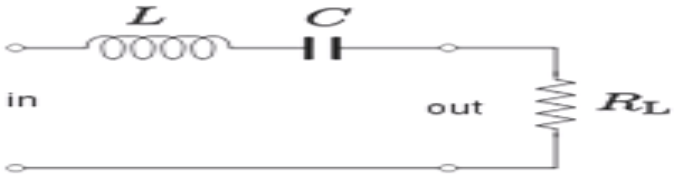
NOTE: (1) Part (a), (b) and (c) are compulsory in each unit.
(2) Attempt either part (d) or (e)
(3) Maximum word limit for part (a) and (b) is 50 words, part (c) is 100 words and part (d) or (e) is 400 words.

Unit I

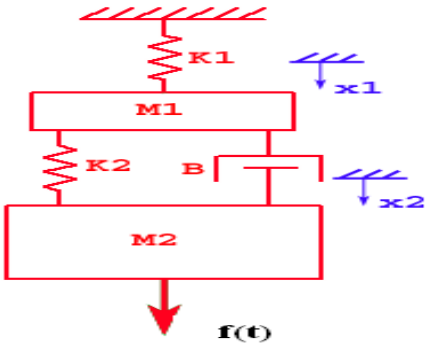
Q. I (a) Differentiate between open loop and closed loop system. (CO1, PO1, 9, 10) 2 Marks

(b) What is difference between linear and nonlinear system. (CO1, PO1, 9, 10) 2 Marks

(c) Find out transfer function of following Network (CO3, PO1, 2, 3, 9, 10) 3 Marks

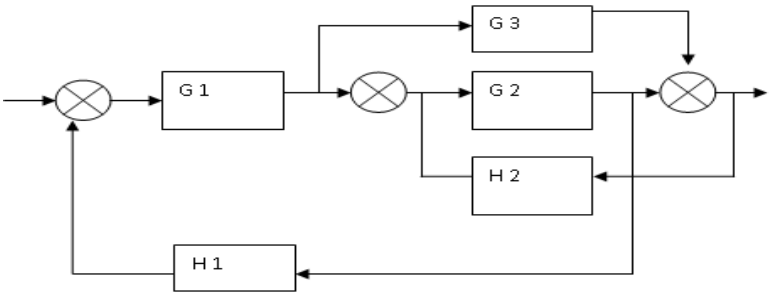


(d) Draw mechanical equivalent diagram, F-I analogous circuit and F-V analogous circuit. (CO3, PO1, 2, 3, 9, 10) 7 Marks



OR

(e) (a) Determine the overall transfer function relating C and R for the system whose block diagram is shown below. (25) (CO3, PO1, 2, 3, 9, 10) 7 Marks



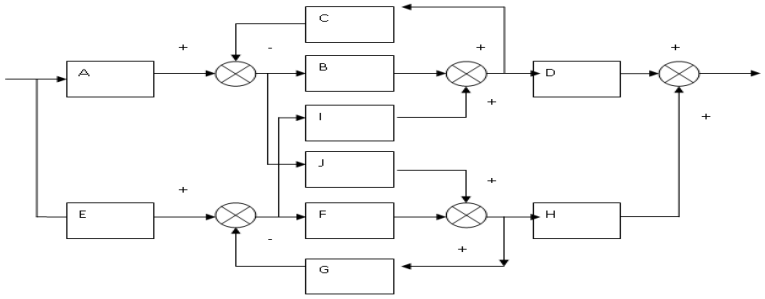
Q. II (a) What is Mason's gain formula. (CO1, PO1, 9, 10) 2 Marks

(b) **Explain absolute and relative stability. (CO2, PO1, 2, 3, 9, 10)** 2 Marks

(c) Determine stability of system whose characteristic equation is given below through Routh Hurwitz criterion.) (CO3, PO1, 2, 3, 9, 10) 3 Marks

$s^5 + s^4 + 2s^3 + 2s^2 + 11s + 10 = 0$

(d) Obtain signal flow graph representation for a system whose block diagram is given. Specify (a) Forward path, (b) Individual loop, (c) Path factors, (d) non touching loops, (e) determine the graph determinant. (CO3, PO1, 2, 3, 9, 10) 7 Marks



OR

(e) The transfer function of unity feedback closed loop control system is given below, Determine the value of K for which the steady state error to ramp input will be 0.02 . (CO4, PO4) 7 Marks

$$\frac{C(s)}{R(s)} = \frac{K}{s^2 + 20s + K}$$

Unit II

Q. III (a) Find the natural frequency and damping ratio for following transfer function. (CO3, PO1, 2, 3, 9, 10) 2 Marks

$$\frac{C(s)}{R(s)} = \frac{Ks + \beta}{s^2 + \alpha s + \beta}$$

(b) Draw the location of root on s-plane and its time response for different values of damping ratio of second order system **(CO2, PO1, 2, 3, 9, 10)** 2 Marks

(c) Analyze the time response of first order system to unit ramp input. (CO4, PO4) 3 Marks

(d) Determine steady state error for unit ramp input for unity feedback (CO3, PO1, 2, 3, 9, 10) 7 Marks
closed loop system whose transfer function is given below.

$$\frac{C(s)}{R(s)}=\frac{Ks+\beta}{s^2+\alpha s+\beta}$$

OR

(e) The open loop transfer function of a control system is given below. Determine static error coefficient for unit step, unit ramp and unit parabolic. (CO3, PO1, 2, 3, 9, 10) 7 Marks

$$(G(s)H(s))=\frac{2(s^2+3s+20)}{s(s+2)(s^2+4s+10)}$$