CONTROL SYSTEMS

Subject Code : EE404PC

Regulations : R18 - JNTUH

Class : II Year B.Tech EEE II Semester

Department of Electrical and Electronics and Engineering

BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

Ibrahimpatnam - 501 510, Hyderabad

CONTROL SYSTEMS (EE404PC)
COURSE PLANNER

I. COURSE OVERVIEW:

In this course it is aimed to introduce to the students the principles and applications of control systems in everyday life. The basic concept of block diagram reduction, time domain analysis solutions to time invariant systems and also deals with the different aspects of stability analysis of systems in time domain and frequency domain.

II. PREREQUISITES:

Linear Algebra and Calculus, Ordinary Differential Equations and Multivariable Calculus
Laplace Transforms, Numerical Methods and Complex variables.

III. COURSE OBJECTIVES:

At the end of the course, the students will be able to:

S.No	Description
1	To understand the different ways of system representations such as Transfer function representation and state space representations and to assess the system dynamic response.
2	To assess the system performance using time domain analysis and methods for improving it.
3	To assess the system performance using frequency domain analysis and techniques for improving the performance.
4	To design various controllers and compensators to improve system performance.

IV .COURSE OUTCOMES:

S.No	Description	Bloom's Taxonomy Level
CO1	**Understand** the modeling of linear-time-invariant systems using transfer function and state space forms.	Knowledge, Understand (Level 1, Level 2)
CO2	**Understand** various feedback control strategies.	Knowledge, Understand (Level 1, Level 2)
CO3	**Analyze** the system response and stability in both time-domain and frequency domain.	Knowledge, Analyze (Level 1, Level 4)
CO4	**Apply and Design** different types of compensators using in time-domain and frequency domain specifications.	Apply, Evaluate (Level 3, Level 5)
CO5	**Analyze** the system response and stability of systems represented in state space form	Analyze (Level 4)
CO6	**Model and Analyze** the linear discretized time systems.	Create, Analyze (Level 5, Level 4)

V. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (PO)		Level	Proficiency assessed by
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineering problems related to Computer Science and Engineering.	2	Lectures, Assignments university exams.
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complexengineering problems related to Computer Science and Engineering and reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Slip tests, Surprise tests and Mock tests
PO3	**Design/development of solutions**: Design solutions for complex engineering problems related to Computer Science and Engineering anddesign 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.	2	Hands on Practice sessions
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and researchmethods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Sessions and model developments
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modernengineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	Practices new methods
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assesssocietal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Computer Science and Engineering professional engineering practice.	-	-
PO7	**Environment and sustainability**: Understand the impact of the Computer Science and Engineering professional engineering solutionsin societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	-	-
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms ofthe engineering practice.	-	-
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader indiverse teams, and in multidisciplinary settings.	-	-
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineeringcommunity 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.	-	-
PO11	**Project management and finance**: Demonstrate knowledge and understanding of theengineering 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.	2	Workshops /Develop new projects

Program Outcomes (PO)		Level	Proficiency assessed by
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage inindependent and life-long learning in the broadest context of technological change.	2	Projects and seminars

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSO)		Level	Proficiency assessed by
PSO1	Talented to analyze, design, and implement electrical & electronics systems and deal with the rapid pace of industrial innovations and developments	2	Participate events, seminars and symposiums Experiments / Tools /Projects
PSO2	Skillful to use application and control techniques for research and advanced studies in Electrical & Electronics Engineering domain.	2	Participate events, seminars and symposiums Experiments / Tools /Projects

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

VII . COURSE CONTENT:SYLLABUS

JNTUH SYLLABUS

UNIT - I

Introduction to Control Problem: Industrial Control examples. Mathematical models of physicalsystems. Control hardware and their models. Transfer function models of linear time-invariantsystems.Feedback Control: Open-Loop and Closed-loop systems. Benefits of Feedback. Blockdiagram algebra.

UNIT - II

Time Response Analysis of Standard Test Signals: Time response of first and second ordersystems for standard test inputs. Application of initial and final value theorem. Design specificationsfor second-order systems based on the time-response. Concept of Stability. Routh-Hurwitz Criteria.Relative Stability analysis. Root-Locus technique. Construction of Root-loci.

UNIT - III

Frequency-Response Analysis: Relationship between time and frequency response, Polar plots,Bode plots. Nyquist stability criterion. Relative stability using Nyquist criterion – gain and phasemargin. Closed-loop frequency response.

UNIT - IV

Introduction to Controller Design: Stability, steady-state accuracy, transient accuracy, disturbancerejection, insensitivity and robustness of control systems. Root-loci method of feedback controllerdesign.Design specifications in frequency-domain.Frequency-domain methods of design.Application of Proportional, Integral and Derivative Controllers, Lead and Lag compensation indesigns. Analog and Digital implementation of controllers.

UNIT - V

State Variable Analysis and Concepts of State Variables: State space model. Diagonalization ofState Matrix. Solution of state equations. Eigen values and Stability Analysis. Concept ofcontrollability and observability. Pole-placement by state feedback. Discrete-time systems. DifferenceEquations. State-space models of linear discrete-time systems. Stability of linear discrete-timesystems.

TEXT BOOKS:

1. M. Gopal, "Control Systems: Principles and Design", McGraw Hill Education, 1997.
2. B. C. Kuo, "Automatic Control System", Prentice Hall, 1995.

REFERENCE BOOKS:

1. K. Ogata, "Modern Control Engineering", Prentice Hall, 1991.
2. I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International, 2009.

GATE

Control Systems: Basic control system components; block diagrammatic description, reduction of block diagrams. Open loop and closed loop (feedback) systems and stabilityanalysis of these systems. Signal flow graphs and their use in determining transfer functions of systems; transient and steady state analysis of LTI control systems and frequency response. Tools and techniques for LTI control system analysis: root loci, Routh-Hurwitz criterion, Bode and Nyquist plots. Control system compensators: elements of lead and lag compensation, elements of Proportional-Integral-Derivative (PID) control. State variable representation and solution of state equation of LTI control systems.

IES SYLLABUS

Transient and steady state response of control systems; Effect of feedback on stability and sensitivity; Root locus techniques; Frequency response analysis. Concepts of gain and phase margins: Constant-M and Constant-N Nichol's Chart; Approximation of transient response from Constant-N Nichol's Chart; Approximation of transient response from closed loop frequency response; Design of Control Systems, Compensators; Industrial controllers.

VIII. LESSON PLAN COURSE SCHEDULE:

BHARAT INSTITUTE OF ENGINEERING & TECHNOLOGY

Mangalpally(V), Ibrahimpatnam(M), R.R.Dist.

CONTROL SYSTEMS

Course Instructor: Mr Gyanesh Singh (EE404PC) — **Class: EEE II (A)**

Session	Date	Topic to be covered	link for ppt	Link for PDF	Link for small projects	Course Learning Outcomes	CO Mapping	Teaching Methodology	Reference Text Books
UNIT- 1 Introduction to Control Problem									
1		Introduction to subject	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L1:Remember	**CO1**	Chalk & Talk	T1-CH1
		Brief description of syllabus	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system				
		Explanation of program	https://drive.google.com/drive/folders/1o9m	https://drive.google.com/drive/folders/1	https://ece-eee.final-year-				

		outcomes and course outcomes.	Xw9Ago0cw5SWXHXJebUYUTswnspAn	o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	projects.in/t/control-system				
2		Concepts of Control Systems- Open Loop and closed loop control systems and their differences	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH1
3		Different examples of control systems	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:Analyze		PPT	T1-CH1
4		Classification of control systems & Transfer function and its properties	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH1
5		Explaination of Feedback systems & Feed-Forward Characteristics	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH3
6		Effects of feedback on control systems & Sensitivity of control systems	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1CH3
7		Introduction Mathematical models of mechanical transitional system with differential equations	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1CH3
8		Problems on mechanical transitional system	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH2
9		Introduction Mathematical models of mechanical	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH2
		rotational system with differential equations	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH2
10		Problems on mechanical rotational system	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH2
11		*Conversion of mechanical system to electrical system-force voltage and	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH2

		force current analogy							
12		Transfer Function of DC Servo motor - AC Servo motor.	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system			Chalk & Talk and practical experim ent	T1-CH4
			https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand			
13		Synchro transmitter and Receiver	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk and practical experim ent	T1-CH4
14		Block diagram representation of systems considering electrical systems with examples	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH4
15		Block diagram algebra	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH2
16		Problems on block diagrams	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH2
17		Representatio n by Signal flow graph & Reduction using mason's gain formula.	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH2
18		Problems on signal flow graphs	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH2
19		***Presentaion Hour***							
20		***# Mock test-1***							
UNIT-II Time Response Analysis of Standard Test Signals									
21		Introduction to Time Response & Standard test signals	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand	**CO2**	Chalk & Talk	T1-CH5
22		Time domain specifications ,order and type of the	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTs	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH5

		system Problems on time domain specifications		wnspAn					
23		Time response of first order & Second order systems – Characteristic Equation of Feedback control systems	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk and practical experiment	T1-CH5
24		Problems on transient response	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH5
25		Type number of the systems and error constants	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH5
26		Steady state errors & Problems on steady state errors	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH5
27		Effects of proportional derivative, proportional integral systems.	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk with simulation experiment	T1-CH5
UNIT-III Frequency-Response Analysis									
28		The concept of stability & Location of roots in S-plane for stability analysis	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand	C03	Chalk & Talk	T1-CH6
29		Stability analysis with characteristic equation of control systems	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH6
30		Routh stability criterion & Problems on Routh criterion	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH6

31		qualitative stability and conditional stability & The root locus concept	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH6
32		construction of root loci	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk and with simulation experiment	T1-CH7
33		Problems on root locus	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH7
34		Problems to find dominant poles & effects of adding poles and zeros to G(s) H(s) on the root loci	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH7
35		***# Bridge Class-2***	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system				
36		Introduction Frequency Response Analysis & definitions of Frequency domain specifications	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH8
37		frequency domain specifications for a second order system	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH8
38		Correlation between time domain and frequency domain specifications & Introduction to frequency response plots	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH8
39		Procedure to draw bode plots & determine phase margin and gain margin and stability analysis	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		PPT	T1-CH8
40		Problems on bode plots	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH8

41		Determination of Frequency domain specifications and transfer function from the Bode Diagram	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk and with simulation experiment	T1-CH8
42		Problems to determine transfer function from bode diagram	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH8
43		Introduction to Polar Plots & Procedural steps to draw polar plots	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk and with simulation experiment	T1-CH8
44		Problems on polar plots	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH8
UNIT-IV Introduction to Controller Design									
45		Introduction to Nyquist plot & Stability analysis using Nyquist criterion	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand	CO4	PPT	T1-CH9
46		Procedural steps to draw Nyquist plots	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH9
47		Effects of adding poles and zeros to G(s)H(s) on the shape of the Nyquist diagrams.	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze			
			https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system			PPT and simulation experiment	T1-CH9
48		Problems on Nyquist plot	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH9
49		***Presentaion Hour***	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXH	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5S	https://ece-eee.final-year-projects.in/t/control-				

			XJebUYUTswnspAn	WXHXJebUYUTs wnspAn	system				
50		Introduction to compensation techniques & Lag compensator and procedure to design it	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH10
51		Lead compensator & Lead Lag compensator and procedure to design it	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH10
52		Problems on compensators & PID controllers	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH10
53		***Presentaion Hour***							
UNIT-V State Variable Analysis and Concepts of State Variables									
54		Introduction to State Space Analysis of Continuous Systems & its advantages and applications	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand	CO5	Chalk & Talk	T1-CH12
55		Definitions of state space, state variables ,state model & State diagram representation of a control system	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH12
56		State space representation of an electrical network and problems on it & derivation of state models from block diagrams	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH12
57		derivation of state models from transfer function using signal flow graph method	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH12
58		derivation of state models from transfer function using direct decomposition method	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH12

59		derivation of state models from transfer function using cascade method	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH12
60		derivation of state models from transfer function using canonical method	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH12
61		derivation of transfer function from state models & state diagram	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH12
62		Diagonalization & Introduction To State Equations	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH12
63		State Transition Matrix And Its Properties & Methods To Determine The Matrix & Problems on state transition matrix	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH12
64		Solving the Time invariant state Equations(non homogeneous)	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH12
65		Solving the Time invariant state Equations(non homogeneous)	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L4:analyze		Chalk & Talk	T1-CH12
66		*Controllability & Observability	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://drive.google.com/drive/folders/1o9mXw9Ago0cw5SWXHXJebUYUTswnspAn	https://ece-eee.final-year-projects.in/t/control-system	L2:understand		Chalk & Talk	T1-CH12

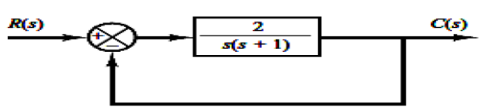
* (content beyond syllabus)

IX. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CO's	Program Outcomes (PO's)												Program Specific Outcomes (PSO)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	-	-	-	-	-	-	-	-	3	2
CO2	2	3	2	2	1	-	-	-	-	-	-	-	3	2
CO3	2	3	3	2	2	-	-	-	-	-	-	-	3	2
CO4	3	3	3	2	2	-	-	-	-	-	-	-	3	2
CO5	2	1	2	2	1	-	-	-	-	-	-	-	2	2
CO6	2	2	2	2	2	-	-	-	-	-	-	-	2	2

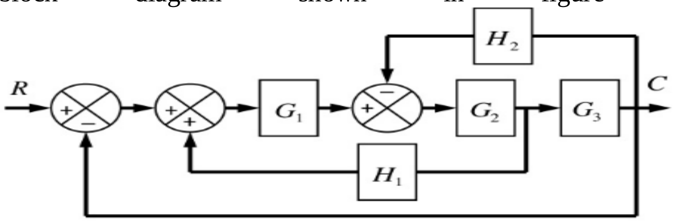
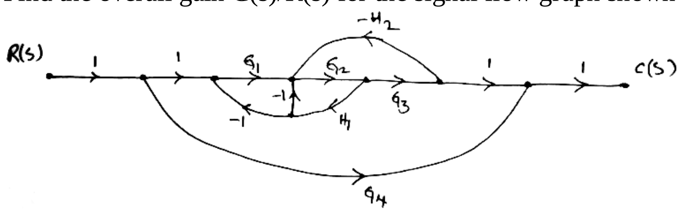
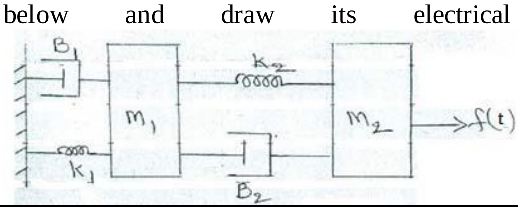
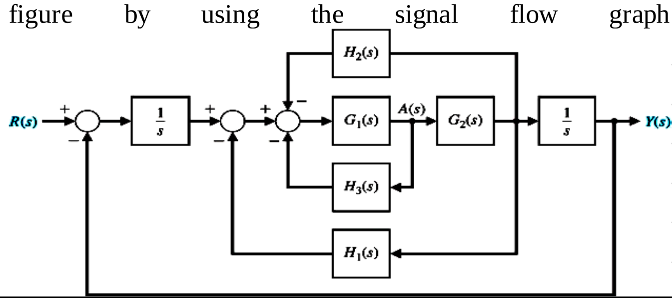
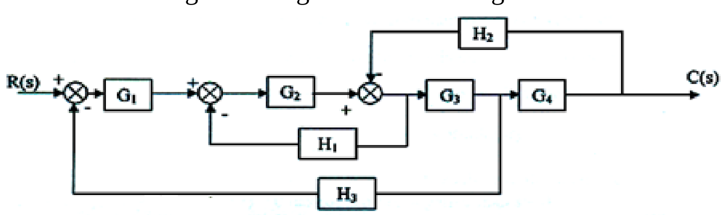
1: Slight (Low)   : Moderate (Medium)   3: Substantial (High)   - : None

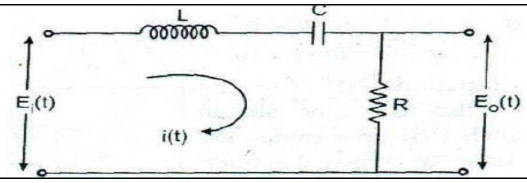
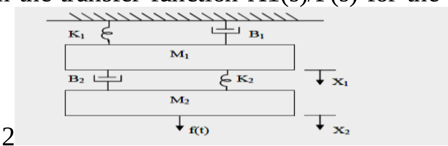
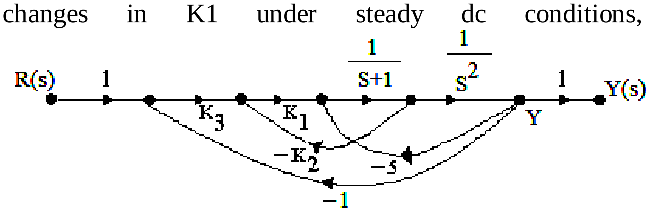
X. QUESTION BANK: (JNTUH)
UNIT.1
Short Answer Question

S.No	Question	BloomsTaxonomy Level	Course Outcome
1	Write the Manson's gain formula. What are the basic properties of SFG?	L2:UNDERSTAND	C01
2	Differentiate between linear and non linear control systems. Describe the open loop and closed loop control system	L4:ANALYZE	C01
3	List out the applications of Synchro transmitter and receiver? Syncro acts as error detector? Justify?	L3:APPLY	C01
4	Explain the effect of negative feedback in control systems. Find the TF of following system (figure 1).  Figure 1	L2:UNDERSTAND	C01
5	What is feed back? Explain the effects of feedback. List the advantages and disadvantages of feedback systems.	L2:UNDERSTAND	C01
6	Explain the rules for block diagram reduction technique.	L2:UNDERSTAND	C01
7	Find the impulse response of the system described $G(s) = \frac{2}{s^2 + 2s + 6}$, $H(s) = \frac{1}{s + 2}$.	L5:EVALUATE	C01
8	When is a control system said to be robust? Explain with suitable example.	L2:UNDERSTAND	C01
9	Describe a two phase a.c. servomotor and derive its transfer function.	L2:UNDERSTAND	C01
10	Give the advantages of transfer function.	L2:UNDERSTAND	C01

Long Answer Questions:

S.No	Question	BloomsTaxonomy Level	Course Outcome

1.	Compare the AC and DC servomotors.For the system represented by the block diagram shown in figure 1.FindC/R. 	L5:EVALUATE	C01
2	Find the overall gain C(s)/R(s) for the signal flow graph shown in figure 2. 	L5:EVALUATE	C01
3	Derive the transfer function armature controlled DC servo motor and draw its block diagram.	L6:CREATE	CO1
4	Explain any two examples of closed loop control systems.	L2:UNDERSTAND	CO1
5	Explain translatory and rotary elements of mechanical systems Discuss electrical analogous of mechanical rotational systems	L2:UNDERSTAND	CO1
6	Write the differential equations to represent the following system in figure below and draw its electrical equivalent circuit 	L5:EVALUATE	C01
7	a)Find the transfer function of series RLC circuit b) Obtain the transfer function Y(s)/R(s) from block diagram shown below figure by using the signal flow graph method. 	L5:EVALUATE	C01
8	Obtain the transfer function for the system represented by block diagram shown below figure using the block diagram reduction technique. 	L5:EVALUATE	C01
9	Find the transfer function of the network given figure.	L5:EVALUATE	C01

<table>
<tr><td></td><td>
</td><td></td><td></td></tr>
<tr><td>10</td><td>Obtain the transfer function X1(s)/F(s) for the mechanical system shown figure 2 
.</td><td>L5:EVALUATE</td><td>C01</td></tr>
<tr><td>11</td><td>A servo system is represented by the signal flow graph shown in Figure 1. The nominal values of the parameters are K1 =1, K2 = 5 and K3 = 5. Determine the overall transfer functionY(S)/ R(S) and its sensitivity to changes in K1 under steady dc conditions, s = 0.

</td><td>L5:EVALUATE</td><td>C01</td></tr>
</table>

UNIT-2
Short Answer Questions:

S.No	Question	BloomsTaxonomy Level	Course Outcome
1.	What are the standard test signals used in control systems?	L1:REMEMBER	CO2
2	What is the effect of damping on peak overshoot in transient response? Define characteristic equation..	L2:UNDERSTAND	CO2
3	Define rise time,peaktime,delaytime,settling time and peak over shoot.	L2:UNDERSTAND	CO2
4	What is the effect of P, PI controller on the system performance?	L2:UNDERSTAND	CO2
5	What is steady state response?	L2:UNDERSTAND	CO2
6	Distinguish between type and order of a system.	L4:ANALYZE	CO2

Long Answer Questions:

S.No	Question	BloomsTaxonomy Level	Course Outcome
1.	The open-loop transfer function of a unity feedback control system is given by G(s)=9/s(s+3). Find the natural frequency of response, damping ratio, damped frequency and time constant.	L5:EVALUATE	CO2
2	For unity feedback control system the open loop transfer function $G(s)=10(s+2)/s^2(s+4)$. Find the ess when the input is $r(t)=3-2t+3t^2$ and find Kp ,Kv , and Ka.	L5:EVALUATE	CO2

3	Explain the following: a) Steady state error b) positional error constant c) Velocity error constant d) acceleration error constant e) Step response.	L2:UNDERSTAND	CO2
4	A unity feed-back control system has its open-loop transfer function given by $G(s) = \frac{4s+1}{4s^2}$ Determine an expression for the time response when the system is subjected to a) Unit impulse function b) Unit step input function.	L5:EVALUATE	CO2
5	A unity feedback system has $G(s) = \frac{1}{s(s+4)}$. The input to the system is described by r(t) = 4+6t+2t 3P Find the steady state error.	L5:EVALUATE	CO2
6	A unity feedback control system has an open loop transfer function G(s) = 16/S(S+2).Determine the natural frequency, damping factor, percentage overshoot and time at which the maximum overshoot occurs	L5:EVALUATE	CO2
7	Determine the error coefficients and static error for $G(s) = \frac{1}{s(s+1)(s+10)}$, H(s) = s + 2 b) Find out the output of the undamped second order system when the input applied to the system is unit step input.	L5:EVALUATE	CO2
8	Obtain the unit – step response of a unity feedback control system whose open –loop transfer function is $G(s) = \frac{1}{s(s+1)}$. Obtain also the rise time, peak time, maximum overshoot and settling time.	L5:EVALUATE	CO2
9	The open loop transfer functions of three systems are given as a) $\frac{4}{(s+1)(s+2)}$ b) $\frac{2}{s(s+4)(s+6)}$ c) $\frac{5}{s^2(s+3)(s+10)}$ Determine respectively the positional, velocity and acceleration error constants for these systems. Also for the system given in determine the steady state errors with step input u(t)=1; ramp input r(t) = t and acceleration input $r(t) = \frac{1}{2}t^2$	L5:EVALUATE	CO2
10	Find the delay time, rise time, peak time, settling time and peak overshoot for unity feedback system with open loop transfer function. $G(s) = \frac{16}{s(s+6)}$	L5:EVALUATE	CO2

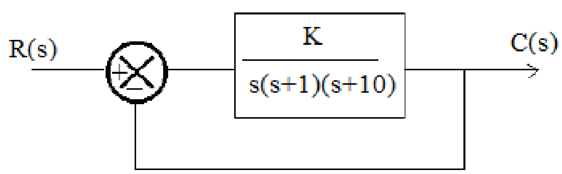
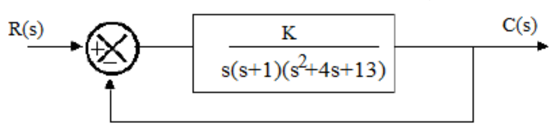
UNIT-3
Short Answer Questions:

S.No	Question	BloomsTaxonomy Level	Course Outcome

1.	Define a stable system.(or) Define stability.	L2: UNDERSTAND	CO3
2.	Explain the basics of root locus plot.	L2: UNDERSTAND	CO3
3.	Write the necessary conditions of Routh - Hurwitz criteria.	L2: UNDERSTAND	CO3
4.	Write the drawbacks of RH criteria.	L2: UNDERSTAND	CO3
5.	Mention the condition for system stability using Bode plot.	L2: UNDERSTAND	CO3
6.	Define angle of departure and angle of arrival in root locus.	L2: UNDERSTAND	CO3
7.	What are frequency domain specifications?	L2: UNDERSTAND	CO3
8.	Define Gain margin and Phase margin.	L2: UNDERSTAND	CO3
9.	Define i) Minimum phase transfer function ii) Non minimum phase transfer function.	L2: UNDERSTAND	CO3
10.	Enlist the steps for the construction of Bode plots.	L2: UNDERSTAND	CO3
11.	Define Phase cross over and gain cross over frequency.	L2: UNDERSTAND	CO3
12.	Write short notes on the correlation between the time and frequency response	L2: UNDERSTAND	CO3

Long Answer Questions:

S.No	Question	Blooms Taxonomy Level	Course Outcome
1.	Sketch the Root locus for. Also find range of ‘K’ for system to be stable. $G(s)H(s) = \frac{K}{s(s+4)(S+11)}$	L5:ANALYZE	CO3
2.	a)Determine the RH stability of given characteristic equation, $s^4 + 8s^3 + 18s^2 + 16s + 5 = 0.$ b) Sketch the root locus of the system, whose open loop transfer function is, $G(s) = \frac{K(s+15)}{s(s+1)(s+5)}$	L2:UNDERSTAND	CO3
3.	Given $G(s) = \frac{Ke^{-0.2s}}{s(s+2)(s+8)}$. Find K so that the system is stable with, a) GM=2db, b) PM=45^0	L5:EVALUATE	CO3
4.	Explain Conditional stability & Relative stability.What is a Routh-Hurwitz criterion and explain its stability predicting conditions.	L2:UNDERSTAND	CO3
5.	Explain Frequency domain specifications in detail. Also write the comparison between times domain and frequency domain specifications. function	L2:UNDERSTAND	CO3
6.	Find the phase margin and gain margin for the system with open loop transfer function. $G(s) = \frac{5(1+0.01S)}{s(1+0.1S)}$	L3:APPLY	CO3
7.	The open loop transfer function is given by $G(s)H(s) = \frac{K(1+4s)}{s^2(1+s)(1+2s)}$,Determine the stability of closed loop system.	L3:APPLY	CO3
8.	Using Routh-Hurwitz criterion check whether systems represented by the following characteristics equations are stable or not. Comment on the location of roots. Determine the frequency of sustained oscillations if any $S^3+20S^2+9S+100=0$	L3:APPLY	CO3
9.	Explain the following control action with neat schematic diagram and derive its necessary equations. i) Proportional ii) Integral iii) Derivative	L3:APPLY	CO3

	iv) Proportional plus integral		
10.	Sketch the root locus of the system: $G(s)=\frac{K(S+3)}{S(S+6)(S^2+2S+2)}$ i) Find marginal value of K ii) Find the value of K for damping ratio of 0.5	L3:APPLY	CO3
11.	Sketch the bode plot for the given system whose H(s) =1, and $G(S)=\frac{1}{S(S+4)(S+0.2)}$ a) Find gain margin b) Find the phase margin for damping ratio of 0.5	L3:APPLY	CO3
12.	The open-loop transfer function of a unity feedback system is given by G(s)=500/s(1+0.1s) Find the peak overshoot and time peak overshoot. If peak overshoot is to be reduced by 20%, what is the change in the gain?	L5:EVALUATE	CO3
13.	Explain the effects of adding poles and zeros to G(s)H(s) on the root loci by considering one the example.	L2:UNDERSTAND	CO3
14.	Sketch the root locus plot of a unity feedback system whose open loop T.F is $G(s)=\frac{K(s^2-2s+2)}{(s+2)(s+3)(s+4)}$.	L3:APPLY	CO3
15.	Consider the system shown in Figure 3. Draw the Bode-diagram of the open-loop transfer function G(s) with K = 1. Determine the phase margin and gain margin. Find the value of K to reduce the phase margin by 10^0. 	L3:APPLY	CO3
16.	Sketch the root loci for the system shown in Figure 2. 	L3:APPLY	CO3
17.	For unity feedback system given by $G(s)=\frac{K}{s(s+0.5)(s^2+0.6s+10)}$ a) Find the stability using RH criterion b) for stable system find the range of K value.	L3:APPLY	CO3

UNIT-4
Short Answer Questions:

S.No	Question	BloomsTaxonomy Level	Course Outcome
1.	What is polar plot? Define gain and phase margins	L2:UNDERSTAND	CO3
2.	Explain Nyquist stability criterion.	L2:UNDERSTAND	CO3
3.	Distinguish between polar plots & Nyquist plots	L2:UNDERSTAND	CO3
4.	What is “Nyquist Contour”?	L2:UNDERSTAND	CO3

5.	Explain the significance of compensation?	L2:UNDERSTAND	CO3

Long Answer Questions:

S.No	Question	BloomsTaxonomy Level	Course Outcome
1.	With the help of Nyquist plot assess the stability of a system G(s) = 2/S(S+3) . What happens to stability if the numerator of the function is changed from 3to 30?	L2:UNDERSTAND	CO3
2.	The open-loop transfer function of a system is given by $G_p(s) = \frac{K}{s(1+0.1s)(1+0.2s)}$ Design a lag-lead compensator to meet the Kv=100sec^{-1} and Phase margin $\geq 30^0$.	L3:APPLY	CO3
3.	Discuss the effect of adding poles &zeros to G(s)H(s) on the shape of Nyquist plots 7.	L2:UNDERSTAND	CO3
4.	A system is given by G(s) =S+1/S(S+2)(S+4).Sketch the Nyquist plot & hence determine the stability of the system.	L5:EVALUATE	CO3
5.	Explain the need of lead compensator and obtain the transfer function of lead- lag compensator.	L2:UNDERSTAND	CO3
6.	The open loop transfer function of certain unity feedback control system is given by G(S) = S (S + 4) (S + 80) K . It is desired to have the phase margin to be at least 330 and velocity error constant KV = 30 Sec−1 . Design a phase lag series compensator?	L3:APPLY	CO3

UNIT-5
Short Answer Questions:

S.No	Question	BloomsTaxonomy Level	Course Outcome
1.	What is state diagram?.	L2:UNDERSTAND	CO4
2.	Define: i) State ii) State variables iii) State space representation	L2:UNDERSTAND	CO4
3.	Discuss the significance of State Space Analysis?	L2:UNDERSTAND	CO4
4.	Mention any four advantages of state variable representation	L2:UNDERSTAND	CO4
5.	What are the properties of state transition matrix?	L2:UNDERSTAND	CO4

Long Answer Questions:

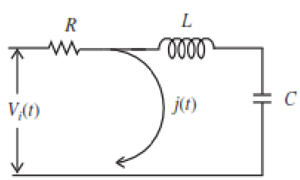
S.No	Question	BloomsTaxonomy Level	Course Outcome

1.	Find the state transition matrix for the following matrix, $A = \begin{bmatrix} 1 & 0 \\ -1 & 1 \end{bmatrix}$.	L2:UNDERSTAND	CO4
2.	The state equation of a linear-time invariant system is given as, $\dot{X} = \begin{bmatrix} 0 & 5 \\ -1 & -2 \end{bmatrix} X + \begin{bmatrix} 1 \\ 1 \end{bmatrix} r$ and $y = \begin{bmatrix} 1 & 1 \end{bmatrix} X$, and , Find the transfer function and draw the state diagram.	L2:UNDERSTAND	CO4
3.	Obtain the state space representation for the following differential equation. $\ddot{y} + 5\dot{y} + 7y = 114$ Where 'y' is the output and 'u' is the input.	L2:UNDERSTAND	CO4
4.	Considering the vector matrix differential equation describe the dynamics of the system as X = [0 1; -6 -5]. Determine state transition matrix?	L2:UNDERSTAND	CO4
5.	A feed back system has a closed loop transfer function.Y(S)/V(S)=10(S+4)/S(S+1)(S+3).Construct canonical state models for this system?	L3:APPLY	CO4
6.	Obtain the state model of the system whose transfer function is given as.Y(S)/V(S)=10(S+4)/S(S+1)(S+3).	L3:APPLY	CO4
7.	Consider the matrixA=[1 2 3;2 7 4;5 7 9] . Compute e^{At}?	L5:EVALUATE	CO4
8.	Obtain the state variable representation of an armature controlled D.C motor?	L2:UNDERSTAND	CO4

OBJECTIVE QUESTIONS:
JNTUH:

UNIT-1

1. For the network shown in figure P2.43, V_i (t) is the input and i(t) is the output. Transfer function V_i (t)/i(t) is given by



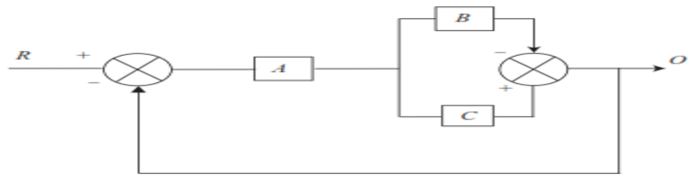
(a) $\dfrac{Cs}{LCs^2 + RCs + 1}$ (b) $\dfrac{C}{LCs^2 + RCs + 1}$

(c) $\dfrac{Cs}{RCs^2 + LCs + 1}$ (d) $\dfrac{C}{RCs^2 + LCs + 1}$

2. The transfer function of the system is given by

(a) $\frac{O}{R} = \frac{ABC}{1 + ABC}$ (b) $\frac{O}{R} = \frac{A + B + C}{1 + AB + AC}$

(c) $\frac{O}{R} = \frac{AB + AC}{ABC}$ (d) $\frac{O}{R} = \frac{AB + AC}{1 + AB + AC}$



3. In regeneration feedback the transfer function is given by

(a) $\frac{G(s)}{R(s)} = \frac{G(s)}{1 + G(s)H(s)}$ (b) $\frac{G(s)}{R(s)} = \frac{G(s)H(s)}{1 - G(s)H(s)}$

(c) $\frac{G(s)}{R(s)} = \frac{G(s)H(s)}{1 + G(s)H(s)}$ (d) $\frac{G(s)}{R(s)} = \frac{G(s)}{1 - G(s)H(s)}$

4. Type of the system depends on the

(a) No. of its poles (b) Difference between the no. of poles and zeros

(c) No. of its real poles (d) No. of poles it has at the origin

5. A system has the following transfer function

$$G(s) = \frac{100(s + 5)(s + 50)}{s^4(s + 10)(s^2 + 3s + 10)}$$

The type and order of the system are respectively

(a) 4 and 9 (b) 4 and 7

(c) 5 and 7 (d) 7 and 5

6. The step response of the system is $c(t) = 1 - 5e^{-t} + 10e^{-2t} - 6e^{-3t}$. Then the impulse response is

(a) $5e^{-t} - 20e^{-2t} + 18e^{-3t}$ (b) $5e^{t} - 20e^{2t} + 18e^{-3t}$

(c) $5e^{-t} + 20e^{-2t} + 18e^{-3t}$ (d) $5e^{-t} + 20e^{-2t} - 18e^{-3t}$

7. Given a unity feedback with $G(s) = \frac{K}{s(s + 4)}$

The value of K for the damping ratio of 0.5 is

(a) 1 (b) 16 (c) 4 (d) 2

8. A unity feedback control system has forward path transfer function G(s) is given by $G(s) = \frac{10(1 + s)}{s^2(s + 1)(s + 5)}$.

The steady state error due to unit parabolic input $r(t) = \frac{t^2}{2}U(t)$ is

(a) 0 (b) 0.5 (c) 1 (d) Infinite

9. If the time response of a system is given by the following expression

$y(t) = 5 + 3\sin(\omega t + \delta_1) + e^{-3t}\sin(\omega t + \delta_2) + e^{-5t}$

Then the steady state part of the above response is given by

(a) $5 + 3\sin(\omega t + s_1)$ (b) $5 + 3\sin(\omega t + \delta_1) + e^{-3t}\sin(\omega t + \delta_2)$

(c) $5 + e^{5t}$ (d) 5

10. The impulse response of a system is $5e^{-10t}$, its step response is equal to

(a) $0.5e^{-10t}$ (b) $5(1-e^{-10t})$

(c) $0.5(1-e^{-10t})$ (d) $10(1-e^{-10t})$

UNIT-2

1. The transfer function of a system is 10/ ((1+s) when operated as unity feedback system, the steady state error to unit step input is

   (a) 0 (b) 1/11 (c) 10 (d) Infinity

2. Which of the following gives the steady state error for a unity feedback system excited by

   $u_s(t) + tu_s(t) + t^2\frac{u_s}{2}$

   (a) $\frac{1}{2+K_p} + \frac{1}{K_v} + \frac{1}{K_a}$ (b) $\frac{1}{1+K_p} + \frac{1}{K_v} + \frac{2}{K_a}$

   (c) $\frac{1}{K_p} + \frac{1}{K_v} + \frac{1}{K_a}$ (d) $\frac{1}{1+K_p} + \frac{1}{K_v} + \frac{1}{K_a}$

3. The steady state error due to a ramp input for a type-2 system, is equal to

   (a) Zero (b) Infinite

   (c) Non-zero number (d) Constant

4. The steady state error due to a ramp input for a type-1 system, is equal to

   (a) $2\xi\omega_n$ (b) $2\xi/\omega_n$

   (c) $4\xi/\omega_n$ (d) None of these

5. Which of the following is the steady-state error of a control system with step-error, ramp-error and parabolic-error constants K_p, K_v, K_a , respectively for the input $(1-t^2)3\mu(t)$

   (a) $\frac{3}{1+K_p} - \frac{3}{2K_a}$ (b) $\frac{3}{1+K_p} + \frac{6}{K_a}$

   (c) $\frac{3}{1+K_p} - \frac{3}{K_a}$ (d) $\frac{3}{1+K_p} - \frac{6}{K_a}$

6. A control system, having a unit damping factor, will give

   (a) A critically damped response (b) An oscillatory response

   (c) An undamped response (d) No response

7. Principles of homogeneity and superposition are applied to

   (a) Linear time-variant systems (b) Nonlinear time-variant systems

   (c) Linear time-invariant system (d) nonlinear time-invariant systems

8. The transfer system of a control system is given as

   $$T(s) = \frac{K}{x^2 + 4s + K}$$

   where, K is the gain of the system in radians/amp. For this system to be critically damped, the value of K should be

   (a) 1 (b) 2 (c) 3 (d) 4

9. The response c(t) to a system is described by the differential equation

   $$\frac{d^2c(t)}{dt^2} + 4\frac{dc(t)}{dt} + 5c(t) = 0$$

   The system response is:

   (a) Undamped (b) Under damped

   (c) Critically damped (d) Oscillatory

10. The open-loop transfer function of a unity-feedback control system is given by

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

If the gain K is increased to Infinity, then the damping ratio will tend to become

(a) Zero (b) 0.707 (c) Unity (d) Infinity

UNIT-3

1. A second-order system exhibits 100% overshoot. Its damping coefficient is:
   (a) Equal to 0 (b) Equal to 1 (c) Less than 1 (d) Greater than 1
2. In the type-1 system, the velocity error is:
   (a) Inversely proportional to the bandwidth of the system
   (b) Directly proportional to gain constant
   (c) Inversely proportional to gain constant
   (d) Independent of gain constant
3. A second-order system has the damping ratio ξ and undamped natural frequency of oscillation ω_n. The settling time at 2% tolerance band of the system is
   (a) $\frac{2}{\xi\omega_n}$ (b) $\frac{3}{\xi\omega_n}$
   (c) $\frac{4}{\xi\omega_n}$ (c) $\xi\omega_n$
4. When the time period of an observation is large, the type of error is:
   (a) Transient error (b) Steady-state error
   (c) Half-power error (d) Position-error constant
5. An under damped second-order system with negative damping will have the two roots:
   (a) On the negative real axis as real roots
   (b) On the left-hand side of the complex plane as complex roots
   (c) On the right-hand side of the complex plane as complex conjugates
   (d) On the positive real axis as real roots
6. Which of the following expresses the time at which second peak in step response occurs for a second-order system?
   (a) $\frac{\pi}{\omega_n\sqrt{1-\xi^2}}$ (b) $\frac{2\pi}{\omega_n\sqrt{1-\xi^2}}$
   (c) $\frac{3\pi}{\omega_n\sqrt{1-\xi^2}}$ (d) $\frac{\pi}{\sqrt{1-\xi^2}}$
7. If the characteristic equation of a closed-loop system is $s^2 + 2s + 2 = 0$, then the system is
   (a) Over damped (b) Critically damped (c) Under damped (d) Undamped
8. For making an unstable system stable:
   (a) Gain of the system should be increased.
   (b) Gain of the system should be decreased.
   (c) The number of zeros to the loop transfer function should be increased.
   (d) The number of poles to the loop-transfer function should be increased.
9. While forming a Routh's array, the situation of a row zeros indicates that the system:
   (a) Has symmetrically located roots (b) Is not sensitive to variations in gain
   (c) Is stable (d) Is Unstable
10. When all the roots of the characteristic equation are found in the left of an s-plane, the response due to the initial condition will:
   (a) Increase to infinity as time approaches infinity
   (b) Decrease to zero as time approaches infinity
   (c) Remain constant for all time (d) Be oscillating

11. The Routh–Hurwitz criterion cannot be applied when the characteristic equation of the system contains any coefficients which are:

(a) Negative real and exponential functions of s

(b) Negative real, both exponential and sinusoidal functions of s

(c) Both exponential and sinusoidal functions of s

(d) Complex, both exponential and sinusoidal functions of s

12. Consider the following statements: Routh–Hurwitz criterion gives

1. Absolute stability
2. The number of roots lying on the right half of the s-plane.
3. The gain margin and phase margin

Which of the statements are correct?

(a) 1, 2 and 3 (b) 1 and 2

(c) 2 and 3 (d) 1 and 3

13. A system has a single pole at the origin. Its impulse response will be:

(a) Constant (b) Ramp (c) Decaying exponential (d) Oscillatory

14. The open-loop transfer function of a unity-feedback control system is

$$G(s) = \frac{K(s+10)(s+20)}{s^2(s+2)}$$

The closed-loop system will be stable, if the value of K is:

(a) 2 (b) 3 (c) 4 (d) 5

15. Which one of the following application software is used to obtain an accurate root locus plot?

(a) LISP (b) MATLAB (c) dBASE (d) Oracle

16. Consider the following statements with regard to the bandwidth of a closed-loop system:

1. In a system, where the low-frequency magnitude is 0 dB on the Bode diagram, the bandwidth is measured at the -3-dB frequency.

2. The bandwidth of the closed-loop control system is a measurement of the range of fidelity of response of the systems.

3. The speed of response to a step input is proportional to the bandwidth.

4. The system with the larger bandwidth provides a slower step response and lower fidelity ramp response.

Which of the statements give above are correct?

(a) 1, 2 and 3 (b) 1, 2 and 4 (c) 1, 3 and 4 (d) 2, 3 and 4

17. Which of the following is not necessarily valid for root-locus pattern?

(a) The n finite zeros and m poles are plotted on the s-plane. Then (m – n) indicates the number of non-finite zeros.

(b) The number of poles gives the number of loci.

(c) A value of s on the real axis is a point on the root locus, if the total number of poles and zeros on the real axis to the right of the point is even.

(d) There are as many asymptotes as non-finite zeros.

18. An open-loop transfer function of a feedback system has m poles and n zeros (m > n). Consider the following statements:

1. The number of separate root loci is m.

2. The number of separate root loci is n.

3. The number of root loci approaching infinity is (m-n).

4. The number of root loci approaching infinity is (m-n).

Which of the statements given above are correct?

(a) 1 and 4 (b) 1 and 3

(c) 2 and 3 (d) 2 and 4

19. Which of the following effects are correct in respect of addition of a pole to the system loop transfer function?

1. The root locus is pulled to the right.

2. The system response becomes slower.
3. The steady state error increases.
Of these statements:
(a) 1 and 2 are correct. (b) 1, 2 and 3 are correct.
(c) 2 and 3 are correct. (d) 1 and 3 are correct.

20. The instrument used for plotting the root locus is called:
(a) Slide rule (b) Spiral (c) Synchro (d) Selsyn

UNIT 4

1. If the compensated system shown in Figure P7.50 has a phase margin of 60 at the crossover frequency of 1 rad/sec, then the value of the gain K is:
(a) 0.366 (b) 0.732 (c)1.366 (d) 2.738

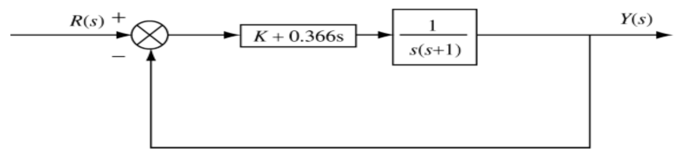


Figure P7.50 Figure for Objective Question 175.

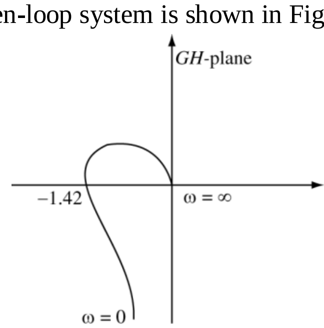
2. In the GH (s) plane, the Nyquist plot of the loop-transfer function $G(s)\,H(s) = \frac{\pi e^{-0.25}}{s}$ passes through the negative real axis at the point:
(a) $(-0.25, j0)$ (b) $(-0.5, j0)$
(c) $(-1, j0)$ (d) $(-2, j0)$

3. The gain margin of a unity-feedback control system with the open-loop transfer function $G(s) = \frac{s+1}{s^2}$ is:
(a) 0 (b) 1/√2 (c)√2 (d) α

4. The open-loop transfer function of a unity feedback control system is given as $G(s) = \frac{as+1}{s^2}$ The value of a to give a phase margin of 45 is equal to:
(a) 0.141 (b) 0.441 (c) 0.841 (d) 1.141

5. The Nyquist plot of a loop transfer function G(s)H(s) of a closed-loop control system passes through the point (-1, j0) in the G(s)H(s) plane. The phase margin of the system is:
(a) 0 (b) 45 (c) 90 (d) 180

6. The polar plot of a type -1, 3 pole, open-loop system is shown in Figure P7.49. The closed-loop system is:



(a) Always stable
(b) Marginally stable
(c) Unstable with one pole on the right half s-plane

(d) Unstable with two poles on the right half s-plane

7. The Nyquist plot of G(jω)H(jω) for a closed control system passes through the (-1, j0) point in the GH-plane. The gain margin of the system in dB is equal to:
   (a) Infinite (b) Greater than zero (c) Less than zero (d) Zero

8. A unity-feedback system has the open-loop transfer function
   The Nyquist plot of G encircles the origin:
   (a) Never (b) Once (c) Twice (d) Thrice

9. The gain and phase crossover frequencies in rad/sec are respectively:
   (a) 0.632 and 1.26 (b) 0.632 and 0.485
   (c) 0.485 and 0.632 (d) 1.26 mA and 0.632 V

10. Which of the following polar diagrams corresponds to a lag network?

11. The system with the open-loop transfer function has a gain margin of:
    (a) -6dB (b)0dB (c) 3.5 dB (d) 6 dB

12. The gain margin and the phase margin of a feedback system with are:
    (a) 0 dB, 08 (b) α, α (c) α; 0 (d) 88:5dB; α

13. Non-minimum phase-transfer function is defined as the transfer function, which has:
    (a) Zeros in the right-hand s-plane (b) Zeros only in the right-half s-plane
    (c) Poles in the right-half s-plane (d) Poles in the left-half s-plane

14. In the Bode plot of a unity-feedback control system, the value of phase of G(jω) at the gain crossover frequency is -125, the phase margin of the system is:
    (a) -125 (b) -55 (c) 55 (d) 125

15. Consider the Bode-magnitude plot shown in Figure P7.21.

UNIT 5

1. A state variable system with the initial condition and the unit step input u(t) has the state transition equation

2. Given the homogenous state space equation the steady state value of given the initial value of is

3. The state variable equations of a system are: The system is
(a) Controllable but not observable (b) Observable but not controllable
(c) Neither controllable nor observable (d) Controllable and observable

4. The transfer function, , of a system described by the state equations

5. For a system with the transfer function the matrix A in the state-space form X = AX + Bu is equal to:

6. Given a system represented by equation

The equivalent transfer function representation G(s) of the system is:

7. A system is described by state equation

The state transition matrix of the system is:

8. The state equation of a system is
The poles of this system are located at:
(a) -1,-9 (b) -1, -20 (c) -4, -5 (d) -9, -20

9. The state space representation of a system is given Then the transfer function of the system is:

WEBSITES:

1. http://nptel.iitm.ac.in
2. http://www.ieeecss.org
3. www.wikipedia.com
4. www.wikibooks.org
5. www.google.com

EXPERT DETAILS:

1. Prof. M. Gopal, Department of Electrical Engineering, IIT Delhi
2. Prof. S.D. Agashe, Department of Electrical Engineering, IIT Bombay
3. Prof. S. Majhi, Department of Electrical Engineering, IIT Guwahati
4. Dr. IndraniKar, Department of Electrical Engineering, IIT Guwahati

JOURNALS:

1. IEEE Control Systems Magazine
2. International Journal of Systems, Control and Communications
3. The International Journal of INTELLIGENT CONTROL AND SYSTEMS
4. ICGST International Journal on Automatic Control and System Engineering
5. Journal of Control Engineering and Technology

LIST OF TOPICS FOR STUDENT SEMINARS:

1. Concept of Control Systems
2. Mathematical Modeling of Control Systems
3. Block Diagram reduction Techniques
4. Signal flow Graph.
5. Time Response Analysis
6. Time Domain Specifications
7. Frequency Response Analysis
8. Root Locus Techniques
9. Bode Plots

CASE STUDIES /SMALL PROJECTS:

1. Design of PI controller for speed control of induction motor.
2. Speed control of DC Servo motor with mathematical equations
3. Closed loop control of BLDC motor to run exactly at rated speed.
4. Control and stability analysis of two wheeled road vehicles.
5. Realization of transfer function using OP-AMP