

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET415	CONTROL SYSTEMS ENGINEERING	OEC	2	1	0	3

Preamble: Control Engineering is not limited to any engineering discipline, but is equally applicable to mechanical, chemical, electrical, aeronautical engineering. The most characteristic quality of control engineering is the opportunity to control machines, industrial and economic process for the benefit of society. This course aims to provide a strong foundation on classical control theory. In this course modelling, time domain analysis, frequency domain analysis and stability analysis of linear systems based on transfer function approach will be discussed.

Prerequisite: Knowledge of Laplace transforms.

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Identify the elements of control system.
CO 2	Develop transfer function models of systems.
CO 3	Analyse the relation between pole locations with the transient response of first and second order systems.
CO 4	Determine the stability of LTI systems.
CO 5	Apply the concept of Root locus to assess the performance of linear systems.
CO 6	Determine the frequency domain specifications from Bode plot, Polar plot and Nyquist plot.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	-	-	-	-	-	-	-	1
CO 2	3	2	-	-	-	-	-	-	-	-	-	1
CO 3	3	2	-	-	2	-	-	-	-	-	-	1
CO 4	3	2	-	-	-	-	-	-	-	-	-	1
CO 5	3	2	-	-	2	-	-	-	-	-	-	1
CO 6	3	2	-	-	2	-	-	-	-	-	-	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions:**Course Outcome 1 (CO1)**

1. Explain with an example how does the feedback element affects the performance of a closed loop system. (K3, PO1, PO2 and PO12)
2. What is the function of controller and sensor in a closed loop system? (K2, PO1)
3. What are the modifications required to convert an open loop system to a closed loop system? (K1, PO1, PO12)

Course Outcome 2 (CO2)

1. Problems related to derivation of transfer function of mechanical systems. (K3, PO1 and PO12)
2. Define transfer function and derive the transfer function of an RC network. (K3, PO1, PO2 and PO12)
3. Write short notes on Force- voltage and Force – current analogy? (K1, PO1, PO12)

Course Outcome 3 (CO3)

1. What is the effect of location of roots on S-plane on the transient response of a system? (K1, PO1, PO12)
2. What is the change in transient response of a second order system due to the addition of poles? Illustrate with an example. (K1, PO1, PO2, PO12)
3. What is the significance of settling time in control system? (K1, PO1, PO12)

Course Outcome 4 (CO4)

1. Problems related to application of Routh's stability criterion for analysing the stability of a given system. (K3, PO1, PO2, PO12)
2. Plot the impulse response of a second order system for different location of poles on S-plane. (K3, PO1, PO2, PO12)

3. How can we relate asymptotic stability to location of roots of characteristic equation?
K2, PO1, PO2, PO12)

Course Outcome 5 (CO5)

1. Determine the value of K such that the closed loop system with $G(s)H(s) = \frac{K}{s(s+1)(s+4)}$ is oscillatory, using Root locus. (K3, PO1, PO2, PO12)
2. Construct the Root locus for the closed loop system with $G(s)H(s) = \frac{K}{s(s^2+2s+2)}$ and determine the value of K to achieve a damping factor of 0.5. (K3, PO1, PO2, PO12)
3. Problems on root locus for systems with positive feedback. (K3, PO1, PO2, PO12)

Course Outcome 6 (CO6)

1. Problems related to assess the stability of the given system using Bode plot. (K3, PO1, PO2, PO3, PO12)
2. Problems related to Polar plot. (K3, PO1, PO2, PO12)
3. Explain Nyquist stability criterion. (K2, PO1, PO2, PO12)

Model Question Paper

PAGES: 2

QPCODE:

Reg. No: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION

MONTH & YEAR

Course Code: EET415

Course Name: CONTROL SYSTEMS ENGINEERING

Max. Marks: 100

Duration: 3 Hours

PART A

Answer all Questions. Each question carries 3 Marks

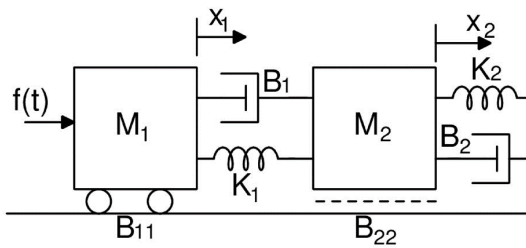
1. Write short notes on Force- voltage and Force – current analogy?
2. Explain Mason's gain formula?
3. Define damping ratio.
4. Derive and sketch the time response of a first order system.
5. What are dynamic error coefficients? What are their merits?
6. Define BIBO Stability. What is the requirement of BIBO Stability?
7. How to determine break away and break in point in root locus plot?
8. What is the significance of dominant pole?
9. Write a short note on the correlation between time and frequency response
10. Explain Nyquist stability criterion

PART B ELECTRICAL AND ELECTRONICS

Answer any one full question from each module. Each question carries 14 Marks

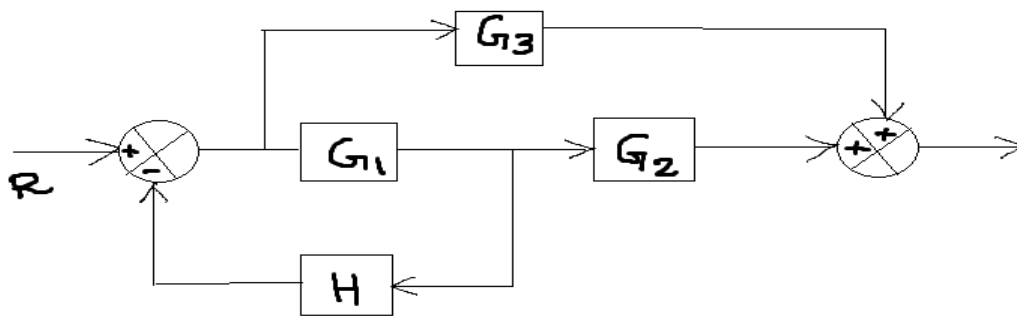
Module 1

9. a. Derive the transfer function for the mechanical system shown in figure. 10



b. Distinguish between open loop system and closed loop system 4

10. a. Reduce the block diagram shown in figure 10



b. Define transfer function and derive the transfer function of an RC network 4

Module 2

11 a. Sketch the time response of a general second order underdamped system and explain the specifications 6

b. The damping ratio of a system is 0.6 and the natural frequency of oscillation is 8 rad/sec. Determine the rise time, peak overshoot and peak time 8

12a. Distinguish between type and order of a system 5

b. The open loop transfer function of a unity feedback system is

$$G(s) = 20/s(s + 10)$$

What is the nature of response of closed loop system for unit step input? 9

Module 3

13 a. Plot the impulse response of a second order system for different location of poles on S-plane. 9

b. What is the effect of location of roots on S-plane on the transient response of a system? 5

14 a. A unity feedback system has a open loop transfer function of 7

$$G(s) = 10/(s + 1)(s + 2)$$

Determine steady state error for unit step input

- b. Using Routh criterion determine the value of K for which the unity feedback closed

loop system with $G(s) = \frac{K}{s(s^2 + 20s + 8)}$ is stable. 7

Module 4

- 15 a. What is the relation between stability and coefficient of characteristic polynomial? 2
 b. Explain the methods to find the crossing points of Root locus in imaginary axis. 4
 c. Sketch the root locus for the unity feedback system whose open loop transfer function is given by: 8

$$G(s) = \frac{K}{s(s + 4)(s^2 + 4s + 20)}$$

16. Draw the root locus for a unity feedback system having forward path transfer function,

$$G(s) = \frac{K}{s(s+1)(s+5)} \quad 8$$

- (a) Determine value of K which gives continuous oscillations and the frequency of oscillation.
 (b) Determine the value of K corresponding to a dominant closed loop pole with damping ratio 0.7 6

Module 5

17. Consider a unity feedback system having an open loop transfer function

$$G(s) = k/s(1 + 0.2s)(1 + 0.05s)$$

- (a) Sketch the polar plot 8
 (b) Determine the value of K so that
 (i) Gain margin is 18 db
 (ii) Phase margin is 60° 6

18. (a) The open loop transfer function of a system is given by

$$G(s) = k/s(1 + 0.2s)(1 + 0.5s)$$

Sketch the Bode plot 8

- (b) From the Bode plot determine the value of K so that

- (i) Gain margin of the system is 6 db
- (ii) Phase margin of the system is 25°

Syllabus

Module 1

Feedback Control Systems (10 hours)

Open loop-and closed loop control systems: Transfer function of LTI systems- Mechanical and Electromechanical systems – Force voltage and force current analogy - block diagram representation - block diagram reduction - signal flow graph - Mason's gain formula - characteristic equation..

Module 2

Performance Analysis of Control Systems (5 hours)

Time domain analysis of control systems: Transient and steady state responses - time domain specifications - first and second order systems - step responses of first and second order systems.

Module 3

Error Analysis and Stability (6 hours)

Error analysis: Steady state error analysis and error constants -Dynamic error coefficients.

Stability Analysis: Concept of BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems - Routh's stability criterion-

Module 4

Root Locus Technique (6 hours)

Root locus technique: Construction of Root locus- stability analysis- effect of addition of poles and zeroes.

Module 5

Frequency Domain Analysis (9 hours)

Frequency domain specifications- correlation between time domain and frequency domain responses.

Polar plot: Concepts of gain margin and phase margin- stability analysis

Bode Plot: Construction- Concepts of gain margin and phase margin.

Nyquist stability criterion (criterion only)

Text books

1. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers
2. Ogata K, Modern Control Engineering, 5/e, Prentice Hall of India.
3. Nise N. S, Control Systems Engineering, 6/e, Wiley Eastern
4. Dorf R. C. and Bishop R. H, Modern Control Systems, 12/e, Pearson Education

Reference Books

1. Kuo B. C, Automatic Control Systems, 7/e, Prentice Hall of India
2. Desai M. D., Control System Components, Prentice Hall of India, 2008
3. Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill.
4. Imthias Ahamed T. P, Control Systems, Phasor Books, 2016

Course Contents and Lecture Schedule:

Module	Topic coverage	No. of Lectures
1	Feedback Control Systems (10 hours)	
1.1	Terminology and basic structure of Open loop and Closed loop control systems- Examples of Automatic control systems (block diagram representations only).	2
1.2	Transfer function approach to feed back control systems- Mechanical and Electromechanical systems	2
1.3	Force –voltage , force –current analogy.	2
1.4	Block Diagram Reduction Techniques.	2
1.5	Signal flow graph- Mason’s gain formula, Characteristic Equation.	2
2	Performance Analysis of Control Systems (5 hours)	
2.1	Time domain analysis of control systems: Transient and steady state responses- Impulse and Step responses of first and second order systems Time domain specifications.	4
2.2	Time domain specifications.	1
3	Error analysis and Stability(6 hours)	
3.1	Error analysis: Steady state error analysis - static error coefficient of Type 0, 1, 2 systems. Dynamic error coefficients.	2
3.2	Stability Analysis: Concept of stability-BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems.	2
3.3	Application of Routh's stability criterion to control system analysis- Relative stability.	2
4	Root Locus Technique (6 hours)	
4.1	Root locus technique: General rules for constructing Root loci – stability from root loci -	5
4.2	Effect of addition of poles and zeros on Root locus	1

5	Frequency domain analysis (9 hours) ELECTRICAL AND ELECTRONICS	
5.1	Frequency domain specifications- correlation between time domain and frequency domain responses.	2
5.2	Polar plot: Concepts of gain margin and phase margin- stability analysis.	2
5.3	Bode Plot: Construction of Bode plots- gain margin and phase margin- Stability analysis based on Bode plot .	4
5.4	Nyquist stability criterion	1

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