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# SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION (R), MAY 2023**
**ELECTRICAL AND ELECTRONICS ENGINEERING**
**(2020 SCHEME)**

**Course Code :** **20EET302**

**Course Name:** **Linear Control Systems**

**Max. Marks :** **100** **Duration: 3 Hours**

***Ordinary (linear) graph sheet, Semi-log graph sheet, Polar graph sheet should be provided for the students.***

## PART A

***(Answer all questions. Each question carries 3 marks)***

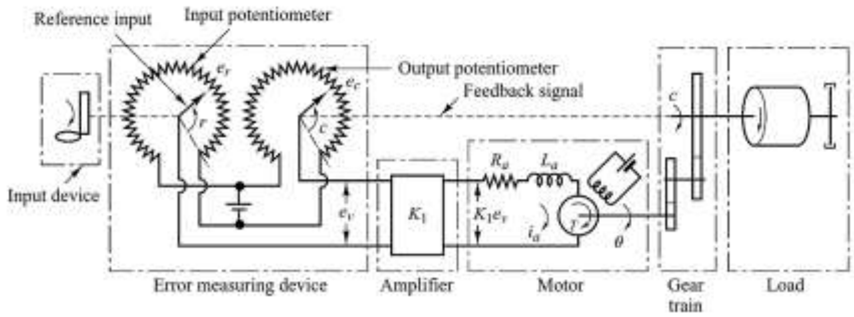
1. State the significance of feedback in a closed-loop control system.
2. Discuss three control applications of stepper motors.
3. Differentiate between impulse and step responses of first-order systems in the time domain.
4. Compare and contrast the differences between BIBO stability and asymptotic stability in the stability analysis of control systems.
5. What is the purpose of compensators in control system design?
6. What are PID controllers and their significance in control systems?
7. Outline the stability analysis performed using the root locus method.
8. How does the gain margin affect the stability and robustness of a control system?
9. Provide a brief overview of M and N circles in control systems, explaining their purpose and significance in stability analysis.
10. How can the Bode plot be utilized for the design of compensators in control systems?

## PART B

***(Answer one full question from each module, each question carries 14 marks)***

### MODULE I

11\. a) Consider the servo system shown in Figure. Obtain the transfer function between the motor shaft angular displacement Θ and the error voltage $e_v$. Obtain also a block diagram for this system and a simplified block diagram when $L_a$ is negligible. (9)



b) Consider a control system with the following open-loop transfer function: $G(s) = \frac{(s+3)(s+4)}{(s^2+2s+1)}$

i. Determine the characteristic equation for the system. (5)
ii. Find the poles and zeroes of the system.
iii. Calculate the type and order of the system.
iv. Discuss the stability of the system based on the locations of the poles.

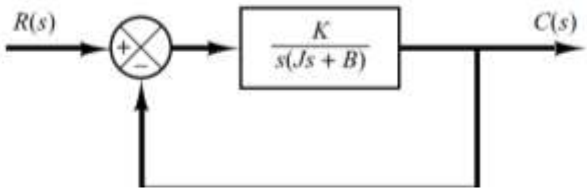
**OR**

12. a) Explain the need for controllers and compare feedback, cascade, and feed-forward control. (8)

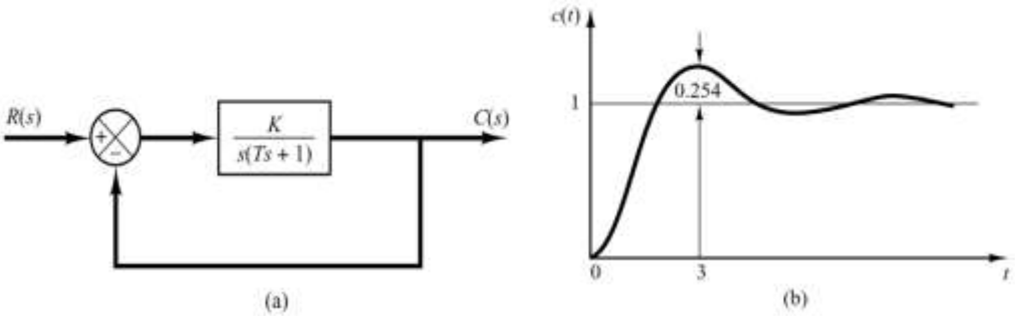
b) How are gyroscopes used in control systems? Explain the principle of operation and the control applications of gyroscopes in areas such as navigation, stabilization, and attitude control. (6)

**MODULE II**

13. a) Obtain the step response of a servo system for the underdamped case as shown in the figure. (7)

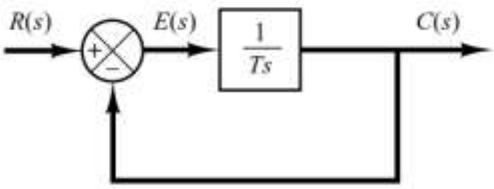



b) When the system shown in Figure (a) is subjected to a unit-step input, the system output responds as shown in Figure (b). Determine the values of K and T from the response curve. (7)

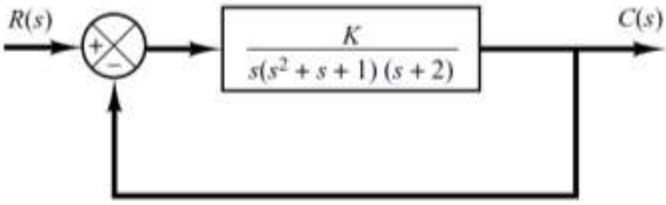



**OR**

14. a) Obtain the step response for the first-order system shown in the figure. (7)



b) Consider the system shown in the figure. Using the Routh criterion, determine the value of K for stability. (7)



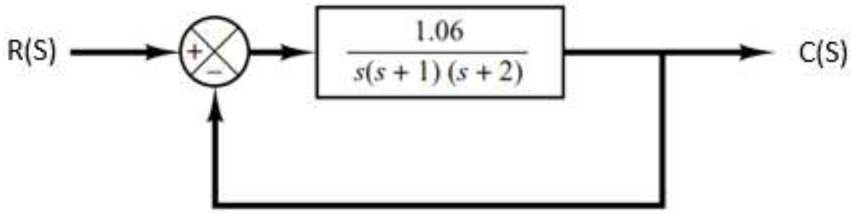

## MODULE III

15. a) Sketch the root locus for the positive feedback system, with $G(s)=\dfrac{K(s+2)}{(s+3)(s^2+2s+2)}$ and $H(s)=1$. Hence determine the range of K for the system stability. (10)

b) Explain the Ziegler-Nichols open-loop tuning method for PID controllers. (4)

**OR**

16. Consider the system shown in Figure. Design a lag Compensator to increase the static velocity error constant $K_v$ to about 5 $sec^{-1}$ without appreciably changing the location of the dominant closed-loop poles. (14)




## MODULE IV

17. a) Sketch the bode plot for the following transfer function and determine phase margin and gain margin. $G(s)=\dfrac{75(1+0.2s)}{s(s^2+16s+100)}$ (10)

b) Discuss three commonly used frequency domain specifications. (4)

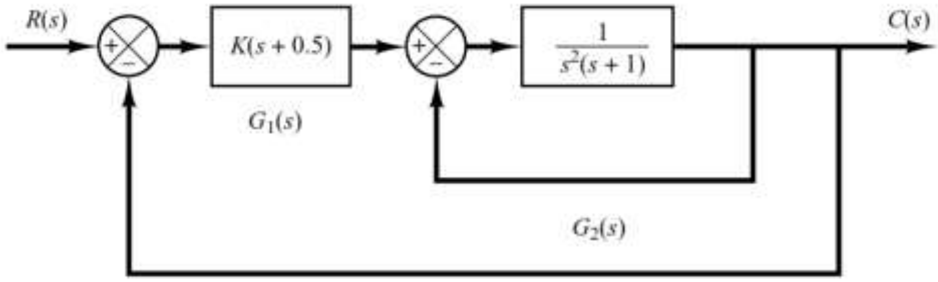
**OR**

18. a) The open loop transfer function of a unity feedback system is given by $G(s)=\dfrac{1}{s(1+s)^2}$. Sketch the polar plot and determine the gain and phase margin. (10)

b) Describe the effect of transportation lag and non-minimum phase systems on the stability of control systems. (4)

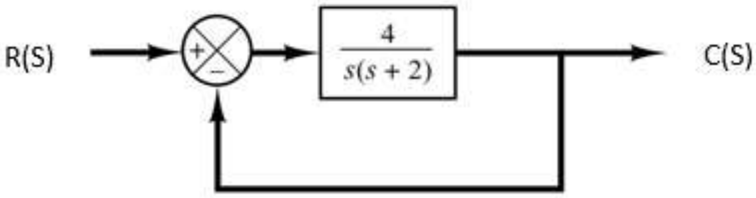
## MODULE V

19. Consider the control system shown in Figure. The system involves two loops. Determine the range of gain K for stability of the system by the use of the Nyquist stability criterion. (The gain K is positive) (14)




**OR**

20. a) Consider the system shown in Figure. The open-loop transfer function is $G(s)=\frac{4}{s(s+2)}$ .Design a lead compensator for the system so that the static velocity error constant $K_v$ is 20 $sec^{-1}$, the phase margin is at least 50°, and the gain margin is at least 10 dB. (10)




b) Compare the characteristics and design considerations of lag and lead compensators in control systems. (4)

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