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Roll No. 18

National Institute of Technology Hamirpur (H.P.)

End-Semester Theory Examination, November, 2023

Branch: ECE
Course Name: Control System
Time: 03 Hours

Semester: 7^{th} Sem
Course Code: EC-411
Maximum Marks: 50

Important instructions:

- **Answer Everything:** Each question adds up to your total score, so make sure to tackle them all.
- **Calculator Usage:** Feel free to use calculators for any number crunching.
- **Flying Solo:** This is a solo journey – no teaming up, electronic gadgets, or extra materials allowed.
- **No Shenanigans:** Marks will be deducted for misconduct without any warning, so let's keep it above board.
- **Questions? Just Ask:** If any question seems a bit tricky, don't hesitate to ask the invigilator for some guidance.

Good Luck!

Welcome to your Control Systems Challenge! Your goal is to control the "system" – all the questions. Your answers are the inputs for this system, aimed at achieving your desired output – the marks you aspire for. Picture the entire question paper as the system, and your mastery of it will be key. Control your marks! Let's dive into the system.

Q1. Consider the system: (3)

$$y'' + y' + 8y = 8u; \quad y'(0) = 0, \quad y(0) = 0$$

where y and u are output and input, respectively. Determine time domain specifications for a unit step input: (a) Settling time (within 2% of the steady-state value (b) Peak overshoot

Q2. Find the Gain Margin (G.M.) for the system having an open-loop transfer function (OLTF): (4)

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

Q3. For a unity feedback system (5)

$$G(s) = \frac{k(s+2)}{s^3 + ms^2 + 3s + 2}$$

which is marginally stable and oscillates with a frequency of 2.5 rad/s, calculate k and m.

Q4. For the unity feedback system: (4)

$$G(s) = \frac{10(s+1)}{s^2(s+2)(s+10)}$$

with $r(t) = (10 + 5t + t^2)u(t)$, find the steady-state error.

Q5. Sketch the polar plot for a system with an OLTF: (4)

$$GH(s) = \frac{1}{(s+1)(s+2)(s+3)}$$

Q6. Draw the Nyquist plot for the system with OLTF: (5)

$$GH(s) = \frac{10}{(s+1)(s+2)}$$

and comment on the closed-loop stability.

Q7. Draw the asymptotic or approximate Bode plot for the given OLTF: (7)

$$GH(s) = \frac{2500s(s+10)^2(s+50)^3(s+200)^4}{(s+2)(s+20)^2(s+100)^3(s+500)^4}$$

Q8. Given a state-space model: (5+4+3=12)

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 5 \end{bmatrix} u; \quad y = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Find:

(a) Transfer function and forced time response for a unit step input.

(b) Initial response for $\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$.

(c) Analyze the controllability and observability of a system

Q9. Convert the following transfer functions into state-space representations: (6)

(a)

$$\frac{Y(s)}{U(s)} = \frac{s+5}{s^3 + 2s^2 + 4s + 3}$$

(b)

$$\frac{Y(s)}{U(s)} = \frac{1}{(s+1)(s+2)(s+3)}$$

Q10. Bonus Question: *Consider your life as a state space model, where each state variable represents a unique aspect of your existence. The dynamics of your life are governed by the system matrix, and external influences act as input signals. Reflect on the philosophical implications of viewing life through the lens of a state space representation. How does the concept of controllability and observability in state space resonate with the pursuit of understanding oneself and the world?* ***(No regrading requests will be entertained for this question)*** (8)