Department of Computer Systems Engineering,
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Final Term Exam (Fall 2023)
Time Allowed: 2 hours
Total Pages: 2 (including this)

Course Title: Control Systems
Course Code: CSE-310
Max Marks: 50

INSTRUCTIONS:

1. Write your name and registration number on the question paper; and write your complete particulars/ details as required on the front sheet of answer sheet.
2. All questions are compulsory. There are total four questions. Any question attempted twice will be marked zero.
3. Please write the same question number while attempting it and do not renumber the questions yourself.
4. This paper is closed book. All answers must be supported by facts and calculations.
5. Use blue or black ink only. Any answer or part of answer written with pencil will be marked zero.

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The following formula might be helpful in solving the problems.

$$P = [B \quad AB \quad A^2B \quad \dots \quad A^{n-1}B]$$

$$Q = \begin{bmatrix} C \\ CA \\ CA^2 \\ \dots \\ CA^{n-1} \end{bmatrix}$$

$$G(s) = C(sI - A)^{-1}B + D$$

Question 1 (10 Marks): Consider the following system:

$$\dot{x}(t) = Ax(t) + Bu(t)$$
$$y(t) = Cx(t).$$

where

$$A = \begin{bmatrix} 0 & 3 & 1 \\ 2 & 8 & 1 \\ -10 & -5 & -2 \end{bmatrix}, \; B = \begin{bmatrix} 10 \\ 0 \\ 0 \end{bmatrix}, \; C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$$

Is the following system stable? Also find out how many poles are in the left half-plane and right half-plane. Your answer must be supported by some calculations and facts.

Question 2 (10 Marks): Using the Routh-Hurwitz criterion, tell whether the following transfer function is stable or not for value of $K = 1.55$.

$$P(s) = \frac{K^2 - 15K}{s(s^2 + s + 1)(s + 2) + K}$$

Question 3 (20 Marks): Consider the following system:

$$\dot{x}(t) = Ax(t) + Bu(t)$$
$$y(t) = Cx(t).$$

where

$$A = \begin{bmatrix} -2 & 0 \\ 0 & 1 \end{bmatrix}, \; B = \begin{bmatrix} 2 \\ 1 \end{bmatrix}, \; C = \begin{bmatrix} 3 & 0 \end{bmatrix}$$

It seems that the above system is unstable. Is it possible to stabilize the system using a suitable controller? (Your answers should be based on facts and calculations.) If it is possible to stabilize the above system, then design a suitable controller K or L.
Guide for choosing desired location of controller eigenvalues: Consider registration number $15PWCSE1234$, then $f = 1, g = 2, h = 3, i = 4$. Choose your controller poles as $(-f \times 2, -g \times 2, -h \times 2, -i \times 2)$ and obersver eigenvalues as $(-f \times 10, -g \times 10, -h \times 10, -i \times 10)$. Use your own registration number instead of $15PWCSE1234$.

Question 4 (10 Marks): Consider the following second order system:

$$\dot{x}(t) = Ax(t) + Bu(t)$$
$$y(t) = Cx(t).$$

where

$$A = \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix}, \; B = \begin{bmatrix} k_1 \\ k_2 \end{bmatrix}, \; C = \begin{bmatrix} k_3 & k_4 \end{bmatrix}$$

Determine the range of values for k_1, k_2, k_3 and k_4 such that this system is controllable and observable.