UNAM

UNIVERSITY OF NAMIBIA

SCHOOL	ENGINEERING AND THE BUILT ENVIRONMENT		
DEPARTMENT	ELECTRICAL AND COMPUTER ENGINEERING		
SUBJECT	CONTROL ENGINEERING		
SUBJECT CODE	TECP3891		
DATE	MAY/JUNE 2024		
DURATION	3 HRS	**MARKS**	100

First Opportunity Examination

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This question paper consists of **5** pages excluding this front page.

Instructions

1. Closed book examination.
2. Read the questions carefully
3. Answer **5 questions** out of 6 questions
4. Marks for each question are indicated
5. Start each question on a fresh paper
6. Additional materials: None

QUESTION 1 [20]

1.1 A system is critically damped. How will the system behave, if the gain of the system is increased? **[2]**

1.2 Consider the closed loop system shown in **Fig. Q 1.2.** where z and p are real numbers.

1.2.1 Find the set of values of z and p such that the feedback loop is BIBO stable. Draw the range of values of p and z (***Hint: Take values of p and z to be on the y and x-axis respectively)*** **[7]**

1.2.2 Assume D(s) = 0. Find the set of values of z and p such that the closed-loop system achieves the following transient specifications to a step input: settling time $T_s \leq$ 4sec, $\%OS \leq 1\%$. Draw the range of values of p and z (***Hint: Take values of p and z to be on the y and x- axis respectively)*** **[11]**

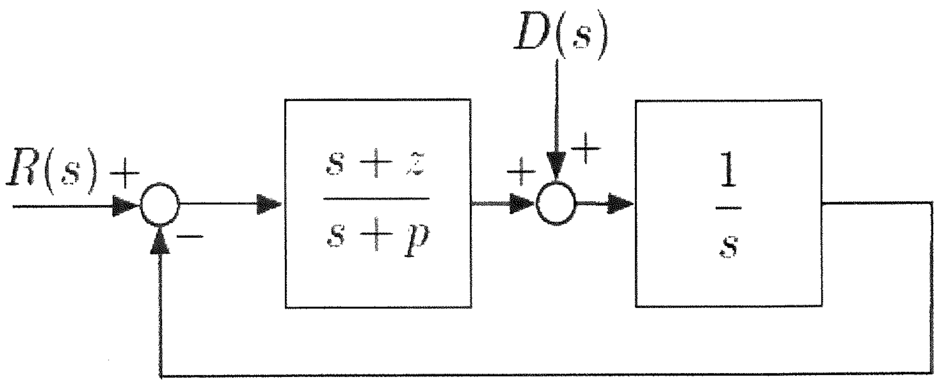

Fig. Q 1.2

QUESTION 2 [20]

For the system shown in **Fig. Q. 2:**

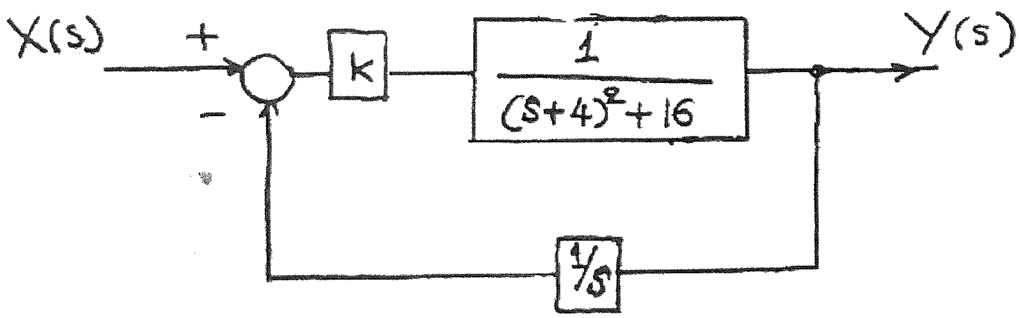

Fig. Q. 2

2.1 Draw a root locus for this system. Determine and indicate any departure angles, asymptote intersection and break away points **[12]**

2.2 Find the range of K for stability of the system **[5]**

2.3 Determine the point where the root loci cross the imaginary axis and the corresponding value of K **[3]**

QUESTION 3 [20]

3.1 Define the term Robust stability. Using equations explain how a polynomial $P(s)$ is robust Stable **[8]**

3.2 There are two performance factors for a first-order differential equation. What are they? Explain what each factor means in terms of response of the system **[5]**

3.3 **Fig. Q. 3.3** shows unit step response of a system G(s), determine its transfer function **[7]**

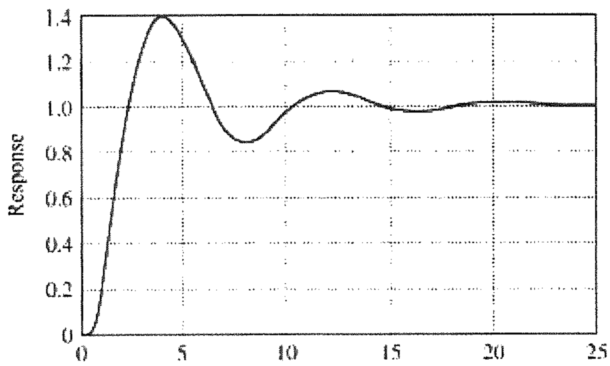

Fig. Q. 3.3

QUESTION 4 [20]

4.1 For the Electrical network shown in **Fig.Q.4.1**:

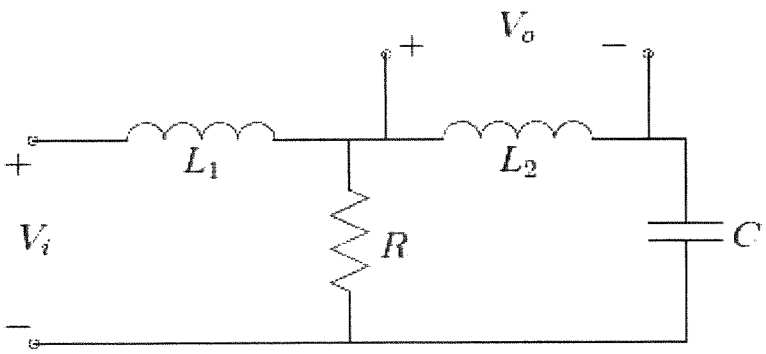

Fig.Q.4.1

4.1.1 Derive its mathematical model in Laplace transform (S- Domain) **[3]**

4.1.2 Using equations in **4.1.1**. determine the state and output equations of the system in a Vector- matrix form **[7]**

4.2 Write the state equations in vector matrix of the control system with the prespecified state variables in the **Fig Q.4.2** **[10]**

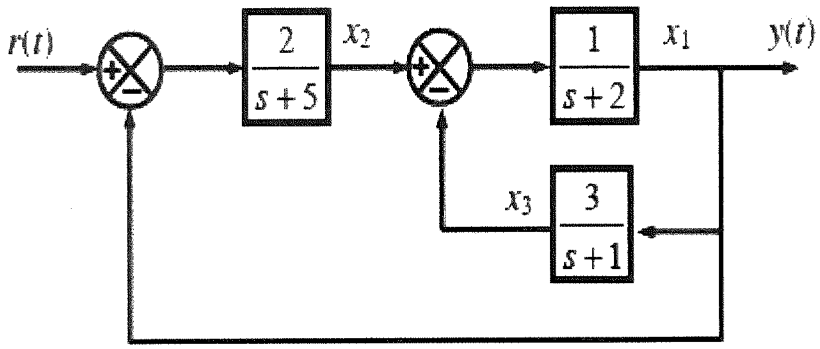

Fig. Q 4.2

QUESTION 5 [20]

5.1 State **3 (THREE)** reasons why modeling a physical system is important in control system **[3]**

5.2 List **3 (THREE)** advantages of Block diagram reduction as a techniques of modelling dynamic systems **[3]**

5.3 Obtain the transfer functions X1(s)/F(s) of the mechanical system shown in **Fig. Q.5.3.** **[8]**

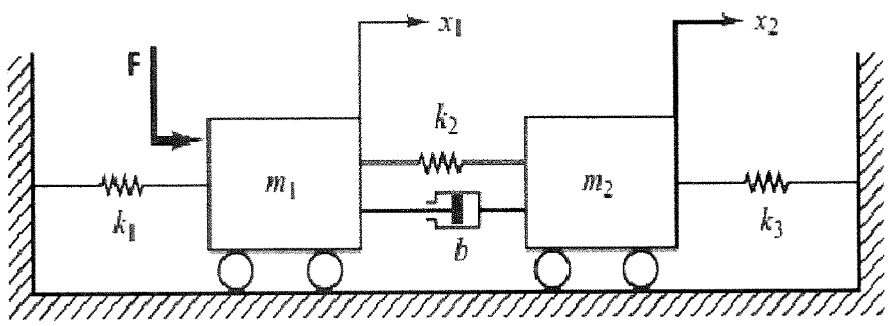

Fig. Q.5.3

5.4 Obtain a closed loop transfer function of the system in **Fig.5.4.** Select the gain K_1 and K_2 so that the closed loop system is critically damped with two equal poles at s = -10 **[6]**

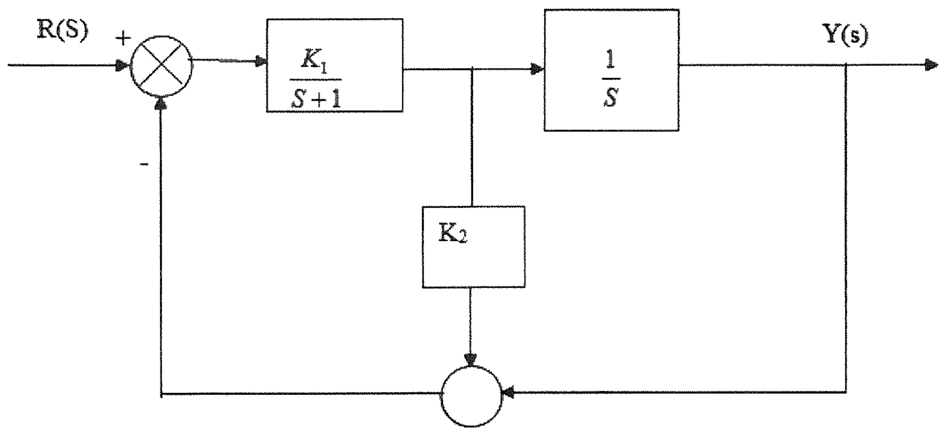

Fig. Q.5.4

QUESTION 6 [20]

6.1 A Control System is having a percentage overshoot of 40%, and the production manager is recommending a PI Controller to reduce the overshoot to 20%, as a Control System Engineer will you recommend the PI controller? Justify your answer. **[3]**

6.2 Derive the closed loop equation of PI controller with a first order plant, and show that the natural frequency ωn and damping ratio ζ can be controlled independently for a unit step input **[7]**

6.3 **Fig. Q. 6.3** Shows a closed loop system with transfer function

$$G_{P}=\frac{1}{S(S+2)}$$

You are required to design a controller G(s) so that the closed loop system meets the following specifications:

1. The damping ratio of the dominant be $\zeta = 0.45$
2. The velocity error constant must be $K_V = 0.20$

6.3.1 Using proportional controller $G_c(s) = K$, determine the value of K to receive to achieve the desired closed loop state steady accuracy requirement **[2]**

6.3.2 Using the proportional controller in 6.3.1, determine the damping ration of the dominant closed loop poles. Can we achieve both specifications using proportional controller, *K*? Justify your answer **[8]**

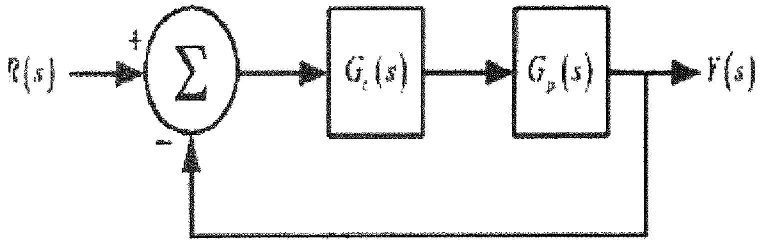

Fig. Q. 6.3