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## UNIVERSITY EXAMINATIONS

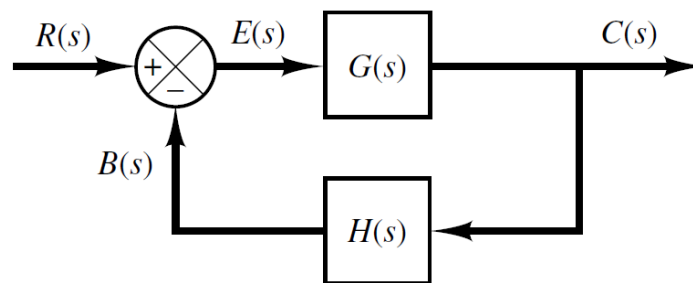
**EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN  
ELECTRICAL AND ELECTRONIC ENGINEERING**

**EENG 272: CONTROL SYSTEMS I****STREAMS: BSc. EENG****TIME: 2 HOURS****DAY/DATE: TUESDAY 09/04/2024****8.30 A.M. – 10.30 A.M.****INSTRUCTIONS**

- Answer question ONE and any other TWO questions
- Do not write on the question paper

**QUESTION ONE (30 MARKS)**

- a) With the aid of a diagram, describe a closed loop system. (4 marks)
- b) Define the transient response of a system? (2 marks)
- c) Derive the transfer function equation for the system below. (4 marks)



- d) Give three examples of control systems applications. (3 marks)
- e) The output of a proportional plus integral control action is described by the equation below. Find the transfer function that describes the relationship. (3 marks)

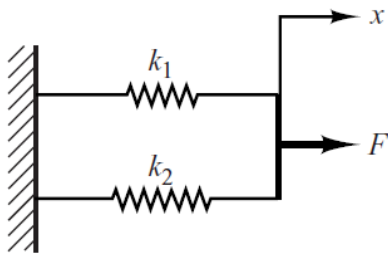
$$u(t) = K_p e(t) + \frac{K_p}{T_i} \int_0^t e(t) dt$$

- f) Linearize the nonlinear equation in the region  $8 < x < 10$ ,  $2 < y < 4$  (4 marks)

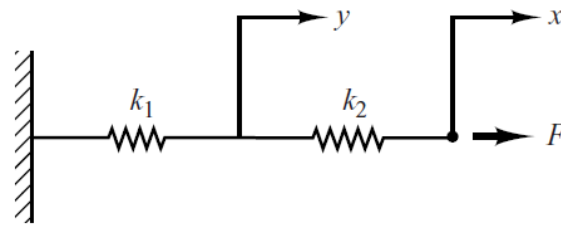
$$z = x^2 + 4xy + 6y^2$$

- g) Define the term “order of a system” (2 marks)

- h) Find the equations of force for the systems shown below and their equivalent spring constants. (5 marks)

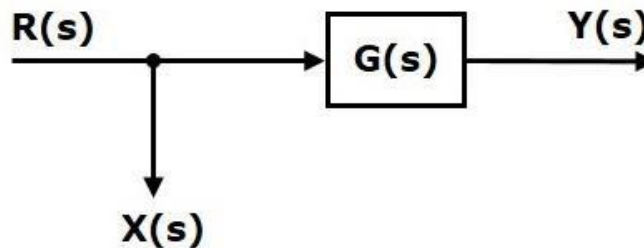


(a)



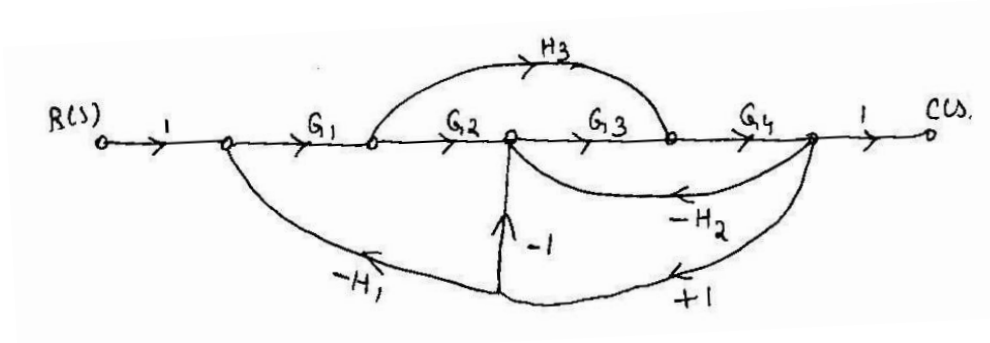
(b)

- i) Consider the block diagram shown in the following figure. Use an equivalent figure that will shift the take off point after the block. (3 marks)

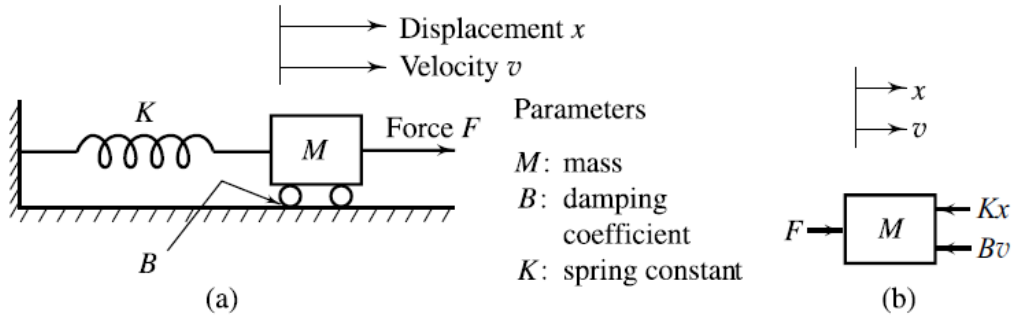


**QUESTION TWO (20 MARKS)**

- a) Determine the transfer function  $C(S) / R(S)$  using Mason’s gain formula for the signal flow graph shown. (6 marks)



- b) Given the mass damper spring system below, derive the equation of force for the system. (4 marks)



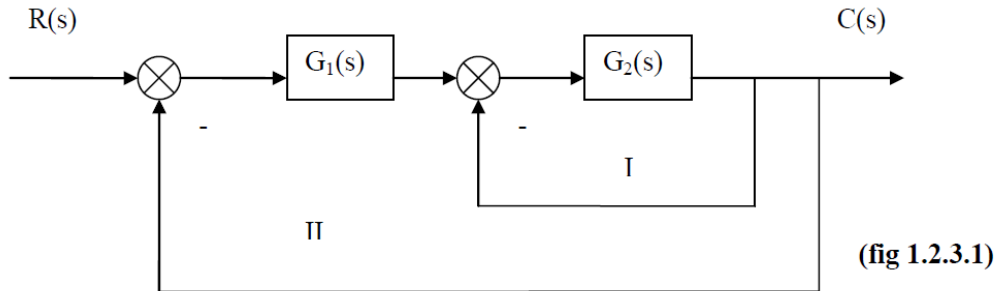
- c) Draw the Bode magnitude and phase plot of the following open-loop transfer function and determine gain margin, phase margin and absolute stability? (10 marks)

$$G(s)H(s) = \frac{1}{s(s+1)}$$

**QUESTION THREE (20 MARKS)**

- a) Find the overall transfer function  $C(s) / R(s)$  for the block diagram shown below.

(6 marks)



- b) A system is described by following mathematical equations. Find its corresponding block diagram model. (4 marks)

$$\dot{x}_1 = 3x_1 + 2x_2 + 5x_3$$

$$\dot{x}_2 = x_1 + 4x_2 + 3x_3$$

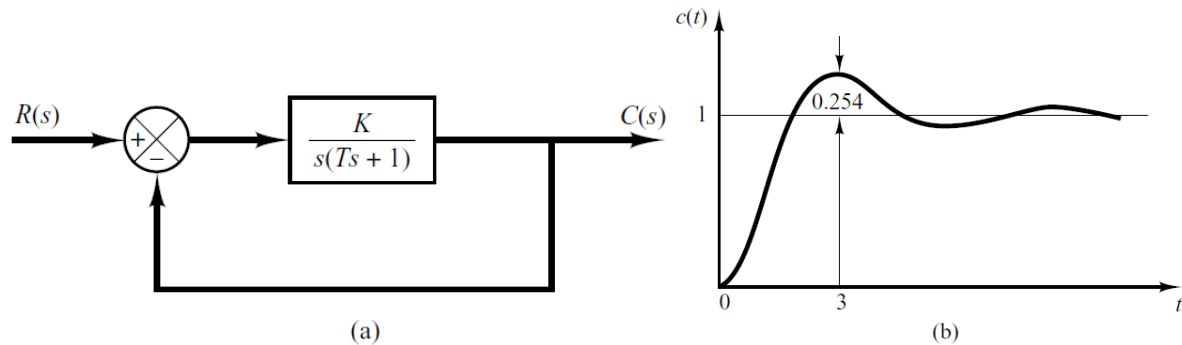
$$\dot{x}_3 = 2x_1 + x_2 + x_3$$

- c) Find the inverse Laplace transforms of the equations below:

I)  $Ms^2 X(s) + bsX(s) + kX(s) = F(s)$  (3 marks)

II)  $X(s) = \frac{1}{s^2 + 9s + 20}$  (3 marks)

- d) 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. **(4 marks)**



#### QUESTION FOUR (20 MARKS)

- a) Discuss the significance of a controller. **(2 marks)**
- b) Define a PI controller and write down the equation describing the output of a PI controller? **(4 marks)**
- c) Find the inverse Laplace transform of the function below using the method of partial fraction expansion. **(5 marks)**

$$F(s) = \frac{32}{s^3 + 4 \cdot s^2 + 4 \cdot s}$$

- d) Illustrate by a graphical representation the poles and zeros of the following function. **(5 marks)**

$$G(s) = \frac{10(s+2)}{s(s+1)(s+3)^2}$$

- e) Find stability of the following system given  $H(s) = 1$  using Routh-Hurwitz stability criterion. **(4 marks)**

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