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## UNIVERSITY EXAMINATIONS

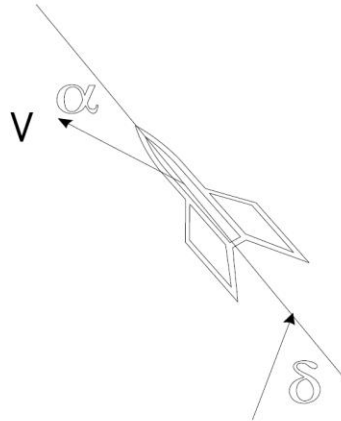
**EXAMINATION FOR THE AWARD OF SCIENCE IN ELECTRICAL AND  
ELECTRONIC ENGINEERING**

**EENG 373: CONTROL SYSTEMS II****STREAMS: BSc. EENG****TIME: 2 HOURS****DAY/DATE: TUESDAY 19/12/2023****2.30 P.M. – 4.30 P.M.****INSTRUCTIONS:**

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

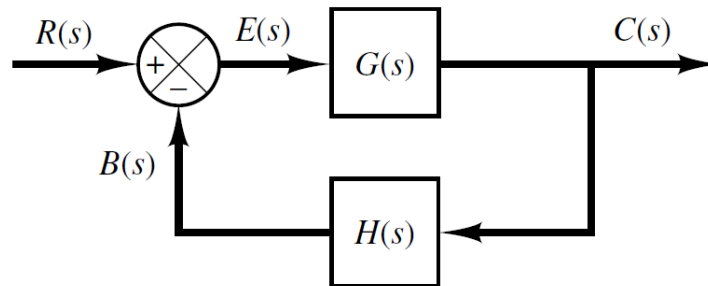
**QUESTION ONE (30 MARKS)**

- a) A fluid level control system includes a tank, a level sensor, a fluid source and an actuator to control fluid inflow. Show how the fluid level could be digitally controlled using a block diagram. (4 marks)
- b) A ballistic missile is required to follow a predetermined flight path by adjusting its angle of attack  $\alpha$  (the angle between its axis and its velocity vector  $v$ ). The angle of attack is controlled by adjusting the thrust angle  $\delta$  (angle between the thrust direction and the axis of the missile). Draw a block diagram for a digital control system for the angle of attack including a gyroscope to measure the angle and a motor to adjust the thrust angle  $\delta$ . (4 marks)



*Missile angle of attack control*

- c) Transient response of a system? (2 marks)
- d) Derive the transfer function equation for the system below. (4 marks)



- e) For each of the following equation, determine the order of the equation then test it for (i) Linearity. (ii) Time-invariance. (6 marks)

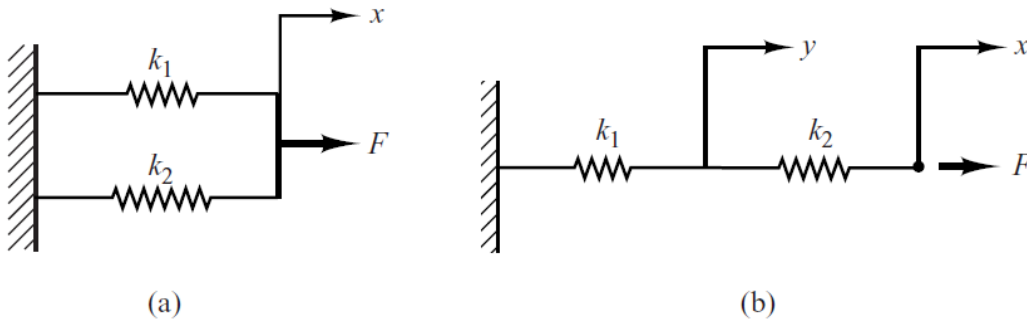
- (a)  $y(k+2) = y(k+1) y(k) + u(k)$
- (b)  $y(k+3) + 2 y(k) = 0$
- (c)  $y(k+4) + y(k-1) = u(k)$
- (d)  $y(k+5) = y(k+4) + u(k+1) - u(k)$
- (e)  $y(k+2) = y(k) u(k)$

- f) Use the linearity of the z-transform and the transform of the exponential function to obtain the transforms of the discrete-time functions.
  - i)  $\text{Sin}(k\omega T)$  (4 marks)
  - ii)  $\text{cos}(k\omega T)$  (4 marks)
- g) What is an order of a system? (2 marks)

**QUESTION TWO (20 MARKS)**

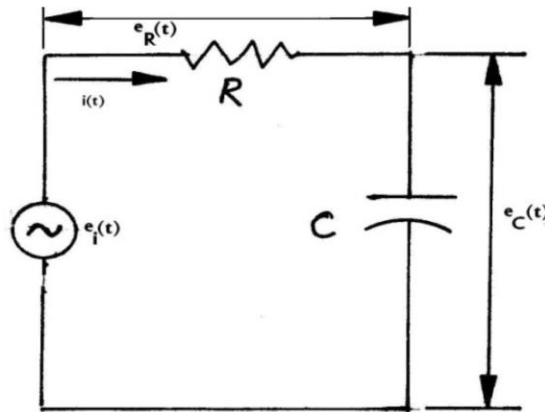
a) Find the equations of force for the systems shown below and their equivalent spring constants.

(5 marks)



b) Find system transfer function between voltage drop across the capacitance and input voltage in the following RC circuit as shown

(5 marks)



c) Use the Routh-Hurwitz criterion to investigate the stability of the systems

a) 
$$G(z) = \frac{5(z - 2)}{(z - 0.1)(z - 0.8)}$$

b) 
$$G(z) = \frac{10(z + 0.1)}{(z - 0.7)(z - 0.9)}$$

(8 marks)

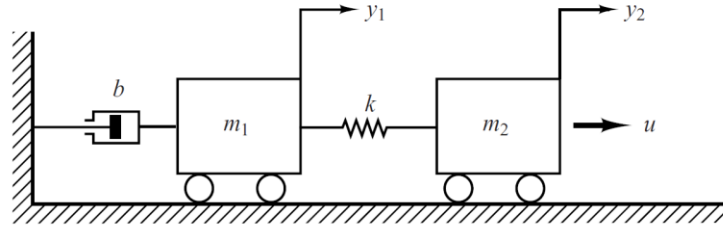
d) Find the partial fractions for the transfer function

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

(2 marks)

**QUESTION THREE (20 MARKS)**

- a) Obtain a state-space representation of the system shown (12 marks)



- b) A system is described by following mathematical equations. Find its corresponding block diagram model. (6 marks)

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

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

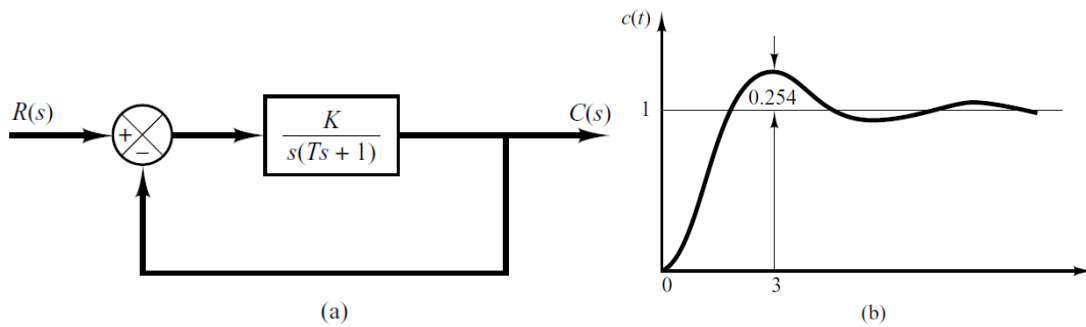
$$\dot{x}_3 = 2x_1 + x_2 + x_3$$

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

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

**QUESTION FOUR (20 MARKS)**

- a) 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. (6 marks)



- b) Find the inverse Laplace transform of the function below using the method of partial fraction expansion. **(5 marks)**

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

- c) Illustrate by a graphical representation the poles and zeros of the following function. **(4 marks)**

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

- d) Suppose a system with the transfer function below. Show the state space realization of its continuous time and discrete time respectively.  $m=1, b=10, k=20$ . **(5 marks)**

$$\frac{X(s)}{F(s)} = \frac{1}{ms^2 + bs + k}$$

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