



TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering and Technology

Department of Mechanical & Automotive Engineering

UNIVERSITY EXAMINATION FOR:

Bachelor of Technology in Mechanical Engineering

TMC 4324: CONTROL AND INSTRUMENTATION

END OF SEMESTER EXAMINATION

SERIES: AUGUST 2024 EXAM

TIME: 2 HOURS

DATE: Pick Date Select Month Pick Year

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **five** Questions; Question ONE is compulsory. In addition attempt any Other TWO Questions.

Do not write on the question paper.

Question ONE

- (a) State any two differences between the open loop and the closed loop control systems (4 marks)
- (b) Define a system and distinguish between a physical model and a mathematical model as applied to control systems. (3 marks)
- (c) For the control system of Figure Q1 (c), derive the closed loop transfer function. (4 marks)

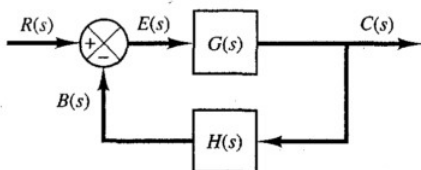


Figure Q1 (c)

- (d) Differentiate between span and range of an instrumentation system. (2 marks)
- (e) Explain what is meant by an intelligent or a smart instrument (2 marks)
- (f) Repeatability and reproducibility are synonymous terms. Comment. (3 marks)
- (g) Sketch the response of a second order measuring instrument and state the expressions of the static sensitivity, undamped natural frequency and damping ratio. (2 marks)

Question Two

- (a) Explain the principle of operation of Resistive sensors (3 marks)
- (b) A given 500 Ω nickel RTD has $\alpha = 0.00618 (\Omega/\Omega)/^{\circ}\text{C}$ at 0 $^{\circ}\text{C}$. Calculate its sensitivity, and determine the resistance at 101 $^{\circ}\text{C}$. (3 marks)

- (c) Explain the following transducer classifications
 i) Active transducers and Passive transducers
 ii) Transducers and Inverse transducers (4 marks)
- (d) Explain the working principle and application of light dependent resistor (LDR) sensor (2 marks)
- (e) Define the transfer function of control system. (2 marks)
- (f) Distinguish between poles and zeros of a transfer function. (4 marks)
- (g) State the advantages and limitations of a PID controller (2 marks)

Question THREE

- (a) Find the response, $c(t)$ to a unit step input, $r(t) = u(t)$, assuming zero initial conditions if the transfer function of the system, $G(s)$, is

$$G(s) = \frac{1}{s+2} \quad (6 \text{ marks})$$

- (b) Define the following terms:

- i) Rise time
 ii) Settling time

(2 marks)

$$G(s) = \frac{36}{s^2 + 4.2s + 36}$$

- (c) Given the transfer function below, determine the natural frequency ω_n and the damping ratio ζ (2 marks)

$$G(s) = \frac{36}{s^2 + 4.2s + 36}$$

- (d) Derive the expressions for the output voltage E_{Th} and equivalent impedance for general resistive deflection Bridge shown in Figure Q 3 (d)

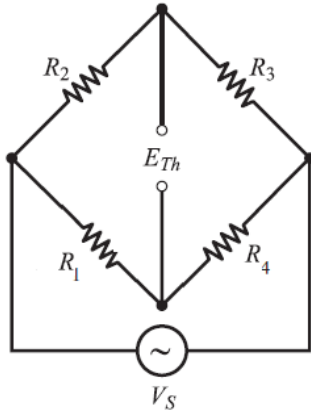


Figure Q 3 (d)

(7 marks)

- (b) List any three properties of a practical op-amp.

(3 marks)

Question FOUR

- (a) State what is meant by stability in a system (3 marks)
- (b) Consider a sixth-order system with characteristic equation:
 $s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$
 Use Routh's stability criterion to determine the system's stability (7 marks)
- (c) If a DAC has a minimum voltage of zero volts, a maximum voltage of 10.22 volts, with a resolution of 20 millivolts, find the number of bits it has. (3 marks)
- (d) Describe the operation of a counter ramp type analogue to digital converter (7 marks).

Question FIVE

- (a) Distinguish between an $X-Y$ recorder and $X-t$ recorder (2 marks)
- (b) Explain what is meant by a direct recording instrument (2 marks)
- (c) Explain with the help of diagram the working of a galvanometer type strip chart recorder. (6 marks)
- (d) control system is represented by:

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

- i) Find the analytical expression for the magnitude frequency response and the phase frequency response.
- ii) Plot the Bode diagram of the system.

(10 marks)

