



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: NOVEMBER 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) Define a control system (2 marks)
- (b) In order to improve the performance of the control systems feedback is employed. Briefly explain the effect of feedback on the following:
- Overall gain
 - Sensitivity
 - Stability
 - Noise
- (4 marks)
- (c) Identify the input and output for an automatic washing machine. (2 marks)
- (d) State the difference between servomechanism and regulatory control schemes (2 marks)
- (e) Explain what is meant by an intelligent or a smart instrument (2 marks)
- (f) Identify the sensing, signal conditioning and data presentation in the liquid in glass thermometer. (3 marks)
- (g) A load cell is calibrated in an environment at a temperature of 21°C and has the following deflection/load characteristic:

Load (kg)(21°C)	0	50	100	150	200	Load (kg) (35°C)	0	50	100	150	200
Deflection (mm)	0.0	1.0	2.0	3.0	4.0	Deflection (mm)	0.2	1.3	2.4	3.5	4.6

When used in an environment at 35°C, its characteristic changes to the following:

Determine the sensitivity at 21°C and at 35°C. Calculate the total zero drift and sensitivity drift at 35°C. Hence determine the zero drift and sensitivity drift coefficients (in units of $\mu\text{m}/^\circ\text{C}$ and $(\mu\text{m per kg})/ (^\circ\text{C})$). (5 marks)

Question Two

- (a) State any TWO advantages of electrical transducers (2 marks)
- (b) Explain the difference between a sensor and a transducer (2 marks)
- (c) A resistance potentiometer has a sensitivity of 10 V/mm . Find the output voltage for a displacement of 2 mm (2 marks)
- (d) With the aid of a schematic and circuit diagram, describe the construction and operation of a Linear variable differential transformer transducer (LVDT) (4 marks)
- (e) Determine the output $Y(s)$ of the system shown in Figure Q 2 (e) when there is an input $X(s)$ to the system as a whole and a disturbance signal $D(s)$ at the point indicated. (6 marks)

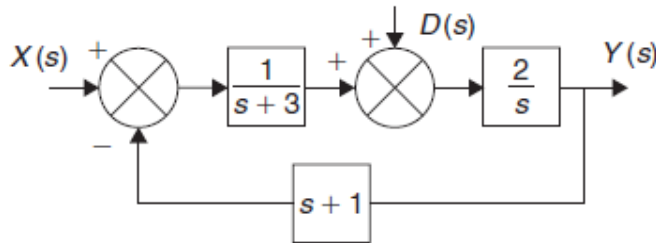


Figure Q2 (e)

- (f) A simple open-loop speed control system consists of an electronic amplifier and a motor. The block diagram is shown in Figure Q2 (f) where V_1 is the input demand signal. The transfer function, A , for the amplifier is 10 V/V , and that for the motor, M , is $12 (\text{rad/s})/\text{V}$. Determine the system transfer function, and hence calculate the demand signal required to produce an output speed of 120 rad/s . (4 marks)

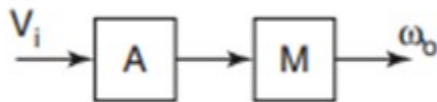


Figure Q2 (f)

Question THREE

- (a) State what is meant by modeling. (2 marks)
- (b) A circuit consisting of RC elements as shown in Figure Q3 (b). Find system transfer function. (5 marks)

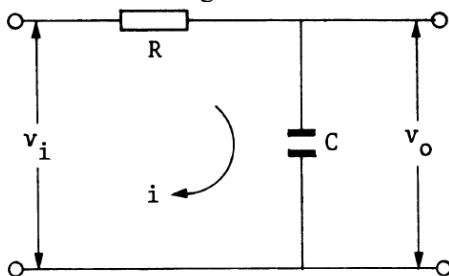


Figure Q3 (b)

- (c) Obtain the pole-zero map of the following transfer function. (3 marks)
- $$Y(s) = \frac{(s-2)(s+2+4j)(s+2-4j)}{(s-4)(s-4)(s-5)(2+1+5j)(s+1-5j)}$$
- (d) Explain any FOUR different functions which the signal conditioning equipment is expected to perform on the transduced signal. (4 marks)

- (e) Describe the effect of low pass, high pass, Band pass and Notch filters (4 marks)
- (f) List any two requirements of an instrumentation amplifier (2 marks)

Question FOUR

- (a) Distinguish between absolute stability and relative stability (2 marks)
- (b) The characteristic equation for a feedback control system is given by:
 $s^4 + 20s^3 + 15s^2 + s + K = 0$
 - i) Find the range of K for stability
 - ii) Determine the frequency in rad/sec at which the system will oscillate
 - iii) Find the number of roots of the characteristic equation that lie in the right half of the s -plane when $K = 5$ (8 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. (2 marks)
- (d) State the Nyquist sampling theorem. (2 marks)
- (e) Explain the advantages of digital indicating instruments over their analog counterparts (2 marks)
- (f) Define an XY recorder. (1 mark)
- (g) Explain the function of a recording head in a magnetic tape recorder. (3 marks)

Question FIVE

- (a) Describe a low pass RC filter. Derive the expression for its transfer function as well as an expression for the cut-off frequency, Draw its frequency response characteristic (6 marks)
- (b) State why an AC amplifier is used, instead of a DC amplifier for low level signals (2 marks)
- (c) Give two uses for an isolation amplifier. (2 marks)
- (d) State any TWO advantages and Two disadvantages of Nyquist plots (4 marks)
- (e) State and explain Nyquist stability criterion (2 marks)
- (f) Define constant M - and constant N -circles. (2 marks)
- (g) Explain how the closed-loop frequency response of the system can be obtained from the open-loop frequency response using constant M - and constant N -circles (2 marks)