

SULIT



Second Semester Examination
2022/2023 Academic Session

July/August 2023

EEM323 – Instrumentation & Measurement Systems

Duration : 3 hours

Please check that this examination paper consists of **SIX (6)** pages of printed material including appendix before you begin the examination.

Instructions : This paper consists of **FOUR (4)** questions. Answer **ALL** questions.

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1. a) Describe the terms: "transducer and sensor" with suitable example for each term.

(15 marks)

- b) Describe the characteristics for data transmission protocols between two devices using the RS-232, RS-422 and RS-485. Also, include the description regarding half-duplex and full-duplex.

(50 marks)

- c) Provide one example of handshaking protocol utilized for RS-232 data communication.

(35 marks)

2. a) Explain the operation of a Wheatstone Bridge and why it is commonly used in signal conditioning circuit, including description of the balanced and unbalanced bridge.

(20 marks)

- b) Explain the operation of an instrumentation amplifier and why it is typically used in a sensor instrumentation circuit.

(20 marks)

- c) What is the effect aliasing in signal condition stage and how to overcome the problem?

(20 marks)

- d) An unbalanced bridge circuit converts temperature sensor resistance into a differential voltage that is amplified by an instrumentation amplifier. The temperature sensor has a resistance of 120 ohms at 35°C and a resistance range of 90 to 150 ohms.

- (i) Design a DC bridge circuit with a 10V supply that will give zero output at 35°C using; [a. $R_3 = R_4 = 1000$ ohms; b. $R_3 = 120$ ohms, $R_4 = 1000$ ohms]

- (ii) Sketch the output voltage over the range of operation at 5 ohms increment for both designs. [a. $R_3 = R_4 = 1000$ ohms; b. $R_3 = 120$ ohms, $R_4 = 1000$ ohms]

- (iii) Determine the zero based linear approximation of the bridge output responses.

(40 marks)

3. a) Temperature is a very widely measured and frequently controlled variable used in numerous industrial applications. It forms an important governing parameter in the thermodynamic and heat transfer operations such as steam raising, gas turbines in power generations and propulsion systems. Electrical methods are usually preferred for the measurement of temperature as they furnish a signal which can be detected, amplified or used for control purposes. One of the examples of electrical method is the electrical resistance thermometers. Design a resistance thermometer using the following information:

Type of metal: copper

Diameter of wire, d : 0.02 mm

Resistance, R at 0°C : 100 Ω

Resistivity coefficient of copper, ρ : $1.7 \times 10^{-6} \Omega\text{-cm}$

Temperature coefficient of copper, α : $0.0043^\circ\text{C}^{-1}$

- (i) Sketch and label your design showing the essential components clearly.

(10 marks)

- (ii) Calculate the length of the wire used for the design.

(20 marks)

- (iii) Determine the value of resistance if your design is used to measure boiling water.

(20 marks)

- (iv) Assess the influence of metal used, diameter and length of the wire in the electrical resistance thermometer design. The type of metal used for the thermometer is changed to platinum. It has a resistance of 140.5 and 100.0 Ω at 100°C and 0°C , respectively. If the resistance becomes 305.3 Ω when it is in contact with hot gas, determine the temperature of the gas. (Given: Resistivity coefficient of platinum, ρ : $10.5 \times 10^{-6} \Omega\text{-cm}$; Temperature coefficient of platinum, α : $0.0039^\circ\text{C}^{-1}$)

(20 marks)

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- b) A new experimental strain gauge is mounted on a 0.25 inch diameter steel bar in the axial direction. The gauge has a measured resistance of 120Ω , and when the bar is loaded with 500 pound in tension, the gauge resistance increases by 0.01Ω . What is the gauge factor of the gauge? (Given: Modulus of elasticity of steel, $E: 30 \times 10^6$ psi).

(30 marks)

4. a) A venturimeter shown in Figure 4 is used to measure the flow in a liquid pipeline. The diameter of the inlet and the throat is 15 cm and 8 cm, respectively. The venturi tube is attached to a U-tube manometer containing oil of specific gravity 0.8.

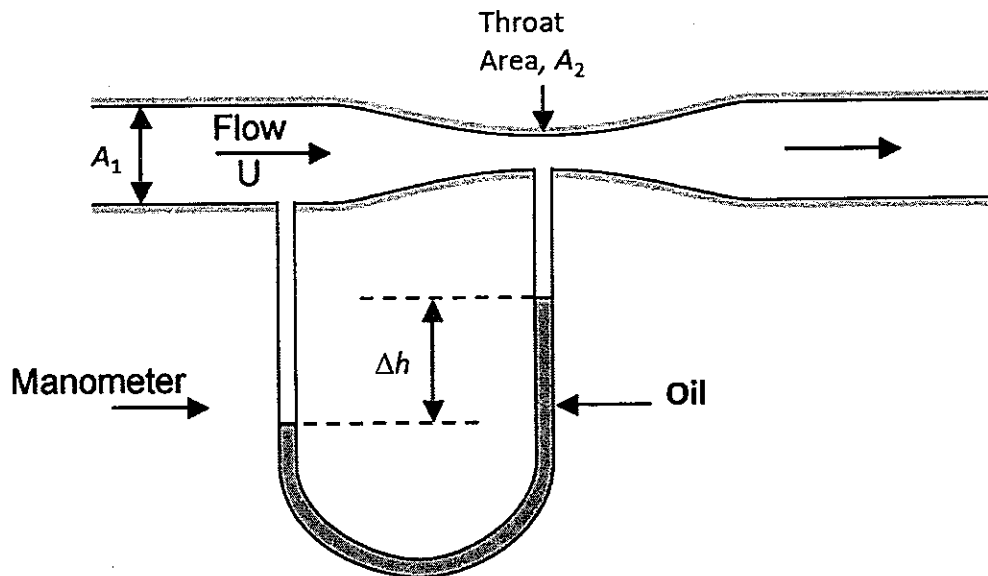


Figure 4

Based on the given situation:

- (i) Derive the rate of discharge as

$$Q_{actual} = c_d \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2g\Delta h}$$

(20 marks)

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- (ii) If the liquid density is 2 kg/m^3 and the manometer reading shows 10 cm when the liquid flow rate is $0.11 \text{ m}^3/\text{s}$, estimate the coefficient of discharge.

(40 marks)

- b) A mass-spring-damper vibrometer is designed with the following features:

Mass, $m = 200 \text{ g}$

Spring stiffness, $k = 1.5 \text{ N / mm}$

Damping ratio, $\xi = 0.5$

- (i) Determine the amplitude of the recorded motion if a motion signal of $3 \sin 200 t$ (mm) was measured using the instrument.

(20 marks)

- (ii) What will be the maximum frequency for the instrument if the error is limited not to exceed 15%?

(20 marks)

APPENDIX

Question	Course Outcome (CO)	Programme Outcome (PO)
1	1	PO1
2	2	PO2
3	3	PO3
4	3	PO4