



UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022**

COURSE NAME : INSTRUMENTATION AND MEASUREMENT IN OIL AND GAS

COURSE CODE : BEJ 44903

PROGRAMME CODE : BEJ

EXAMINATION DATE : JULY 2022

DURATION : 3 HOURS

INSTRUCTION

1. ANSWER ALL QUESTIONS
2. THIS FINAL EXAMINATION IS AN **ONLINE ASSESSMENT AND CONDUCTED VIA OPEN BOOK.**

TERBUKA

THIS QUESTION PAPER CONSISTS OF SEVEN (7) PAGES

- Q1** (a) Explain the function of the measurement system and the basic requirements for measurement. (4 marks)
- (b) An auditor from “Norway Engineering Sdn. Bhd.” has discovered that most of the defective instruments in “National Conductor Holdings” were caused by the surrounding workplace such as temperature, pressure, etc. Discover the possible contents of the auditor’s report. (6 marks)
- (c) Weather research has been carried out to measure the fluctuation of temperature of the industrial area near the neighborhood. The readings are recorded for half of the month every day continuously at 7:00 am at the same location by the researcher. **Table Q1(c)** shows the recorded data, determine the mean and the standard deviation of the data. (4 marks)
- (d) A researcher in a chemical plant is measuring some data that have been obtained from a chemical reaction experiment. As usual he will consider several metrology issues such as metrological confirmation; accuracy, uncertainty and bias. Briefly explain and justify why he has to consider the metrology terminologies. (6 marks)
- Q2** (a) A Wheatstone bridge is connected for a Varley loop test as shown in **Figure Q2(a)** consists of a defective conductor and a healthy conductor connected at the cable terminal located 10miles from the test set. The cable has a resistance of 0.05Ω per 1000 ft.
- (i) When the switch is set to position a, the circuit is balanced, construct the equation for positions a and b. (4 marks)
- (ii) When switching to position a, the bridge is balanced $R_1 = 1 \text{ k}\Omega$, $R_2 = 100 \Omega$, and $R_3=100 \Omega$. When switching to position b, the bridge is balanced with $R_3 = 99 \Omega$. Calculate the value of R_x in both conditions. (4 marks)
- (iii) If the resistance of the shorted cable is $0.05 \Omega/\text{meter}$, estimate the distance from the bridge to a ground fault. (2 marks)
- (b) **Figure Q2(b)** shows a schematic diagram of a Serial-Capacitor type bridge which is operating at 0.5 kHz . Given that the value for the resistor R_a , R_b , R_c are 2000Ω , 2800Ω and 52Ω , respectively. The capacitor C_e is $0.5 \mu\text{F}$. Estimate the value of the components in “ Z_x ”. (10 marks)

- Q3** (a) A Transducers are vital tools for industrial application.
- (i) Identify two functions of a transducer. (2 marks)
 - (ii) Describe the differences between self-generating and passive transducers with an example for each type. (4 mark)
- (b) Strain gauge is used for linear displacement measurement. By illustrating with a suitable diagram, explain the construction and the principles of operation of a strain gauge to measure strain. (5 marks)
- (c) A resistance strain gauge with gauge factor, $G = 2$ is mounted firmly on a stainless steel bar. The original length of the bar is 15 cm, however a pressure 200 Mpa is applied and caused the length of the bar reduced 0.001% from its original form. During the pressure applied, the strain gauge has experience resistance change of $650 \mu\Omega$, evaluate the resistance when the pressure applied is zero. (5 marks)
- (d) Referring to the circuit shown in **Figure Q3(d)**, the connecting wires are made of Nickel.
- (i) Estimate the resistance in each of the nickel wires, R wire if the temperature of the circuit rises from 20°C to 40°C . Given the temperature coefficient of nickel, $\alpha_{\text{nickel-20}}$ is $0.005866/^\circ\text{C}$. (2 marks)
 - (ii) Predict the temperature when the total resistance of the nickel wires has the value of 25Ω . (2 marks)
- Q4** (a) **Figure Q4(a)** shows a Computer Numerical Control (CNC) machine tool for drilling holes in a flat plate.
- (i) Highlight why the rotary encoder is used over the linear encoder. (2 marks)
 - (ii) Choose what type of rotary encoder is a feedback device in the system and give your reason. (2 marks)
 - (iii) Construct the block diagram/ components to represent the closed-loop system (6 marks)
- (b) A tank holds water with a depth of 7.0 ft. Estimate the pressure at the tank bottom in psi and Pa (density = 10^3 Kg/m^3). (6 marks)

- (c) Flow is to be controlled from 20 to 150 gal/min. The flow is measured using an orifice plate system such as that shown in **Figure Q4(c)**. The orifice plate with $K=119.5$ (gal/min)/psi^{1/2}. A bellows measures the pressure with an LVDT so that the output is 1.8 V/psi. Solve the range of voltages that result from the given flow range. (4 marks)

Q5 (a) A pressure difference of 1.1 psi occurs across a constriction in a 5 cm diameter pipe. The constriction constant is 0.009 m³/s per kPa.

(i) Determine the flow rate in m³/s (4 marks)

(ii) Determine the flow velocity in m/s. (3 marks)

(b) A measurement of temperature using a sensor that outputs 6.5 mV/°C must measure up to 100 °C. A 6-bit ADC (Analog Digital Converter) with a 10-V reference is used.

(i) Solve the required gain that needs to develop a circuit to interface the sensor and the ADC. (4 marks)

(ii) Design the ADC circuit. (5 marks)

(c) A Voltage to frequency Converter (VFC) consists of a Voltage Controller Oscillator (VCO), a gate pulse generator, and an AND gate. If the output frequency to measured voltage of the VCO is 100. Estimate the measured voltage when 200 pulses are detected during 0.01 seconds. (4 marks)

-END OF QUESTIONS

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Table Q1(c)

| Day | Temperature °C |
|-----|----------------|
| 1 | 32.1 |
| 2 | 29.8 |
| 3 | 30.2 |
| 4 | 31.1 |
| 5 | 32.0 |
| 6 | 29.7 |
| 7 | 30.1 |
| 8 | 34.3 |
| 9 | 31.2 |
| 10 | 31.7 |
| 11 | 30.2 |
| 12 | 29.9 |
| 13 | 29.5 |
| 14 | 30.1 |
| 15 | 29.8 |

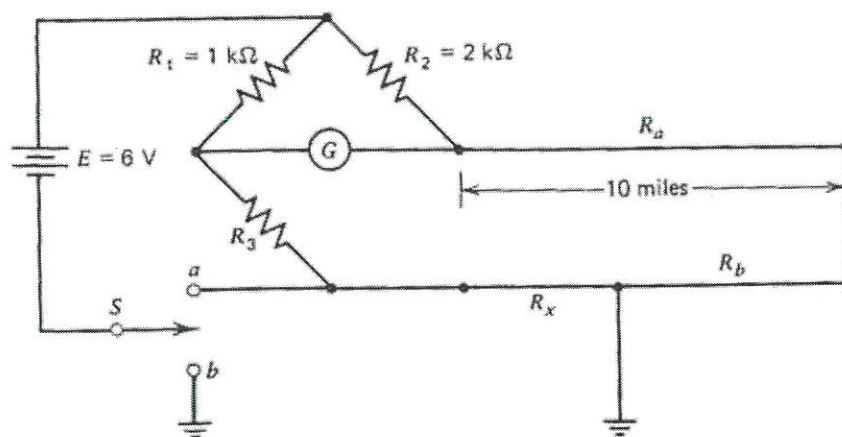
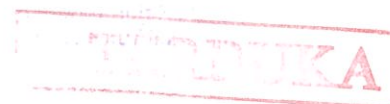


Figure Q2(a)



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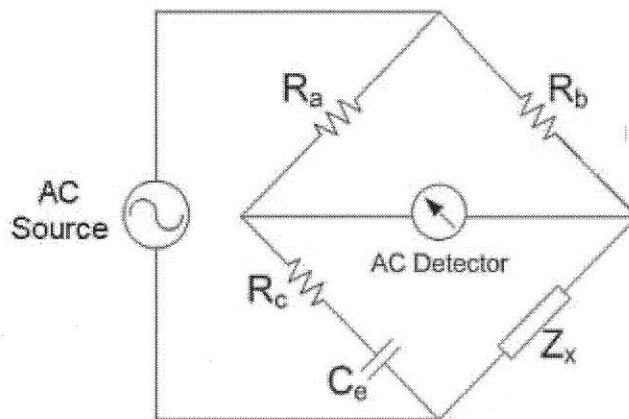


Figure Q2(b)

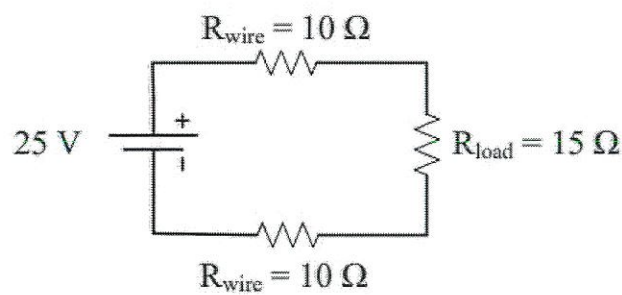


Figure Q3(d)

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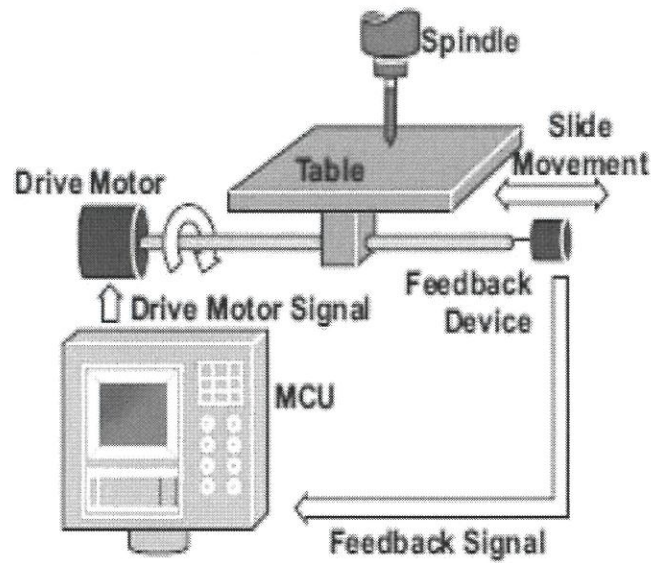
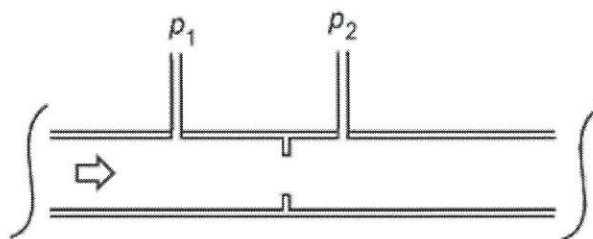


Figure Q4(a)



Orifice Plate

Figure Q4(c)