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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024**

- COURSE NAME : INSTRUMENTATION AND MEASUREMENT
- COURSE CODE : BEJ10702
- PROGRAMME CODE : BEJ
- EXAMINATION DATE : JULY 2024
- DURATION : 2 HOURS
- INSTRUCTIONS :
1. ANSWER ALL QUESTIONS
 2. THIS FINAL EXAMINATION IS CONDUCTED VIA
 - Open book
 - Closed book
 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF SIX (6) PAGES

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Q1 a) A photoelectric transducer can be categorized as photoemissive, photoconductive, or photovoltaic. In photoconductive devices, the resistance of a material is changed when it is illuminated. The relay of **Figure Q1.1** is to be controlled by a photoconductive cell with the characteristics shown in **Figure Q1.2**. The circuit delivers 10 mA at a 30-V setting when the cell is illuminated with about 400 lm/m². The circuit becomes de-energized when the cell is dark.

i) Calculate the required series resistance. (4 marks)

ii) Calculate the level of the dark current. (3 marks)

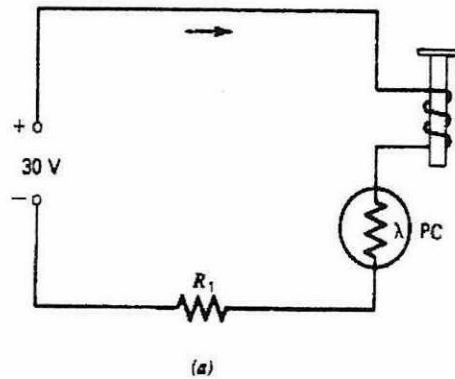


Figure Q1.1 Relay control by a photoconductive (PC) cell.

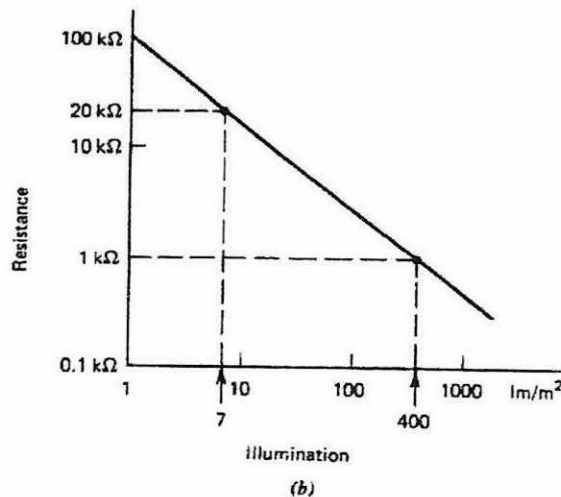


Figure Q1.2 PC cell illumination characteristics.

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b) The measurement and control of fluid pressure has to be one of the most common in all process industries. Due to the great variety of conditions, ranges, and materials for which pressure must be measured, there are many different types of pressure sensor designs.

i) Explain the Pressure Principles focus on the static pressure, dynamic pressure and gauge pressure.

(10 marks)

ii) Describe the advantages and disadvantages of differential pressure (DP) flowmeter and turbine flow meters.

(8 marks)

Q2

a) A Wheatstone bridge is widely used for precise measurement of resistance from approximately 1Ω to the low $M\Omega$ range. List and explain four (4) sources of error that may affect the unknown resistance measurement.

(8 marks)

b) A bridge configuration as shown in **Figure Q2.1** is used to measure temperature by employing a thermistor with the resistance R_x . It is attached to the unknown resistance branch of the bridge.

i) Calculate the value of R_x that will give a balanced bridge condition.

(4 marks)

ii) If the measured voltage $V_{out} = +256 \text{ mV}$, estimate the temperature measured by the thermistor. Note that **Figure Q2.2** shows the plot of the potential R_x versus temperature for the thermistor.

(8 marks)

iii) Redesign the bridge so that the balanced condition will be around 50°C . Change the values for R_1 , R_2 and R_3 as you see fit.

(5 marks)

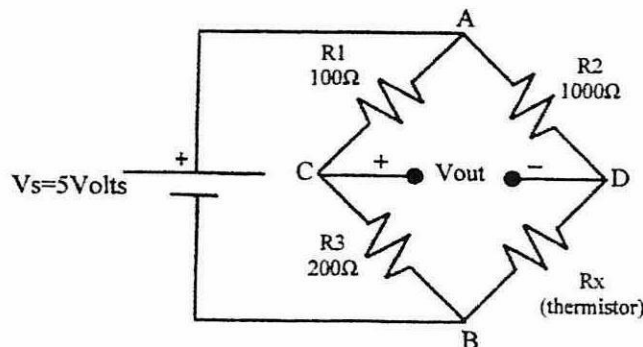


Figure Q2.1

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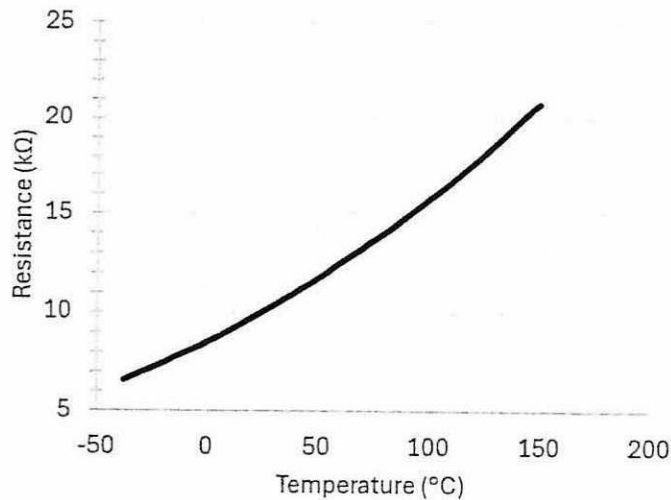


Figure Q2.2

Q3 a) An automatic cutting machine is designed to cut a continuous plastic strip into blocks of specific length as shown in **Figure Q3.1**. It is fed continuously to a cutter via a pair of feeder discs whose diameter is 200mm. An incremental encoder of 100 pulses/rev is coupled to the disc. Determine the number of encoder output pulses, if the block length is

- i) 30 mm
- ii) 1000 mm

(6 marks)

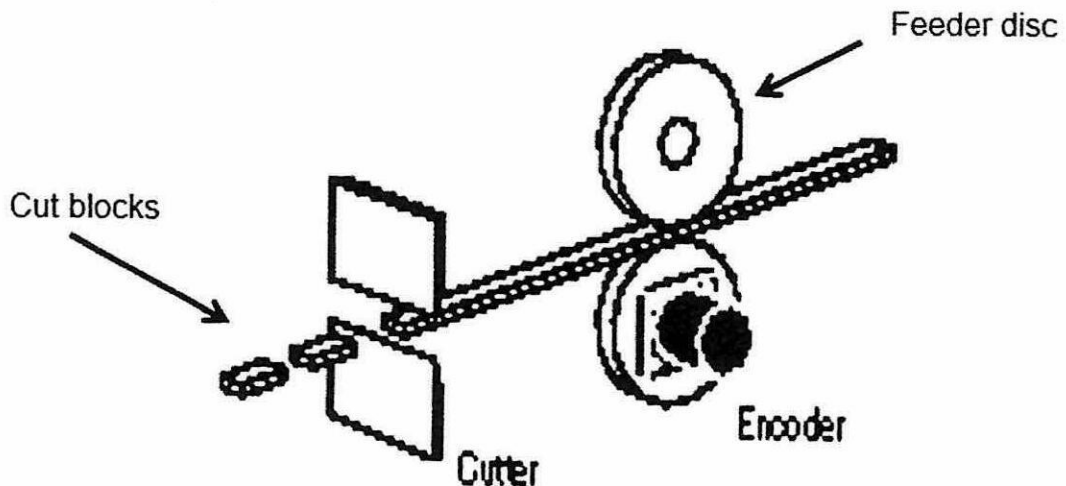


Figure Q3.1 An automatic cutting machine.

b) An engineer has decided to replace the incremental encoder as shown in **Figure Q3.1** with a linear absolute encoder along the shaft. Given the specification of the absolute encoder as stroke length 500mm, 12 bits, gray code. The origin is defined when the table is at the most left and the encoder

reads 0000 0000 1100 Gray Code. The encoder value increases as the table moves to the right.

- i) Explain what Gray Code is using 4-bits binary. (5 marks)
- ii) Explain the reason of using Gray Code. (4 marks)
- iii) Calculate the minimum travel distance possible. (6 marks)
- iv) If the table is to move 250 mm away from the origin, calculate the encoder value in Gray. (4 marks)

Q4 a) Describe the advantages of digital instruments over analog instruments. (5 marks)

b) Logic gates are the building blocks for digital instrumentation. **Figure Q4.1** shows a logic gate configuration consisting of AND, and OR gates.

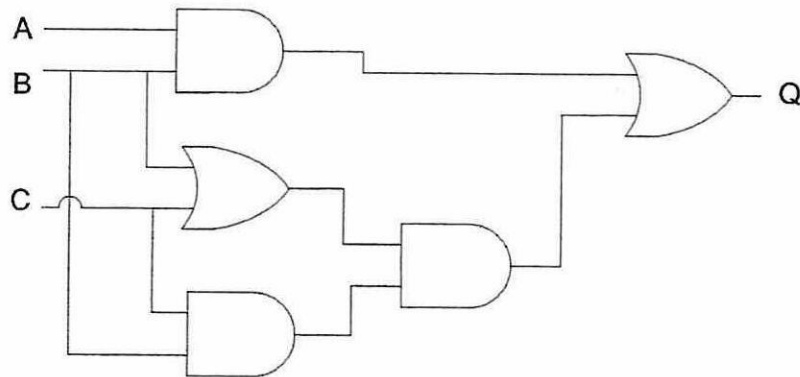


Figure Q4.1

- i) Construct the truth table for this configuration. (4 marks)
- ii) Write the full Boolean expression for Q based on the inputs A, B and C. (2 marks)
- iii) Simplify the Boolean expression for Q using Boolean algebra. (3 marks)

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- iv) Construct the simplified logic gate configuration based on the expression found in (iii). (2 marks)

- v) Construct the truth table for the configuration found in (iv). Show that this truth table is similar to the one found in (i). (4 marks)

- c) A dual-slope Analog Digital Converter (ADC) in **Figure Q4.2** has values of $R = 100 \text{ K}\Omega$ and $C = 0.01\mu\text{F}$, reference voltage V_{ref} is 10V, and the fixed integration time is 10ms. Calculate the conversion time for a 6.8V input. (5 marks)

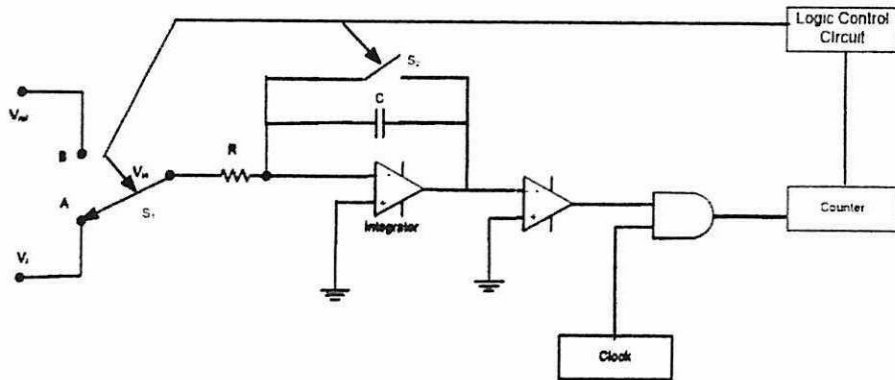


Figure Q4.2

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– END OF QUESTIONS –