

## University of Ruhuna- Faculty of Technology

### Bachelor of Engineering Technology Honors

Level 2 (Semester 2) Examination - November/December 2025

Course Unit: ENT2232 – Instrumentation & Calibration (Theory)

Time Allowed: 2 hours

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- This examination consists of **four (04)** questions in **three (03)** pages.
  - Answer **all** the questions.
  - Read the instructions carefully.
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1. a) Differentiate between direct measurement and indirect measurement. Give one example for each. (04 Marks)
  - b) Differentiate between the following pairs of static characteristics of measuring instruments:
    - i. Accuracy and Precision (04 Marks)
    - ii. Repeatability and Reproducibility (04 Marks)
  - c) Explain three factors that should be considered when choosing the right measuring instrument for a specific application. (06 Marks)
  - d) Discuss how periodic calibration contributes to achieving accuracy, reliability, and safety in industrial settings. (05 Marks)
  - e) Identify two consequences of using uncalibrated instruments in critical processes and suggest how to mitigate these risks. (06 Marks)
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2. a) Differentiate between analog sensors and discrete sensors. Provide one example of each type used in industrial automation. (04 Marks)
  - b) List two common sensors used for temperature measurement and explain how each one works. (04 Marks)
  - c) A resistor measured by three different students produces the following readings: 98.5  $\Omega$ , 99.2  $\Omega$ , and 101.6  $\Omega$ . The manufacturer's true value is 100  $\Omega$ . Calculate the absolute error and percentage error for each measurement. (06 Marks)

Contd.

- d) Explain the following sources of errors in instrumentation:
- Non-linearity
  - Hysteresis
  - Dead space

Include appropriate diagrams to illustrate your explanations. (06 Marks)

- e) A thermocouple sensor outputs 42.3 mV at 105 °C and was calibrated to output 0 mV at 0 °C.
- Determine the transfer function (sensitivity) of the thermocouple. (01 Mark)
  - Calculate the temperature when the sensor outputs 15.8 mV. (02 marks)

3. a) A pressure gauge with a measurement range of 0-20 bar has a quoted inaccuracy of  $\pm 2\%$  f.s. (full scale).

- What is the maximum measurement error expected for this instrument? (02 marks)
- What is the likely measurement error expressed as a percentage of the output reading if this pressure gauge is measuring a pressure of 2 bar? (03 marks)

- b) i. How are electrical measuring instruments classified? (02 marks)
- ii. Why are null-type instruments generally more accurate than deflection-type instruments? (03 marks)
- iii. Define the terms "Indicating instruments", "Recording instruments", and "Integrating instruments". Give examples of each case. (06 marks)

- c) i. What is meant by "traceability" as it relates to calibration? (02 marks)
- ii. Discuss how a process instrument can be calibrated and traceable to SI units through a national standard. Support your answer with a suitable diagram. (07 marks)

4. a) i. What information is typically included in a calibration report? (02 marks)
- ii. Why is instrument calibration necessary, and briefly describe the procedure followed in the calibration of an instrument? (04 marks)

- b) i. What is the difference between a sensor, a transducer, and a converter? (03 marks)
- ii. Discuss three factors to be considered in selecting sensors for industrial use. (03 marks)
- iii. A measurement system consists of three (03) basic functional elements. Using the example of an actual measurement system, give a short description of each of them. (06 marks)

Contd.

- c) i. The graphs (Figure 01) show that each thermocouple produces a different emf value for the same temperature. Identify each thermocouple type corresponding to the curves (1), (2), (3), and (4). (02 marks)

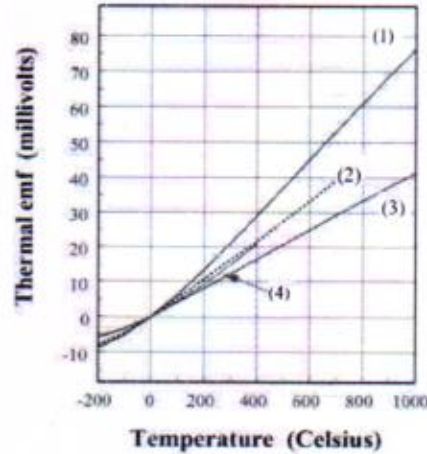


Figure 01: Thermocouple characteristics with reference junction at 0 °C

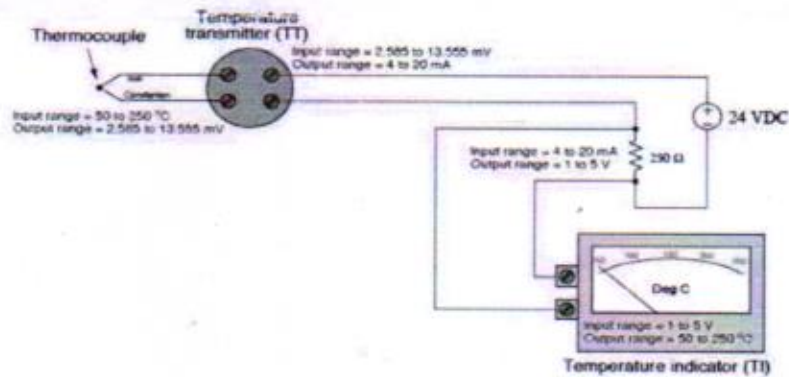


Figure 02: Circuit Diagram of thermocouple temperature-measurement system

- ii. Figure 02 shows a detailed circuit diagram of a temperature-measurement system that uses a thermocouple as a sensing element. Using the information in Figure 02, draw the simplified block diagram of a temperature measurement system. (05 marks)

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