

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering



Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: DMX4409 Sensors
Academic Year	: 2024/2025
Date	: 28 th January 2026
Time	: 09.30-12.30
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
 2. This question paper consists of **Five (5)** questions in **Four (4)** pages.
 3. Answer for each question should commence from a new page.
 4. This is a Closed Book Test (CBT).
 5. Answers should be in clear handwriting.
 6. Answer to all questions.
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Question 01

- a) Briefly explain the elements of a measurement system. [5]
- b) Define signal-to-noise ratio (SNR). Explain why a high SNR is desirable in sensor systems. [5]
- c) Clearly explain the difference between **Sensors** and **Transducers** with suitable examples. [5]
- d) Explain how a transducer converts a physical quantity into an electrical signal, using a suitable example. [5]

Question 02

- a) Differentiate between static and dynamic characteristics of sensors [2]
- b) Briefly explain the following sensor characteristics. [6]
 - i. **Resolution**
 - ii. **Accuracy**
 - iii. **Hysteresis**
- c) Explain how the balance or null condition is achieved in null-type sensors. Illustrate your answer with an example. [5]
- d) A load cell provides a linear output voltage from 0 V to 10 mV for a load range of 0–100 kg. The signal is amplified to 0–2 V and converted using a 14-bit ADC.
 - i. Determine the ADC voltage resolution [2]
 - ii. Find the digital output code for a load of 60 kg. [3]
 - iii. Calculate the minimum detectable change in load. [2]

Question 03

- a) A Capacitive Proximity sensor consists of four basic elements. What are these elements? [4]
- b) Briefly explain the configuration of the VR sensor and its output signal characteristics [5]
- c) Briefly explain the modes of detection used by photoelectric sensors with necessary diagrams. [6]
- d) Figure Q3 shows an encoder disk employed in a robotic joint position sensing system.
 - i. Classify the encoder as absolute or incremental and explain the operating principle. [5]
 - ii. Determine the total number of distinct angular positions measurable by this disk. [3]

- iii. Find the smallest angular displacement that can be detected by the encoder.

[2]

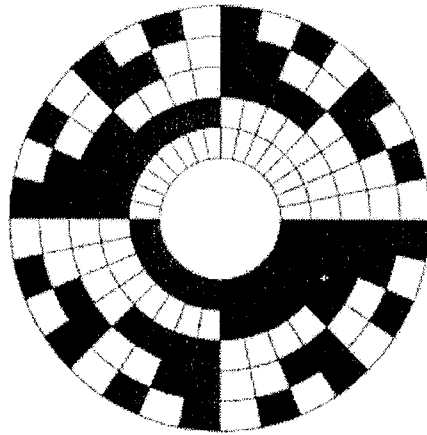


Fig. Q3

Question 04

- a) A voltage source sensor has an output resistance of $2\text{k}\Omega$ and is connected to a voltmeter with an input resistance of $20\text{k}\Omega$.
- Determine the actual voltage measured by the voltmeter if the open-circuit sensor voltage is 5V . [3]
 - Calculate the percentage loading error. [4]
- b) A piezoresistive pressure sensor produces an output voltage range of 0.2 V to 2.2 V for a pressure range of $0\text{--}100\text{ kPa}$. The signal is to be interfaced with a $0\text{--}3.3\text{ V}$ microcontroller ADC.
- Determine the required gain and offset to utilize the full ADC range [3]
 - Suggest a suitable signal conditioning circuit and calculate necessary resistor values. [4]
- c) A thermocouple produces an output of 8 mV over its operating temperature range. The ADC input range is $0\text{--}2.5\text{ V}$.
- Calculate the required gain of the signal conditioning amplifier. [3]
 - Design an op-amp based amplification circuit with suitable resistor values. [5]

- iii. Identify one source of error in thermocouple signal amplification and suggest a mitigation method.

[3]

Question 05

A laboratory wind tunnel uses a variable-speed fan driven by a DC motor. The fan speed must be monitored accurately during aerodynamic experiments. A DC tachometer is mounted on the motor shaft to measure angular speed up to 3000 rpm. The control system requires a stable and noise-free speed feedback signal.

- a) Explain the working principle of a DC tachometer and justify its suitability for this application. [4]
- b) Determine the expected output voltage range of the tachometer if its sensitivity is 20 mV/rpm. [5]
- c) Design a signal conditioning circuit to convert the tachometer output into a ± 10 V standard industrial signal. [5]

(Clearly indicate any assumptions)

- d) Propose a low-pass passive filter to suppress high-frequency noise above 1 kHz and calculate suitable component values. [5]

(Clearly indicate any assumptions)

- e) Discuss the limitations of DC tachometers and suggest one alternative speed sensor for high-speed applications. [3]
- f) Draw a complete sensor circuit diagram showing all sensing, amplifying, filtering, and preprocessing components. [3]

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