

**SENSORS AND TRANSDUCERS
(AEIE 2102)**

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) Which of the followings represents an active transducer?
(a) Thermocouple (b) Thermistor
(c) LVDT (d) Strain gauge.
- (ii) _____ transducer is known as the self-generating transducer.
(a) Active (b) Passive (c) Analog (d) Secondary
- (iii) To measure the temperature of the filament of a burning lamp, the best fit sensor is _____.
(a) Thermocouple (b) Thermistor
(c) RTD (d) Pyrometer
- (iv) The trade name of Iron- Constantan thermocouple is typed as
(a) T (b) J (c) K (d) E
- (v) Following acts as an inverse transducer
(a) Photo diode (b) Transistor
(c) Light emitting diode (d) All of these.
- (vi) LVDT is a/an _____ type of _____ transducer.
(a) inductive, active (b) capacitive, active
(c) inductive, passive (d) capacitive, passive
- (vii) Capacitive transducers relies on a change in
(a) Separation distance between plates (b) Overlapping area of plates
(c) Dielectric constant (d) All of these
- (viii) A Hall-effect sensor detects
(a) Magnetic fields (b) Moisture
(c) Temperature (d) All of these

- (ix) Pt-100, is the most commonly used industry standard of RTD, in which Platinum has a resistance of
 (a) 100 ohm at 0°C (b) 100 ohm at 100°C
 (c) 0 ohm at 100°C (d) 10 ohm at 0°C
- (x) Ultrasonic sensors can measure
 (a) Level of a liquid in a tank (b) Distance between two points
 (c) Flow of a flowing fluid (d) All of these.

Fill in the blanks with the correct word

- (xi) Peltier effect is reverse of ____ effect.
- (xii) Radiation pyrometers are used in the temperature range of _____.
- (xiii) A platinum thermometer has a resistance of 100Ω at 25°C. If the thermometer has a resistance of 200Ω, the corresponding temperature reading will be _____.
- (xiv) The number of capacitor plates in a push-pull type capacitive transducer is _____.
- (xv) One of the applications of a capacitive transducer employing dielectric constant change is _____.

Group - B

2. (a) Differentiate between the following citing suitable examples.
 (i) Transducer and inverse transducer.
 (ii) Active and passive transducer. [[CO3](Remember/LOCQ)]
- (b) Categorize the types of the following transducers:
 (i) 2-junctions formed by two dissimilar materials (ii) Piezo-electric crystal
 (iii) Microphone (iv) Photovoltaic cell. [[CO3](Understand/LOCQ)]
- (c) A voltmeter with an internal resistance 10 MΩ is connected across the output terminals of a linear potentiometer having 100 Ω as the nominal resistance. Calculate the percentage relative error relative to an ideal voltmeter.
[[CO2](Understand/IOCQ)]
4 + 4 + 4 = 12
3. (a) (i) Show and explain a scheme to realize the phase-sensitive transfer characteristic of a LVDT.
 (ii) An application requires a 100 Hz ac source. How can the same be realized by combining an LVDT with a phase-sensitive detector? [[CO3](Analyse/HOCQ)]
- (b) What features should an engineer consider while installing a capacitive type level sensor to gauge the liquid level in a tank? [[CO5](Remember/LOCQ)]
- (c) (i) List some important specifications of a capacitive transducer.
 (ii) Show an arrangement for push-pull arrangement of a capacitive transducer.
[[CO1](Apply/IOCQ)]
(4 + 2) + 2 + (2 + 2) = 12

Group - C

4. (a) (i) Assume a load cell uses a piezoelectric crystal as a load sensor. Someone wants measure the weight of sugar (in a bag). What should be the display?
(ii) Establish the relation between voltage and charge sensitivities of a piezoelectric crystal. *[[CO4](Understand/LOCQ)]*
- (b) A barium titanate piezoelectric transducer has the dimension of 6 mm × 6 mm × 1.5 mm and a voltage sensitivity of 0.012 Vm/N. The barium titanate has a relative permittivity of 1400 and a modulus of elasticity of 12×10^{10} N/m² respectively.
Determine:
(i) Charge generated (ii) Charge sensitivity
(iii) Strain (iv) The output voltage. *[[CO6](Evaluate/IOCQ)]*
(2 + 4) + 6 = 12
5. (a) A large machine is running with a high speed inside a metallic cage. The cage's painted metal door must be shut for the machine to run securely.
(i) What type of sensor should an engineer choose to watch the door's 'open-close' status?
(ii) Present the technical specifications of the sensor used. *[[CO3](Analyse/HOCQ)]*
- (b) How does the size of the metallic object being detected affect an inductive proximity sensor's sensing range? *[[CO4](Remember/LOCQ)]*
- (c) (i) Mention the underlying principle behind the Hall sensor.
(ii) Name the measuring instrument whose operation relies on Hall Effect sensor. *[[CO2](Apply/IOCQ)]*
(2 + 4) + 2 + (2 + 2) = 12

Group - D

6. (a) What is the principle behind the temperature sensing mechanism in an RTD? *[[CO1](Remember/LOCQ)]*
- (b) (i) How do the different RTD configurations affect the measurement accuracy?
(ii) How to check the purity of the material used in Pt 100? *[[CO5](Remember/LOCQ)]*
- (c) Create a scheme to improve the nonlinear resistance versus temperature characteristics of a thermistor. *[[CO6](Create/IOCQ)]*
4 + (4 + 2) + 2 = 12
7. (a) In an optical radiation pyrometer, the observer finds a dark image of the filament on the eye-piece.
(i) What is the significance of such a situation?
(ii) Carry out the actions to be taken by the observer to cause the image of the filament to vanish?
(iii) What is functional temperature range of such a pyrometer? *[[CO2](Apply/IOCQ)]*
- (b) List the specifications of a Thermistor? *[[CO4](Remember/LOCQ)]*

- (c) A thermistor does not have a third wire for ambient temperature correction, unlike a 3-wire RTD. Justify the reason.

[[CO1](Apply/IOCQ)]

(4 + 2) + 3 + 3 = 12

Group - E

8. (a) (i) What is a Geiger Muller counter?
(ii) Explain with a suitable sketch, the working of Geiger-Muller counter. [[CO2](Remember/LOCQ)]
- (b) (i) Interpret the term 'Counter'.
(ii) Draw the labelled Plateau graph of Geiger Muller Counter. [[CO2](Remember/LOCQ)]
- (2 + 5) + (3 + 2) = 12**
9. (a) A stainless steel tank contains oil and water (immiscible liquids). An instrument engineer wants to monitor the level of each liquid in the tank.
(i) Identify an appropriate sensor.
(ii) Explain the working principle of the same. [[CO3](Analyse/IOCQ)]
- (b) Can a GM counter detect X-Rays? Justify your answer? [[CO4](Understand/IOCQ)]
- (c) Suggest a possible sensing method to measure the height of Chandrayan 3's 'Vikram Lander' from the surface of the moon at an instant of time. [[CO5](Understand/IOCQ)]
- (2 + 4) + (1 + 3) + 2 = 12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	44.71	41.67	12.5

Course Outcome (CO):

After the completion of the course students will be able to

1. Acquire the knowledge of mechanical, electromechanical, thermal and magnetic sensors.
2. Explain the working principles of mechanical, electromechanical, thermal and magnetic sensors.
3. Classify sensors based on type of measurands such as strain, force, pressure, displacement, temperature, flow, etc.
4. Design the signal conditioning circuits for the sensors.
5. Justify the selection of Sensors and Transducers in the process of Measurement and instrumentation.
6. Use the sensors in various applications.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.