

FUNDAMENTALS OF SENSORS AND TRANSDUCERS
(AEIE 3221)

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group - A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) An output of 4mv appears across the terminals of LVDT when the core is displaced through a distance of 0.25mm. Determine the sensitivity of the LVDT
(a) 2mv/mm (b) 16 mv/mm
(c) 8mv/mm (d) 6mv/mm
- (ii) Gauge factor of semiconductor type strain gauge is
(a) 2 - 3 (b) 10 - 20
(c) 50 - 200 (d) 6 - 10
- (iii) Thermopiles are generally a collection of _____
(a) RTDs (b) thermistors
(c) thermocouples (d) pyrometers.
- (iv) K - type Thermocouple is made up of
(a) Cu, Constantan (b) Chromel, Constantan
(c) Pt, Pt Rhodium (d) Chromel, Alumel.
- (v) Which of the following transducer can also be used as inverse transducer?
(a) LVDT (b) Piezoelectric transducer
(c) Strain gauge (d) Capacitive transducer.
- (vi) Which of the following transducer is an active transducer?
(a) Strain gauge (b) Thermocouple
(c) Photodiode (d) Resistive potentiometer.
- (vii) To minimize self- heating problem of RTD the current flowing through it is limited between
(a) 1Amp - 2Amp (b) 15mA - 20 mA
(c) 2mA - 8mA (d) 50mA - 100mA.

- (viii) The RTD, assigned PT100, refers to
(a) 100 Ω at 100°C (b) 100 Ω at 0°C
(c) 0 Ω at 0°C (d) 0 Ω at 100°C.
- (ix) Example of synthetic piezo material is
(a) Quartz (b) Lithium sulphate
(c) Rochelle salt (d) None of the above.
- (x) In case of capacitive type level measurement with increase in liquid level, capacitance
(a) increases (b) decreases linearly
(c) decreases exponentially (d) remains constant

Group- B

2. (a) For of a strain gauge, build a relationship of gauge factor with Poisson's ratio and piezoresistive coefficient. How column type load cell is used to measure weight? [(CO2)(Analyze/IOCQ)]
- (b) An N-type semiconductor strain gauge has a nominal resistance of 1000 ohms and a gauge factor of -200 at 25°C. Find the resistance of the strain gauge in ohms when subjected to a strain of $+10^{-4}$ m/m at the same temperature. [(CO3)(Evaluate/HOCQ)]
- (c) What is the maximum sensitivity of a 4 cm, 5 W, 360° rotary type potentiometer having total resistance 1000 ohms? [(CO1)(Analyze/IOCQ)]
(4 + 3) + 3 + 2 = 12
3. (a) Design the equivalent circuit of LVDT and find out the phase shift between the output and input voltage of LVDT without load at secondary. [(CO1) (Evaluate/HOCQ)]
- (b) An LVDT is used for measuring the deflection of a bellows element. The sensitivity of LVDT set up is 8 v per mm. The bellows element is deflected by 0.15mm by a pressure of 0.2×10^6 N/m². Determine the sensitivity of the LVDT in V per N/m² and the pressure when the voltage output of LVDT is 2.5v. [(CO6)(Evaluate/HOCQ)]
- (c) Design and explain a scheme to measure pressure using LVDT. [(CO2)(Remember/LOCQ)]
5 + 4 + 3 = 12

Group - C

4. (a) What is piezoelectric effect? Show how the output voltage of piezoelectric transducer is related to the charge sensitivity of the crystal. [(CO4)(Remember/LOCQ)]
- (b) With a neat diagram of equivalent circuit of piezoelectric transducer for the measurement of displacement find the expression of transfer function. [(CO2)(Analyze/LOCQ)]

- (c) A Piezoelectric crystal has a thickness of 2.5 mm and a voltage sensitivity of 0.05 Vm/N. Determine the output voltage when it is subjected to a pressure of 1.6×10^6 N/m². [[CO6](Evaluate/HOCQ)]
(2 + 3) + 4 + 3 = 12
5. (a) Design and explain how capacitive transducer is used to measure proximity in terms of output voltage with suitable signal conditioning circuit. [[CO1](Analyze/IOCQ)]
- (b) How capacitive transducer is used to measure the level of an electrically conducting liquid in a metallic tank. [[CO6](Understand/LOCQ)]
- (c) How is torque measured by magnetostrictive transducer? [[CO2](Understand/LOCQ)]
4 + 5 + 3 = 12

Group - D

6. (a) State the thermoelectric laws of thermocouple? [[CO2](Remember/LOCQ)]
- (b) Applying the suitable thermoelectric law prove that the connection between thermocouple cold junction and the measuring device using copper wire has no effect on the output voltage of thermocouple. [[CO4](Analyze/LOCQ)]
- (c) Design and explain a software technique for temperature compensation of thermocouple. [[CO4](Evaluate/IOCQ)]
3 + 4 + 5 = 12
7. (a) The resistance of a NTC type thermistor is 10 k Ω at 25°C. Find the resistance of the thermistor at 0°C, provided the thermistor constant β is 4000. [[CO2](Evaluate/HOCQ)]
- (b) How an unknown temperature is measured by RTD with its proper signal conditioning circuit in deflection mode? [[CO3](Analyze/IOCQ)]
- (c) Design a 3 wire RTD connection for signal transmission and prove why it is advantageous over 2 wire RTD connection. [[CO1](Analyze/IOCQ)]
2 + 4 + (2 + 4) = 12

Group - E

8. (a) Establish a relationship between responsivity and quantum efficiency of photodiode. [[CO4](Remember/LOCQ)]
- (b) A photodiode has a quantum efficiency of 60% when photons of energy 1.2×10^{19} J are incident upon it. Find out the operating wavelength of the photodiode. [[CO4](Analyze/HOCQ)]
- (c) Explain the direct band gap semiconductor based light emitting diode with a neat diagram. [[CO3](Understand/LOCQ)]
5 + 3 + 4 = 12
9. (a) Design a gas vacuum type photoemissive cell and explain the operation of it. [[CO1](Analyze/LOCQ)]

- (b) Describe the process of detecting nuclear radiation by Geiger Muller counter. [(C06)(Analyze/LOCQ)]
- (c) Explain the operation of a photovoltaic cell with a neat diagram. What are smart sensors? [(C05)(Understand/LOCQ)]
- 4 + 4 + (3 + 1) = 12**
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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	50	29	21

Course Outcome (CO):

After the completion of the course students will be able to

1. Use different methods for converting a physical parameter into an electrical quantity.
2. Select the best fit transducers, including those for measurement of temperature, strain, motion, position and light intensity.
3. Choose proper sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like displacement, stress, force, acceleration, flow, etc.
4. Acquire knowledge on high temperature sensing systems used in steel, aluminium, and copper plants.
5. Learn basic principle of smart sensors.
6. Identify different type of sensors used in real life applications and know their importance.

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