

**INTRODUCTION TO SMART SENSING TECHNOLOGY FOR AI
(AEIE 2206)**

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) Which of the following transducer can also be used as inverse transducer?
(a) LVDT (b) Piezoelectric transducer
(c) Strain gauge (d) Capacitive transducer.
- (ii) Example of synthetic piezoelectric material is
(a) Quartz (b) Rochelle salt
(c) Lithium sulphate (d) Tourmaline.
- (iii) An 'n' type semiconductor strain gauge has a nominal resistance of 1000 ohms and a gauge factor of -100 at 25° c in ohms. When subjected to a tensile strain of 100 micrometer/meter at the same temperature, the resistance of the strain gauge is
(a) 1010 ohms (b) 1020 ohms (c) 990 ohms (d) 900 ohms.
- (iv) For translational wire wound resistive potentiometer having 150 turns per cm, the resolution is
(a) 0.05 cm (b) 0.0067 cm (c) 0.001 cm (d) 0.01 cm.
- (v) In capacitive microphone capillary tube is used to
(a) equalize pressure to the diaphragm
(b) reduce deflection of the membrane
(c) get steady output
(d) reduce error in measurement.
- (vi) 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.
- (vii) Best accuracy in measurement available for RTD is in
(a) 2-wire configuration (b) 3-wire configuration
(c) 4-wire configuration (d) Any of the above.

- (viii) Thermopiles are generally a collection of _____
(a) RTDs (b) Thermistors
(c) Thermocouples (d) Pyrometers.
- (ix) _____ sensor is used for tracking rotation or twist.
(a) Proximity (b) Temperature
(c) Pressure (d) Gyroscope
- (x) What are the parts that are present in the accelerometer sensor?
(a) Capacitor sensor
(b) Piezoelectric effect, analog display, digital display
(c) Piezoelectric effect and capacitor sensor
(d) Capacitor sensor, digital Display.

Group- B

2. (a) What is loading effect for a resistive type potentiometer? How it affects the output voltage of resistive potentiometer for the measurement of linear displacement. *[[CO1] (Analyze/IOCQ)]*
- (b) A strain gauge having nominal resistance 100 ohms and gauge factor 2 is cemented on a cantilever beam having modulus of elasticity $Y = 205 \times 10^6$ KN/m² and cross sectional area 5.5 cm². The strain gauge is connected to one arm of a Wheatstone Bridge having supply voltage 7.5 volt. The unbalance voltage of the bridge for the axial force given to the steel bar is 0.55 mV. Find the force applied to the cantilever beam. *[[CO1](Evaluate/HOCQ)]*
- (c) Design and explain any temperature compensation circuit for strain gauge while measuring strain. *[[CO6] (Analyze/IOCQ)]*
- (2 + 4) + 4 + 2 = 12**
3. (a) Build a relationship of gauge factor of a strain gauge with Poisson's ratio and piezoresistive coefficient. *[[CO2] (Analyze/IOCQ)]*
- (b) Find the sensitivity of a parallel plate type capacitive transducer for measuring linear displacement. *[[CO1] (Evaluate/HOCQ)]*
- (c) With necessary circuit diagram explain the operation of a capacitive type proximity pick-up. *[[CO3] (Remember/LOCQ)]*
- 4 + 4 + 4 = 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. *[[CO2] (Understand/LOCQ)]*
- (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 0.15 mm 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 2.5 V. *[[CO3] (Evaluate/HOCQ)]*

- (c) Draw the phase demodulator circuit of LVDT and explain the operation of it. [[CO6] (Analyse/IOCQ)]
4 + 4 + 4 = 12
5. (a) Draw the equivalent circuit of piezoelectric transducer for the measurement of displacement and find the expression of its transfer function. [[CO4] (Analyse/IOCQ)]
(b) What is Hall field? Explain how Hall field is developed in an n-type Hall element. [[CO2] (Understand/LOCQ)]
(c) A Hall Effect element used for measuring a magnetic flux density gives an output voltage of 12.5 mV. The element is made up of Silicon and is 4.5 mm thick and carries a current of 5 A. The Hall coefficient is 4.1×10^{-6} Vm A-Wb/m². Find out the magnetic flux density. [[CO3] (Evaluate/HOCQ)]
4 + (2 + 3) + 3 = 12

Group - D

6. (a) What do you mean by law of intermediate conductors for thermocouple? What is the consequence of this law? [[CO5] (Remember/LOCQ)]
(b) Can thermocouples be used to harvest energy from sunlight? Explain with necessary schematic diagram. [[CO3] (Analyse/IOCQ)]
(c) Describe with neat sketch how photodiode can be used to measure angular speed of a rotating shaft. [[CO6] (Create /HOCQ)]
(2 + 1) + 5 + 4 = 12
7. (a) How do the temperature-resistance characteristics of Pt100 and Pt500 differs? Explain with necessary characteristics curve. [[CO4] (Analyse/IOCQ)]
(b) A thermistor showing resistances 10 K ohm at 25°C. Its characteristic constant is 4000°K. At what temperature the thermistor will show a resistance of 3.5 K Ohm? [[CO5] (Evaluate/HOCQ)]
(c) Design a circuit for burnt out detection of a thermocouple. [[CO6] (Apply/IOCQ)]
4 + 4 + 4 = 12

Group - E

8. (a) State the features of the intelligent instrument. [[CO1] (Remember/LOCQ)]
(b) Draw and describe the architecture of a smart transmitter. [[CO2] (Understand/LOCQ)]
(c) What do you understand of a smart sensor network? [[CO2] (Understand/LOCQ)]
2 + 6 + 4 = 12
9. (a) Draw and describe the schematic illustration of MEMS components. [[CO1] (Remember/LOCQ)]
(b) Explain working of piezoresistive micro-accelerometers with necessary schematic diagram. [[CO2] (Analyse/IOCQ)]
(c) Explain working of capacitive micro-accelerometers with necessary circuit diagram. [[CO2] (Analyse/IOCQ)]
4 + 4 + 4 = 12

| <i>Cognition Level</i> | <i>LOCQ</i> | <i>IOCQ</i> | <i>HOCQ</i> |
|--------------------------------|--------------|--------------|--------------|
| <i>Percentage distribution</i> | <i>33.33</i> | <i>42.71</i> | <i>23.96</i> |

Course Outcome (CO):

After the completion of the course students will be able to

1. Identify the sensors for measurement of various physical parameters like displacement, pressure, force, temperature etc.
2. Interpret the operation of various sensors/transducers used for measurement of physical parameters.
3. Apply their knowledge to select right kind of sensors/transducer for application in hand.
4. Analyze the response of the sensors/transducers for fruitful information.
5. Judge the performance of the sensors.
6. Design signal conditioning unit for the sensors.

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