

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) Which of the followings forms the basis of Electrical signal in a transducer?
(a) Current (b) Resistance
(c) Inductance (d) All of (a), (b) & (c).
- (ii) Which of the followings is self generating transducer?
(a) Primary (b) Inverse
(c) Passive (d) Active.
- (iii) The trade name of Chromel-Alumel thermocouple is typed as
(a) T (b) J
(c) K (d) R.
- (iv) The sensor that produces a large change in its resistance with temperature, but is very non-linear is
(a) a semiconductor temperature sensor
(b) a platinum resistance thermometer
(c) thermistor
(d) total radiation pyrometer.
- (v) Which one of the followings can act as an inverse transducer?
(a) Electrical resistance potentiometer (b) LVDT
(c) Capacitive transducer (d) Piezoelectric crystal.
- (vi) Dummy strain gauges are used for
(a) compensation of temperature changes (b) increasing bridge sensitivity
(c) calibration of strain gauges (d) all of (a), (b) & (c).
- (vii) Radiation pyrometers are used in the temperature range of _____.
(a) 0 – 550 °C (b) 550 – 1000 °C
(c) -250 – 550 °C (d) 1500 – 2500 °C

- (viii) Which of the following optical transducers is an active transducer?
 - (a) Photo-emissive cell
 - (b) Photo-diode
 - (c) Photo-transistor
 - (d) Photo-voltaic cell.
- (ix) Input signal to smart sensor is fed from _____
 - (a) Power supply
 - (b) Transducer
 - (c) Volt meter
 - (d) All of the mentioned in (a), (b) & (c).
- (x) A light emitting diode (LED) emits light when it is ____biased and a photodiode provides sensible current when it is ____ biased.
 - (a) forward, reverse
 - (b) forward, forward
 - (c) reverse, forward
 - (d) reverse, reverse

Group - B

- 2. (a) Differentiate between the following citing suitable examples.
 - (i) Transducer and inverse transducer
 - (ii) Active and passive transducer
 - (iii) Primary and secondary transducers
 - (iv) Analog and digital transducers. [[CO6](Remember/LOCQ)]
- (b) What type of transducer a piezoelectric crystal is? Can the Piezo-electric transducers be used as static and dynamic force sensors? Justify. [[CO2](Remember/LOCQ)]

8 + (1 + 3) = 12

- 3. (a) In a full bridge, how many strain gauges are used? Derive the expression of sensitivity of a full bridge configuration employing strain gauge(s). [[CO4](understand/LOCQ)]
- (b) Is it necessary any temperature compensation for full bridge configuration? Justify your answer. [[CO2](Understand/IOCQ)]
- (c) The operation of a LVDT depends on the mutual inductance of coils. In Fig.1, insert dots to the coils to realize a differential output. [[CO1](Analyze/IOCQ)]

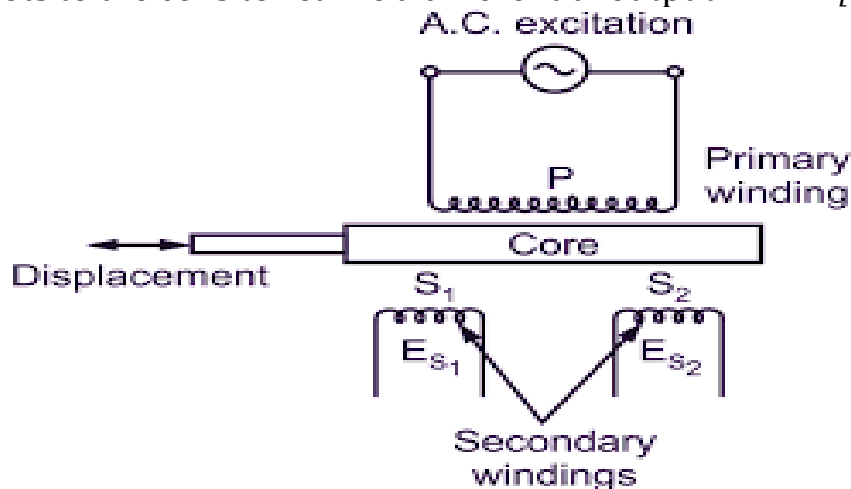


Fig.1

- (d) Assume ac excitation and core movement frequencies are 1 KHz and 10 Hz respectively. What should be the frequency of the LVDT's differential output in Fig. 1? [[CO1] (Analyze/IOCQ)]

(1 + 5) + 2 + 2 + 2 = 12

Group - C

4. (a) Justify the statement “Piezoelectric effect is direction sensitive” with appropriate diagram. [[CO4](Evaluate/IOCQ)]
(b) A commission engineer mounts two piezo-electric transceivers along the vertical axis of the horizontally mounted liquid carrying pipeline to monitor the velocity of a flowing fluid. What will be the velocity information? Justify. [[CO4](Remember/HOCQ)]
(c) Suggest any other application from the set-up in question (4 b). [[CO4](Remember/HOCQ)]
(d) Present some of the applications of piezoelectric crystals. [[CO4](Remember/LOCQ)]
4 + 4 + 2 + 2 = 12
5. (a) Show a push-pull type arrangement of a capacitive transducer. How does it work? [[CO4](Understand/LOCQ)]
(b) Find an expression to show the input-output response of a push-pull type capacitive transducer. [[CO2](Analyze/IOCQ)]
(c) Produce a scheme to measure the moisture content using a capacitive transducer. [[CO1](Create/HOCQ)]
(1 + 3) + 4 + 4 = 12

Group - D

6. (a) Define the Seebeck effect. What type of transducer is a device that relies on Peltier effect? [[CO4](Remember/LOCQ)]
(b) Generate a scheme to measure the average temperature of a distillation tower using three thermocouples placed at the top, centre and bottom. Draw the electrical equivalent circuit of such an arrangement of thermocouples. [[CO1](Create/HOCQ)]
(c) Specify at least two thermocouples in terms of trade name, generic name and temperature range. Plan to check the health of a thermocouple. [[CO1](Apply/HOCQ)]
(2 + 1) + 4 + (3 + 2) = 12
7. (a) How to choose the most appropriate two materials for the thermocouples? Explain with examples. [[CO3](Analyze/IOCQ)]
(b) Specify at least three thermocouples in terms of trade name, generic name and temperature range. [[CO3](Remember/Understand/LOCQ)]
(c) How does one check the health of a thermocouple? [[CO3](Analyze/HOCQ)]
4 + 6 + 2 = 12

Group - E

8. (a) A costly tachometer-based RPM (Rotation per minute) sensor of a rotating motor is malfunctioning.

An engineer wants to replace that with a low cost speed sensor. He goes to the engineering store and finds an LED-Photodiode module. Create and explain a scheme for measurement of RPM of the motor using the LED-Photodiode module. [[CO4](Create/HOCQ)]

- (b) LDR shows a non-linear response between light intensity and resistance. Show a scheme to make the response fairly linear. Derive an expression that supports the scheme. [[CO3](Understand/LOCQ)]

(2 + 4) + (2 + 4) = 12

9. (a) What is a smart sensor? Mention some of its applications.

[[CO5](Remember/LOCQ)]

- (b) Construct the block diagram of a smart Sensor.

[[CO5](Understand/LOCQ)]

- (c) Differentiate between Normal Sensor & Smart Sensor.

[[CO5](Analyse/IOCQ)]

(2 + 2) + 4 + 4 = 12

<i>Cognition Level</i>	<i>LOCQ</i>	<i>IOCQ</i>	<i>HOCQ</i>
<i>Percentage distribution</i>	48.96	22.92	28.12

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.*