

**FUNDAMENTALS OF SENSORS AND TRANSDUCERS
(AEIE 3221)**

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 following is a digital transducer?
(a) Thermistor (b) LVDT (c) Encoder (d) RTD.
- (ii) In an instrument, the smallest measurable input is known as
(a) Threshold (b) Resolution (c) Sensitivity (d) Dead zone
- (iii) The gauge factor of semiconductor strain gauge is higher than ordinary metal wire resistive strain gauge because of
(a) Piezoresistive (b) Temperature effect
(c) Zener breakdown in the material (d) Its small size
- (iv) The least suitable transducer for static pressure measurement is
(a) Semiconductor strain gauge (b) Metal wire strain gauge
(c) Variable capacitive transducer (d) Piezoelectric transducer.
- (v) Length change of a ferrous material in a magnetic field is called
(a) Villari effect (b) Magnetostriction
(c) Wiedeman effect (d) Matteucci effect.
- (vi) In optical pyrometer, the temperature is measured by
(a) the thermoelectric effect
(b) photoelectric effect
(c) comparison of brightness of the source with that of the standard source
(d) none of these.
- (vii) Thermocouple measurement effect error arise from
(a) poor junction connections
(b) thermal gradients
(c) de-calibration of thermocouple wires
(d) all of the above.

- (viii) In a variable reluctance type inductive transducer, the coil has an inductance of 5mH, where the iron piece is 1.5mm. When it is moved towards the electromagnet by 0.025mm, the coil inductance will be
 (a) 6.02 mH (b) 3.98 mH
 (c) 5.08 mH (d) 4.92 mH.
- (ix) A certain crystal has a coupling coefficient of 0.32. How much electrical energy must be applied to produce an output of 7mJ of mechanical energy?
 (a) 21.9 mJ (b) 2.24mJ
 (c) 7 mJ (d) 21.9 mJ.
- (x) Ultrasound is generally generated by
 (a) Direct piezoelectric effect (b) Inverse piezoelectric effect
 (c) Piezoresistive effect (d) Faraday effect.

Fill in the blanks with the correct word

- (xi) RTD is a (linear/nonlinear) device _____.
- (xii) A thin circular wire of soft iron has a gauge factor 3.8. The poisson ratio of the soft iron is? _____.
- (xiii) A unity ratio quarter bridge strain measuring circuit produces an output of 1 mV for a strain 500 micro strain when the bridge excitation is 4 V .the gauge factor of the element is _____.
- (xiv) Bimorph is made of _____ materials.
- (xv) A piezoelectric crystal measuring 6mm* 6mm*1.8mm is used to measure a force. Its voltage sensitivity is 0.055 Vm/N. what is the force if voltage developed is 120 V. _____.

Group - B

2. (a) What are the basic component of a potentiometer. [[CO1](Remember/LOCQ)]
 (b) When a load R_L is connected in parallel with potentiometer circuit (R_p) excited by V_{in} , hence derive the relation between the output and input. [[CO2](Apply/IOCQ)]
 (c) A resistance wire strain gauge with gauge factor of 2 is bonded to a steel structure subject to a stress of 100MN/m². The modulus of elasticity of that structure of hat structure is 200GN/m². Calculate the percentage change in value of the gauge resistance due to applied stress. [[CO2](Apply/IOCQ)]
2 + 5 + 5 = 12
3. (a) Describe with proper diagram the operation of LVDT for measuring displacement. [[CO1](Remember/LOCQ)]
 (b) Hence derive the relation between input 'x' and output 'e_o' from the electrical circuit diagram of LVDT and show that 180° phase is changed. [[CO2](Apply/IOCQ)]
3 + (6 + 3) = 12

Group - C

4. (a) If a capacitor is hollow cylindrical shape, derive its capacitance value. [[CO6](Analyse/HOCQ)]
- (b) A capacitive transducer with its plate separation of 0.05mm under static condition has a capacitance $5 * 10^{-12}$ F. Determine the displacement that causes a change of capacitance of $0.75 * 10^{-12}$ F. [[CO3](Apply/IOCQ)]
- (c) Show that the ultrasonic flow measurement system, using frequency shift is independent of the sonic velocity. [[CO2](Apply/IOCQ)]
- 4 + 4 + 4 = 12**
5. (a) What are the different types of materials available to manufacture piezoelectric sensors? Define charge sensitivity? [[CO3](Remember/LOCQ)]
- (b) A barium titanate block has the dimensions 5mm* 5mm* 2.5mm. The force acting on it is 5N. The charge sensitivity of barium titanate is 150 pC/N and its permittivity is $12.5 * 10^{-9}$ F/m. If the modulus of elasticity of barium titanate is $12 * 10^6$ N/m², then calculate the strain induced. [[CO3](Apply/IOCQ)]
- (4 + 2) + 6 = 12**

Group - D

6. (a) What is cold junction compensation technique of thermocouple? What is the software compensation method of cold junction compensation technique of thermocouple? [[CO4](Remember/LOCQ)]
- (b) Why platinum is preferred to other materials for making RTD? Draw the complete temperature measurement scheme using RTD with instrumentation amplifier. [[CO4](Analyse/HOCQ)]
- (2 + 4) + (2 + 4) = 12**
7. (a) When is a thermistor selected as a temperature sensor ? Draw the temperature characteristics curve of thermistor. [[CO4](Remember/LOCQ)]
- (b) What are the advantages of using radiation pyrometer at high temperatures? [[CO4](Remember/LOCQ)]
- (c) If at 25°C, a platinum wire has a resistance of 100Ω, what length would be required for a wire of diameter 0.005 cm. The resistivity is 10.60 μΩ cm. What would be its resistance at 500°C and $\alpha = 0.00397$? [[CO4](Apply/IOCQ)]
- (2 + 2) + 3 + 5 = 12**

Group - E

8. (a) Describe the basic principle of LDR sensor. Draw the characteristics curve of LDR. [[CO2](Remember/LOCQ)]
- (b) A photo transducer is connected with a 2kΩ collector load. What will be the output voltage when the illumination level is zero? If the illumination level is 200W/m² then what will be output voltage? [[CO6](Apply/IOCQ)]
- (4 + 2) + 6 = 12**

9. (a) The light wavelength that Si can absorb is 1.12 μm . What is the approximate band gap of Si? *[[CO2] (Analyse/HOCQ)]*
- (b) What is Geiger –Muller counter? How does it function? Explain how the counting efficiency of a G-M counter for α particle, β particles and γ rays can be increased. *[[CO1](Remember/LOCQ)]*
- (c) How is the nonlinearity taken care of in a present day smart sensor? *[[CO5](Apply/IOCQ)]*
- 3 + (2 + 2 + 2) + 3 = 12**
-

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	37.5	48.96	13.54

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.*