SENSORS AND TRANSDUCERS
(AEIE 2202)

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) The units of relative permeability and free space permeability are
(a) farad/meter and dimensionless respectively
(b) dimensionless and farad/meter respectively
(c) farad/meter and farad/meter respectively
(d) none has any unit.

(ii) Capacitive transducer can be used for the measurement of liquid level, the principle of the operation used in this case is
(a) change of capacitance with the change of distance between the plates
(b) change of the area of the plates
(c) change of dielectric strength
(d) none of the above.

(iii) Poisson's ratio for a metal is 0.35. Neglecting piezo-resistance effect, the gauge factor of a strain gauge made of this metal is
(a) 0.35 (b) 0.65 (c) 1.35 (d) 1.70.

(iv) Magnetostrictive transducer can be used to measure _____
(a) force (b) acceleration
(c) torque (d) all of these.

(v) Dummy strain gauges are used for
(a) calibration of strain gauges (b) compensation of temperature
(c) increasing bridge sensitivity (d) all of these.

(vi) Piezoelectric crystals are used for measurement of _____ changes.
(a) static (b) dynamic
(c) both (a) and (b) (d) any of these.

(vii) Which of the optical transducer is an active transducer?
(a) Photoemissive cell (b) Photo diode
(c) Photo transistor (d) Photovoltaic cell.

(viii) Hall Effect is clearly visible in _____
(a) pure conductors (b) semiconductors
(c) super conductors (d) metals.

(ix) Inductive proximity sensors can be effective only when the objects are of _____ materials.
(a) ferromagnetic (b) paramagnetic
(c) diamagnetic (d) all of these.

(x) In an LVDT, the residue voltage is observed due to
(a) harmonics and stray capacitance (b) creeping error
(c) hysteresis loss (d) eddy current loss.

Group – B

2. (a) Show an arrangement to extract the amplitude as well as the phase information contained in the A.C. output of an LVDT. How do you reduce the iron losses in an LVDT?

(b) An engineer wrongly connects the terminals of the secondary windings of an LVDT. Show the output voltage versus displacement pattern observed by the engineer. What is the importance of dot convention in an LVDT? What are the basic features of an instrumentation amplifier?

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

3. (a) A strain gauge has a nominal resistance of 600Ω and a gauge factor of 2.5. The strain gauge is connected in a dc bridge with other resistance of 600Ω each. A 4V battery excites the bridge. If the strain gauge undergoes a strain of 100μm/mm, find the magnitude of the bridge output. Mention the bridge configuration.

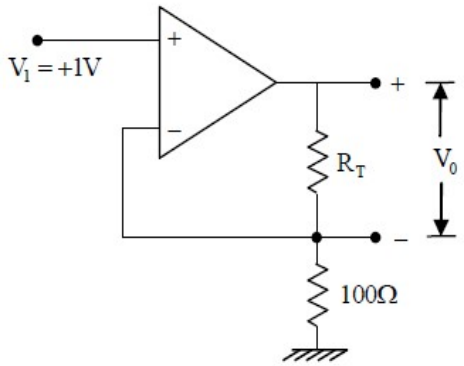
(b) Show a neat and labeled diagram of the push-pull arrangement of a capacitive transducer and prove that the change in capacitance has a linear relation with the displacement.

(5 + 1) + (2 + 4) = 12

Group – C

4. (a) A barium titanate piezoelectric transducer has dimensions of 6 mm × 6 mm × 1.5 mm and a voltage sensitivity of 0.012 Vm/N. Relative

permittivity c ulus of elasticity of the barium tit
Determine:
(i) the outp
(ii) charge s
(iii) strain
(iv) charge
force ap



ıe transducer. The

(b) What is the equivalent circuit. Derive an e y making suitable simplifying as

6 + (1 + 1 + 4) = 12

5. (a) What do you mean by negative and positive magneto-resistive effects?

   (b) How will you measure acceleration using magneto-resistive transducer?

(2 + 4) + 6 = 12

Group – D

6. (a) Draw an equivalent electrical circuit of a thermopile. How can one measure an average temperature of a reaction column using thermocouples? Explain it with a suitable electrical circuit.

   (b) A thermocouple with reference junction temperature at 20^0C gives an output of 5 mV. If the thermocouple sensitivity is 50μV/^{0}C, then calculate the measured temperature. What is a 'burnout' feature of a thermocouple?

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

7. (a) In an engineering store, many good and bad RTDs are present. How would an engineer segregate the good and the bad RTDs?

   An RTD may be specified as Pt 75, Pt 100, Pt 1000, Pt 10000 etc. In a datasheet of an RTD the number, following Pt is missing (Pt___). How can one find the missing number?

   (b) In the figure given, R_T is a Pt 100 RTD temperature sensor whose characteristic resistance-temperature relation is given by $R_T = R_0(1+\alpha T)$ where, α for platinum is 0.00385/^{0}C and T denotes the temperature of the hot element. Assuming an ideal Op-Amp, find the value of T when the value of V_0 is 1.39V.

(3 + 3) + 6 = 12

Group – E

8. (a) Under which conditions the ultrasonic sensor is used for velocity measurement of a flowing fluid. Using an ultrasonic sensor, draw and explain a scheme to measure the velocity of a flowing liquid, compensating the error due to the variation of ultrasonic velocity.

   (b) Describe the working of the Scintillation counter. Explain the term "counter" in Scintillation counter.

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

9. Write short notes on any two of the following:
   (i) Optical pyrometry
   (ii) Inductive proximity sensor
   (iii) Geiger-Müller counter
   (iv) Photomultiplier tube
   (v) Photodiode and its applications.

6 + 6 = 12