

**SENSORS AND TRANSDUCERS**  
**(AEIE 2102)**

**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. The sensitivity of the LVDT is  
(a) 2mv/mm      (b) 16 mv/mm      (c) 8mv/mm      (d) 6mv/mm
- (ii) The gauge factor of a strain gauge having poisson's ratio 1.8 is  
(a) 3.2              (b) 4.6              (c) 5              (d) 6
- (iii) Which of the following sensor is used to measure unknown magnetic field?  
(a) Thermocouple                      (b) LDR  
(c) Hall Transducer                      (d) Capacitive transducer
- (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) A quarter bridge strain measuring circuit produces an output of 2 mV for a strain of 500 micro strain when the bridge excitation voltage is 5 volts. The gauge factor of the element is  
(a) 1.2              (b) 2.5              (c) 3.2              (d) 4.2
- (vii) 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
- (viii) For rotational wire wound resistive potentiometer having 150 turns per cm and diameter D of the circular construction, angular resolution is  
(a) 0.326/D      (b) 0.764/D      (c) 360/D      (d) 0.234/D

- (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) A strain gauge having nominal resistance of 100 ohms and gauge factor 2. It is cemented on a cantilever beam having modulus of elasticity  $Y=205 \times 10^6$  KN/m<sup>2</sup> and cross sectional area 5.5 cm<sup>2</sup>. 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. [(CO6) (Evaluate/HOCQ)]
- (b) Build a scheme to measure fluid velocity in a pipe line using strain gauge with proper explanation. [(CO5) (Analyse/IOCQ)]
- (c) Design and explain any temperature compensation circuit for strain gauge while measuring strain. What is loading effect of a resistive potentiometer? [(CO4)(Create/HOCQ)]
- 4 + 3 + (3 + 2) = 12**
3. (a) Find the sensitivity of a parallel plate type capacitive transducer for measuring linear displacement. [(CO2) (Evaluate/HOCQ)]
- (b) Design a scheme to measure the level of an electrically conducting liquid in a metallic tank by using capacitive transducer. [(CO5)(Analyse/IOCQ)]
- (c) Design and explain a scheme to measure pressure using LVDT. [(CO5)(Create/HOCQ)]
- 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) (Analyze/IOCQ)]
- (b) Draw the equivalent circuit of piezoelectric transducer for the measurement of displacement and find the expression of its transfer function. [(CO4) (Evaluate/HOCQ)]
- (c) A Piezoelectric crystal has a thickness of 3.5 mm and a voltage sensitivity of 0.07Vm/N. Determine the output voltage when it is subjected to a pressure of  $3.6 \times 10^6$  N/m<sup>2</sup>. [(CO6)( Evaluate/HOCQ)]
- (2 + 3) + 4 + 3 = 12**

5. (a) What is Hall field? Explain how Hall field is developed in an n-type Hall element. [(CO1) (Understand/LOCQ)]
- (b) Design a scheme for non-contact type current measurement by using Hall Effect transducer. (CO5) (Analyze/IOCQ)]
- (c) How is torque measured by magneto strictive transducer? [(CO2)(Understand/LOCQ)]

**(2 + 3) + 4 + 3 = 12**

**Group - D**

6. (a) Why cold junction compensation is required in thermocouple? Design a cold junction compensation circuit for continuous temperature measurement. [(CO2) (Analyze/IOCQ)]
- (b) Calculate the temperature of a specimen, if the cold junction temperature is 2° C and voltmeter gives 48μv for the specimen temperature. A chart of temperature vs voltage of the thermocouple when cold junction at 0° C is given below

Temperature (° C)	Voltage (μv)
0	35
10	45
20	55
30	65
40	75
50	85
60	95
70	105

[(CO5) (Evaluate/HOCQ)]

- (c) State the law on the basis of which radiation pyrometer works. Describe the operation of a radiation type pyrometer with a neat diagram. [(CO1)( Understand/LOCQ)]
7. (a) The resistance of a NTC type thermistor is 10kΩ at 25°C. Find the resistance of the thermistor at 0°C , provided the thermistor constant β is 4000. [(CO3) (Evaluate/HOCQ)]
- (b) How an unknown temperature is measured by RTD with its proper signal conditioning circuit in deflection mode? [(CO4) (Analyze/IOCQ)]
- (c) Design a 3 wire RTD connection for signal transmission and prove why it is advantageous over 2 wire RTD connection. [(CO4)( Analyze/IOCQ)]

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

**Group - E**

8. (a) Explain the operation of light dependent resistor. What is the relationship between the dark resistance of it and the light intensity falling on it? [(CO1) (Understand/LOCQ)]
- (b) What are the absorption coefficient and quantum efficiency of a photodiode? [(CO2) (Understand/LOCQ)]
- (c) When  $2 \times 10^{11}$  photons each with a wavelength of  $0.70 \mu m$  are incident on a photodiode, on average  $1.0 \times 10^{11}$  electrons are collected at the terminals of the device. Determine the quantum efficiency and the responsivity of the photodiode at  $0.70 \mu m$ . [(CO6)(Evaluate/HOCQ)]
- (4 + 1) + (2 + 2) + 3 = 12**
9. (a) Design a gas vacuum type photo emissive cell and explain the operation of it. [(CO1) (Analyze/IOCQ)]
- (b) Construct the set-up of measuring intensity of nuclear radiation by Scintillation counter with proper explanation. [(CO2) (Create/HOCQ)]
- (c) Design a scheme to measure fluid flow rate in a pipe line by transit time response type ultrasonic flow meter. [(CO5)(Analyze/IOCQ)]
- 4 + 4 + 4 = 12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	21.88%	39.58%	38.54%

**Course Outcome (CO):**

After the completion of the course students will be able to

1. Acquire the knowledge of mechanical, electromechanical, thermal and magnetic sensors.
2. Explain the working principles of mechanical, electromechanical, thermal and magnetic sensors.
3. Classify sensors based on type of measurands such as strain, force, pressure, displacement, temperature, flow, etc.
4. Design the signal conditioning circuits for the sensors.
5. Justify the selection of Sensors and Transducers in the process of Measurement and instrumentation.
6. Use the sensors in various applications.

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

Department & Section	Submission Link
AEIE	<a href="https://classroom.google.com/c/NDA2MDA4OTc1NTUx/a/NDc1MTQzMjY4OTAy/details">https://classroom.google.com/c/NDA2MDA4OTc1NTUx/a/NDc1MTQzMjY4OTAy/details</a>