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3 (Sem-5/CBCS) PHY HE 1

2023

**PHYSICS**

(Honours Elective)

Paper : PHY-HE-5016

*(Experimental Techniques)*

Full Marks : 60

Time : Three hours

***The figures in the margin indicate full marks for the questions.***

1. Choose the correct answer from the given options : 1×7=7
- (a) Which one is the most accurate measurement of diameter of a wire according to significant figure ?
- (i) 4 mm
  - (ii) 4.0 mm
  - (iii) 4.00 mm
  - (iv) 4.000 mm

Contd.

- (b) The incorrect statement is
- (i) inherent fluctuations are inherently unstable and lead to measurements which fluctuate in time
  - (ii) thermal noise occurs due to the thermodynamic fluctuations of the electron gas in a conductor
  - (iii) shot noise occurs due to the collection of electrons at an electrode
  - (iv) noise power varies as  $1/\sqrt{\text{frequency}}$
- (c) Effect of EMI (electromagnetic interference) is
- (i) distorted signals received by communication devices
  - (ii) electric shocks and burns
  - (iii) total electric circuit failure or damage
  - (iv) All of the above
- (d) The mean free path of molecules
- (i) increases with increase of pressure
  - (ii) decreases with increase of pressure
  - (iii) independent of pressure
  - (iv) None of the above

- (e) Which type of temperature transducer operates based on the variation in electrical resistance with temperature ?
- (i) Thermocouple
  - (ii) Piezoelectric sensor
  - (iii) Linear variable differential transformer (LVDT)
  - (iv) RTD (Resistor Temperature Detector)
- (f) What is a key advantage of digital instruments over analog instruments ?
- (i) Greater sensitivity
  - (ii) Simplicity in design
  - (iii) Improved accuracy and resolution
  - (iv) Ability to handle a wider range of measurements
- (g) Which instrument is specifically designed to measure the quality factor ( $Q$ ) of a coil and is commonly used in radio frequency (RF) and communication applications ?
- (i) RLC bridge
  - (ii) Digital multimeter
  - (iii) Oscilloscope
  - (iv) Spectrum analyser

2. Answer the following : 2×4=8

- (a) Define significant figures and errors in measurements.
- (b) Distinguish between periodic and aperiodic signals.
- (c) Explain the significance of calibration in the context of measurement system and transducers.
- (d) Explain the fundamental principle behind the measurement of electrical current ( $I$ ) and voltage ( $V$ ).

3. Answer **any three** of following : 5×3=15

- (a) Calculate standard deviation for the set of numbers 6, 8, 10, 12 and 14.
- (b) Discuss electrostatic shielding and grounding as safety measures.
- (c) Define pumping speed of a pump. Show that pumping speed

$$S = \frac{V}{t_1 - t_2} \ln \left( \frac{P_1}{P_2} \right)$$

where  $V$  is volume of the vessel.  $P_1$  and  $P_2$  are pressures at the instants  $t_1$  and  $t_2$ . 1+4=5

- (d) Explain briefly a digital multimeter (DMM) with the help of a block diagram.
- (e) Explain in detail the working principle of a digital LCR bridge.

4. Answer the following : (*any three*)

10×3=30

(a) (i) What is EMI shielding ? Give its mechanism. 2+3=5

(ii) Define S/N ratio and noise figure of a system.

The voltage output from a transducer has a steady value of 0.95 V with a fluctuating component of 0.35 V. If the noise figure of the transducer is 1.3, what is the signal to noise ratio in the measured quantity ? 5

(b) Describe the principle, construction and working of a diffusion pump.

(c) (i) Describe the various techniques used in signal conditioning and their role in ensuring accurate measurements. 7

- (ii) A strain gauge transducer has a resistance of 120 ohms under zero stress conditions. When subjected to stress, its resistance changes by 6 ohms. Calculate the gauge factor (GF) of the strain gauge. 3
- (d) (i) Explain the principle of operation and applications of strain gauges and inductance change transducer (specifically, LVDT) in detail. 7
- (ii) A capacitance change transducer has an initial capacitance ( $C_0$ ) of 100  $\mu F$ . When subjected to a change in position, its capacitance increases by 5  $\mu F$ . Calculate the percentage change in capacitance. 3
- (e) (i) A thermistor is a type of temperature sensor with a known resistance temperature characteristic. A particular NTC (Negative Temperature Coefficient) thermistor has resistance of 10,000 ohms ( $10k\Omega$ ) at  $25^\circ C$

and a resistance of 1,000 ohms ( $1\text{ k}\Omega$ ) at  $100\text{ }^\circ\text{C}$ . Assume that the resistance-temperature relationship follows the Steinhart-Hart equation :

$$\frac{1}{T} = A + B \ln R + C (\ln R)^3$$

where

$T$  is absolute temperature in Kelvin.

$R$  is the resistance of the thermistor in ohms.

$A$ ,  $B$  and  $C$  are constants specific to the thermistor's resistance-temperature curve.

For this thermistor the constants are :

$$A = 1.3934 \times 10^{-3} \text{ per kelvin}$$

$$B = 2.3921 \times 10^{-4} \text{ per kelvin}$$

$$C = 9.9034 \times 10^{-8} \text{ per kelvin}$$

Calculate the temperature (in  $^\circ\text{C}$ ) when the thermistor has a resistance of 5,000 ohms. 5

(ii) A  $Q$ -meter is used to measure the quality factor ( $Q$ ) of a coil. In a particular measurement setup, the  $Q$ -meter is set to operate at frequency of 1 MHz. The voltage across the coil is measured to be 2.5 volts ( $V$ ), and the current passing through it is 50 mA. Calculate the quality factor ( $Q$ ) of the coil based on this measurement. 5

(f) Write short notes on :  $2\frac{1}{2} \times 4 = 10$

- (a) Gross error
  - (b) Mean free path
  - (c) Ionization gauge
  - (d) Thermocouple
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