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 : $1\times7=7$

   (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*

(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)*** $10 \times 3 = 30$

(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 fluctnating 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_o) of 100 pF. When subjected to a change in position, its capacitance increases by 5 pF. 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 ($10\,k\Omega$) at $25\,°C$

and a resistance of 1,000 ohms ($1\,k\Omega$) at 100 °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 :

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

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

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

Calculate the temperature (in °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 : $2\frac{1}{2}\times4=10$

(a) Gross error

(b) Mean free path

(c) Ionization gauge

(d) Thermocouple
