53 (IE 302) FNIN

2016

FUNDAMENTALS OF INSTRUMENTATION

Paper : IE 302

Full Marks : 100

Time : Three hours

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

*Answer **any five** questions.*

1. *(a)* Draw the block diagram of Instrumentation/Measurement system and describe the important functional elements. 6

   (b) Discuss in brief the following classifications : 6

   (i) Absolute and Secondary Instruments

(ii) Indicating, Recording and Integrating Instruments.

(c) Write the dimensions of the following quantities : 8

Acceleration, Charge, Work done, EMF, Magnetic flux and Inductance.

2. (a) Describe in brief the following errors and its causes : 6

(i) Limiting errors

(ii) Instrumental errors

(iii) Environmental errors.

(b) The resistance of an unknown resistor is determined by Wheatstone bridge. The solution for the unknown resistance is stated as

$$R_4 = \frac{R_2 R_3}{R_1}$$

where limiting values of various resistances are :

$R_1 = 200\Omega \pm 2\%$

$R_2 = 300\Omega \pm 1\%$

$R_3 = 100\Omega \pm 0{\cdot}5\%$

Calculate the limiting error of the unknown resistor R_4 and also show the range of actual value for resistor R_4. 4

(c) The energy stored in a parallel plate capacitor per unit volume (energy density) is given by :

$$w = K \in^a V^b d^c$$

where, K = A constant,

$\in$ = Permittivity of medium,

V = Voltage between plates, and

d = Distance between plates.

Determine the values of a, b and c. 7

(d) Define Primary Standard and Secondary Standard. 3

3. (a) Describe in brief the static characteristics of an Instrumentation system. Also, give suitable examples. 12

(b) The table given below lists a sample of experimental data : 8

Value	Frequency of Occurence
3	1
4	3
5	4
6	4
7	2
8	2
9	1

Calculate :

(i) Arithmetic mean
(ii) Mean deviation
(iii) Standard deviation
(iv) Probable error of the mean
(v) Standard deviation of the mean
(vi) Standard deviation of the standard deviation.

4. (a) Mention the properties of Gaussian distribution.

In a certain manufacturing process, the diameters of shafts produced has a mean diameter of 20 *cm* and a standard deviation of 0·5*mm*. If the shaft diameters range from 19·9 to 20·1*cm* are acceptable, how many rejects would you expect in a random list of 100 shafts. 9

(b) A study was conducted to determine the effectiveness of a vaccine in cembating an infectious disease. In an area where the disease was prevalent, a total of 200 people were tested, 80 of whom were vaccinated in the last 12 months and 120 were not. In each case, it was noted whether they contracted the disease and, if so, whether it was in severe or mild form. Test if the vaccine is effective. Use 5% significance level. 8

	No disease	Mild	Severe
Vaccinated	45	25	10
Not Vaccinated	30	50	40

(c) Define loading error. How loading error in an instrument is related to input impedance and output impedance ? 3

5. (a) Standard weights x_i are suspended on a spring and the corresponding lengths y_i are measured. It is known that for a linear spring the lengths should follow the linear relation :

$$y = \alpha + \beta x$$

(i) Determine, using the principle of least squares, the values of α and β, for the following set of data :

x_i	y_i
2	7·35
4	8·25
6	9·20
8	10·20
10	11·00
12	12·05

(ii) Determine also the internal estimate of uncertainties in the values of α and β. 10

(b) Derive the differential equation describing the dynamics of mechanical translational system subjected to a step input force. Also write the differential equation describing the time response of a series RLC circuit when a step voltage is applied to it. 6

(c) Derive the equations for time response of a first order system when subjected to a unit step input. 4

6. *(a)* Define Calibration. Discuss the following in brief : 7

(i) Purpose of Calibration

(ii) Procedure of Calibration.

(b) Describe a method for the calibration of ammeter and voltmeter. 8

(c) Define : Speed of response, measuring Lag and Fidelity. 5

7. *(a)* Write short notes on ***any two*** of the following : 14

(i) Types of Testing

(ii) Classification of Transducers

(iii) Primary and Secondary standards for voltage.

(b) Name the standard test signal and discuss in brief with mathematical expressions. 6