Total No. of printed pages = 6

19/3rd Sem/UIE304

2021

FUNDAMENTALS OF INSTRUMENTATION

Full Marks – 100

Time – Three hours

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

Answer any *five* questions.

1. (a) Explain the functions of different fundamental elements of an instrument system with neat block diagram and example (pressure actuated thermometer). 10

   (b) Distinguish between transducer and sensor ? 4

   (c) Explain briefly the following : 2+2+2=6

   (i) Commonly used op-amp circuits

   (ii) Applications of op-amp

   (iii) Feedback in amplifier.

2. (a) What are the different standards in measurement ? Explain with examples. 10

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(b) Discuss the factors relating to selection of instruments. 4

(c) An elastic type of pressure-measurement instrument is of diaphragm type. The central deflection of the diaphragm was found to be 0.3 mm of an applied pressure of 10^6 Pa. The output displacement of the diaphragm has been fed to an LVDT (linear variable differential transducer) with a built-in amplifier having a sensitivity of 50 V/mm. Finally, the output is displayed on an analog voltmeter which has a radius of scale line as 70 mm and has a voltage range from 0 to 10 volts in an arc of 160°C. Determine the sensitivity of the given diaphragm gauge in terms of mm/bar (1 bar = 10^5 Pa). 6

3. (a) Explain the estimation of propagation of uncertainties in compound quantities and derive the expression for overall internal estimated uncertainty. 10

(b) The governing equation for the capillary tube viscometer according to Hagen-Poiseuellu equation :

$$Q = \frac{\pi D^4}{128 \eta L} \Delta p$$

Where, Q is the volume flow rate of the fluid in the capillary tube, D the diameter of the capillary, η the coefficient of dynamic viscosity of the fluid, L the length of the capillary tube and Δp the pressure difference across the two ends of the tubes.

If Q, L, D and Δp are measured with an uncertainty of $\pm$ 2%, how accuracy in η is known ? Further, if the uncertainty in the measurement of D is reduced to $\pm$ 0.1% by using improved instrumentation, what is the improvement achieved in the uncertainty of η ? 10

4. (a) Differenciate between accuracy and precision. 4

(b) Define the following terms : 1×6=6

(i) Repeatability

(ii) Reproducibility

(iii) Speed of response

(iv) Rangeability

(v) Sensitivity

(vi) Lag.

(c) A load cell calibrated at a temperature of 20°C has the following output/input :

Load in kN	0	0.4	0.8	0.12	0.16	0.20
Deflection of meter in mm	0	8	16	24	32	40

When it is used in an environment of 50°C, its characteristics change to the following :

Load in kN	0	0.4	0.8	0.12	0.16	0.20
Deflection of meter in mm	4	13	22	31	42	54

(i) Determine zero drift, sensitivity drift and sensitivity drift per °C change in the ambient temperature.

(ii) If 0.6 mm of scale division can be read with a fair degree of certainty, then determine the resolution of the instrument in both the cases, i.e., at 20°C and 50°C.

2×3=6

(d) A thermometer, idealised as a first-order system with a time constant of 2.2 seconds, is suddenly given an input of 180°C from 0°C.

(i) What will be the reading of the thermometer after 1.4 seconds ?

(ii) Determine its reading if it is initially held at 20°C.

2×2=4

5. (a) What are the instrumental and environmental errors ? How can they be avoided ? 6

(b) A thermometer with time constant of 60 seconds is used for measurement temperature cycling with 600s time period. Calculate.

(i) Ratio of output to input

(ii) Time lag. 4

(c) Explant any two types of statistical error estimation techniques. 10

6. (a) Derive the response of the first order and second order (undamped) system with unity feedback and unity step input. 10

(b) The following data pertain to a torque sensing transducer connected to the shaft of an electrical motor which drives a load : 5

Input torque (Sinusoidal with frequency varying)	τ = 2 rad/s
Maximum permissible error	e = $\pm$10 per cent
Moment of inertial of load	J = 0.16 kg m^2
Torsional constant of the shaft	q = 1.28 Nm/rad

Determine the following :

(i) Natural frequency

(ii) Damping ratio

(iii) Damping natural frequency

(iv) Time constant of the system.

(c) What is calibration ? And define any four types ? 5