Ref. No.: Ex/IEE/PC/B/T/213/2024

B.E. INSTRUMENTATION AND ELECTRONICS ENGINEERING SECOND YEAR FIRST SEMESTER EXAM 2024

Subject: FUNDAMENTALS OF INSTRUMENTATION **Time 3 hr** **full marks 100**

CO1

1	a. Write down the advantages and disadvantages of computer based measurement system b. What are the desirable characteristics of a good measurement system? c. Distinguish between analog and digital readout systems and discuss the merit each d. Explain the role of electronic circuits in the field of computer based instrumentation e. Define 'total uncertainty' in the reading of an instrument and indicate the factors responsible for this.	4X5=20
OR	a. Explain to what extent the experimenter is responsible for introducing error in a measurement and States some of the ways by which he can reduce them b. Define the class of standard available for use and calibration c. Differentiate between Even signal and Odd signal. d. Define: Signal to Noise Ratio and Instrument Efficiency. Differentiate between Johnson noise and shot noise? e. For a capillary tube viscometer is the well-known Hagen Poiseuille equation $$Q = \frac{\pi D^4}{128 \eta L} \Delta p$$ Q Is the volume fluoride of the fluid in the capillary tube D the diameter of the capillary tube η the coefficient of the dynamic viscosity of the fluid, L length is the length of the capillary; ΔP is the pressure difference across two ends of the tube; Q, L,D and ΔP are measure with an uncertainty of +-1%, how accurately is η known? Further If the uncertainty of the measurement of D is reduced to plus minus 0.1 by using improve instrumentation what is the improvement achieved in the uncertainty of η?	3+3+ 3+5+6=20

CO2

2	a. Define repeatability and reproducibility and discuss why an instrument should possess these features. b. what is meant by the stability of a measurement system? indicate which class of instruments are required to be more stable? c. explain the term 'fidelity' and so how it is really expressed? d. Discuss the performance of two first order systems when cascaded. Will the combination become an underdamped system? Justify. e. Define the settling time of physical systems and how it varies with the damping factor for a second order system. And also show how it's natural frequency is affected by damping factor.	3+3+3+5+ 6=20
OR	a. An instrument consists of a first order sensing element and a second order data presentation device the time constant of the first order element is 0.0 15 and static sensitivity is 4 millivolts per degree centigrade, the second order device has an undamped natural frequency of 100 rad/second and damping ratio of 0.5 with static sensitivity of 5 mm/mV. Draw the frequency response of the systems b. What is meant by the critical damping condition of a system? Explain why certain physical systems are operated under critical Damping conditions. c. Show the response curves of a second order physical system subjected to an impulse and input function. Discuss the nature of problems faced when the order of a physical system is larger than 2. d. Define the dynamic error of a first order system.	6+6+6+2= 20

CO3

3 Any two

a. Define limiting errors. Derive the expression for relative limiting errors. 4+6=10

Guaranteed value

An unknown resistance of a Wheatstone Bridge is Rx=R2xR3/R1,

where R1= 1000± 0.5%

ohm, R2 =1000±0.5% ohm , R3=842±0.5% ohm

Determine the unknown resistance and relative limiting error (in Percentage) , limiting error in percent, guaranteed value of unknown resistance

b. Define 'deviation' and 'standard deviation of a set of measured values.? 4+6=10

An experiment has been carried out get the temperature dependence resistance of a copper wire. The ideal variation is represented by $R=R0(1+\alpha T)$ where R resistance at temperature T degree centigrade and R0 resistance at zero degree centigrade, α temperature coefficient of resistance. The following observations of R and T were obtained

Temperature T (°C)	*Resistance R (Ω)*	*Temperature T (°C)*	*Resistance R (Ω)*
10	12.4	50	14.6
20	13.0	60	15.2
30	13.7	70	15.3
40	13.9	80	16.0

1. using the method of the least squares, determine the slope and intercept for the best fitting straight line assuming temperature values to be accurate
2. hence, evaluate the best value of α
3. Determine the standard deviation for the slope and Intercept
4. hence, evaluate the standard deviation in α

C. 5+5=10

1) In an air cooled engine cylinder simulation study a circular cooling fan was heated in central region and place in an air stream . 10 temp measuring devices were placed at equal distance radially on the field for temperature. during a test run the following data was obtained. determine the coefficient for the car of the form $T = C_0 + C_1R$

Using graphical method, method of sequential differences, and method of least squares.

Radius R, (cm)	*Temperature T (°C)*	*Radius R (cm)*	*Temperature T (°C)*
2	75.5	12	62.1
4	73.1	14	59.4
6	70.5	16	57.2
8	67.7	18	54.8
10	64.2	20	52.2

2) A set of machine bearings of a particular make were tested for wear at different operating temperature controlled by an oil bath. The following results are obtained:

Operating temperature x (in °C)	100	150	200	250	300	350	400
Amount of wear y (in mg/100 h of operation)	3.2	5.2	5.8	7.9	9.6	11.7	13.2

a. Plot the points on the graph and verify linear relationship exist between x and y
b. Find the linear list regressing y on x (that is assuming the temperature value given in the data wear without error)
c. Estimate the amount of wear at 325 and 0° centigrade
d. Comment on estimated amount of wear given by equation for an operating temperature of 0° centigrade.

CO 4

4 Any four

a. Show how a capacitive transducer can be used to monitor the thickness of an insulating sheet in motion, without making physical contact; comment on the linearity and sensitivity of the system. 5+5+5+5 =20

b. Describe the constructional features of a linear variable differential transformer and comment on its merits in comparison to a push-pull self-inductive transducer.

c. Define the term Piezo-resistive coefficient and explain why semiconductor strain gauges have high values for the gauge factor. Why are resistance strain gauges used in pairs?

d. Explain the principle of working constructional details and applications of photo transistors. Explain why are they preferred for digital applications. Draw their characteristics

e. A flat frequency response within 10% is required from a piezo-electric crystal. Find the value of minimum frequency for which it can be used if the time constant is 2 ms. Find also the phase shift.

5 Any two

a. How does fringing effect change accuracy of measurement? Derive an expression for Hall coefficient and Hall Voltage? Describe operation of closed loop current sensor designed based on Hall effect. 2+4+4=10

b. Compare 2 wire, 3 wire and 4 wire RTD with details. Why platinum is chosen over all other metal for construction of RTD? Discuss with characteristic curve and other relevant points. 4+2+4=10

Show how reluctance variation due to air gap variation in the self-inductance of a coil influences its sensitivity

c. Explain temperature compensation methods can be applied to semiconductor strain gauges. What is shunt calibration? 4+6=10

A 120-ohm strain gauge is connected in a Wheatstone Bridge as shown in figure below. An 18-volt DC supply in series with resistance Rx powers the bridge. Determine the minimum value of resistance Rx so that the power dissipated in the strain gauge is less than 15 mW