B.E. Mechanical Engineering Third Year 2nd Semester Examination – 2024
(3nd Year 2nd Semester)

Subject: **Measurement and Instrumentation**

Time: Three hours **Full Marks: 100**

Answer any **FIVE** *questions. Different parts of the same question should be answered together.*
Assume any relevant data if necessary.
Use of Gaussian Error Function Tables permitted.

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1. (a) With respect to a measurement system distinguish between measured value and true value. 5

(b) Give a schematic of a spring-loaded pressure gauge and explain its function. Also draw a block diagram to indicate the different functional elements of the system 10

(c) Considering input (q_i) and output (q_o) of a linear instrument, explain static sensitivity, zero drift and sensitivity drift. Give an example to illustrate the terms. 5

2. (a) What is meant by static calibration? 5

(b) What are the advantages and disadvantages of such a null type device in comparison to a deflection type device? 5

(c) A silicon-integrated circuit chip contains 5000 identical transistors. Measurements are made on the current gain of each transistor and they have a mean of 20 and standard deviation of 1.5. The probability distribution of the measurements is Gaussian. Calculate the number of transistors that have current gain between 19.5 and 20.5. Use of error function table allowed 10

3. (a) With suitable examples establish the desired relationships between the output and input for both stiffness and compliance in order to minimize loading effect under static condition 7

(b) Describe the operation of a Linear Velocity Differential Transformer? 8

(c) Why is temperature compensation important for strain gauges, and what methods are employed to achieve it 5

4. (a) Explain different types of errors of an instrument 5

(b) Consider a single strain gage of resistance of 120Ω mounted along the axial direction of an axially loaded specimen of steel (E 200 GPa). If the percentage change in

length of the rod due to loading is 3% and the corresponding change in resistivity of the strain gage material is 0.3%, estimate the percentage change in the resistance of the strain gage and its gage factor; Poisson's ratio = 0.3. If the strain gage is connected to a measurement device capable of determining change in resistance with an accuracy of ±0.02 Ω, what is the uncertainty in stress and strain that would result in using this measurement device. 15

5. (a) Define accuracy and sensitivity of an instrument. 5

(b) A thermocouple can be considered as a single capacity system with a time constant of 100 ms and unity gain. It is immersed in a heat bath whose temperature is varying at 1°C/s (ramp input) from 0°C. When the actual temperature of the heat bath is 70 °C, what will be the error in reading of the thermocouple? 15

6. (a) Differentiate between active and passive transducers with examples. 5

(b) What will be (i) the undamped natural frequency, (ii) the damping ratio, (iii) the damped natural frequency, (iv) the maximum percentage overshoot and (v) the 2% settling time for a measurement system that is represented by the following equation 15

$$4d^2q_o/dt^2 + 8dq_o/dt + 16q_o = 16q_i$$

7. (a) A Bourdon pressure gauge having a linear calibration has a 50 mm long pointer. It moves over a circular dial having an arc of 270°. It displays a pressure range of 0 to 15 bar (1 bar = 105 Pa). Determine the sensitivity of the Bourdon gauge in terms of scale length per bar (i.e., mm/bar). 10

(b) For an underdamped second order system explain with a sketch the meaning of the terms – rise time, peak time, 2% settling time, maximum percentage overshoot. 10

8. Write short notes on any FOUR of the following: (a) Stability of linear dynamic systems; (b) Flow and effort variables; (c) Dead-weight type pressure gauge; (d) Hysteresis and threshold; (e) Primary and secondary standards. 4x5 =20