B.E. MECHANICAL ENGINEERING THIRD YEAR SECOND SEMESTER - 2022

Subject: **MEASUREMENT & 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 z-function Tables permitted.

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[1] (a) Classify different applications of measurement systems.
(b) What are the different functional elements of a measurement system? Explain with a suitable example.
(c) Compare between (i)*null-type* and *deflection-type* devices; (ii) *active* and *passive* transducers. **[05+09+06]**

[2] (a) For a first order system with time constant τ and static sensitivilty K, obtain an expression for sytem response $q_o(t)$ to a ramp input $q_i(t) = At$, where A is a constant. Show the input and response on a graph. Indicate the steady state time lag on the figure.
(b) 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 suitable table is allowed. **[10+10]**

[3] (a) Describe the principle of operation of resistance type strain gauge and obtain an expression for gage factor.
(b) For an ammeter connected to a circuit with an equivalent resistance R_s and voltage source E_o, obtain the criterion to minimize loading effect. Assume suitable symbols for the ammeter parameters. **[12+8]**

[4] (a) Describe the principle of operation of an LVDT.
(b)Consider a single strain gage of resistance of 120 Ω mounted along the axial direction of an axially loaded specimen of steel (E=200 GPa). If the percentage change in resistance of the gage due to loading is 5.1% and the corresponding change in resistivity of the strain gage material is 0.3%, estimate the percentage change in the length 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 ±0.02Ω, what is the uncertainty in stress and strain that would resu,lt in using this measurement device? **[10+10]**

[5] (a) The discharge coefficient C_q of an orifice can be found by collecting the water that flows through during a time interval when it is under a constant head h as per the relation $C_q = 4W/\{\pi t\rho d^2\sqrt{2gh}\}$. Find C_q and its possible uncertainty if: W=390±0.25kg; d=12±0.03mm; t=600±2s; g=9.81±0.00981m/s^2; ρ=1050±1.05kg/m^3; h=3.6±0.03m.
(b) Explain the modeling of uncertainty using t-distribution. Give a sketch to show the uncertainty envelope around the best fit line. **[12+8]**

[6] (a) With respect to a measurement system distinguish between measured value and true value.
(b) What are the different types of bias associated with calibration of an instrument?
(b) With suitable sketches, explain the different methods of filters used in measurement systems.
(c) What is the difference between measurement method and measurement process? **[5+5+6+4]**

[7] Write short notes on any **FOUR** of the following: (a) Dead-weight type pressure gauge; (b) Generalized static compliance and stiffness; (c) Resolution and scale readability; (d) Gage factor of a strain gauge; (e) Stability of linear dynamic systems; (f)) Time constant of 1st order systems. **[05X4]**