B.E. Mechanical Engineering Third Year 2nd Semester Examination – 2023
(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) Briefly explain the classification of measurements. [6]

(b) Give a schematic of a Digital Revolution Counter and explain its function. Also draw a block diagram to indicate the different functional elements of the system [8]

(c) Explain the method of signal filtering for correction of the effects of spurious inputs. Elaborate with reference to a spring-loaded pressure gauge. [6]

[2] (a) What is meant by *static calibration*? What are the different steps for performing a calibration? [7]

(b) Explain the working of a Bourdon tube pressure gauge with a neat sketch [5]

(c) The thickness of a set of gaskets varies due to random manufacturing disturbances, but thickness values measured belong to a Gaussian distribution. If the mean thickness is 3mm and standard deviation is 0.25, calculate the percentage of gaskets that have a thickness greater than 2.5 mm. [8]

[3] (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 ammeter connected to a circuit with an equivalent resistance Rs and voltage source Eo, obtain the criterion to minimize loading effect. Assume suitable symbols for the ammeter parameters. [7]

(c) Explain different types of errors of an instrument. [3]

[4] (a) Name the different types of biases possible in a measurement system. [4]

(b)Describe the operation of a Linear Velocity Differential Transformer? [6]

(c) An obstruction type flowmeter is used to measure the flow of air at low velocities. The relation describing the flow rate is: Calculate the percentage uncertainty in the mass flow rate for the following conditions: Cd = 0.92 ± 0.005 (from calibration data); p_1= 175 kPa ±3.5 kPa; T_1=2940K ±10K; Δp =9.8 kPa ±0.035 kPa; $A = 6.5 \times 10^{-4}$ m^2 ± 6.5×10^{-7} m^2. [10]

[5] (a) The following input-output data of an instrument are expected to follow a linear relation of the form $q_o=mq_i+b$. Obtain the best linear relation in accordance with a least-square analysis. Calculate the standard deviations of input, output, slope and intercept from the predicted straight line relation: [10]

q_i	0.9	2.3	3.3	4.5	5.7	6.7
q_o	1.1	1.6	2.6	3.2	4.0	5.0

(b) Obtain an expression for the time constant for the mercury-in-glass thermometer assuming suitable symbols for all the parameters in the analysis. [7]
(c) What is the significance of time constant for a first order dynamic system? [3]

[6] (a)What will be (a) the undamped natural frequency, (b) the damping ratio, (c) the damped natural frequency, (d) the maximum percentage overshoot and (e) the 2% settling time for a measurement system that is represented by the following equation $d^2q_o/dt^2+4dq_o/dt+25q_o=25q_i$ [10]

(b) Describe the principal of operation of a simple resistance strain gauge and obtain an expression for the *gauge factor*. [10]

[7] Write short notes on any **FOUR** of the following: (a) Resistance Temperature Detector or RTD; (b) Flow and effort variables; (c) Active and Passive Transducer; (d) Hysteresis and threshold; (e) Primary and secondary standards. [05X4]