B.E. MECHANICAL ENGINEERING THIRD YEAR SECOND SEMESTER EXAM 2019

Subject: **Mechanical 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) Classify different applications of measurement systems.
(b) What are the different functional elements of a measurement system? With a suitable example identify the elements.
(c) Compare between (i) *null-type* and *deflection-type devices*; (ii) digital and analogue signal. [05+09+06]

[2](a) With a block diagram, explain the *generalized input-output configuration* of a measurement system.
(b) Explain the use of filters as a *method of elimination* of spurious input.
(c) Show how the spurious input can be eliminated using *high gain feedback.* [06+07+07]

[3](a) What is *linearity* of an instrument? With a sketch discuss how it is specified.
(b) Derive the expression for static sensitivity and time constant for a liquid bulb thermometer.
(c) With suitable examples establish the desired relationships between the output and input for both impedance and stiffness in order to minimize loading effect under static conditions. [05+06+09]

[4] (a) With respect to a measurement system distinguish between *measured value* and *true value*"?
(b) What are different types of *bias* associated with calibration of an instrument?
(c) The viscosity of castor oil is determined by "falling sphere method" using the following expression of viscosity: $\mu=\frac{2r^2}{9U}(\rho_s-\rho_l)g$, where $r = 1.58 \times 10^{-3}$ m $\pm 3.2 \times 10^{-5}$ m; $U = 76.92 \times 10^{-3}$ m/s $\pm 1.7 \times 10^{-4}$ m/s; ρ_l=953.4 kg/m^3 $\pm$ 0.097 kg/m^3; ρ_s=7850 kg/m^3 $\pm$ 1.297 kg/m^3; g = 9.81 m/s^2 $\pm$ 0.03 m/s^2. Evaluate the nominal value of the viscosity and its overall uncertainty. Identify the critical component in the measurement system that may require more accurate measurement in order to improve the overall uncertainty. [06+04+10]

[5] (a) The following average pressure (P)-mercury column height (h) data of a pressure gage are expected to follow a linear relation of the form $P = mh + b$. Obtain the best linear relation in accordance with a *least-square analysis*. Calculate the *standard deviations* of *slope* and *intercept* from the predicted straight line relation.

V(MPa)	*h(mm)*	
	Increasing	*Decreasing*
0.15	0.11	0.12
0.30	0.26	0.24
0.47	0.43	0.46
0.69	0.57	0.52
0.95	0.85	0.84
1.18	1.13	1.17
1.19	1.18	1.21

(b) When a voltage of 20 V is suddenly applied to a moving coil voltmeter, it is observed that the pointer of the instrument rises to 22V before eventually settling down to read 20 V. What is the damping factor of the system? If the undamped natural frequency is 6.5 rad/s, what is the damped natural frequency, peak time and 2% settling time of the system? [12+08]

[Turn over

[6] (a) The thickness of a steel emerging from a rolling mill, varies due to random manufacturing disturbances, but thickness values measured belong to a Gaussian distribution. For 25 measurements of thickness of steel, the mean is 4mm and the standard deviation is 0.02646. (i) How many measurements are below 4.00mm? (ii) How many measurements are above 3.95mm? (iii) How many measurements are between 3.98mm and 4.02mm?

(b) Obtain an expression for the time constant for the mercury-in-glass thermometer assuming suitable symbols for all the parameters in the analysis. What is the significance of time constant for a first order dynamic system? [12+08]

[7] Write short notes on any **FOUR** of the following:

(a) Static sensitivity and zero drift;
(b) Hysteresis and threshold;
(c) Amplitude gain of an LVDT;
(d) Confidence level and coverage factor;
(e) Modeling of uncertainty using *t*-distribution;
(f) Types of strain gages.

[05X4]