Bachelor of Mechanical Engineering Examination, 2017
(3rd Year 2nd Semester)
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.

[1] (a) 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.
(b) What is meant by a *null-type device*? Explain with a suitable example. What are the advantages of such a device over a *deflection-type device*? [10+10]

[2] (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?
(c) 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 22 V before eventually settling down to read 20 V. What is the damping factor of the system? [7+5+8]

[3] (a) What is meant by the statement – "*a measurement system is in good statistical control*"?
(b) What is a *standard*? Explain what are *primary* and *secondary standards*?
(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 $r=(1.58\times10^{-3}\pm3.2\times10^{-5})$m; $U=(76.92\times10^{-3}\pm1.7\times10^{-4})$m/s; $\rho_l=(953.4\pm0.097)$kg/m^3; $\rho_s=(7850\pm1.297)$kg/m^3; $g=(9.81\pm0.03)$m/s^2. Evaluate the nominal value of the viscosity and its overall uncertainty. [06+04+10]

[4] (a) With suitable sketches, explain the different types of filters used in measurement systems.
(b) Draw a schematic of a static-pressure probe. Explain how the method of opposing inputs is applicable to the device.
(c) A pressure transducer exhibits a temperature sensitivity of 0.1 units per °C and pressure sensitivity of 2.5 units per MPa. If the temperature changes by 20°C during a measurement of 120MPa pressure, determine the error due to dual sensitivity. [6+9+5]

[5] (a) Static calibration of an instrument gives the data as given in the table below. Find out (a) the equation of best-fit straight line and (b) q_i and its error limits if the instrument is used after calibration and reads q_o=5.72.

q_i	q_o	
	Increasing values	*Decreasing values*
0	-0.07	0.01
5	1.08	1.16
10	2.05	2.10
15	3.27	3.29
20	4.28	4.36
25	5.41	5.45
30	6.43	6.53
35	7.57	7.61
40	8.66	8.75

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(b) In a particular manufacturing process, bricks are produced in batches of 10,000. If the bricks have a mean length of 200mm with a standard deviation of 20mm, calculate the number of bricks with a length – (i) between 198 and 202 mm; (ii) greater than 170mm. [12+08]

[6] (a) Describe the principle of operation of an LVDT.

(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 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 result in using this measurement device? [10+10]

[7] Write short notes on any **FOUR** of the following: (a) generalized static compliance and stiffness; (b) active and passive transduces; (c) resolution and scale readability; (d) different types of strain gages; (e) time constant of 1st order systems; (f) static calibration of measurement systems.