

**Bachelor of Mechanical Engineering Examination, 2017**  
(3<sup>rd</sup> Year 2<sup>nd</sup> 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  $r = (1.58 \times 10^{-3} \pm 3.2 \times 10^{-5})\text{m}$ ;  $U = (76.92 \times 10^{-3} \pm 1.7 \times 10^{-4})\text{m/s}$ ;  
 $\rho_l = (953.4 \pm 0.097)\text{kg/m}^3$ ;  $\rho_s = (7850 \pm 1.297)\text{kg/m}^3$ ;  $g = (9.81 \pm 0.03)\text{m/s}^2$ . 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  $120\Omega$  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  $\pm 0.02\Omega$ , 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 transducers; (c) resolution and scale readability; (d) different types of strain gages; (e) time constant of 1<sup>st</sup> order systems; (f) static calibration of measurement systems.