**Bachelor of Mechanical Engineering Examination, 2017**
**(2nd Year 2nd Semester OLD)**
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) What is meant by a null-type device? Explain with a suitable example.
(b) With a block diagram, explain the *generalized input-output configuration* of a measurement system. Identify the different possible input-output(s) with reference to a mercury manometer. [8+12]

[2] (a) Considering input ($q_i$) and output ($q_o$) of a linear instrument, explain *static sensitivity*, *zero drift* and *sensitivity drift*. Give an example to illustrate the terms.
(b) 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+10]

[3] (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 meant by *static calibration*? [5+5+6+4]

[4] (a) 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 error function table allowed.
(b) The following average velocity ($V$)-hydraulic gradient ($i$) data of a Reynolds apparatus are expected to follow a linear relation of the form $V = mi + b$. 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.

| $V$(m/s) | $i$ | |
|---|---|---|
| | *Increasing* | *Decreasing* |
| 0.015 | 0.0011 | 0.0012 |
| 0.030 | 0.0026 | 0.0028 |
| 0.047 | 0.0043 | 0.0046 |
| 0.069 | 0.007 | 0.0072 |
| 0.095 | 0.011 | 0.013 |
| 0.118 | 0.013 | 5.45 |
| 0.191 | 0.018 | 0.020 |

[8+12]

[5] (a) A mercury thermometer has a capillary tube of 0.25 mm diameter. If the bulb is made of a zero-expansion material, what volume must it have if a sensitivity of 4 mm/$^0$C is desired? Assume operation near 20$^0$C where the thermal coefficient of expansion of mercury is $182\times10^{-06}$ per °C. If the bulb is spherical and is immersed in stationary air, estimate the time constant. Take density of mercury to be 13600kg/m$^3$, specific heat = 0.15kJ/kg°C and heat transfer coefficient = 20W/m$^2$-°C.
(b) What is meant by linearity of an instrument? With a sketch discuss how linearity is specified. [12+8]

[6] (a) Describe the principle of operation of a resistance type strain gauge and obtain an expression for its gage factor.

(b) For a voltmeter 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 voltmeter parameters. [12+8]

[7] Write short notes on any **FOUR** of the following: (a) measurement method and measurement process; (b) hysteresis and threshold; (c) active and passive transduces; (d) root-sum-square uncertainty from component errors; (e) stability of dynamic systems; (f) flow and effort variables. [4×5]