Faculty of Engineering | **Philadelphia University** | Mechanical Eng. Dep.

Engineering Measurements (620344)

First Exam

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Student Name: **Student ID number:**

Problem #1: chose the correct answer and fill the given table **(10marks)**

Question	1	2	3	4	5	6	7	8	9	10
Answer										

The following information are for questions 1 – 4. a voltmeter is used to measure voltage across a resistance is divided into 30 grades from 0V to 30V as shown in the figure. If the exact value was 10.6V and 5 readings were recorded: 9.9, 10.1, 10.6, 10.7 and 10.3 V. Assume that the distance between two consecutive grading is 3 degrees.

Q_1: The sensitivity of this device would be

a. 3degree/V b. 0.1V/degree c. 10.6 V/degree d. 30V/degree

Q_2: The precision of this device

a. 0.8V b. 0.1V c. 0.38 V d. 0.42 V

Q_3: mean value of these readings is

a. 10.6 V b. 10.32V c. 9.9V d. 7.37V

Q_4: the arithmetic median (الوسيط الحسابي) value of these readings is

a. 10.3V b. 10.6V c. 9.9V d. 10.7V

Q_5: in calibration process we compare with standard value. This value can be

a. primary standard b. secondary standard c. known input d. all the mentioned

Q_6: the following system: $5(d^3x/dt^3)+6(dx/dt)-2=t^4$ **is**

a. 1st order b. 2nd order c. 3rd order d.4th order

Q_7: we called the time needed to achieve 90% response from the step input

a. time constant b. rise time c. settling time d. none of the mentioned

Q_8: Uncertainty in measurements is near to

a. errors b. accuracy c. level of confidence d. none of the mentioned

Q_9: Systematic error is error

a. errors in the instrumentation b. fixed shift in multi-readings taken by the same device c. comes from the operator d. none of the mentioned

Q_{10}: Selection of measurement method and measuring instrument depends on

a. uncertainty b. time c. cost d. all the mentioned

Problem #2: an experiment designed to measure the heat flow through a metal plate. If the heat conduction is governed by the following relation: $Q = kA\frac{T_o - T_i}{\Delta x}$ if the values of k, A, T_i, T_o and Δx are measured as: $k = 40WC^{-1}m^{-1} \pm 0.1\%$, $A = 1.25m^2 \pm 1\%$, $\Delta x = 0.002m \pm 2.5\%$, $T_i = 35C \pm 1C$ and $T_o = 50C \pm 2C$.

Calculate the heat transfer (in W) and the uncertainty in heat transfer. **(5marks)**

$$w_Q = \sqrt{\left(\frac{\partial w}{\partial k}w_k\right)^2 + \left(\frac{\partial w}{\partial A}w_A\right)^2 + \left(\frac{\partial w}{\partial T_o}w_{To}\right)^2 + \left(\frac{\partial w}{\partial Ti_i}w_{Ti}\right)^2 + \left(\frac{\partial w}{\partial \Delta x}w_{\Delta x}\right)^2}$$

$$\frac{\partial w}{\partial k} = A\frac{T_o - T_i}{\Delta x} = 1.25\frac{50-35}{0.002} = 9.375kW/(kuint) \text{ and } w_k = (40)(0.001) = 0.04$$

$$\frac{\partial w}{\partial A} = k\frac{T_o - T_i}{\Delta x} = 40\frac{50-35}{0.002} = 300kW/m^2 \text{ and } w_A = (1.25)(0.01) = 0.0125$$

$$\frac{\partial w}{\partial To} = \frac{kA}{\Delta x} = \frac{(40)(1.25)}{0.002} = 25kW/(kuint) \text{ and } w_{To} = 2C$$

$$\frac{\partial w}{\partial Ti} = -\frac{kA}{\Delta x} = -\frac{(40)(1.25)}{0.002} = -25kW/(kuint) \text{ and } w_{To} = 1C$$

$$\frac{\partial w}{\partial \Delta x} = kA\frac{T_o - T_i}{\Delta x^2} = (40)(1.25)\frac{50-35}{0.002^2} = 187500kW/(kuint) \text{ and } w_{\Delta x} = (0.002)(0.025) = 5x10^{-5}$$

$$w_Q = 56.68kW \text{ and } Q = (40)(1.25)\frac{(50-35)}{0.002} = 375kW$$

So: $Q = 375kW \pm 56.65kW$ **or** $Q = 375kW \pm 15.11\%$

Problem #3: the data given in the table represent temperature measurements for heated water in a container using a single thermometer. **Find the mean reading, standard deviation, variance, and average of the absolute value of deviation.** **(5 marks)**

Decide if this measurement is single or multi-sample system? Single

Reading No.	Temp, C
1	23
2	25
3	26
4	24
5	27

2. $x_m = \frac{1}{n}\sum_{i=1}^{n} x_i = \frac{1}{5}\sum_{i=1}^{n}(23+25+26+24+27) = 25C$

3. $\sigma = \sqrt{\sum_{i=1}^{n}\frac{1}{n}(x_i - x_m)^2} = \sqrt{\sum_{i=1}^{n}\frac{1}{5}10} = \sqrt{2}$

4. Variance = $\sigma^2 = 2$

5. $\overline{|d_i|} = \frac{1}{n}\sum_{i=1}^{n}|x_i - x_m| = \frac{1}{5}(6) = 1.2$

No.	x_i	$d_i = x_i - x_m$	d_i^2	$\lvert d_i \rvert$
1	23	-2	4	2
2	25	0	0	0
3	26	1	1	1
4	24	-1	1	1
5	27	2	4	2
Sum	125	------	10	6