Measurable Program Outcomes (MPO) and Course Outcomes	
MPO: An ability to apply knowledge of Engineering Measurements	**Course Outcomes**
MPO# 1.2-1 An ability to complete a basic statistical analysis, including producing histograms, identifying probability distributions, and computing mean values, standard deviations, standard deviations of the mean, and confidence intervals	1. Analyze certain types of errors using statistical methods 2. Choose the correct device for the least error or desired accuracy.
MPO# 2.3 An ability to calculate the error/uncertainty propagation for calculations that include multiple terms with uncertainties	3. Calculate the errors and uncertainty in an experimental data
MPO# 2.5 An ability to use common measurement equipment	4. Identify the parameters that control the behavior and response of a measurement system. 5. Ability to find parameters that characterizes the behavior of a thermometer and manometer.

Answer All questions

Q2) State TWO points on each one of the following : **(5 Marks)**

1½

A) Time needed for inspection process.

peak time sitling time

rise time

B) Functions of instrument.

C) Types of instrument assembly (controllable) errors.

mis alinment / non zero initial reading.

½

D) Types of Parasitic errors.

E) Methods to positively improve the response speed of a thermometer.

choos ~~a~~ amaterial with high heat transfer coffecint

" " " low dincity (ρ)

Q2) Write the term defined by each one of the following statements: (5 Marks)

It is a term that refers to the closeness of the output readings over repeated times of measurement when the experiment is repeated several times under the same conditions. (Reproducibility, Precision, Repeatability, Accuracy)	Repeatability
A voltmeter has range 0-100V divided into 200 divisions. One-fifth of the scale divisions can be read with certainty. The resolution is equal to …………. volts	0.1 V
A 2 gm mass is suspended from a simple spring. The deflection is 58mm. The natural frequency of the system is equal to ……..……….Hz	12.~~16~~ ra
The parameter that characterizes and controls the response of the first order system.	time constant
A type of output in which the instrument continuously writes, with pen and ink, the value of the measured quantity against some other variable or against time.	in~~dic~~ato
This is defined as any signal that does not convey useful information.	
For higher sensitivity, the manometer liquid should have (high, low, it has no effect) specific weight.	~~high~~
Is a term used to express the retardation or delay of the system response to a change in input signal. (Error, Resolution, Lag)	~~Error~~
The least change of the measured variable which can be detected at the output of the measuring system is called ……………	~~Resolution~~
The largest change in the measured variable which produces no instrument response is known as ……. Dead Zone	

Q3) Define the term "Error", what are its basic types? Define each type of it.
In a test, temperature is measured several times with variations in apparatus and procedures. After applying the known corrections, the results were:

Temperature °C	29	30	40	41	42	43	44
Frequency	6	10	21	37	19	11	5

3 1/4

Calculate: (a) arithmetic mean, (b) mean deviation, (c) Deviation from the mean, (d) standard deviation, (e) the probable error of one reading, (h) Variance, (i) based on Chauvenet's theory, which data is to be rejected.

DO NOT USE ABBREVIATIONS IN YOUR ANSWER. State clearly the name of each variable calculated and its equation then put the values and show answer.

Error :- the diffrance between the output and the mesure object.

Controllable error :- Wich I know its sorce and can avoid

Random error :- from unknown sorce and I cant get red of

(T) Tempertue C°	(F) Frequency	T* F	(c) deviation $\bar{X} - X$	deviation * Frequency	$(\text{deviation})^2$ * Frequn.	Dev
29	6	174	-10.65	63.9	680.535	
30	10	300	-9.65	96.5	931.2	
40	21	840	0.35	7.35	2.57	
41	37	1517	1.35	49.95	67.43	
42	19	798	2.35	44.65	104.92	
43	11	473	3.35	36.85	123.44	
44	5	220	4.35	21.75	94.6	
	109	4322	32.05	320.95		

(a) arithmetic mean $= \bar{X} = \frac{\sum T \times F}{\sum F} = \frac{4322}{109} = 39.65$ C°

(b) mean deviation $= \frac{\sum(\text{diviation for each} \times F)}{\sum F} = \frac{320.95}{109} = 2.94$

(d) Standerd diviation ...

4) A mercury thermometer has capillary tube of (0.35±0.007) mm diameter. The bulb is made of zero-expansion material. Take the physical properties of the mercury as follows:
Density = (13.6×10^3 ±2.25%) kg/m³, Specific heat = (139 ± 4.2) J/kg °C, Coefficient of volumetric expansion = (0.75×10^{-3} ±1.25%) C^{-1} and heat transfer coefficient across the bulb = (80±2) J/m² s °C.

$d_c = 0.35 \pm 2\%$ mm

$H = 80 \pm 2.5\%$ J/m² s C

(5 Marks)

$\rho = 13.6 \times 10^3 \pm 2.25\%$ kg/m³

$\alpha = 0.75 \times 10^{-3} \pm 1.25\% \, C^{-1}$

$SC = 139 \pm 3\%$ J/kg C

$$\frac{\rho C V_b}{H A_b}\frac{dx_o}{dt} + x_o = \alpha \frac{V_b}{A_c} T_i$$

DO NOT USE ABBREVIATIONS IN YOUR ANSWER. State clearly the name of each variable calculated and its equation then put the values and show answer.

$\frac{1}{6} \times \frac{4}{3} \pi d^3 = V$

A) What volume should it have, if the sensitivity is 1.25 mm/ °C is required? How much is the uncertainty in your answer?

$$1.25 = \alpha \frac{V_b}{A_c} = 0.75 \times 10^{-3} \frac{V_b}{0.096}$$

$W_{d_b} = 0.085$

$A_c = \frac{\pi d^2}{4}$

$A_c = 0.096$ mm²

$d = \sqrt[3]{\frac{K_s A_c^2}{\alpha}}$

$\Rightarrow V_b = 160$ mm³

zero

$$\frac{W_{d_b}}{d_b} = \sqrt{\left(\frac{W_\alpha}{\alpha}\right)^2 + \left(\frac{W_{d_c}}{d_c}\right)^2 + \left(\frac{W_{K_s}}{K_s}\right)^2}$$

B) Calculate the time constant of the thermometer and its uncertainty.

$$\tau = \frac{\rho C V_b}{H A_b} = \frac{13.6 \times 10^3 \times 139 \times 160 \times 10^{-9}}{80 \times 117.7} = 32.12\,s$$

$d_b = 6.12$ mm

$A_b = 4\pi r^2 = 117.7$ mm²

$$\frac{W_\tau}{\tau} = \sqrt{\left(\frac{W_\rho}{\rho}\right)^2 + \left(\frac{W_c}{c}\right)^2 + \left(\frac{W_{d_b}}{d_b}\right)^2 + \left(\frac{W_H}{H}\right)^2} \Rightarrow W_\tau = 1.975\,s$$

C) If this thermometer is taken from 0 °C and suddenly dipped in a water path of 100 °C, what value will it indicate after 1.5 seconds? How much will be this value if the thermometer was initially at 20 °C?

$0 \rightarrow 100$

@ zero

$$T_o = \frac{x_o}{K_s} = 100\left(1 - e^{\left(\frac{-1.5}{32.12}\right)}\right) = 4.56\,C^\circ$$

@ $T_i = 20 C^\circ$

$$T_o = 100\left(1 - e^{\left(\frac{-1.5}{32.12}\right)}\right) + 20\,e^{\left(\frac{-1.5}{32.12}\right)} = 23.65\,C^\circ$$