No. 25.9.2019

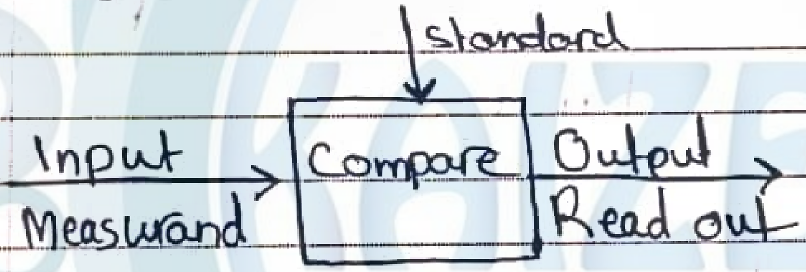
CHAPTER (1)

Measurment: whatever exist, exists in an amount.

Engineering Measurments: obtaining a (1) quantitive comporasion between a (2) predefined standard and a (3) measurand

*Physical quantity I need to measure:

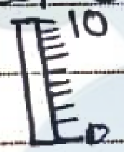
1. Temp. (K)
2. Time (sec)
3. Length (m)
4. Ampere (A)
5. Candela (Ca)
6. Mass (Kg)
7. Mole (mol).



1.3: Fundamental Methods of Measurment

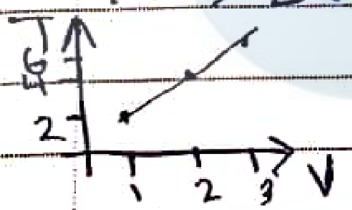
1.3.1: Direct Comparison

ex.



1.3.2: Using a Calibrated System

$T \rightarrow \Delta V$



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1.4: Generalized Measuring System

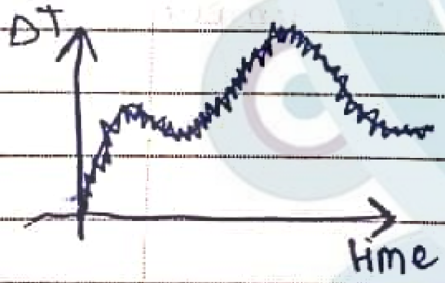
Stage 1: a detection - transduction or sensor - transduser stage

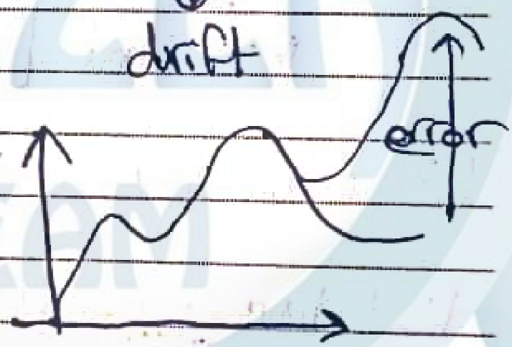
$\Delta T \rightarrow \Delta V$
$\Delta q \rightarrow \Delta$ acceleration
Δ distance $\rightarrow \Delta$ Pressure

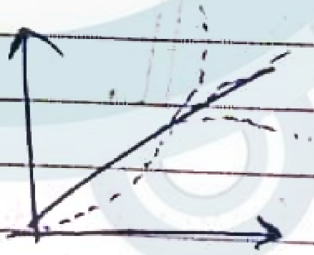
} → calibration →

* we need to the desired sensing measurand
sometimes we sense undesired measurands
ex: enging temp. sensor can sense vibration ← error

Error
- noise: varies rapidly
- drift







Stage 2: Signal Conditioning (not always there)
- amplification
- filter
- integration
- differentiation

Stage 3: Read Out - Recording Stage (Must).

Sensor transducer → Signal Conditioning → Read out

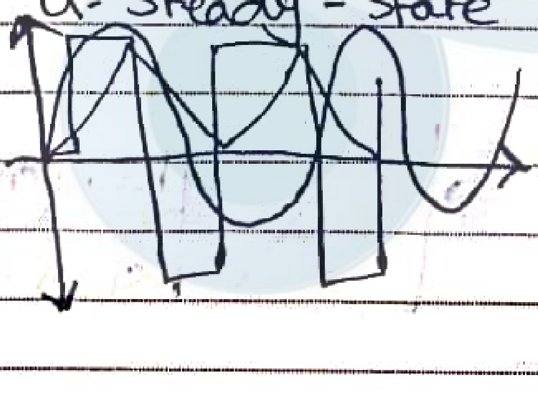
1.5: Types of Input Quantities

1.5.1: Time Dependence

1- Static - Constant in time

2- Dynamic - Varying in time

a- Steady - State periodic



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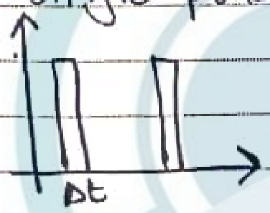
a Non-Repetative or transient

i. single pulse or a periodic



ii. continuing or random

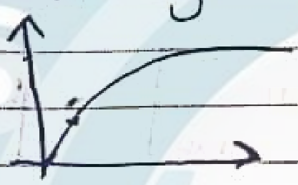
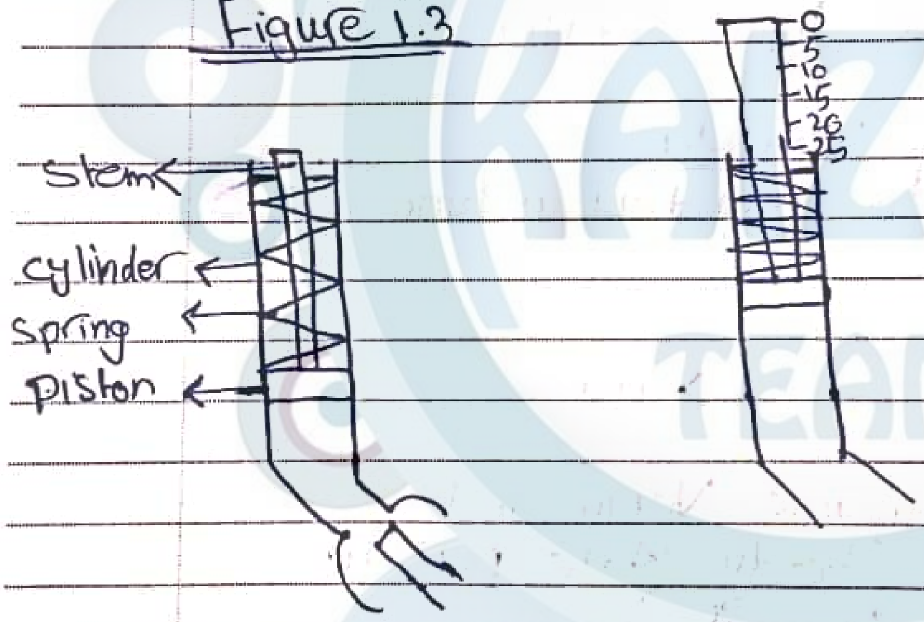
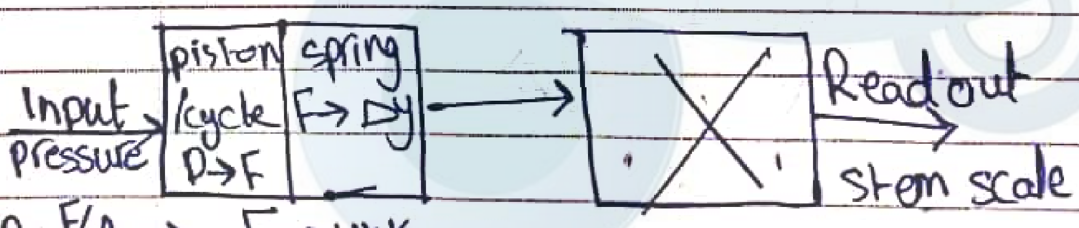


Figure 1.3



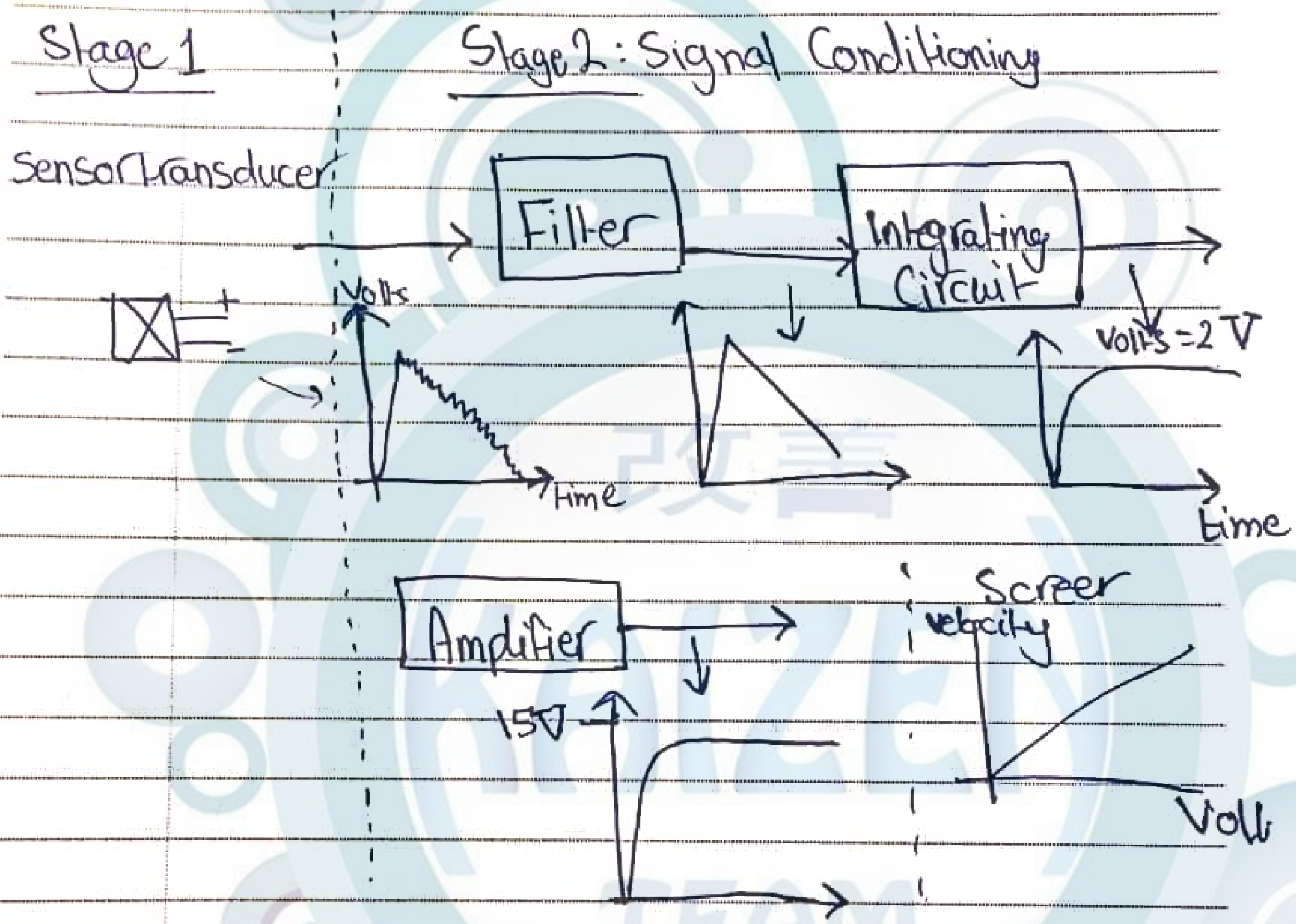


$p = F/A \rightarrow F = \Delta y \times K$

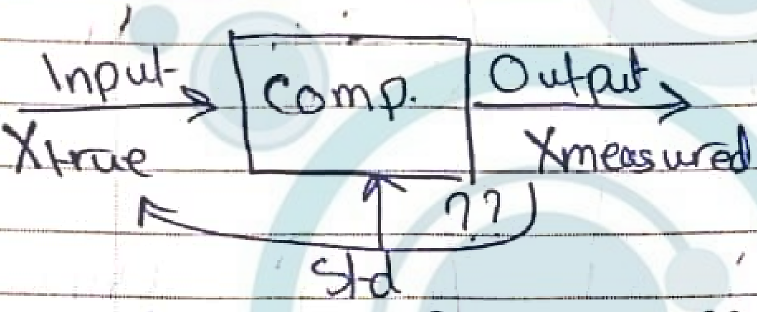
Stage 1 Stage 2

No.

Figure 1.4


Stage 1
Stage 2 : Signal Conditioning
Sensor/transducer
Filter
Integrating Circuit
+
-
Volts
time
Volts = 2 V
time
Amplifier
15V
Screen
velocity
Volt

CHAPTER (3)



Output = 14.5°C + 0.05°C

$\epsilon = X_m - X_{true}$

*uncertenity

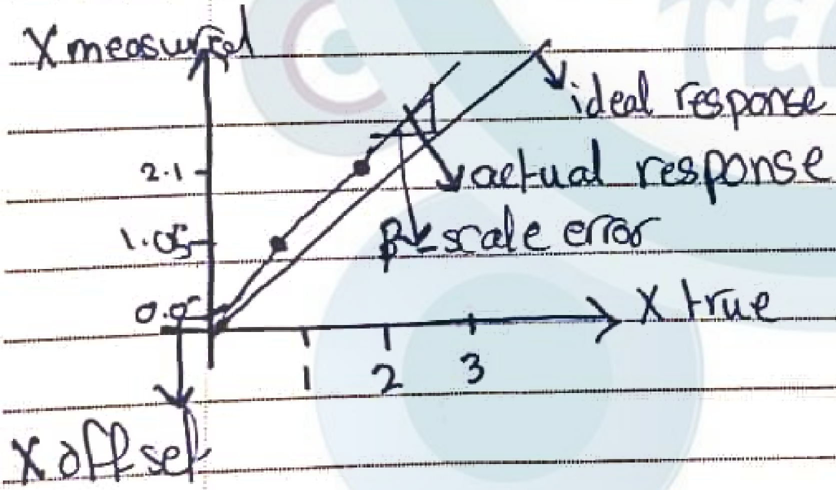
$-u \leq \epsilon \leq +u$

$-u \leq X_m - X_t \leq +u$

$-u - X_m \leq -X_t \leq +u - X_m$

$X_m - u \leq X_t \leq X_m + u$

1. Bias Error



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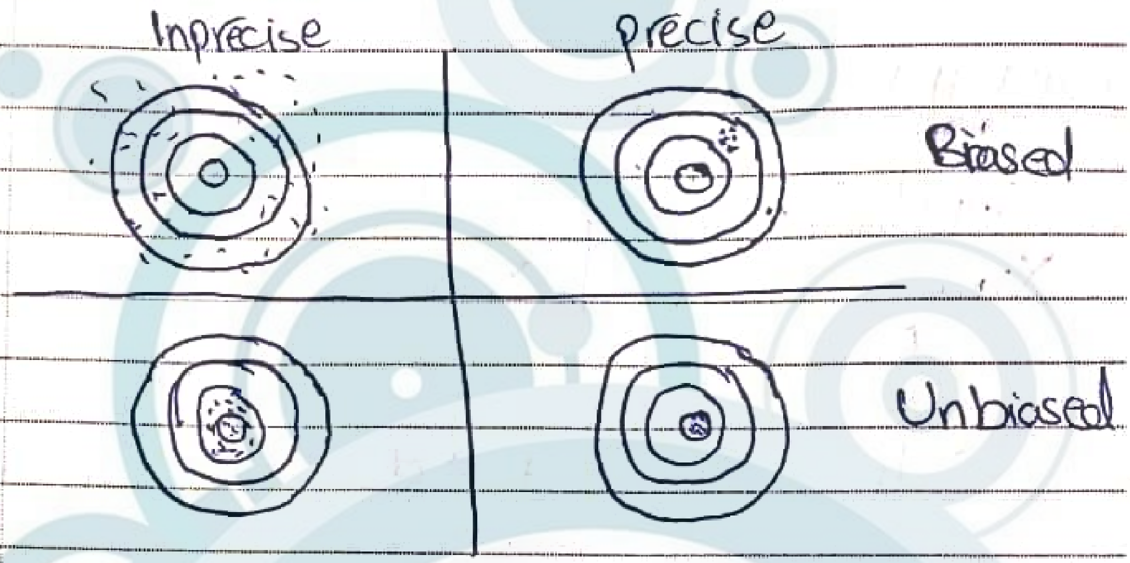
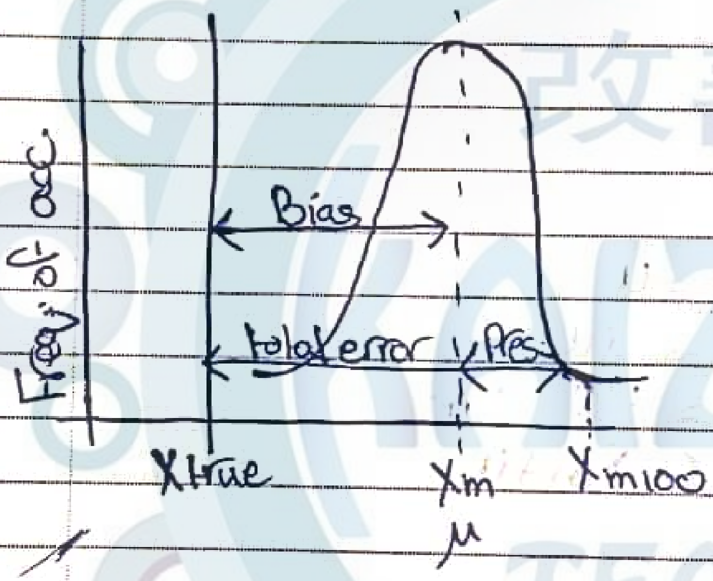

Inprecise
precise
Biased
Unbiased


Freq. of occ.
Bias
total error
Pres.
Xtrue
Xm
μ
Xm100

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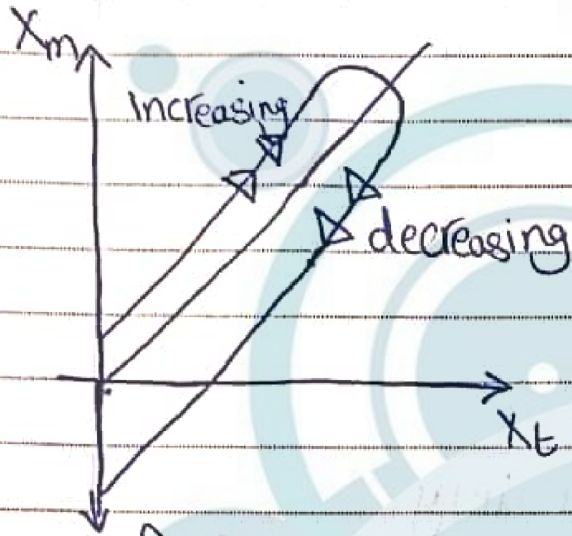
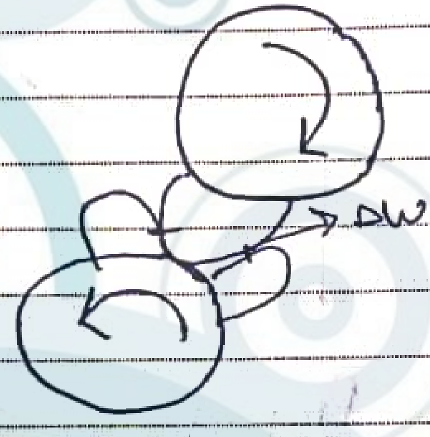
1.



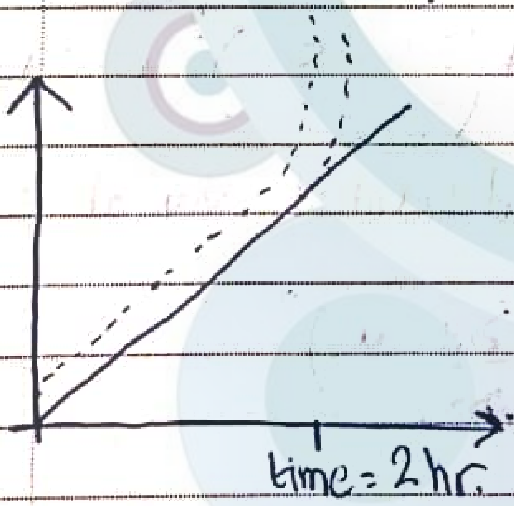


- friction
- hysteresis

- backlash → gears

	Error Cause/Reason	Error Presentation
1.	B	P
2.	P	B
3.	B	P
4.	B	P

2.



- calibration

No.

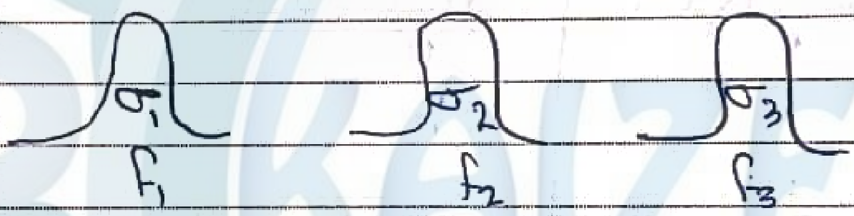
3.

3.10: Propagation of uncertainty

$F = ma$

5 = mass → mass or weight $U = 0.5\ Kg$

4 = acc. → accelometer $U = 0.01\ m/sec^2$



$= \sigma$

$$\sigma_y = \sqrt{\left(\frac{\partial y}{\partial x_1} \times \sigma_1\right)^2 + \left(\frac{\partial y}{\partial x_2}\ \sigma_2\right)^2 + \cdots + \left(\frac{\partial y}{\partial x_n}\ \sigma_n\right)^2}$$

$x_1, x_2, \cdots x_n$: independent variable

$$U_y = \sqrt{\left(\frac{\partial y}{\partial x_1} . u_1\right)^2 + \left(\frac{\partial y}{\partial x_2}\ u_2\right)^2}$$

$F = ma$

$$\frac{\partial F}{\partial m} = a \qquad \frac{\partial F}{\partial a} = m$$

$$= 4 \qquad\qquad = 5$$

$$U_F = \sqrt{(4 \times 0.5)^2 + (5 \times 0.01)^2}$$

No.

Q33: a 68 KΩ resistor is paralled with a 12 KΩ resistor, each has a ±10% tolerance what will be the nomial resistance and the uncertainty of the combination.

nomial: $R_{eq} = \frac{R_1 . R_2}{R_1 + R_2} = 10.2\ K\Omega$

uncertainty: $U_{R_1} = \frac{10}{100} \times 68 = 6.8\ K\Omega$

$U_{R_2} = \frac{10}{100} \times 12 = 1.2\ K\Omega$

$U_{Req} = \sqrt{\left(\frac{\partial R_{eq}}{\partial R_1} U_{R_1}\right)^2 + \left(\frac{\partial R_{eq}}{\partial R_2} U_{R_2}\right)^2}$

$\frac{\partial R_{eq}}{\partial R_1} = \frac{R_2^2}{(R_1+R_2)^2} = 0.025$

$\frac{\partial R_{eq}}{\partial R_2} = \frac{R_1^2}{(R_1+R_2)^2} = 0.707$

$U_{Req} = \sqrt{(0.025 \times (6.8)^2 + (0.707 \times 1.2)^2}$

$= 0.08\cancel{8}85$

No.

Ex 3.13: $y = A \dfrac{x_1^m \cdot x_2^n}{x_3^k}$

$$\frac{\partial y}{\partial x_1} = A m \frac{x_1^{m-1} \, x_2^n}{x_3^k} = \frac{A m}{x_1} \frac{x_1^m \, x_2^n}{x_3^k}$$

$$u_y = \sqrt{\left(\frac{A m}{x_1} \left\{ \frac{x_1^m \, x_2^n}{x_3^k} u_1 \right\}\right)^2 + \cdots}$$

$$= \sqrt{\left(\frac{m}{x_1} u_1\right)^2 \cdot y^2}$$

$$\frac{u_y}{y} = \sqrt{\left(\frac{m}{x_1} u_1\right)^2 + \left(\frac{n}{x_2} u_2\right)^2 + \left(\frac{-k}{x_3} u_3\right)^2}$$

$F = m'a'$

$\dfrac{u_1}{m} = \dfrac{0.5}{4}$ $\qquad \dfrac{u_2}{a} = \dfrac{0.01}{5}$

$$\frac{u_F}{F} = \sqrt{\left(\frac{0.5}{4} \times 1\right)^2 + \left(\frac{0.01}{5} \times 1\right)^2}$$

No.

Q3.4: five 100 Ω resistors, each having 5% tolerance, connected in series

$$R_{eq} = R_1 + R_2 + \dots + R_5 = 500\ \Omega$$

$$\frac{\partial R_{eq}}{\partial R_1} = 1$$

$$U_{Req} = \sqrt{(1\times5)^2 + (1\times5)^2 + \dots + (1\times5)^2} = 11.18\ \Omega$$

Q3.17: power $P = I.V. = I.R^2 = \frac{V}{R^2}$, $I = 3.2\ A$

$R = 1000\ \Omega$

Instrument	Resolution	Uncertainty %
Voltmeter	1.0 mV	0.5% $= \frac{U_V}{V}$
Ohmmeter	1.0 Ω	0.1% $= \frac{U_R}{R}$
Ammeter	0.1 A	0.5% $= \frac{U_A}{A}$

$$\frac{U_y}{y} = \sqrt{\left(m.\frac{U_1}{X_1}\right)^2 + \left(n.\frac{U_2}{X_2}\right)^2}$$

For $P = I.V.$

$$\frac{U_P}{P} = \sqrt{(1\times0.5)^2 + (1\times0.5)^2} = 0.707\%$$

$$\frac{U_P}{P} = \sqrt{(2\times0.5)^2 + (1\times0.1)^2} = 1.0049\%$$

FIVE APPLE

No.

Ex 3.15 : $Q = KA_2\sqrt{g_c(P_1-P_2)/\rho}$

$(U_y)_P$
$(U_y)_B$ $\rightarrow U_y = \sqrt{U_P^2 + U_B^2}$

flow meter = $\frac{\text{Volume}}{\text{Sec}}$

$Q \propto A_2\sqrt{g_c \frac{\Delta P}{\rho}}$

$K = \frac{Q}{A_2\sqrt{g_c\frac{\Delta P}{\Delta \rho}}}$

$K = \frac{4w}{\pi D^2 t}\sqrt{\frac{1}{2\rho\Delta P}}$

$Q = \frac{\text{Volume}}{\text{time}} = \frac{\text{mass}(w)}{\text{density}\cdot\text{time}}$

$A_2 = \pi/4\ D_2^2$

ΔP = pressure of difference.

Variable	Bais %	St Dev ~~Precission~~ %
w	1.0	0.1
D	0.2	0
t	0	1.0
density	0.02 with temp. or 0.2 with no temp.	0.002
ΔP	0.1	1

Scanned by CamScanner

No.

$$\frac{U_K}{K} = \sqrt{\left[\left(1 \times \frac{U_w}{w}\right)^2 + \left(2 \times \frac{U_{D_2}}{D_2}\right)^2 + \left(\frac{U_t}{t}\right)^2 + \left(\frac{1}{2} \times \frac{U_\rho}{\rho}\right)^2 + \left(\frac{1}{2} \times \frac{U_{D\rho}}{D\rho}\right)^2\right]}$$

$$\frac{B_K}{K} = \left[(1.0)^2 + (2 \times 0.2)^2 + (0)^2 + (1/2 \times 0.02)^2 + (1/2 \times 0.1)^2\right]^{1/2}$$

$$= 1.08\%$$

$$\frac{\sigma_K}{K} = \left[(0.1)^2 + (2 \times 0)^2 + (1.0)^2 + (1/2 \times 0.02)^2 + (1/2 \times 1)^2\right]^{1/2}$$

$$= 1.12\%$$

$$\frac{P_K}{K} = 1.96 \times (0.0112) = 2.2\%$$

$$\frac{U_K}{K} = \sqrt{\frac{B_K}{K}^2 + \frac{P_K}{K}^2} = 2.45\%$$

3.9.1: Single-Sample Precision

$$P = Z_{\alpha/2} \frac{\sigma_c}{\sqrt{n}}$$

$$P = 1.96\,\sigma$$

$$\sigma = E.\epsilon$$