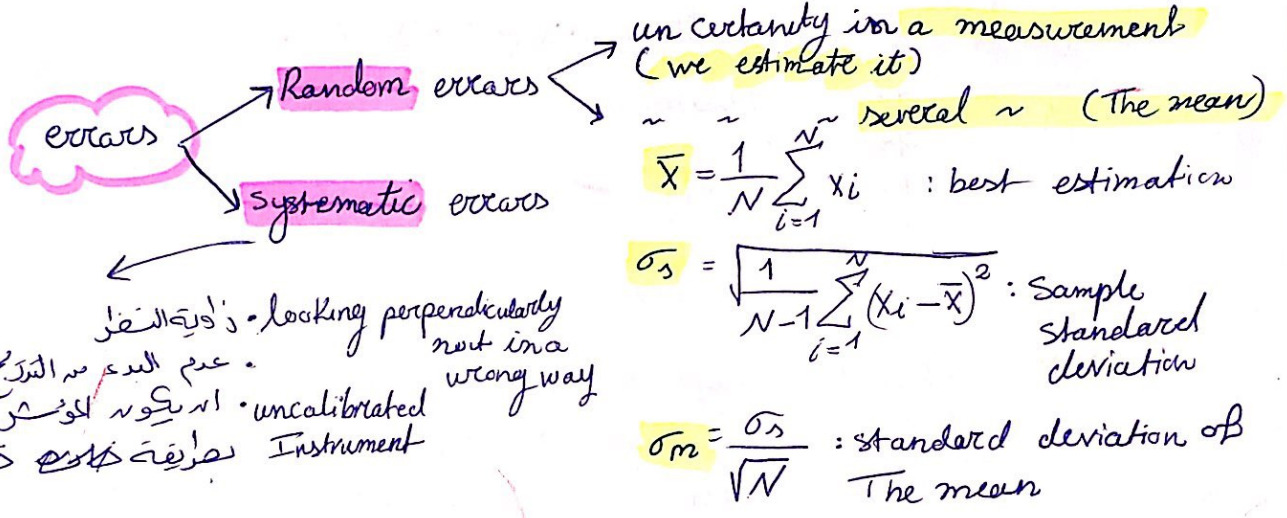


# Measurements and Uncertainties

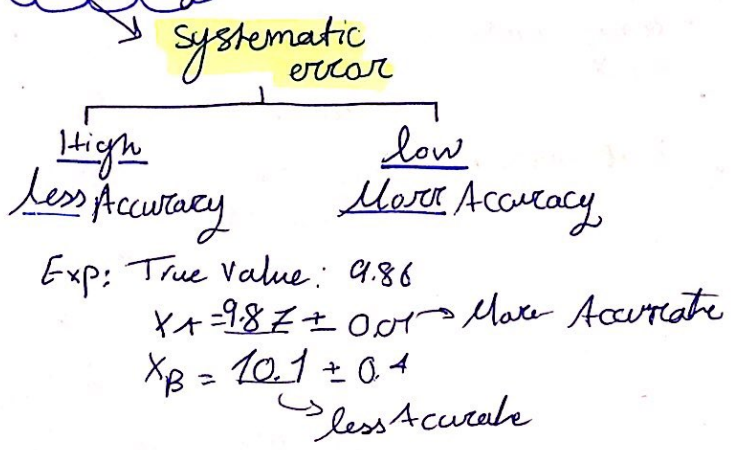
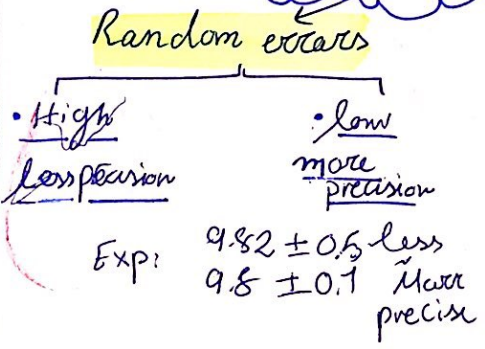
## Sources of errors:

- 1- Choice of instruments
- 2- The Experimenter
- 3- The Environment
- 4- The way the experiment is done
- 5- The way the physical quantity is measured

A measurement can never be taken without any error. But it can be estimated when all errors are very small



## Precision and Accuracy



Alaa Ebtawi

# Discrepancy test : accepted / not accepted

- \* True value X
- \* Result  $\bar{X} \pm \Delta X$

- steps:

- 1-  $D = |X - \bar{X}|$
- 2-  $2 \times \Delta X$
- 3- if  $D > 2\Delta X$  not accepted  
if  $D \leq 2\Delta X$  accepted

## significant figures

هي اللرقام المتوفرة التي عن عن عددها .

- Exp:
- 900: 1 significant
  - 900: 3 ~
  - 9000: 4 sig
  - 0.020: 2 sig

$\Delta X$ : should always be 1 sig figure unless the leading digit was one  
Then we keep the digit after

Exp 0.123  $\approx$  0.12  
0.16  $\approx$  0.2  
or 1.6

## Rounding Rules :-

- any number less than 5 and we fix the sig. fig
- " " more ~ 5 we round the last sig fig up
- if it was 5:
  - Exp 3.5  $\rightarrow$  40  
العدد 3.5
  - 4.5  $\rightarrow$  40  
العدد 4.5
  - 0.7251  $\rightarrow$  0.73  
2 sig fig

## Values

### \* Addition and subtraction

- The no with the fewest decimal places limits the number of decimal places in the result

المقادير العشرية

### \* Multiplication and division

- we find how much of sig fig there is in the numbers multiplied: The less controls the result

الحد الأدنى

$$\sqrt{13} = 3.782 \approx 3.8$$

$$\sqrt{2.4 + 10.2} = \sqrt{12.6} = 3.549$$

تكون أقل المجموع

$$\sin(24) = 0.406 \approx 0.41$$

$$\cos(70) = 0.342 \approx 0.3$$

## Uncertainty

### \* Addition and subtraction

$$R = x \pm y \quad \Delta R = \Delta x + \Delta y \quad \text{general rule}$$

### \* Constant Multipliers

$$R = ax \pm by \quad \Delta R = a\Delta x + b\Delta y$$

But if a and b are not const  
Then

$$\Delta R = a\Delta x + x\Delta a + b\Delta y + y\Delta b$$

### \* Multiplication and division

$$A = xy$$

$$\frac{\Delta A}{A} = \frac{y\Delta x + x\Delta y}{A}$$

For 2 values

$$\frac{\Delta A}{A} = \frac{y\Delta x}{xy} + \frac{x\Delta y}{xy}$$

For more than 2 values

$$= \frac{\Delta x}{x} + \frac{\Delta y}{y}$$

Alaa Etaiwi

## \* Raising to powers

$$R = x^l y^m z^h$$

$$\frac{\Delta R}{R} = |l| \frac{\Delta x}{x} + |m| \frac{\Delta y}{y} + |h| \frac{\Delta z}{z}$$

✓ \*  $R = e^x$   
العقد الشبكي

$$\hookrightarrow \Delta R = e^x \Delta x$$

\*  $R = \ln x$

$$\hookrightarrow \Delta R = \frac{1}{x} \Delta x$$

\*  $R = \sin \theta$

$$\hookrightarrow \Delta R = \cos \theta \Delta \theta$$

\*  $R = \cos \theta$

$$\hookrightarrow \Delta R = -|\sin \theta| \Delta \theta$$

في حالة الزوايا الراديان Rad

عند طرفه  $2\pi \rightarrow 180$

→ الاشتقاق المتعدد

•  $R = R(x, y, z)$

$$\hookrightarrow \Delta R = \left| \frac{\partial R}{\partial x} \right| \Delta x + \left| \frac{\partial R}{\partial y} \right| \Delta y + \left| \frac{\partial R}{\partial z} \right| \Delta z$$

اشتقاق متعدد

Alaa Etaiwi