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 take without any error. But it can be estimated when all errors are very small

errors → Random errors → uncertainty in a measurement (we estimate it)
~ ~ ~ several ~ (The mean)

$$\bar{X} = \frac{1}{N}\sum_{i=1}^{N} x_i$$: best estimation

$$\sigma_s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$: Sample standard deviation

$$\sigma_m = \frac{\sigma_s}{\sqrt{N}}$$: standard deviation of The mean

errors → Systematic errors

- looking perpendicularly not in a wrong way
- uncalibrated Instrument

Precision and Accuracy

Random errors

- High → less precision
- low → more precision

Exp: 9.82 ± 0.5 less
9.8 ± 0.1 More precise

systematic error

High → less Accuracy
low → More Accuracy

Exp: True value: 9.86
$X_A = 9.87 \pm 0.01$ → More Accurate
$X_B = 10.1 \pm 0.1$ → less Accurate

Alaa Etaiwi

Discrepancy test : accepted / not accepted

* True value X
* Result $\overline{X} \pm \Delta X$

- steps:
1- $D = |X - \overline{X}|$
2- $2^x \Delta X$
3- if $D > 2\Delta X$ not accepted
   if $D \leq 2\Delta X$ accepted

significant figures

• هي الأرقام المعنوية التي يعبر عنها

Exp: 900: 1 significant
900.: 3 ~
900.0: 4 sig
0.020: 2 sig

ΔX: should always be 1 sig figure unless the leading digit was one Then we keep the digit after Exp 0.123 ≈ 0.12
0.16 ≈ 21 or 1.6

Rounding Rules :-

• any number less than 5 we fix the sig. fig
• ~ ~ more ~ 5 we round the last sig fig up
• If it was 5: Exp 3.5 → 40
(رقم زوجي)
45 → 40
(رقم فردي)
0.7251 → 0.73
(رقم زوجي)

Alaa Hatem

Values

* **Addition and substraction**

- The n° with the fewest decimal places limits the number of decimal places in the result

* **Multiplication and division**

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

- $\sqrt{15} = 3.782 \approx 3.8$ (2 s.f)

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

- $\sin(24) = (0.406) \approx 0.41$
- $\cos(70) = 0.342 \approx 0.3$

Uncertainity

* **Addition and substraction**

$R = X \pm y \quad \Delta R = \Delta x + \Delta y$: 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

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

* **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

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

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

* $R = e^x$ (الاس السالب)

↳ $\Delta R = e^x \Delta x$

* $R = \ln X$

↳ $\Delta R = \frac{1}{X} \Delta x$

* $R = \sin \theta$

↳ $\Delta R = \cos\theta \, \Delta\theta$

* $R = \cos\theta$

↳ $\Delta R = |-| \sin\theta \, \Delta\theta$

لـ Rad نحول الخطأ من الدرجات

عن طريق $2\pi \rightarrow 180$

→ الاستقام العضوي

• $R = R(X, y, z)$

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

استقام جزئي

Alaa Etaiwi