Lab III

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تلخيص المادة النظرية.

Measurements and Uncertainties:-

- There are many Sources of errors:-
  1. Choice of instruments
  2. The enviroment
  3. The way the experiment is done
  4. Experimenter
  5. The way the physical quantity is measured

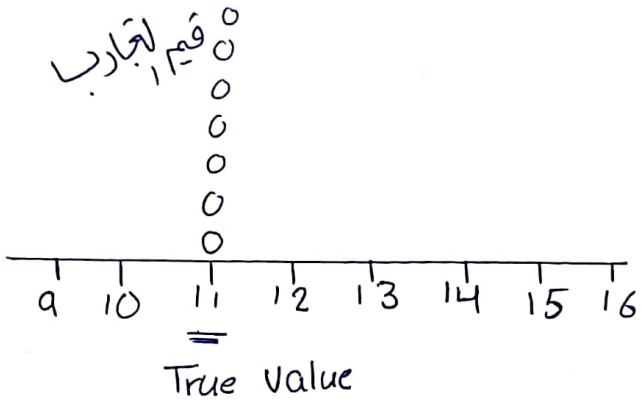
- Types of Errors:-
  1. Random errors: "Affect preision"
  هي أخطاء لا يمكن تلافيها (غير معلومة الحصول غالباً)
  2. Systematic errors: "Affect accuracy"
  هي أخطاء معلومة الحصول ويمكن تلافيها (من الأجهزة)

⟹ So what is the diffrence between accuracy and precision?!

precision: دقة وقرب قيم القياس من بعضها البعض

accuracy: دقة القيمة المقاسة (متوسط القيم) من القيمة الحقيقية (True value)

Case 1 : accurate, precise



هذه الحالة :

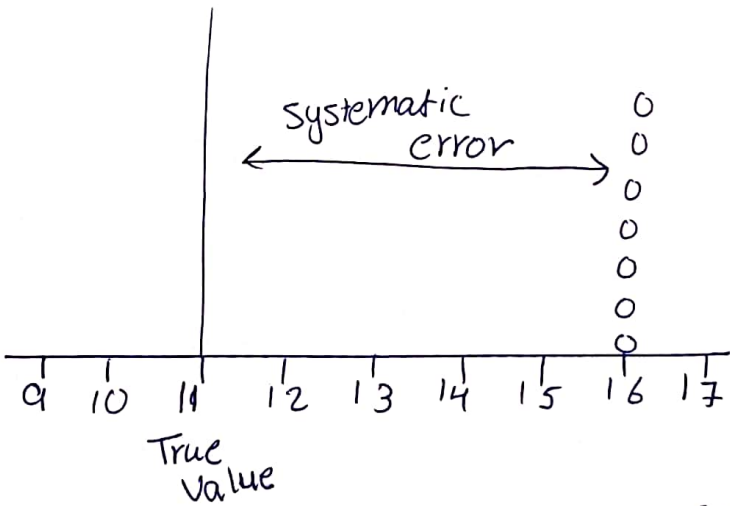
accurate ← لانه متوسط القيم = القيمة الحقيقية

precise ← لانه القيم جميعها متساوية

* هذه الحالة نادرة الحدوث "حيث لا توجد تجارب بدون أخطاء"

Case 2 : not accurate, precie

- أي الخيارين القيم يكون نوع الخطأ (systematic) (إذا كانت جميع القيم أكبر او جميعها أصغر من القيمة الحقيقية)

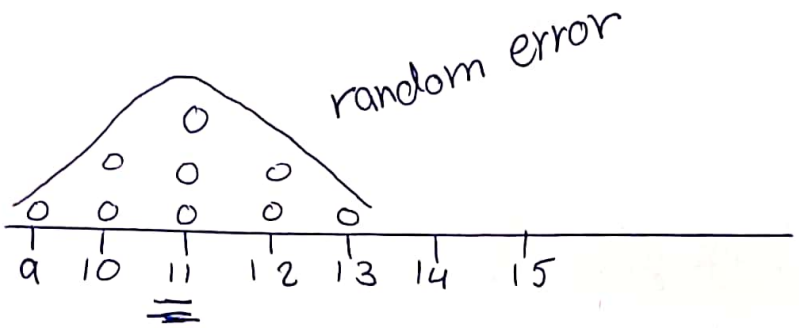


precise : لانه جميع قيم التجربة متساوية

not accurate : لانه متوسط القيم 16 ولا يساوي القيم الحقيقية

accuracy ← تؤثر ← systematic ..

Case 3 : accurate , not precise



$\bar{X} = 11$
متوسط القيم

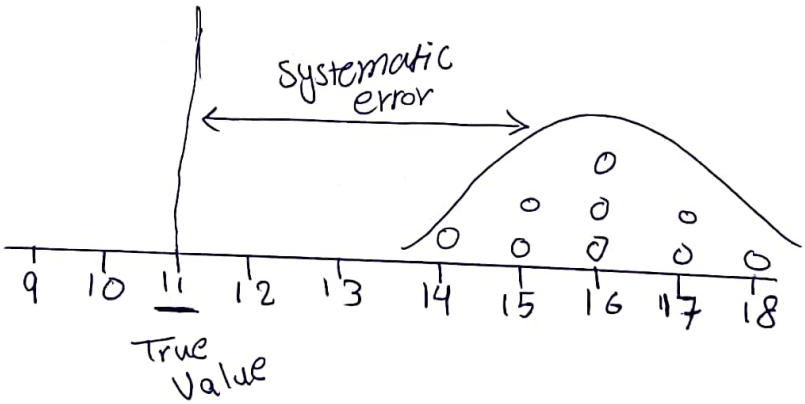
القيمة الحقيقية = متوسط القيم ∴ accurate

القيم متفاوتة وغير متساوية ∴ not precise

precision	تأثر على	random error

Case 4 : not accurate , not precise

- تجمع القيم أكبر من القيمة الحقيقية (systematic)
- القيم متفاوتة (Random)



$\bar{X} = 16$

$\bar{X}$ لا تساوي القيمة الحقيقية : not accurate

القيم متفاوتة :- not precise

accuracy	تأثر على	systematic
precision	تأثر على	Random

Notes:

Small Random error means High precision

Negligible Systematic error means High accuracy

Example

$A = 2.52 \pm 0.02$ cm

$B = 2.58 \pm 0.05$ cm

where the true value = 2.5

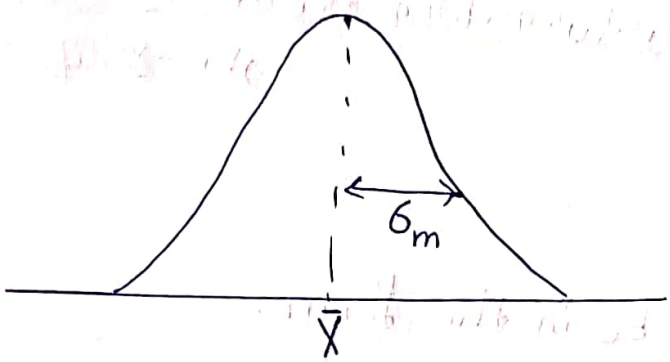
① who is more accurate ?! A

② who is more precise ?! A

→ in the accuracy case we compare the $\bar{X}$ (averege value) with the true value.

→ in the precision we look at the ΔX (uncertainties) "the less in error (ΔX) : more precise"

Some important values :



$\bar{X}$ = average value

$$= \frac{1}{N} \sum_{i=1}^{N} X_i$$

σ_s = The sample standard deviation

σ_m = The standard deviation of the mean

$$\sigma_s = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (X_i - \bar{X})^2}$$

$$\sigma_m = \frac{\sigma_s}{\sqrt{N}}$$

N: عدد القيم (عدد مرات عمل التجربة)

X_i: قيم التجربة في كل مرة

* Discrepancy Test :-

- طريقة إذا كانت القيمة الناتجة من التجربة $\bar{X}$ مقبولة أو لا تقوم بعمل هذا الاختبار.

Steps :-

1. The result should be in this form.

$$\bar{X} \pm \Delta X$$

2. Find $2 * \Delta X$

3. $D = |\bar{X} - X_{True}|$

4. if $D > 2 * \Delta X$ then the value is not accepted

if $D < 2 * \Delta X$ then the value is accepted

* Significant Figures Rules :-

1. Every non-Zero digits are significant figures.

E.g, 454,76 → has (5) significant figures S.f

جميع الأعداد ماعدا الصفر دائما تعتبر رقم معنوي

2. Zeroes → three Cases.

[A] All Zeroes which lie between two non-Zero digits are also S.f.

E.g: 703.004
has (6) S.f

* الأصفار بين الأعداد تعتبر S.f

[B]. All Zeroes after decimal but befor a non-Zero digit is not considerd a significant figure

E.g: 0,00465
has (3) S.f

* الأصفار على شمال العدد لا تعتبر S.f

[C]. All Zeroes at the right enel treated in two ways.

- the number contain decimal point.
- the number not contain decimal point

- الأصفار على يمين العدد بدون فاصلة عشرية لاتعتبر S.f

- الأصفار على اليمين بوجود فاصلة العشرية تحتسب S.f

E.g: 75000 has (2) S.f.
X

* لعدم وجود فاصلة عشرية

E.g: 13300. has (5) S.f.
L

* بسبب وجود فاصلة العشرية

E.g 0.064000 has (5) S.f
X L

3. The Zeroes that written in the form 10^X dont considered as S.f

E.g: $\underset{L}{3.1} * \underset{X}{10^2}$ has (2) S.f

$\underset{L}{6} * \underset{X}{10^{-4}}$ has (1) S.f

Q: what is the number of the S.f?

20 = 1 S.f

730 = 2 S.f

9.0 = 2 S.f

5^2 = 25 = 2 S.f

900 = 1 sf

900. = 3 sf

900.0 = 4 sf

0.02 = 1 Sf

0.020 = 2 Sf

$3.0 * \frac{10^2}{x} = 2$ Sf

* Rounding Rules :-

- Any number more than 5 → round it up.
- Any number less than 5 → stay the same
- if its five.
  → with the odd number → round up.
  → with the even number → stay the same

E.g: Rowel these number up?!

$456 = 450$

$31 = 30$

$101 = 100$

$97 = 100$

$65 = 60$ (العدد قبل الخمسة زوجي)

$35 = 40$ (العدد قبل الخمسة فردي)

$85 = 80$

$95 = 100$

The Calculation :-

1. Addition and Subtraction

The number with fewest decimal places limits the number of decimal places result

E.g:

$R = 10.3 + 108.76 + 0.0349 = 119.0949$

1 2 4

should have 1 decimal place

$119.0949 = 119.1$

1 decimal place

2. Multiplication and division

The s.f of the final result should be equal in digit to the lowest one in the calculation

$2.1 \times 3.004 = 6.3084 \rightarrow 6.3$ 2sf

2sf 4sf should be 2sf

$7.3 \times 41.5 = 301.95 = 30 \times 10^1$

2sf 3sf should be 2sf 2sf.

- The uncertainty :-

The error (uncertainty) → found it by the direct differentiation

1. Addition and Subtraction

$$R = X \pm Y$$

$$\boxed{\Delta R = \Delta X \pm \Delta Y}$$

notic that when

$$R = X - Y$$

$$\boxed{\Delta R = \Delta X + \Delta Y}$$

Since the errors always add

2. Multiplication and division

$$A = XY$$

$$\Delta A = Y\Delta X + X\Delta Y$$

divide by →

$$\frac{\Delta A}{A} = \frac{Y\Delta X}{A} + \frac{X\Delta Y}{A}$$

$$\frac{\Delta A}{A} = \frac{Y\Delta X}{XY} + \frac{X\Delta Y}{XY}$$

$$\boxed{\frac{\Delta A}{A} = \frac{\Delta X}{X} + \frac{\Delta Y}{Y}}$$

3. Raising to a power :-

* $R = x^n y^m z^\ell$

$$\frac{\Delta R}{R} = n\frac{\Delta x}{x} + m\frac{\Delta y}{y} + \ell\frac{\Delta z}{z}$$

* $R = e^x$

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

4. Others :

* $R = \ln x$

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

* $\sin x = R$

$$\Delta R = \Delta x |\cos x|$$

* $\tan x = R$

$$\Delta R = |\sec^2 x| \Delta x$$

5. General Rule :-

$$R : R(x, y, z)$$

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

Example :-

$$R(x, y, z) = x^2 y^3 \sin(x+z)$$

$$\Delta R = \left|2xy^3 \sin(x+z) + x^2 y^3 \cos(x+z)\right| \Delta x + \left|3x^2 y^2 \sin(x+z)\right| \Delta y + \left|x^2 y^2 \cos(x+z)\right| \Delta z$$

Important comments:

1. The uncertainty always has one significant figures.

2. Experimental result must always be round it, such that only significant figures are included.

E.g: 4.7 ± 0.03 ✗ $\quad 4.70 \pm 0.03$ ✓

4.70 ± 0.3 ✗ $\quad 4.70 \pm 0.3$ ✓

4.728 ± 0.0030 ✗ $\quad 4.728 \pm 0.003$ ✓

472.80 ± 0.3 ✗ $\quad 472.8 \pm 0.3$ ✓

Q: if $g = 9.81$ and $\Delta g = 0.0421$ what is the correct form for this result $g \pm \Delta g$.

$\Delta g \rightarrow$ just one S.f

$\therefore \Delta g = 0.0421 = 0.04$

$$g \pm \Delta g = 9.81 \pm 0.04$$

⇒ Solve The exercises in page 23, 24, 25