chapter 1

Units and Physical Measurements

القياسات

Physical quantity

- Any quantity that can be measured and consists of **magnitude** and **unit**

EX:

Mass = 50 kg	
Magnitude	unit

Systems of units

a) **A standard international system (SI) (النظام العالمي)** (M.K.S)

b) **CGS system (النظام الفرنسي أو نظام جاوس)**

c) **The English system (FPS) (النظام البريطاني)**

Quantity	SI	CGS	FPS
Length (L)	Meter (m)	Centimeter (Cm)	Foot (ft)
Mass (M)	Kilogram (Kg)	Gram (g)	Pound (P)
Time (T)	Second (S)	Second (S)	Second (S)

Length Units and Conversions

DR\ A.ElSHABASY

Physical Quantity الكمية الفيزيائية

① Magnitude المقدار

② unit الوحدة

Ex: → Mass = 70 kg

الكتلة — المقدار — الوحدة

الطول Length = 180 cm

Units systems أنظمة الوحدات

	العالمي	الفرنسي	البريطاني
	SI or M.K.S	C.G.S	F.P.S
الطول Length	meter	cm	قدم foot
الكتلة Mass	kg	g	باوند Pound
الزمن Time	s	s	s

Unit	Symbol	Conversion Formula
Mile	mi	1 mi = 1,609.34 m
Kilometer	km	1 km = 1,000 m
Meter	m	1 m = 1 m
Centimeter	cm	1 cm = 0.01 m
Millimeter	mm	1 mm = 0.001 m
Yard	yd	1 yd = 0.9144 m
Foot	ft	1 ft = 0.3048 m
Inch	in	1 in = 0.0254 m

Ex:

- **If 1 ft = 30.48 cm, how many feet are in 2 m?**
- **If 1 mile = 1.60934 km, how many kilometers are in 5 miles?**

Answer

The prefix multipliers

• $10^0 \rightarrow normal$ • $10^3 \rightarrow kilo$ • $10^6 \rightarrow mega$ • $10^9 \rightarrow Giga$ • $10^{12} \rightarrow tera$ • $10^{15} \rightarrow peta$	• $10^{-1} \rightarrow deci$ • $10^{-2} \rightarrow cm$ • $10^{-3} \rightarrow millie$ • $10^{-6} \rightarrow micro\ (\mu)$ • $10^{-9} \rightarrow nano$ • $10^{-12} \rightarrow pico$ • $10^{-15} \rightarrow femto$

There are two types of quantities

a) Fundamental or basis quantities

- **quantities** that we cannot express them with other physical **quantities**

Ex:

1. **Mass (Kg)**
2. **Time (S)**
3. **Length (m)**
4. **Temperature (K)**
5. **Electric current (A)**
6. **Luminous intensity (candle)**
7. **Amount of substance (Mole)**

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b) derivative quantities

- **quantities** we can express them with other physical **quantities**.

Ex:

Area (A) - Volume (V) - Density (ρ) - Pressure (P) - Force (F)

Dimensional analysis

- It is used to indicate the physical quantity and type of unit used to identify it.

Quantity	Dimension
Mass	M
Length	L
Time	T

Very important notes

① Adding and Subtracting Physical Quantities:

- You can only add or subtract physical quantities if they have the same type of dimensions, such as length with length or time with time.

يمكن جمع أو طرح الكميات الفيزيائية فقط إذا كانت لها أبعاد من نفس النوع

- Example: 5 meters + 3 meters = 8 meters. Both quantities are in the same units.
- As a Dimension

$$L + L = L$$
$$M - M = M$$

② Multiplying and Dividing Physical Quantities:

- You can multiply or divide quantities with different dimensions.

يمكن ضرب أو قسمة كميات بأبعاد مختلفة

- Example: To find speed, you divide distance by time

③ Constants with or without

Dimensions:

- **Numbers** and Some constants, like π are **dimensionless**, meaning they don't have units.
- functions like $sin, cos, or\ tan$ they are **dimensionless**, meaning the result has **no units.**
- Other constants, like gravity g or the speed of light c, have dimensions and are measured in specific units.
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Uses for the dimensional formula

① Find some physical quantities' dimensions and units.

إيجاد أبعاد ووحدات بعض الكميات الفيزيائية

Quantity	Law	dimensions	Base unit
Area (A)	$L \times L$	$[L^2]$	m^2
Volume (V)	$L \times L \times L$	$[L^3]$	m^3
Density ($\boldsymbol{\rho}$)	$\frac{Mass}{Volume}$	$[M/L^3]$	Kg/m^3
Speed (v)	$\frac{Distance}{Time}$	$[L/T]$	m/sec
Acceleration (a)	$\frac{velocity}{Time}$	$[L/T^2]$	m/sec^2
Force (F)	$Mass \times acceleration$	$[ML/T^2]$	$Kg.m/s^2 \equiv Newton$
Pressure (P)	$\frac{Force}{Area}$	$[M/LT^2]$	$Kg/m.s^2 \equiv Pascal$

Work (W)or Energy (E)	$Force \times Distance$	$[ML^2/T^2]$	$Kg.m^2/s^2 \equiv Joul$
Momentum	$\boldsymbol{m \times v}$	$[1/T]$	$1/sec$
Surface Tension ($\boldsymbol{\gamma}$)	$\frac{Force}{Length} = \frac{Work}{Area}$	$[M/T^2]$	Kg/s^2
Potential Energy ($\boldsymbol{PE}$)	$Mass \times acceeleration \times Height$	$[ML^2/T^2]$	$Kg.m^2/s^2 \equiv Joul$
Kinetic Energy (KE)	$\frac{1}{2}mv^2$	$[ML^2/T^2]$	$Kg.m^2/s^2 \equiv Joul$
Viscosity ($\boldsymbol{\eta}$)	$\frac{Force}{time \text{ X area}}$		$pacal.sec$

② Check the correctness of some physical equations

التأكد من صحة المعادلات الفيزيائية

يجب أن تكون الأبعاد متساوية على طرفي المعادلة عشان تكون المعادلة صحيحة

$$L.H.S = R.H.S$$

Example 1

Check the validity of these equation $x = \frac{1}{2}vt^2$ where x is distance, v is velocity and t is time

Solution

$$x = \frac{1}{2}vt^2$$

$$LHS = [L]$$

$$RHS = \frac{[L]}{[T]} * [T^2] = [L][T]$$

$$RHS \neq LHS$$

Example 2

Check the validity of these equation $x = vt$

Solution

$$LHS = [L]$$

$$RHS = \frac{[L]}{[T]} * [T] = [L]$$

$$RHS = LHS$$

Example 3

Check the validity of these equation $x = \frac{1}{2}at^2$ where a is acceleration

Solution

$$x = \frac{1}{2}at^2$$

$$LHS = [L]$$

$$RHS = \frac{[L]}{[T^2]}[T^2] = [L]$$

$$RHS = LHS$$

Example 4

Check the correctness of physical equation $s = ut + \frac{1}{2} at^2$. In the equation, s is the displacement, u is the initial velocity, v is the final velocity, a is the acceleration and t is the time in which change occurs.

Answer

Example 5

Check the correctness of physical equation $P = (\rho g h)^{1/2}$ where P is the pressure, ρ is the density, g is gravitational acceleration, h is the height.

Answer

③ determine the relationship between some of the physical quantities.

استنتاج بعض المعادلات الفيزيائية

Example 6

The displacement (x) of a particle moving under uniform acceleration (a) is some function of the elapsed time (t) and the acceleration. Suppose we write this displacement $x = k\, a^n t^m$, where k is a dimensionless constant. Find the values of m and n

Solution

$$LHS = RHS$$

$$LHS = L \rightarrow \boxed{1}$$

$$RHS = [L.T^{-2}]^n\, T^m$$

$$RHS = [L]^n[T]^{m-2n} \rightarrow \boxed{2}$$

From 1, 2

$$m - 2n = 0$$

$$n = 1\, , m = 2$$

$$x = kat^2$$

Example 7

Let the periodic time (t) of a simple pendulum is proportion to:

1) **The mass of the pendulum (m)**
2) **The length of the pendulum (l)**
3) **The acceleration due to gravity (g)**

Solution

$$T \propto m^a$$

$$T \propto l^b$$

$$T \propto g^c$$

$$T = k\, m^a l^b\, g^c$$

$$RHS = LHS$$

Example 8

The force *F* acting on a body depends on the mass *m* of the body and its velocity *v*. Suppose we write the force as $F = k\, m^a\, v^b$, where *k* is a dimensionless constant. Find the values of *a* and *b* using dimensional analysis.

Answer