

Chapter 1: Introduction

(Sections 1.5 and 1.6)

Lecture 1

The University of Jordan/Physics Department

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1-5] Units, standards, and the SI system

When we measure the height of a table we may write 2 m .

result of measurement ↑ ↓ unit which is the meter.

Usually, physical quantities have units like:

Quantity

Unit

mass

kg or gram, ..

velocity

m/s or cm/s, ..

Temperature

Celsius, Fahrenheit, ..

But what unit should we use?

Systeme International
in French

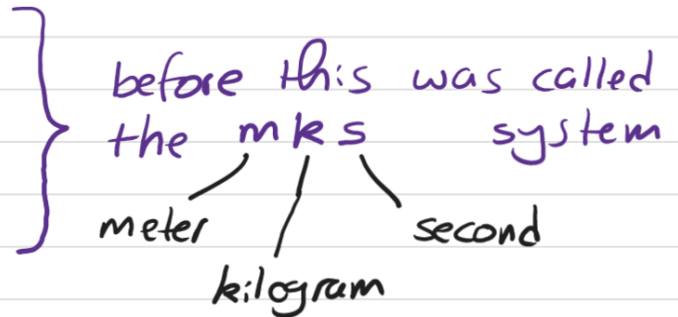
In the International System (SI system)

The units for Length, Mass, and Time are:

Length : meter (m)

Mass : kilogram (kg)

Time : second (s)



We shall mostly use the SI system (mks).

Sometime people use the cgs system

centimeter for length

gram for mass

second for time

It is easy to change from mks \leftrightarrow cgs. We can use:

$$1 \text{ m} = 100 \text{ cm}, \quad 1 \text{ kg} = 1000 \text{ gram}$$

Why are length(L), mass(M), time(T) are called base units?

consider the following

Velocity	m/s	$\Rightarrow L/T$	} Note that velocity, acceleration and density are expressed in terms of L, M, T .
Acceleration	m/s^2	$\Rightarrow L/T^2$	
Density	kg/m^3	$\Rightarrow M/L^3$	

Similarly, momentum ($p = mv$), force ($F = ma$) are also expressed in terms of L, M, T .

Example: Show that force which has units of (newton) can be expressed in terms of the base quantities L, M, T .

$$F = \overset{\text{mass}}{m} a \quad \text{acceleration}$$

The unit of force is the newton (N).

$$1 \text{ N} = 1 \text{ kg} \cdot \frac{1 \text{ m}}{\text{s}^2} \equiv M \cdot \frac{L}{T^2}$$

Therefore the newton is a derived quantity, since we can express it in terms of a combination of the base units M, L, T .

In the SI system there are SEVEN base quantities

Quantity	Unit	Unit abbreviation
Length	meter	m
Time	second	s
Mass	kilogram	kg
Electric Current	ampere	A
Temperature	Kelvin	K
Amount of Substance	mole	mol
Luminous Intensity	candela	cd

1-6] Converting Units

The length of a pen is 3 ^{in.} inches. Express the length of the pen in terms of cm.

$$1 \text{ in.} = 2.54 \text{ cm}$$

$$\Rightarrow \underset{\substack{\uparrow \\ \text{number}}}{1} = 2.54 \frac{\text{cm}}{\text{in.}}$$

$$\begin{aligned} \therefore \text{length of pen} &= 3 \text{ in.} = 3 \text{ in.} \times 1 \\ &= 3 \cancel{\text{in.}} \times \left(2.54 \frac{\text{cm}}{\cancel{\text{in.}}} \right) \quad \text{conversion factor} \\ &= 3 \times 2.54 \text{ cm} \\ &= 7.62 \text{ cm.} \end{aligned}$$

Example: The speed of a car is 100 km/h. Express the speed in terms of m/s.

$$\text{Note: } 1 \text{ km} = 1000 \text{ m} \Rightarrow 1 = 1000 \frac{\text{m}}{\text{km}}$$

$$1 \text{ h} = 3600 \text{ s} \Rightarrow 1 = \frac{1}{3600} \frac{\text{h}}{\text{s}}$$

$$\therefore 100 \frac{\text{km}}{\text{h}} = 100 \frac{\cancel{\text{km}}}{\cancel{\text{h}}} \times \left(\frac{1000 \cancel{\text{m}}}{\cancel{\text{km}}} \right) \times \left(\frac{1}{3600} \frac{\cancel{\text{h}}}{\text{s}} \right)$$

$$= 100 \times \frac{10}{36} \frac{\text{m}}{\text{s}} = 100 \times \frac{5}{18} \frac{\text{m}}{\text{s}}$$

$$\approx 27.8 \text{ m/s.}$$

Question: A car is moving at 20 m/s. Express the speed in units of km/h.

Answer: 72 km/h .

Question: The area of a plate is 32 cm². Express the area in units of m².

$$1 \text{ m} = 100 \text{ cm}$$

$$\therefore 1 \text{ m}^2 = 10^4 \text{ cm}^2 \Rightarrow 1 = \frac{1}{10^4} \frac{\text{m}^2}{\text{cm}^2}$$

$$\begin{aligned}
 \therefore 32 \text{ cm}^2 &= 32 \text{ cm}^2 \times \left(\frac{1}{10^4} \frac{\text{m}^2}{\text{cm}^2} \right) \\
 &= \frac{32}{10^4} \text{ m}^2 = 32 \times 10^{-4} \text{ m}^2 \\
 &= 0.0032 \text{ m}^2 .
 \end{aligned}$$

Some Metric (SI) Prefixes

Prefix	Abbreviation	value
tera	T	10^{12}
giga	G	10^9
mega	M	10^6
kilo	k	10^3
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

For examples:

$$1000 \text{ m} = 1 \text{ km.}$$

$$5 \times 10^{-6} \text{ m} = 5 \mu\text{m}$$

$$20 \times 10^6 \text{ kg} = 20 \text{ Mkg} \quad \text{and so on.}$$

You should do the following problems from sections 1-5 and 1-6 page 18 of the 7th edition of the text book:

Q13, Q14, Q15

Chapter 1: Introduction

(Sections 1.8)

Lecture 2

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بِسْمِ اللَّهِ
الرَّحْمَنِ الرَّحِيمِ

Section 1-8: Dimensions and Dimensional Analysis

Dimension of velocity v means: what base quantities are used to express velocity.

∴ Dimensions of v are $[L/T]$ base quantities.
length \swarrow \searrow time

This means that velocity is measured in units of
m/s or cm/s or km/h, ...

Note: m, cm, km express length

s, h express time.

What are the dimensions of Force ?

Question: What are the dimensions of force ?

Answer: Remember $F = ma$

\therefore dimensions of force are $[M \frac{L}{T^2}]$

base unit for mass
base unit for length
base unit for time.

We can determine if a relationship is incorrect by using a technique called dimensional analysis

Example: Is the relation

$$v_f = v_i + at^2 \quad \text{incorrect?}$$

Answer: use dimensional analysis. The dimension of v is $[L/T]$ and dimension of time is $[T]$.

$$[\frac{L}{T}] \stackrel{?}{=} [\frac{L}{T}] + [T^2]$$

same dimensions

different dimension

The first and second terms have the same dimensions.

BUT the dimensions of the third term are different.

∴ relation is incorrect.

Consider $v_f = v_i + \frac{1}{2} a t$

dimensional analysis gives

$$\left[\frac{L}{T} \right] \stackrel{?}{=} \left[\frac{L}{T} \right] + \left[\frac{L}{T^2} \times T \right]$$

∴ $\left[\frac{L}{T} \right] = \left[\frac{L}{T} \right] + \left[\frac{L}{T} \right]$ All terms have the same dimensions.

This means that the relation is dimensionally correct.

BUT the equation is incorrect.

If an equation is dimensionally correct it does NOT have to be correct from the physics point of view.

The correct equation is

$$v_f = v_i + a t$$

- correct from the physics point of view
- dimensionally correct.

Example: For a simple pendulum, the period of oscillation is

$$\text{period of pendulum} \rightarrow T = 2\pi \sqrt{\frac{l}{g}}$$

Is the above relation dimensionally correct?

$$[T] \stackrel{?}{=} \sqrt{\frac{L}{L/T^2}} \quad \text{note } 2\pi \text{ has No dimensions}$$

$$[T] \stackrel{?}{=} \sqrt{T^2} \Rightarrow [T] = [T] \quad \checkmark \text{ dimensionally correct.}$$

Q14] P 18 of the textbook.

One hectare is defined as $1.000 \times 10^4 \text{ m}^2$.

One acre is defined as $4.356 \times 10^4 \text{ ft}^2$.

How many acres are in one hectare?

$$1 \text{ hectare} = 1.000 \times 10^4 \text{ m}^2 \times \left(\frac{\text{ft}}{0.3048 \text{ m}} \right)^2 \times \left(\frac{\text{acre}}{4.356 \times 10^4 \text{ ft}^2} \right)$$

$$\therefore 1 \text{ hectare} = 1.000 \times 10^4 \times \frac{1}{(0.3048)^2} \times \frac{1}{4.356 \times 10^4} \text{ acre}$$

$$\therefore 1 \text{ hectare} = 2.471 \text{ acre}$$

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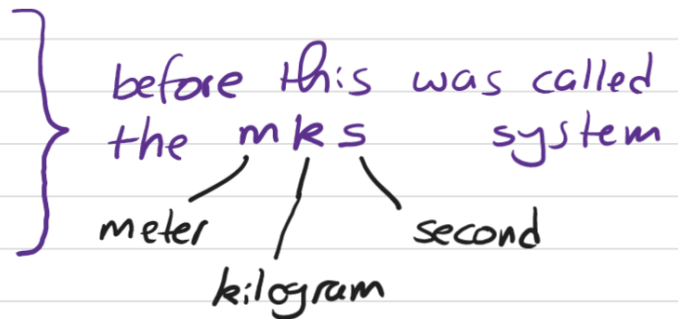
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