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, ..
Temprature	Celsius, Fahrenheit, ..

But what unit should we use?

In the International System (SI system) — Systéme International in French

The units for Length, Mass, and Time are:

Length : meter (m)

Mass : kilogram (kg)

Time : second (s)

before this was called the mks system

m — meter, k — kilogram, s — second

We shall mostly use the SI system (mks).

Sometime people use the cgs system

c — centimeter for length, g — gram for mass, s — second for time

It is easy to chang from mks $\rightleftarrows$ cgs. We can use:

1 m = 100 cm, 1 kg = 1000 gram

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

Consider the following

Velocity	m/s	$\Rightarrow$	L/T
Acceleration	m/s^2	$\Rightarrow$	L/T^2
Density	kg/m^3	$\Rightarrow$	M/L^3

Note that velocity, acceleration and density are expressed in terms of L, M, T.

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.

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

The unit of force is the newton (N).

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

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 Substence	mole	mol
Luminous Intensity	candela	cd

1-6] Converting Units

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

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

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

$$\therefore \text{length of pen} = 3 \text{ in.} = 3 \text{ in} \times 1$$

$$= 3 \cancel{\text{in.}} \times \overbrace{\left(2.54 \frac{\text{cm}}{\cancel{\text{in.}}}\right)}^{\text{conversion factor}}$$

$$= 3 \times 2.54 \text{ cm}$$

$$= 7.62 \text{ cm}.$$

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

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

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

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

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

$$\approx 27.8\ m/s.$$

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 $32\ cm^2$. Express the area in units of m^2.

$1\ m = 100\ cm$

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

$$\therefore \quad 32\ cm^2 = 32\ \cancel{cm^2} \times \left(\frac{1}{10^4} \frac{m^2}{\cancel{cm^2}} \right)$$

$$= \frac{32}{10^4}\ m^2 = 32 \times 10^{-4}\ m^2$$

$$= 0.0032\ m^2 .$$

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 m = 1 km.

5×10^{-6} m = 5 μm

20×10^{6} kg = 20 Mkg   and so on.

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

Q 13, Q 14, Q 15

Chapter 1: Introduction

(Sections 1.8)

Lecture 2

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بسم الله الرحمن الرحيم

Section 1-8: Dimensions and Dimensional Analysis

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

$\therefore$ Dimensions of v are $[L/T]$ — base quantities.

length — time

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

Note: m, cm, km expreess 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 $\left[\overset{\text{base unit for mass}}{M}\, \frac{L}{T^2} \right]$

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 $[T]$.

$$\underbrace{\left[\frac{L}{T}\right] \overset{?}{=} \left[\frac{L}{T}\right]}_{\text{same dimensions}} + \underbrace{[T^2]}_{\text{different dimension}}$$

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

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

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

This means that the relation is <u>dimensionally correct</u>.
BUT the equation is <u>incorrect</u>.
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 pendullum, the period of oscillation is

$$\underset{\text{period of pendullum}}{T} = 2\pi\sqrt{\frac{l}{g}}$$

Is the above relation dimensionally correct?

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

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

Q14] P. 18 of the textbook.

One hectar is defined as $1.000 \times 10^4\ m^2$.
One acre is defined as $4.356 \times 10^4\ ft^2$.
how many acres are in one hectar?

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

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

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

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