Units

Physical quantities

‘Physical Quantity’?

A physical quantity is anything **measurable.**

Five litres of petrol
is a volume of liquid.

It means 5 x 1 litre

Volume is a physical quantity.

It is measurable, has a size e.g. 5 and a unit, e.g. litre

All physical quantities have a **magnitude**
(size i.e. how much)
and……

and...
a unit!

Quick revision activity from last lesson:

Spend about a minute on each one

1. How many kW are there in 3 GW?

Answer: $(3 \times 10^9)/10^3$

$= 3 \times 10^6$

2. How many mm are there in 2 km?

Answer: $(2 \times 10^{3})/10^{-3}$

$= 2 \times 10^{6}$

3. How many nm are there in a mm?

Answer: $10^{-3}/10^{-9}$

$= 10^{6}$

4. Convert 85 km/h into m/s

Answer: $(85 \times 10^3)/(60 \times 60)$

$= 23.6$ m/s

5. How many m^2 are there in a km^2 ?

Answer: $10^3 \times 10^3$

$= 10^6$

So, what physical quantities do you know already?

Spend a couple of minutes listing as many as you can.

You will have met all of these in Physics and Science

Mass, Length, Time,
Area, Volume, Density

In Describing Motion

Distance, Speed
Displacement, Velocity,
Acceleration

In Forces and Motion

Force, Momentum, Impulse

In Pressure

Pressure, Volume, Temperature

In Forces and Energy

Work, Energy,
Kinetic Energy,
Gravitational Potential Energy,
Elastic Potential Energy,
Power, Efficiency

In Thermal Physics

Temperature,
Specific Heat Capacity

In Electricity

Amount of Charge,
Electric Current,
Potential Difference,
Resistance, Power

In Atomic and Nuclear Physics

Decay Rate

All except one in the above have units.

Any ideas which one?

Efficiency

is a ratio of two physical quantities with the same unit, so the units cancel out (refractive index is the same)

We take just seven of these as base quantities

All others come from i.e. are generated from these base or fundamental quantities.

The base quantities are...

Length

Time

Mass

Temperature

Electric Current

Amount of Substance

And……

Luminous Intensity (not used in A Level Physics)

In 1971 world's scientists agreed on a common system of units for those 7 base quantities. These are....

These are the SI units.

SI = Systeme Internationale

These are...

metre
for length

second
for time

kilogram
for mass

kelvin
for temperature

ampere
for electric current

mole
for amount of substance

And...

candela
for luminous intensity

Here's a summary

Base Quantity	SI Unit & Abbreviation
Length	metre, m
Time	second, s
Mass	kilogram, kg
Temperature	kelvin, K
Electric current	ampere, A
Amount of substance	mole, mol
Luminous Intensity	candela, cd

What are other quantities called?

Take speed. It's defined by

speed = distance/time

Speed = distance/time

The equation is derived from two base quantities.

So speed is a derived quantity.

Volume of cuboid =

length x width x height

Width and height are also lengths.
So volume is a derived quantity.

Density = mass/volume

This is derived from a base quantity, mass and another derived quantity, volume. So density is a derived quantity.

Any quantity that's defined in terms of base or other derived quantities must then be a derived quantity.

Accordingly, a derived quantity should also have units.

This is simple. The units come from the defining equation.

But first .... a quick maths recap

A quick maths recap 1

The unit of speed is m/s
This can also be written as ms^{-1}

Why? Because m/s is m x 1/s and 1/s is the same as s^{-1} hence m x s^{-1} = ms^{-1}

A quick maths recap 2

The unit of acceleration is m/s^2
This can also be written as ms^{-2}
Why? Because m/s^2 is $m \times 1/s^2$ and $1/s^2$ is the same as s^{-2} hence $m \times s^{-2} = ms^{-2}$

THIS COMES UP ALL THE TIME IN A LEVEL PHYSICS – YOU MUST BE CONFIDENT USING THIS TECHNIQUE

Derived units……

Units of volume =
unit of
(length x length x length)
= m x m x m
= m^3

Units of density =

unit of mass/unit of volume

$= kg/m^3$

$= kgm^{-3}$

Units of velocity =

unit of displacement/unit of time

= m/s

= ms^{-1}

Units of acceleration =

units of velocity/units of time

$= ms^{-1}/s$

$= ms^{-2}$

Units of force =

= units of mass x units of acceleration

= $kg \times ms^{-2}$

= $kgms^{-2}$

This looks unfamiliar as we know that force is measured in newtons, N

Units of force = $kgms^{-2}$

This looks unfamiliar as we know that force is measured in newtons, N

Is 1 N same as 1 $kgms^{-2}$?

Yes, exactly. The **newton** is a **derived unit.**

Class work

Find the units of pressure in terms of the base units! (hint: start with the GCSE equation for pressure, and you will also need the base units for the Newton)

Units of pressure =

= unit of force/ unit of area

= $kgms^{-2}/ m^2$

= $kgm^{-1}s^{-2}$

Again this looks unfamiliar as we know that pressure is measured in pascals, Pa. The pascal is another example of a derived unit.

Class work (more difficult)

The resistance force F on a body of cross sectional area A moving at constant speed v in a fluid is given by $F = kAv$.

Find the SI units of k in terms of base units (hint: make k the subject of the equation first).

Answer

$k = F/Av$

Units of k =

= units of force/ (units of area x units of speed)

$= (kgms^{-2}) / (m^2 ms^{-1})$

$= kgm^{-2}s^{-1}$

Is there any use for these exercises?!!

The above is an example of dimensional analysis. It uses homogeneity in physics equations. Homogeneity means uniform. A homogeneous mixture of tea with sugar will have same sugar concentration everywhere!

Homogeneity of Equations

An equation in Physics makes sense only if the left hand side (lhs) quantity and the right hand side (rhs) quantity have the same units, AND the lhs magnitude is the same as the rhs magnitude.

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Can

$5\ ms^{-1} = 5\ s$?

You can't say a speed is the same as a time interval, can you?

An equation in Physics makes sense only if the left hand side (lhs) quantity and the right hand side (rhs) quantity have the same units, AND the lhs magnitude is the same as the rhs magnitude.

Thank you!