Unit Analysis

IB PHYSICS | SCIENCE SKILLS

Welcome to IB Land!

Since this course is *International* all of the units must be in the "European" format rather than the "American" format

This means that instead of writing units with a fraction slash, we must use negative exponents

7 m/s	$m\ s^{-1}$	$6.67\ \frac{Nm^2}{kg^2}$	$N\ m^2\ kg^{-2}$
$9.81\ m/s^2$	$m\ s^{-2}$	$2.2\ \frac{J}{K}$	$J\ K^{-1}$
$87\ g/cm^3$	$g\ cm^{-3}$	$8.31\ \frac{J}{K \times mol}$	$J\ K^{-1}\ mol^{-1}$

Dimensional Analysis

We can use equations with units that we know to find units that we don't.

$$p = m \times v$$

$$= [\mathrm{kg}]\left[\frac{\mathrm{m}}{\mathrm{s}}\right]$$

Variable	Unit
Momentum **p**	kg m s^{-1}
Mass **m**	Kilogram [kg]
Velocity **v**	Meters per second [ms^{-1}]

Dimensional Analysis

Units

Constants have units too! That's what makes our equation valid

$$F = G\frac{m_1 m_2}{d^2}$$

$$G = \frac{F d^2}{m_1 m_2} = \frac{[\mathrm{N}][\mathrm{m}]^2}{[\mathrm{kg}][\mathrm{kg}]}$$

$$= \frac{[\mathrm{N}][\mathrm{m}]^2}{[\mathrm{kg}]^2}$$

Variable	Unit
Force **F**	Newton [N]
Mass **m_1** and **m_2**	Kilogram [kg]
Distance **d**	Meter [m]
Universal Gravitation Constant **G**	N m^2 kg^{-2}

Dimensional Analysis

The units used, depend on the other values

$$Q = mc\Delta t$$

$$m = \frac{Q}{c\Delta t} = \frac{620}{(0.458)(15)}$$

$$m = \frac{Q}{c\Delta t} = \frac{\cancel{\mathrm{J}}}{\cancel{\mathrm{J}}\,\mathrm{g}^{-1}\cancel{\mathrm{K}^{-1}}\,\cancel{\mathrm{K}}}$$

90.2 g

Variable	Value
Heat Energy **Q**	620 J
Mass **m**	
Specific Heat **c**	0.458 J g^{-1} K^{-1}
Temp Change **Δt**	15 K

Remember Conversions? | 1

How many kilometers in 26.2 miles?

$$\frac{26.2\ \cancel{\text{mi}}}{1} \times \frac{5\ \text{km}}{3.1\ \cancel{\text{mi}}} = \mathbf{42.3\ km}$$

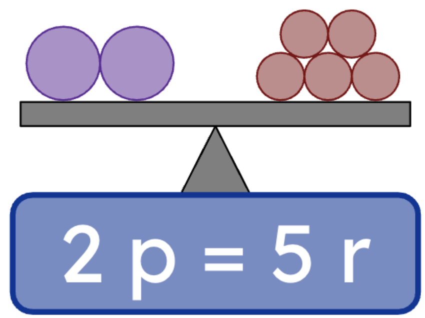
5 km = 3.1 mi

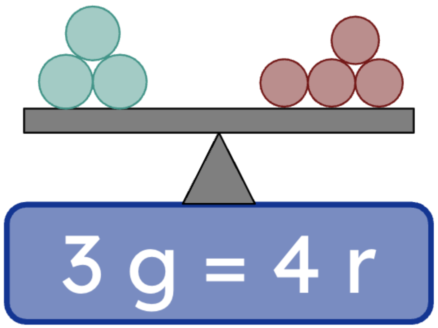
Remember Conversions? | 2

10 purple equals how many green?

$$\frac{10\ \cancel{p}}{1} \times \frac{5\ \cancel{r}}{2\ \cancel{p}} \times \frac{3\ g}{4\ \cancel{r}} =$$

$$\mathbf{18.75\ g}$$





Conversions to Memorize

1 m	=	1000	mm
1 m	=	100	cm
1 km	=	1000	m

1 day	=	24	hr
1 hr	=	60	min
1 min	=	60	s

Do these without a calculator:

45 cm = 0.45 m

35.2 km = 35,200 m

21 mm = 2.1 cm

320 mm = 0.32 m

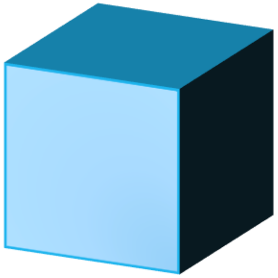
Conversions with Exponents

Units

How many cm² are there in 1 m²?

$$100 \times 100 = 100^2 = \mathbf{10,000\ cm^2}$$

How many cm³ are there in 1 m³?



$$100 \times 100 \times 100 = 100^3 = \mathbf{1,000,000\ cm^2}$$

Conversions with Exponents

Units

Convert the Following:

5 mm^2 → m^2

$$5\ \mathrm{mm}^2 \times \frac{1\ \mathrm{m}}{1000\ \mathrm{mm}} \times \frac{1\ \mathrm{m}}{1000\ \mathrm{mm}} = \boxed{\mathbf{0.000005\ m^2}}$$

$$5\ \mathrm{mm}^2 \times \left(\frac{1\ \mathrm{m}}{1000\ \mathrm{mm}}\right)^2 = \boxed{\mathbf{0.000005\ m^2}}$$

Conversions

Units

Prefix	Abbreviation	Value
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

Use the IB Table to make a conversion factor for the unfamiliar ones

$$1 \text{ prefix} = 10^{??} \text{ base}$$

$$1 \text{ MW} = 10^{6} \text{ W}$$

$$1 \text{ ns} = 10^{-9} \text{ s}$$

$$1 \text{ μg} = 10^{-6} \text{ g}$$

Conversions

Prefix	Abbreviation	Value
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

64 MW → W

$$1\ \text{MW} = 10^6\ \text{W}$$

$$\frac{64\ \text{MW}}{1} \times \frac{10^6\ \text{W}}{1\ \text{MW}} = \mathbf{64 \times 10^6\ W}$$

0.00089 C → μC

$$1\ \mu\text{C} = 10^{-6}\ \text{C}$$

$$\frac{0.00089\ \text{C}}{1} \times \frac{1\ \mu\text{C}}{10^{-6}\ \text{C}} = \mathbf{890\ \mu C}$$

256 nm → m

$$1\ \text{nm} = 10^{-9}\ \text{m}$$

$$\frac{256\ \text{nm}}{1} \times \frac{10^{-9}\ \text{m}}{1\ \text{nm}} = \mathbf{256 \times 10^{-9}\ m}$$

Lesson Takeaways

A.1

- ❑ I can represent fractional units with negative exponents
- ❑ I can use dimensional analysis to determine unknown units from an equation
- ❑ I can convert units using dimensional analysis
- ❑ I can convert squared and cubed units