Name: .... School: ....

A Level Physics

We look forward to meeting you in September.

Please complete the following sections of this booklet prior to arriving at St Joseph's.

1. MATHS

a) Re-arranging Equations

b) Prefixes

c) Units

3. WAVES

a) Waves and the wave equation

b) Frequency and Time period

2. VECTORS

a) Displacement

4. ELECTRICITY

a) Current

b) Voltage

5. CERN

Chapter 1 : Maths

a) Rearranging Equations

The first step in learning to manipulate an equation is your ability to see how it is done once and then repeat the process again and again until it becomes second nature to you.
In order to show the process once I will be using letters rather than physical concepts.

You can rearrange an equation $a = b \times c$ with

b as the subject $b = \frac{a}{c}$

or c as the subject $c = \frac{a}{b}$

Any of these three symbols a, b, c can be itself a summation, a subtraction, a multiplication, a division, or a combination of all. So, when you see a more complicated equation, try to identify its three individual parts a, b, c before you start rearranging it.

Worked examples

Equation	First Rearrangement	Second Rearrangement
$v = f \times \lambda$	$f = \frac{v}{\lambda}$	$\lambda = \frac{v}{f}$
$T = \frac{1}{f}$	$1 = T \times f$	$f = \frac{1}{T}$
$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$	$1 = v \times \left(\frac{1}{u} + \frac{1}{f}\right)$	$v = \frac{1}{\frac{1}{u} + \frac{1}{f}}$

THINK! As you can see from the third worked example, not all rearrangements are useful. In fact, for the lens equation only the second rearrangement can be useful in problems. So, in order to improve your critical thinking and know which rearrangement is the most useful in every situation, you must practise with as many equations as you can.

NOW TRY THIS!

From now on the multiplication sign will not be shown, so $a = b \times c$ will be simply written as $a = bc$

Fill in the blank spaces with your own examples.

<table>
<tr><th>Equation</th><th colspan="2">First Rearrangement</th><th colspan="2">Second Rearrangement</th></tr>
<tr><td>(refractive index) $n = \frac{c}{v}$</td><td colspan="2">$c =$</td><td colspan="2">$v =$</td></tr>
<tr><td>(current) $I = \frac{\Delta Q}{\Delta t}$</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>(electric potential) $V = \frac{\Delta E}{\Delta Q}$</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>(power) $P = \frac{\Delta E}{\Delta t}$</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>(power) $P = VI$</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>(resistance) $R = \frac{V}{I}$</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>(power) $P = I^2 R$</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>(power) $P = \frac{V^2}{R}$</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>(stress) $\sigma = \frac{F}{A}$</td><td colspan="2">$F =$</td><td colspan="2">$A =$</td></tr>
<tr><td>(strain) $\varepsilon = \frac{x}{l}$</td><td colspan="2">$x =$</td><td colspan="2">$l =$</td></tr>
<tr><td>(Young's modulus) $E = \frac{Fl}{ax}$</td><td>$l =$</td><td>$F =$</td><td>$x =$</td><td>$a =$</td></tr>
<tr><td>(resistance) $R = \frac{\rho L}{A}$</td><td></td><td colspan="2"></td><td></td></tr>
</table>

b) How to use and convert prefixes

Mathematical Prefixes

Prefix	Symbol	Name	Multiplier
femto	F	quadrillionth	10^{-15}
pico	P	trillionth	10^{-12}
nano	n	billionth	10^{-9}
micro	μ	millionth	10^{-6}
milli	m	thousandth	10^{-3}
centi	c	hundredth	10^{-2}
deci	d	tenth	10^{-1}
deka	da	ten	10^{1}
hecto	h	hundred	10^{2}
kilo	k	thousand	10^{3}
mega	M	million	10^{6}
giga	G	billion†	10^{9}
tera	T	trillion†	10^{12}
peta	P	quadrillion	10^{15}

When you are given a variable with a prefix you must convert it into its numerical equivalent in standard form before you use it in an equation.

FOLLOW THIS! Always start by replacing the prefix symbol with its equivalent multiplier.
For example: 0.16 μA = 0.16 x 10^{-6} A
3 km = 3 x 10^{3} m
10 ns = 10 x 10^{-9} s

DO NOT get tempted to follow this further (for example: 0.16 x 10^{-6} A = 1.6 x 10^{-7} A and also 10 x 10^{-9} s = 10^{-8} s) unless you are absolutely confident that you will do it correctly. It is always safer to stop at the first step (10 x 10^{-9} s) and type it like this into your calculator.

NOW TRY THIS!

1.4 kW =

10 μC =

24 cm =

340 MW =

46 pF =

0.03 mA =

52 Gbytes =

43 kΩ =

0.03 MN =

c) Units

When performing calculations it is always important to state the units you will be using in the calculation and include the units with your final answer. In most cases it is best to convert all values into the standard SI units. For example, when calculating the speed of a car, if the data given in the question is "the car travelled a distance of 1.5km in 2.5 minutes", convert the distance and time before you perform the calculation.

e.g. 1.5km = 1500m, 2.5 minutes = 150s

So average speed = distance / time = 1500/150 = $10ms^{-1}$

Alternative units

Some quantities have units which most people recognise and use readily.

e.g Force = newtons (N), Energy = joules (J)

However for all quantities there are other, equally correct units. These are often derived from equations

e.g. 1 From Newton's 2nd law: Force = mass x acceleration

Mass is measured in kg, acceleration is measured in ms^{-2}

So an alternate unit of force must be $kgms^{-2}$ so $1N = 1kgms^{-2}$

e.g.2 Work done = force x distance

In Physics 'Work' is the transfer of energy so work is measured in joules (J)

However, looking at the equation, work = N x m, so 1J = 1Nm

Try these examples:

1) Match the following quantities with their units
   a) Match up with their standard unit in column 1
   b) Find an alternate unit from column 2, showing how you used the equations

	Standard units	alternate units
Power (energy transferred / time)	Newtons per metre^2 (Nm^{-2})	$kgms^{-2}$
Weight (mass x gravity)	kilogram metres per second ($kgms^{-1}$)	$kgm^{-1}s^{-2}$
Pressure (force/area)	Newtons (N)	Ns
Momentum (mass x velocity)	Watts (W)	Js^{-1}

Chapter 2 : Vectors

Displacement

In order to get from point A to point B, knowing the distance you need to travel is not enough, you must also know the direction you need to travel in. This information, distance plus direction, is known as the displacement from A to B and has the symbol, s. It is a vector quantity since all vectors have both size and a direction.

Scale drawings

The simplest way to draw a displacement is to draw an arrow – the length of the arrow tells you the Distance, and the way the arrow points shows the Direction.

We can do this even for very large displacements so long as we scale down.

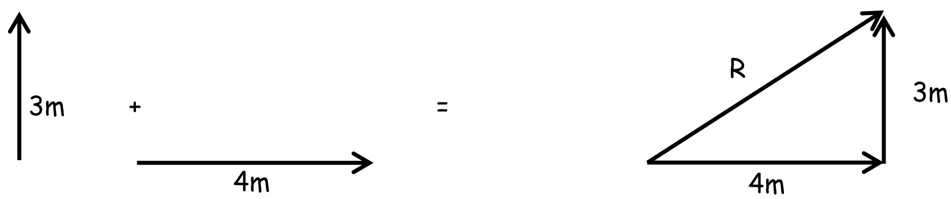
For example, a displacement of 3 metres upwards could be represented by an arrow of length 3 centimetres. Using the same scale (1cm = 1m) a displacement of 7 metres to the right would be an arrow of length 7 cm pointing right.

Addition of 2 displacements

We can't simply add together the two displacements as this does not account for the different directions of the displacements. What we do is this:

1) Draw arrows representing the two vectors
2) Place the arrows one after the other "tip to tail"
3) Draw a third arrow from the start to the finish. This is your displacement.

For example, consider adding a displacement of 4 metres to the right to one of 3 metres upwards (using a scale of 1cm to 1m)



R is called the resultant, it is the sum of the two displacements added as vectors.
You can find the size of R either by measuring the arrow and scaling up or by Pythagoras.
In this case it is 5m in length.

Vector Questions

Have a go at these

(draw your vectors at the bottom of this sheet and continue onto the back)

1) Draw arrows representing the following displacements to the given scale
   a) 3 miles upwards (1cm to 1 mile)
   b) 12m to the right (1cm to 2m)
   c) 4mm downwards (1cm to 1mm)
   d) 3.5km northeast (1cm to 1 km)
   e) 5cm south west (1cm to 1cm)

2) Find the lengths of the following displacements by drawing arrows "tip to tail"
   Choose a suitable scale for your vectors.
   a) 5m right and 12m up
   b) 8m up and 4m left
   c) 6cm right and 8cm left
   d) 15 miles down and 20 miles left

Vectors diagrams:

Vectors diagrams (continued) :

Chapter 3 : Waves

a) The wave equation

The wave equation relates speed, frequency and wavelength

For a wave of frequency f (in hertz), wavelength λ (in metres) and the wave speed (in metres per second) the wave equation is:

$$V = f \times \lambda$$

In other words:

$$\text{Speed } (ms^{-1}) = \text{Frequency (Hz)} \times \text{wavelength (m)}$$

Look at these examples of using the wave equation:

1) Sound is a longitudinal wave. If a sound has a frequency of 250Hz and a wavelength of 1.32 metres, what is the speed of the sound in air ?
   $V = f \times \lambda$ so $v = 250 \times 1.32 = 330ms^{-1}$

2) All electromagnetic waves travel at 3×10^8 ms^{-1} in free space.
   If a radio signal has a wavelength of 1.5 kilometres, what is its frequency?
   $V = f \times \lambda$, so $f = v/\lambda$, so $f = 3 \times 10^8/1500 = 200kHz$ (2×10^5 Hz)

3) If a wave has speed $50ms^{-1}$ and a frequency of 0.8Hz, what is its wavelength?
   $V = f \times \lambda$, so $\lambda = v/f$, so $\lambda = 50/0.8 = 62.5m$

Now have a go at these questions:

1)What is the frequency of a water wave of wavelength 0.4m and wave speed $0.7ms^{-1}$?

2)What is the wavelength of radio waves of frequency 1×10^8 Hz ? ($v = 3 \times 10^8 ms^{-1}$)

3)What is the speed of a wave of frequency 800Hz and wavelength 2.5 metres?

4)What is the frequency of a sound wave of wavelength 0,25 metres ? ($v=330ms^{-1}$)

5)What is the speed of a wave with a frequency of 3Hz and a wavelength of 1.4 metres?

6)What is the wavelength if the wave speed is $150ms^{-1}$ and the frequency is 600Hz?

b) Frequency and the time period

Consider one point on a wave.
If it has a time period of 0.2 seconds, i.e. it takes 0.2 seconds to complete one full oscillation, then in one second it will complete 5 full oscillations.
It has a frequency of 5 hertz

The number of oscillations of one point on a wave every second is called the frequency of the wave. It has the symbol f and is measured in hertz (symbol Hz)

1) If you know the time period T, you can work out the frequency using f = 1/T
2) If you know the frequency f, you can work out the time period using T = 1/f

Examples

1) One coil of a spring oscillates with a time period of 0.008 seconds.
   What is the frequency of the wave passing along the spring?
   F = 1/T = 1/0.008 = 125Hz

2) A wave has a frequency of 350Hz. What is the period of oscillation of one point on that wave?
   T= 1/f = 1/350 = 0.0029s

Now you try these questions:

1) Ripples on the surface of a pond have a frequency of 12Hz. What is the time period of oscillation of particles in the water?

2) One turn is a slinky spring takes 0.45 seconds to complete one full oscillation. What is the frequency of the wave on the spring?

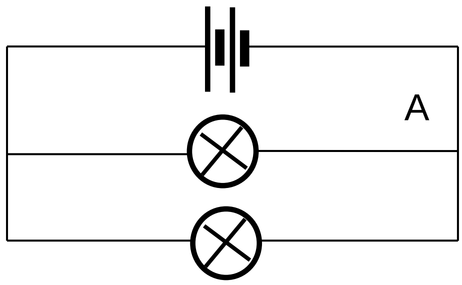
3) A radio signal has frequency of 8×10^5 Hz (800 kHz). What is the time period of the oscillations of the electromagnetic field?

4) Oscillations in a sound wave have a time period of 0.0002 seconds. What is the frequency of the sound?

Chapter 4: Electricity

a) Electric current

We can easily build an electric circuit in which the electric current has a choice about which wire to travel down – two lamps connected in parallel is a good example.



Consider what happens at point "A". The current from the power supply can go down either of two possible routes. It can be difficult to work out precisely how much goes down each wire, but one thing is certain:

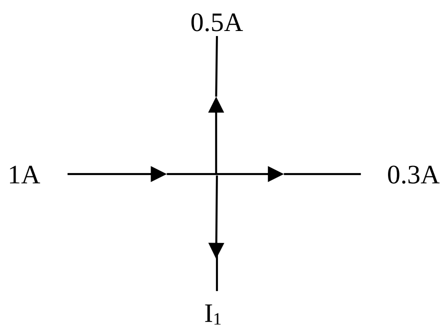
The total amount of current leaving the junction every second must be the same as the total amount entering it every second

or more concisely:

The sum of the currents going into a junction = sum of the currents going out

This is a simplified statement of Kirchoff's 1st law

Consider the following examples with one unknown current.
In order to find the unknown current we simply use the rule.



The sum of the current in = sum of currents out

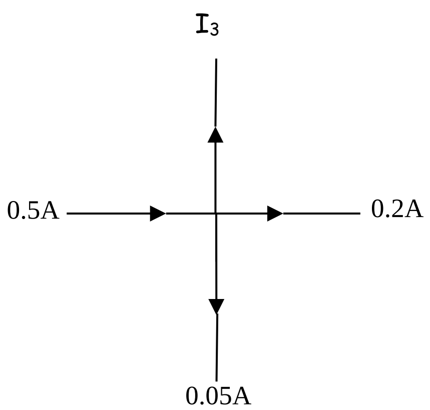
$1A = 0.5A + 0.3\ A + I_1$

$1A = 0.8A + I_1$

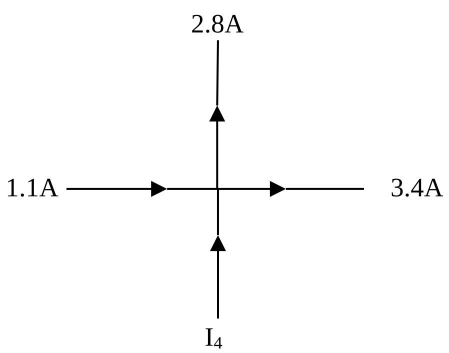
So $I_1 = 0.2\ A$

Now try these

1)



2)



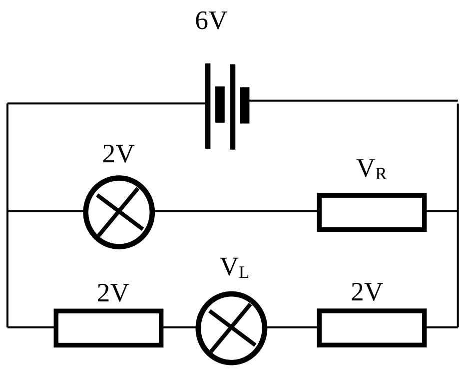
b) Electric voltage

Energy is given to charged particles by the power supply and taken off them by components in the circuit. Since energy is conserved, the amount of energy one coulomb of charge loses when going around the circuit must be equal to the energy given by the power supply. Furthermore , this must be true regardless of the route the charge takes around the circuit. So we can say that in most cases:

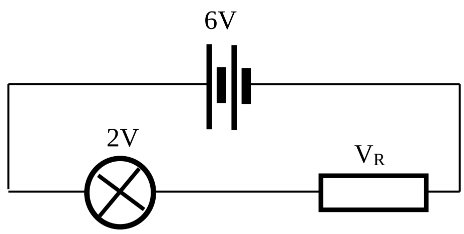
For any closed loop in a circuit the sum of the voltages across the components must be equal to the voltage of the power supply

This is a simple case of Kirchoff's 2nd law

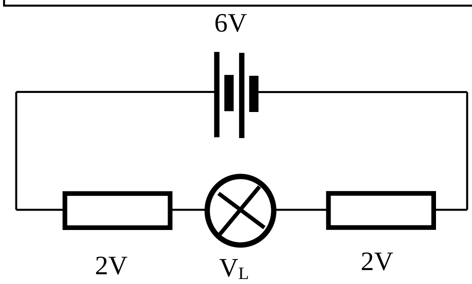
Look at the example below. What are the voltages across the lamp V_L and across the resistor V_R



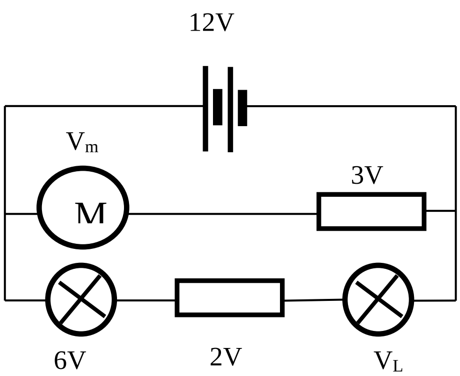
First look at the top loop.
$6V = 2V + V_R$
So $V_R = 4V$



Now look at the outside loop.
$6V = 2V + V_L + 2V$
So $V_L = 2V$

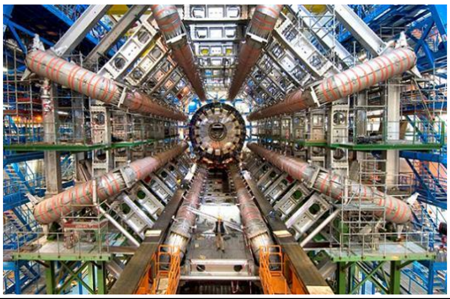


Now try this example:
Calculate the voltage across the motor V_m and the voltage across the lamp V_L



Chapter 5: CERN

CERN is a 27 kilometre long circular underground Nuclear Particle facility under the Swiss/French border near Geneva.



In around 100 words do your best to explain exactly what they actually do at CERN trying to discuss the science involved and the aims of the project:

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