# Physics

## TRANSITION BOOKLET YEAR 11 INTO YEAR 12

I am delighted you have chosen to study Physics A level next year at The Bishops' High School. A level Physics at Bishops' is an exciting, and at times a challenging subject that you will find helps to explain the world around you. You will learn about the physical world and go on understand the concepts that can explain fascinating and interesting phenomena. Using mathematical skills previously developed at GCSE to model, explain and predict the behaviour of the world in which we live is extremely rewarding. Mathematics is simply part of the language of Physics and by using it confidently will allow you to fulfil so much more of your academic potential. The scale of the physical world is immense, and you will study the very small (e.g. atomic radii) to the very large (astronomical distances such as light-years and parsecs) and lots in between.

Physics is a well-respected and challenging course that is highly valued by all post-education bodies; many of the skills developed are easily transferrable into a variety of other areas of expertise. Physics is a subject that can offer opportunities to you from both employers and Universities leading to careers in Astronomy, aeronautical engineering, nuclear and atomic research, architecture and Earth sciences; and many more.

To hit the ground running in September I thought I would give you some information about what you will be studying in this two-year course.
In addition, I have put together some information pages about each topic you will cover in the first year, some useful websites and clips to watch and some tasks I would like you to complete before September. These tasks are important to complete so that you have the correct level of background knowledge needed to start the course.

**Qualification at a glance**

Specification: - AQA GCE A level in Physics (7408)

Assessment: - - AQA GCE A level in Physics consists of three externally examined papers and the Science Practical Endorsement.

- Students are expected to carry out 12 core practical experiments that are identified in the content.
- Students complete three exam papers in May/June of Y13
  Paper 1 – Measurements, particles, waves, electricity and periodic motion, covers topics 1 to 5, and 6.1; worth 34%
  Paper 2 – Further mechanics, thermal physics, fields and nuclear physics, covers topics 6 to 8; worth 34%
  Paper 3 – Practical skills and data analysis across all topics; and the astronomy topic; worth 32%

**Year 12**

In the first year of the qualification, you will cover five topics, along with six core practicals related to these topics

**Topic 1** – Measurements and their errors

**Topic 2** – Particles and radiation

**Topic 3** – Waves

**Topic 4** – Mechanics and materials

**Topic 5** – Electricity

**Year 13**

In the second year of the qualification, you will cover four topics, along with six core practicals related to these topics

**Topic 6 –** Further Mechanics and materials

**Topic 7 –** Fields and their consequences

**Topic 8 –** Nuclear Physics

**Topic 9 –** Astronomy

**Useful websites**

Details about specification: - https://filestore.aqa.org.uk/resources/physics/specifications/AQA-7407-7408-SP-2015.PDF

Details about degree courses: - https://digital.ucas.com/search

Details about careers: - https://www.prospects.ac.uk/graduate-jobs

Revision notes: - https://www.physicsandmathstutor.com/physics-revision/a-level-aqa/

## Topic 1 – Measurements and their errors

Introducing 'SI base units'

The base units are the set of seven units of measure from which all other SI units can be derived. The ones you need to know are:

•Mass: Kilogram (kg)

•Length: Metre (m)

•Time: Second (s)

•Current: Amps (A)

•Temperature: Kelvin (K)

•Amount of Substance: Mole (mol)

From AQA: 'Students should know that every measurement has some inherent uncertainty'.

This just means the **good experimental design** will attempt to **reduce the uncertainty** in the outcome of an experiment.

In assessing uncertainty, there are several issues that must be considered.

These include:

- the resolution of the instrument used
- the manufacturer's tolerance on instruments
- the judgments that are made by the experimenter
- the procedures adopted (e.g. repeated readings)
- the size of increments available (e.g. the size of drops from a pipette)

The uncertainty in a reading is ± half the smallest division, e.g. for a thermometer the smallest division is 1°C so the uncertainty is ±0.5°C. The uncertainty in a measurement is at least ±1 smallest division, e.g. a ruler, must include both the uncertainty for the start and end value, as each end has ±0.5mm, they are added so the uncertainty in the measurement is ±1mm.

Digital readings and given values will either have the uncertainty quoted or assumed to be ± the last significant digit e.g. 3.2 ± 0.1 V, the resolution of an instrument affects its uncertainty.

Measurement example: The p.d. across a resistor using a voltmeter (measuring in 0.01V divisions)

If the reading is say 12.02V, then this should be quoted as 12.02±0.01V as 0.01 is the **rounded uncertainty** in the measurement and is 'usually' the same as the smallest interval (precision) of the instrument; you will learn why this is so, during the course.

Dealing with anomalous results.

At GCSE, you were often taught automatically to ignore anomalous results. At A-level, students should think carefully about what could have caused the unexpected result and therefore whether it is anomalous. A student might be able to identify a reason for the unexpected result and so validly regard it as an anomaly. For example, an anomalous result might be explained by a different experimenter making the measurement, a different solution or a different measuring device being used. In the case where the reason for an anomalous result occurring can be identified, the result should be recorded and plotted but may then be ignored. **However, it is best practice whenever an anomalous result is identified for the experiment to be repeated.**

Random errors affect precision, meaning they cause differences in measurements which causes a spread about the mean. You cannot get rid of all random errors. An example of random error is electronic noise in the circuit of an electrical instrument.

To reduce random errors:

● Take at least 3 repeats and calculate a mean, this method also allows anomalies to be identified.

● Use computers/data loggers/cameras to reduce human error and enable smaller intervals.

● Use appropriate equipment, e.g. a micrometer has higher resolution (0.1 mm) than a ruler (1 mm).

Systematic errors affect accuracy and occur due to the apparatus or faults in the experimental method. Systematic errors cause all results to be too high or too low by the same amount each time. An example is a balance that isn't zeroed correctly (zero error) or reading a scale at a different angle (this is a parallax error).

To reduce systematic error:

● Calibrate apparatus by measuring a known value (e.g. weigh 1 kg on a mass balance), if the reading is inaccurate then the systematic error is easily identified.

● In radiation experiments correct for background radiation by measuring it beforehand and excluding it from final results.

● Read the meniscus (the central curve on the surface of a liquid) at eye level (to reduce parallax error) and use controls in experiments**.**

The uncertainty of a measurement is the bounds in which the accurate value can be expected to lie e.g. 20°C ± 2°C , the true value could be within 18-22°C

**TASKS (two to do)**

**Summarise the main differences and similarities between taking measurements at GCSE and at A-level**

**Make a list of the new keywords and their meanings from the above notes**

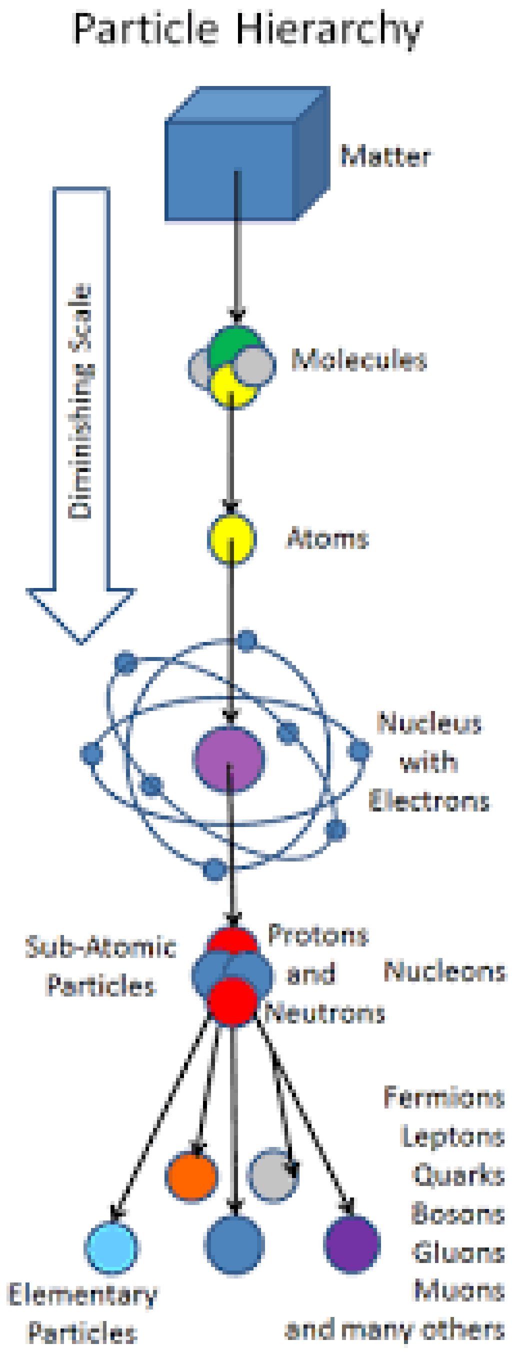
**Useful websites and clips to watch**

https://www.youtube.com/watch?v=LezXeEssD4g

https://www.youtube.com/watch?v=ul3e-HXAeZA

https://www.physicsandmathstutor.com/physics-revision/a-level-aqa/measurements-and-errors/

## Topic 2 – Particles and radiation




Before the periodic table, scientists struggled to find order amongst the vast number of elements. We now fully accept the periodic table as a means of achieving this. Elements were grouped according to their chemical properties.

For many years, the same problem existed for high-energy particle-physicists: such an array of different particles, with no apparent order. Thankfully, we now have sufficient knowledge to categorise particles through experimental work and the development of appropriate theory based on observations.

Your understanding at GCSE was limited to the particles used to 'build atoms' however, these 'building block' particles are themselves often made up of even smaller particles, they are not truly 'fundamental'.

The particles you will start to learn about are fundamental,

namely: 6 quarks, 6 antiquarks, 6 leptons, 6 antileptons and some force carriers.

This image refers to 'fundamental particles' as 'elementary particles', this is common practice and is acceptable

Radiation and radioactive decay have already been studied at GCSE; but at A-level, with the introduction of more information you will learn how the conservation of energy as well as charge can used to explain the presence of further particles.

Below is a 'flow chart' approach to the basics of radioactive decay; by combining the familiar periodic table with new particle knowledge enables a more complete picture to emerge.

### Alpha radiation (α)

- Usually occurs with very large nuclei
- An alpha particle consists of 2 protons plus 2 neutrons
- After decay:
  - Proton number (Z) decreases by 2
  - Nucleon number (A) decreases by 4

$$^{A}_{Z}X \rightarrow \, ^{A-4}_{Z-2}Y + \, ^{4}_{2}\alpha$$

### Beta radiation (β -)

- Occurs with nuclei that have too many neutrons. In the nucleus a neutron decays into a proton and an electron.
- The electron is emitted as the beta particle
- An antineutrino is also emitted !
- After decay:
  - Proton number (Z) increases by 1, Nucleon number (A) does not change

$$^{A}_{Z}X \rightarrow \, ^{A}_{Z+1}Y + \, ^{0}_{-1}\beta + \overline{\upsilon}$$

### Gamma radiation (γ)

- This often occurs straight after alpha or beta decay. The new nuclide formed often has excess energy which is released by gamma emission. No change occurs to either the proton or nucleon numbers as a result of gamma decay.

**TASKS (two to do)**

**Summarise the main properties of all the 'fundamental' particles you can find**

**Write out each of the three radioactive decay processes, identifying the elements as well as the decay products in each case**

**Useful websites and clips to watch**

https://www.youtube.com/watch?v=Qq5pogHUeHg

https://www.youtube.com/watch?v=lUhJL7o6_cA

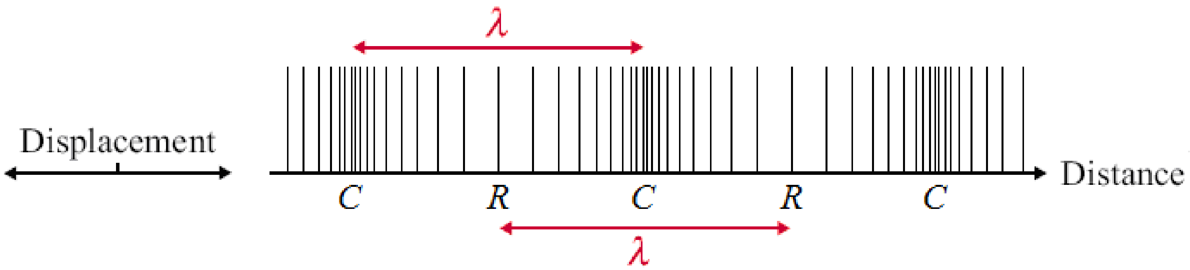
https://www.physicsandmathstutor.com/physics-revision/a-level-aqa/particles-and-radiation/

## Topic 3 -Waves

All waves are caused by oscillations and all transfer energy without transferring matter. This means that a sound wave can transfer energy to your eardrum from a far speaker without the air particles by the speaker moving into your ear. We will now look at the two types of waves and how they are different

**Longitudinal Waves**

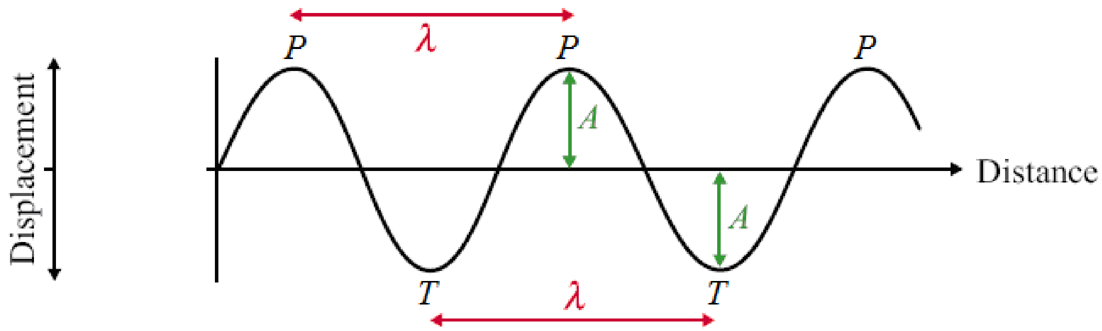
Here is a longitudinal wave; the oscillations are parallel to the direction of propagation (travel).
Where the particles are close together we call a compression and where they are spread we call a rarefaction.
The wavelength is the distance from one compression or rarefaction to the next.
The amplitude is the maximum distance the particle moves from its equilibrium position to the right of left.




*<u>Example</u>:*
*sound waves*

**Transverse Waves**

Here is a transverse wave; the oscillations are perpendicular to the direction of propagation.
Where the particles are displaced above the equilibrium position we call a peak and below we call a trough.
The wavelength is the distance from one peak or trough to the next.
The amplitude is the maximum distance the particle moves from its equilibrium position up or down.




*<u>Examples</u>:*
*water waves,*
*Mexican*
*waves and*
*waves of the EM spectrum*

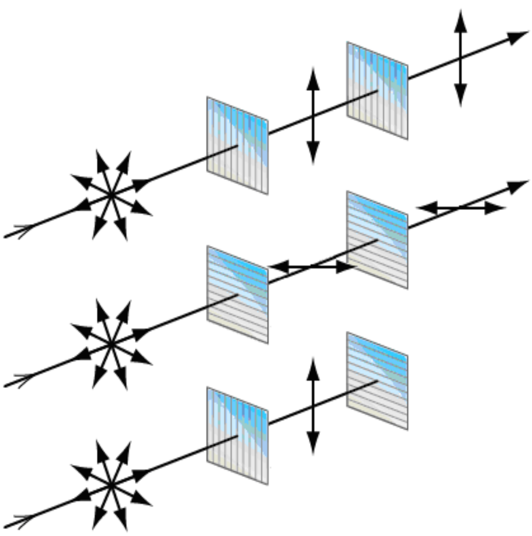
EM waves are produced from varying electric and magnetic field.

**Polarisation**

Polarisation restricts the oscillations of a wave to one plane. In the diagrams the light is initially oscillating in all directions. A piece of Polaroid only allows light to oscillate in the same direction as it.

- In the top diagram the light passes through a vertical plane Polaroid and becomes polarized in the vertical plane. This can then pass through the second vertical Polaroid.
- In the middle diagram the light becomes polarized in the horizontal plane.
- In the bottom diagram the light becomes vertically polarized but this cannot pass through a horizontal plane Polaroid.

This is proof that the waves of the EM spectrum are transverse waves. If they were longitudinal waves the forwards and backwards motion would not be stopped by crossed pieces of Polaroid; the bottom set up would emit light.



**Applications**

TV aerials get the best reception when they point to the transmission source so they absorb the maximum amount of the radio waves.

**TASK**

**Polarisation is a new concept to you, put into your own words how this concept is evidence that EM waves are transverse. Also, investigate and explain two applications of polarisation.**

**Useful websites and clips to watch**

https://www.youtube.com/watch?v=h5KBL1BPX1A&list=PLGvD8d3gDHUXRbumPNgFNV-xx5n6sBqKL&index=1

https://www.youtube.com/watch?v=HH58VmUbOKM

https://www.physicsandmathstutor.com/physics-revision/a-level-aqa/waves/

## Topic 4 – Mechanics and materials

**Scalars and Vectors**

Central to the study of **mechanics** is the idea of the **vector** quantity that not only has a value, but **direction** as well. Any quantity that does not specify a direction is a **scalar**.

| Vector | Scalar | Unit |
|---|---|---|
| Displacement | Distance | Metres (m) |
| Velocity | Speed | Metres per second ($ms^{-1}$) |
| Acceleration | | Metres per second$^2$ ($ms^{-2}$) |
| Momentum | | Newton seconds (Ns) |
| Force | | Newtons (N) |
| | Work , Energy | Joules (J) |
| | Voltage | Volts (V) |
| | Temperature | Degrees Celsius (°C), Kelvin (K) |
| | Frequency | Hertz (Hz) |

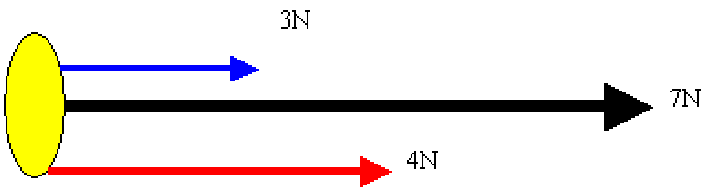
**Adding Vectors**

A vector can be represented on paper by an arrow drawn to scale.

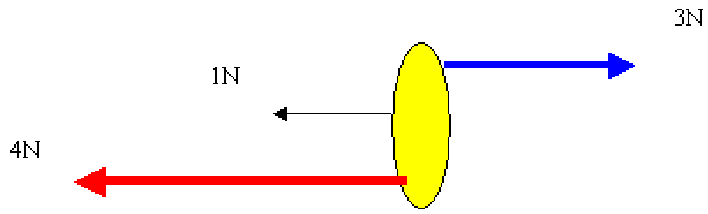
Tail Head

If the force vectors of 3N and 4N are in the **same** direction, they simply **add** together.

The heavy arrow indicates the **resultant** force. The **resultant** force is the force that has the same **effect** as the two **component** forces added together.



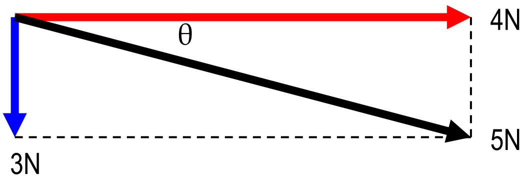

If the vectors are in **opposite** directions, we **subtract**. We can see that the resultant is now just 1 N.




If the two vectors are at 90° use **Pythagoras' Theorem**.

Resultant$^2 = 3^2 + 4^2 = 9 + 16 = 25$.

$\therefore$ Resultant = $\sqrt{(25)}$ = **5 N**

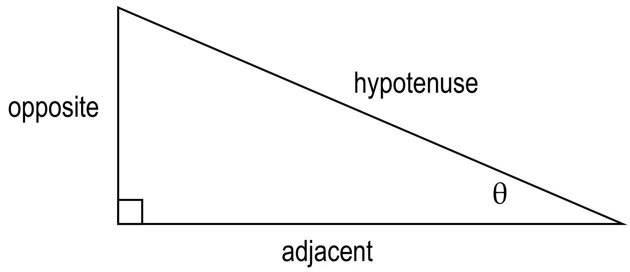



The direction of any vector is found at its tail. To find the direction of the 5N resultant vector we use trigonometry to determine the size of one of the angles at its tail. To work out the angle we use the tan function:

$\tan\theta = ¾ = 0.75 \Rightarrow \theta = \tan^{-1}(0.75) =$ **36.9°** The resultant vector is an angle of $36.9^0$ to the 4N vector.

You need to understand trigonometrical functions in order to resolve vectors, and to work out the angles that the resultants make.

Sines, cosines and tangents are ratios between the sides of a triangle for a given angle.



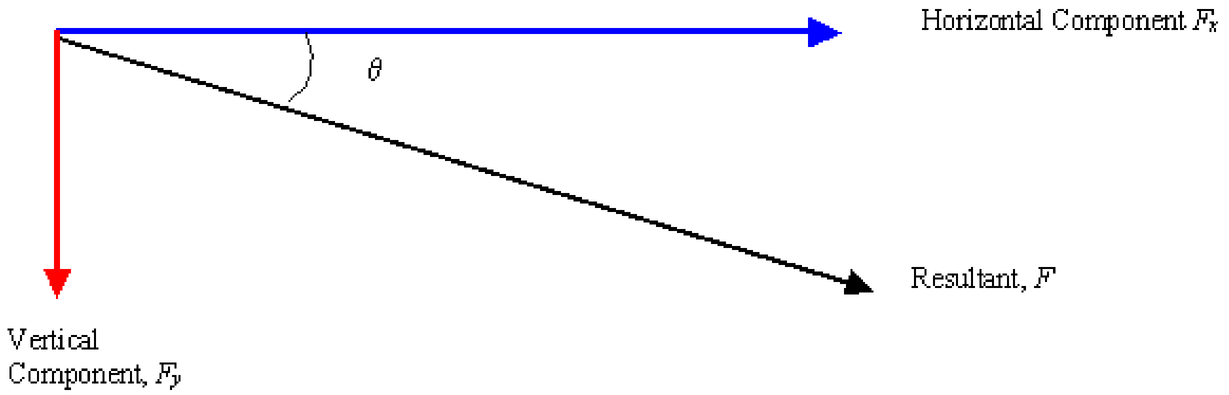

$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}}$$

$$\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$$

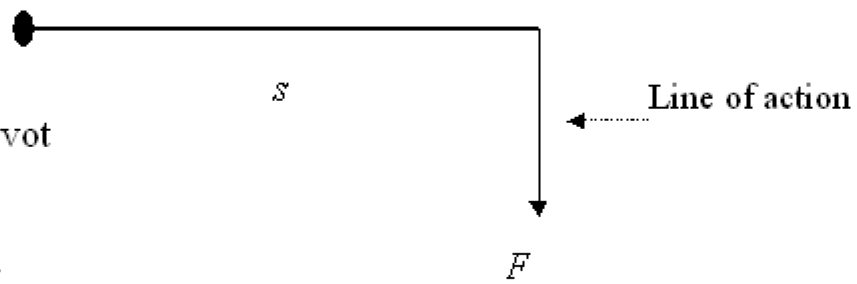
**Resolution of Vectors**

We can resolve any vector into two **components** at **90º** to each other.  They are called the **vertical** and the **horizontal** components. The resultant has the same **effect** as the two components added together.




**$F_x = F \cos\theta$**        **$F_y = F \sin\theta$**

**MOMENTS**




If we have hinged or pivoted body,Pivot

any force applied changes the

rotation of that body about the pivot.

The turning effect is called a **moment**.

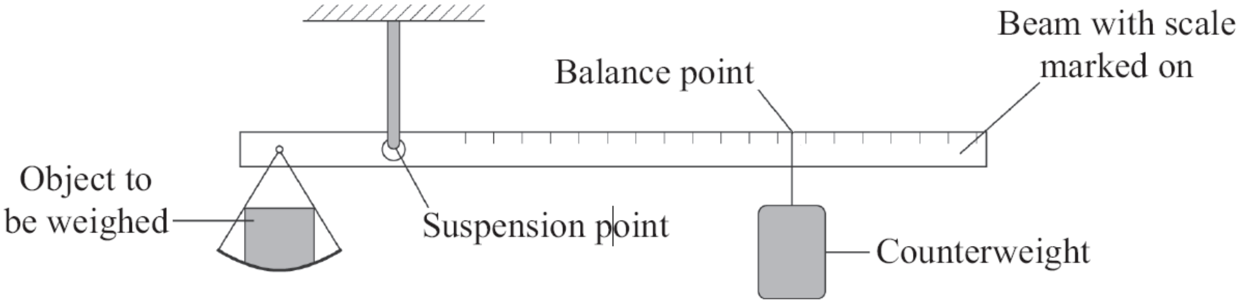
The equation is:    Moment = force × **perpendicular** distance   Units are Newton metres (Nm).

**Moments** have a direction.  As they are turning effects, we can talk of **clockwise** and **anti-clockwise** moments. By convention, **clockwise** is **positive**.

**TASK**

Scalars, Vectors and Moments
Extended Writing Task: **Using Moments**

Here is an example of an application of the principle of moments. The device, pictured below, consists of beam suspended from one point and is used to find the mass of objects.




Describe and explain how the device would be operated. Your answer should include:

- An account of how the device would be used to find the mass of an object
- An explanation of the principles of moments and how they apply in this situation
- An explanation of how it could be recalibrated to measure the value of greater masses
- Details of how you could improve the precision of the measurements taken.

Continue this task on lined paper.

**Useful websites and clips to watch**

https://www.youtube.com/watch?v=fMkctIXg8P0&list=PLGvD8d3gDHUVgyxA8evex35dWdWpl47k3

https://www.youtube.com/watch?v=7x6SpYdkjC4

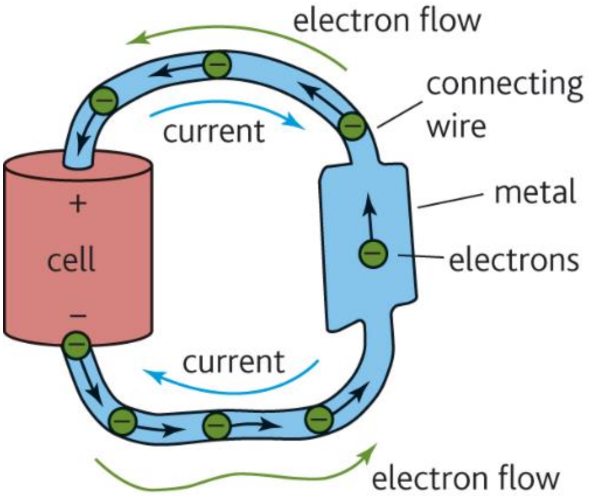
https://www.physicsandmathstutor.com/physics-revision/a-level-aqa/mechanics-and-materials/

## Topic 5 – Electricity

In order for electrical current to flow, there must be a **complete circuit** and a source of **potential difference**.

This suggests that something is moving around the circuit. We call what move 'charge carriers'. (*in metals, these are the **electrons*** ).
When a potential difference is applied across the metal, these electrons are **attracted** towards the positive terminal and **repelled** by the negative terminal.

The early day physicists got it wrong when they said that electric current flows from positive to negative. When the mistake was discovered, they decided to stick to the positive to negative, so all conventional current flows from positive to negative.



The size of the current is measured in **Amperes** using an ammeter. The faster the electrons move the larger the current.

One **Ampere** flows when **6.25x10$^{18}$ electrons** pass a given point in a circuit each second.

*Scientists decided that it was easier to use a unit to describe the charge that this number of electrons carry (**the coulomb**) rather than counting individual electrons. You would buy a 1 kg bag of sugar rather than counting all the crystals in it.*

One **coulomb** of charge contains **6.25x10$^{18}$ electrons**.

Therefore each electron has a charge of **-1.6x10$^{-19}$ Coulomb**.

In every circuit there is a component that 'puts energy in'. e.g. cell, battery, photocell, generator.
And there are components that 'receive energy'. e.g. bulb, buzzer, motor. This energy is carried by the electrons.

In a typical circuit, the cell supplies each electron with electrical potential energy. The electron then transfers this energy to the bulb as it passes through it.
The energy supplied by the cell is called 'electromotive force (emf)' and the energy used by the components is called' potential difference (pd)' or 'voltage'.
Both emf and pd are measured in volts.

What is a 'Volt' ?

When 1 Coulomb of charge (6.2x10$^{18}$ electrons) transfers 1 Joule of energy, it is said that the potential difference is 1 Volt.
So '1 Volt is 1 Joule per Coulomb'

**TASK**

**In your own words write your own definitions of the amp and the volt**

**Useful websites and clips to watch**

**https://www.youtube.com/watch?v=NWCi2jUh2o8&list=PLGvD8d3gDHUWKVRa5ATicyKAdcWkM0AQS**

**https://www.youtube.com/watch?v=k01ycafePJg&list=PLGvD8d3gDHUWKVRa5ATicyKAdcWkM0AQS&index=3**

**https://www.physicsandmathstutor.com/physics-revision/a-level-aqa/electricity/**

## Mathematical skills and layout

In physics all non-base quantities are called **derived quantities** and are defined by equations.
E.g. (a) Define speed. (b) Define charge.

**(a) speed = distance / time** **(b) charge = current × time.**

The units of these new quantities are **derived units** and are established from these same equations. So,

**(b) The unit of speed = unit of distance / unit of time = m / s = $\underline{m{\cdot}s^{-1}}$ ('**metres per second')*

**(c) The unit of charge = the unit of current × the unit of time = <u>A·s</u> ('**amp second')

| |
|---|
| *NOTE: At A level we write divided units, such as 'metres <u>per second</u>' as $ms^{-1}$ **not** m/s. |

In the SI system, many of these derived units get their own name. For example, the SI unit of charge is the coulomb (C). So we can say that one coulomb is equal to one amp second. or **C = A s**

Any SI unit can be expressed in terms of base units. To find the base units work though the defining equations one by one, unit you end up with the base units. For example, what are the base units of a Joule? This requires two steps:

- Energy (Work) = Force × distance moved, So one joule = one newton metre (**J = N·m**)
- Force is defined from F = m a, so one newton = one kilogram metre per second squared (or **$N = kg{\cdot}m{\cdot}s^{-2}$**)
- Therefore, a joule = **N m** = **$(kg{\cdot}m{\cdot}s^{-2})$ m** = **$\underline{kg{\cdot}m^2{\cdot}s^{-2}}$**

1. **Complete the table below.**
   Try working these out rather than looking them up. You can use the earlier answers to help with the harder ones.

| **Derived quantity** | **Defining equation** | **Standard SI unit (if applicable)** | **Equivalent base units** |
|---|---|---|---|
| speed | S = d / t | n/a | $m{\cdot}s^{-1}$ |
| momentum | p = m v | n/a | $kg{\cdot}m{\cdot}s^{-1}$ |
| acceleration | a = (v - u) / t | n/a | |
| Force | F = m a | newton (N) | |
| Power | power = work/time<br>P = W/t | | |
| frequency | frequency = 1/time period<br>f = 1 / T | | $s^{-1}$ |
| Charge | charge = current × time<br>Q = I t | coulomb (C) | A·s |
| potential difference | voltage = work/charge<br>V = W/Q | | |
| resistance | R = V / I | | |
| specific heat capacity | SHC = Energy / (mass × temperature change)<br>$c = Q / (m \times \theta)$ | | |

## Showing your working clearly

*When answering physics questions you need to lay out your working clearly showing all the steps, working left to right and top to bottom. Your final answer should be found to the bottom right of your working and should be underlined. Below is an example for you to base your own answer style on.*

### Ch6, Q4

A white snooker ball with a kinetic energy of 15J collides with a red ball. On impact the white ball stops, transferring all of its KE to the red ball. The mass of the red ball is 120 g. What would be the velocity of the red ball immediately following the collision?

STEPS: Equation being used → rearrange → values inserted
→ calculated answer → units → sig fig

$$KE = \frac{1}{2}mv^2 \quad \therefore \quad \frac{2KE}{m} = v^2 \quad \therefore \quad v = \sqrt{\frac{2\times 15J}{0.12\text{kg}}}$$

$$= 15.8\ \text{ms}^{-1} \quad \underline{= 16\ \text{ms}^{-1} (2sf)}$$

**EIGHT STEPS TO IMPROVE THE QUALITY OF YOUR WORKING**

- ☐ Show all steps
- ☐ Work left to right and top to bottom
- ☐ Rearrange equations before substituting values
- ☐ Your writing should be small and neat. Don't scrawl.
- ☐ You should be able to easily check over your working to find mistakes
- ☐ Plan to use the available answer space wisely
- ☐ Try to leave space for correcting mistakes if you go wrong

**TASK**

**Try these questions, but read these tips first!**

Lay out your working clearly, work step by step, and check your answers. If you get one wrong, go back and try again. Do not be disheartened if they seem difficult to start with, persevere and seek help – you will improve. **Importantly, have fun!**

1. How many $mm^2$ are there in

   (a) $1cm^2$ ? ..........................................................................................................................

   (b) $1\ m^2$ ? ..........................................................................................................................

   (c) $1\ km^2$ ? ..........................................................................................................................

2. How many $cm^3$ are there in

(a) $1mm^3$ ? ..........................................................................................................................................

(b) $1\ m^3$? ..........................................................................................................................................

3. A piece of A4 paper is 210 × 297 mm. All measurements are to the nearest mm. Calculate its area in (a) $mm^2$, (b) $cm^2$, (c) $m^2$. Give answers to the correct number of significant figures.

..........................................................................................................................................................

..........................................................................................................................................................

a) Area = .........................................$mm^2$

b) Area = ......................................... $cm^2$

c) Area = ............................................$m^2$

4. A plastic toy is supplied in a cubic box, 4.0 cm each side. How many of them pack into a carton 80 × 52 × 70 cm? (Students often get the wrong answer and can't see why. Visualise the actual problem don't just rely on maths!)

5. A copper atom has a diameter of 217 pm (pico-meters). How many of them would fit inside $1mm^3$ of copper to 3 sig. fig? (Tip: for simplicity, treat them as cubes of side 217 pm)