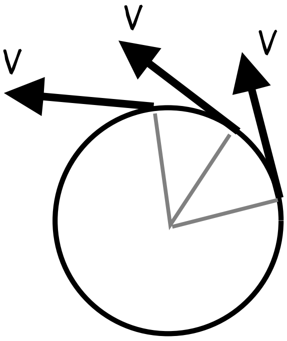
PHYSICS BASIC 1 - REVISION NOTES

MOTION IN A CIRCLE



When an object is travelling in a circular path its speed will remain constant. However the direction of the object is continually changing so the velocity of the body is continually changing and a change in velocity means that there is an acceleration, indicating that the object is not in equilibrium, because there is a resultant force acting on the object.

A resultant force acts on the body, because the velocity is not constant.

Centripetal force - The force acts at right angles to the objects velocity, towards the centre of the circle.

- Centripetal force: $F = \frac{mv^2}{r}$

- centripetal acceleration: $a = \frac{v^2}{r}$

OSCILLATIONS

Examples of free oscillations:

- tuning forkk
- a simple pendulummm
- ruler on the end of a deskk
- vertically oscillating springg

Every oscillator has a frequency of vibration with which it vibrates freely after an initial disturbance.

Observing oscillations:

- A simple pendulumm

Let a pendulum of different lengths swing backwards and forwards at its natural frequency of oscillation.

From this you will find that the pendulum speeds up (accelerates) as it moves towards the centre of the circle. It is moving fastest at the centre and then it slows down again as it moves towards the end of the oscillations. The displacement of the oscillating system varies in a smooth way on either side of the midpoint; the shape is a sine curve and the motion can be described as sinusoidal.

Amplitude is the maximum displacement from the undisturbed position.

Period is the time taken for one oscillation.

Frequency is the total number of oscillations per second.

- $F = \frac{1}{T}$

Phase describes the point that an oscillating mass has reached within the complete cycle of the oscillation. Phase difference between two oscillations is how much they are out of step with one another.

Damped oscillations:
In damped oscillations the amplitude decreases according to a particular pattern. For example a child on a swing knows that the amplitude of their swinging will decline until they come to rest unless more energy is supplied. This happens because of friction between the where the swing is attached and the frame. Energy gets transferred to the surroundings and so the amplitude of the oscillations decreases.

Different degrees of damping affect the time for which an object oscillates.

Examples of forced oscillations:

- If you are sat on a bus the vibrations from the engine are transmitted to your body, causing you to vibrate with the same frequency. These are not free vibrations of the body; they are forced vibrations.
- Waving a metre ruler up and down is forced, but if you hold one end on a desk and twang the other end, it will oscillate freely.

For resonance to occur we need a freely oscillating system. We must also have some way in which the system can be forced to oscillate. When the forcing frequency matches the natural frequency of the system, the amplitude of the oscillations grows dramatically.
Examples:
- Bartons pendulums
- Tacoma Narrows bridge disaster - In this case resonance was not useful
- Musical instruments

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- Microwave cooking- The microwaves have a frequency that matches a natural frequency of vibration of the water molecules. The water molecules in the food are forced to vibrate, and they absorb the radiation. the water gets hotter and the absorbed energy spreads throughout the food and cooks or heats it.

As the degree of damping is increased, the amplitude of resonant vibrations decreases. the resonance peak becomes broader. There is also an effect on the frequency at which the resonance occurs, which becomes lower.

SUPERPOSITION

The principle of Superposition: The resultant amplitude of two or more waves at any point of time is equal to the algebraic sum of the individual amplitudes.

Interference can be observed when two waves from two coherent sources overlap. Constructive interference occurs where waves arrive in phase and destructive interference occurs when they are out of phase by half a cycle.

Coherent means that the waves which meet and cause interference have the same frequency, wavelength, speed and a similar amplitude. Coherent waves have a constant phase difference between them. When coherent waves meet they undergo interference giving regions og high and low amplitude.

If the phase difference is a full wavelength or a multiple of a full wavelength then constructive interference occurs. If the phase difference is half a wavelength or a multiple of half a wavelength then destructive interference occurs.

Diffraction happens when waves arrive at a gap in a barrier and spread into the space beyond. The effect is greatest when the width of the gap is equal to the wavelength of the waves.

ELECTROMOTIVE FORCE AND POTENTIAL DIFFERENCE

The E.M.F of a source in volts is equal to the electrical energy in joules converted into other forms of energy when 1 coulomb of charge is driven around a complete circuit.

- $\text{emf} = \frac{w}{Q}$

E.M.F is applied to sources or electrical power. All supplies have internal resistance which waste energy when current flows. The voltage supplied by a battery or power supply is an electromotive force.

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The voltage across the power supply is an electromotive force, while the voltage across each component in a circuit is the potential difference.

To get an efficient transfer of energy from a source of e.m.f. to an external resistor, the internal resistance should be small compared to the external resistance.

The terminal potential difference of a source can be defined as equal to the energy converted in the external load per coulomb of charge passing through the load between the terminals.

- $V = \varepsilon \frac{R}{R+r}$

R = resistance of external load
r = internal resistance of power supply
V = terminal p.d.
ε = emf of power supply

CAPICITANCE

Capacitors are constructed from two metal sheets, separated by an insulating material, the dielectric.

Capacitors store charge, proportional to the p.d between the plates.

Capacitance is the charge stored per unit of p.d.

A farad is a coulomb per volt.

To charge up a capacitor it must be connected to a voltage.

- Equation defining capacitance: $C = \frac{Q}{W}$
- Equation for the energy stored in a charged capacitor: $W = \frac{1}{2}CV^2$

MAGNETIC FIELDS

A magnetic field is a region in which a current carrying conductor or a magnet can experience a magnetic force.

When a current flows through the wire in a magnetic field it experiences a force perpendicular to both the direction of the current and the direction of the magnetic fields.

When drawing field lines they must not cross and arrows show the direction of a force on a north pole.

ELECTROMAGNETISM

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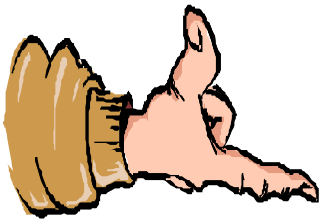
A force might act on a current carrying conductor placed in a magnetic field.

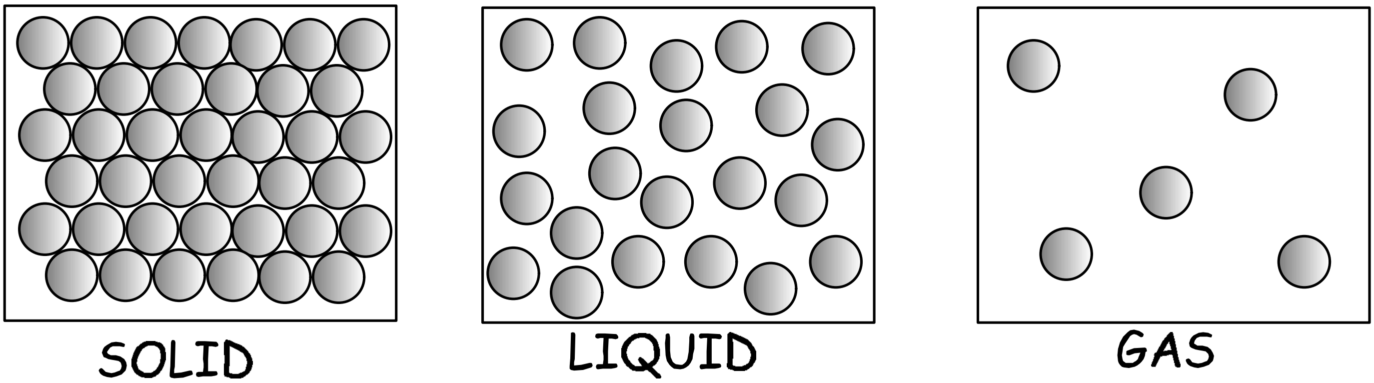
Fleming's left hand rule: This helps to predict the direction of the force on a current carrying conductor in a magnetic field.
First finger - field
Second finger - current
Thumb - thrust



ELECTROMAGNETIC INDUCTION

PHASES OF MATTER

Density = $\frac{\text{mass}}{\text{volume}}$

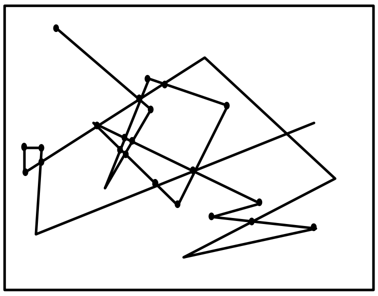


In a solid the particles vibrate around fixed positions. The particles are arranged in an orderly manner within a crystal structure.

Liquids have particles that are slightly further apart than solids and the forces of attraction are therefore slightly less than in solids. The particles can move about within a fixed volume.

Gases have particles that are much further apart than in liquids and there are no forces of attraction. The particles are free to move about in all directions and a gas can take up the whole volume and shape of its container.

Brownian motion can be demonstrated by using a smoke cell. The smoke cell contains air into which a small amount of smoke has been introduced. The cell is lit from the side and the microscope is used to view the smoke grains. The smoke grains show up as tiny specks of reflected light. The way in which they move is shown by a somewhat jerky and erratic path. This is due to the smoke particles colliding with the air molecules. The air molecules are much smaller than the smoke particles so the air particles must be moving much faster than the smoke particles to have this effect.



Pressure = $\frac{\text{force}}{\text{area}}$

A gas exerts pressure on any surface with which it comes into contact.

The pressure in a fluid: $P = \rho gh$

Upthrust in a fluid comes about because there is a difference in pressure at different levels in the fluid.

When a solid is heated the particles vibrate more and more as they gain energy. Eventually the strong forces between the molecules are overcome and the molecules start to move around and the solid has then melted.

When a liquid is heated the particles move faster and the fast moving molecules at the surface will overcome the forces of attraction from the other molecules and will escape. This is evaporation.

When the liquid gets hot enough virtually all the molecules have enough speed and energy to escape each other. The molecules completely break away from each other and this is known as boiling.

When a substance is melting or boiling all the heat energy supplied is used for breaking bonds.

Specific heat capacity of a substance is the amount of energy required to raise the temperature of 1Kg of the substance by 1°C.

The energy transferred in raising the temperature of a substance is given by: $\Delta Q = mc\Delta\theta$

The specific latent heat of a substance is the energy that must be supplied to change the state of 1Kg of the substance.

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The energy transferred in changing the state of a substance is given by: $\Delta Q = mL$

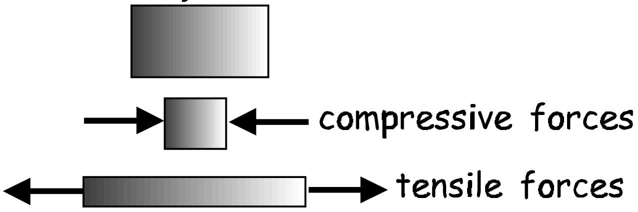
SOLIDS AND THEIR DEFORMATION

In a crystalline structure the particles from which they are made are arranged in a regular way Metals have this type of structure.

In a non crystalline structure the particles are arranged in a more random, jumbled kind of structure. Glass can be quoted as an example of this, in which the atoms are packed together to form an amorphous structure.

Polymers can have crystalline or amorphous structures. They are often a mixture of the two.

Deformation of a material is caused by a force which can be tensile or compressive:



Hookes law: An object obeys Hookes law if the extension produced in it is proportional to the load, provided the elastic limit is not exceeded.

The spring constant is the force per unit extension, or the force needed to extend the spring by one metre.

The strain is the fractional increase in the length of the wire.

- Strain = $\frac{\text{extension}}{\text{original length}}$

- Stress = $\frac{\text{load}}{\text{cross-sectional area}}$

- Young modulus = $\frac{\text{stress}}{\text{strain}}$

Elastic deformation of a material up to the point where the material breaks or is permanently deformed is when you can apply stress to the material, remove it and the material returns to its original length.

Beyond a certain point a material (e.g. copper wire) which is stretched more and more will not return to is original length when the load is removed. It has become permanently deformed and is described as plastic deformation.

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The strain energy in a deformed material can be found from the area under the force extension graph.

The ultimate tensile stress of a material is the point at which a material breaks. We can find this value of stress on a stress-strain graph.

QUANTUM PHYSICS

Both electromagnetic radiation and matter exhibit wave-particle duality -that is, they show both wave-like and particle-like behaviours depending on the circumstances.

The equation below is used to calculate the energy of photons.
h = Planck constant, E = energy of photon and f = frequency of the radiation of which it is part.

- $E = hf$

The photoelectric effect and line spectra are phenomena explained in terms of electromagnetic radiation.

The minimum frequency which that light must have in order to release electrons from the metal is called the threshold frequency.
We start with a photon of energy hf. It is absorbed by an electron. Some of the energy (∅) is used in escaping from the metal, the rest remains as kinetic energy of the electron.

- $hf = \varnothing + \frac{1}{2}mv^2_{max}$

de broglie wavelength: $\lambda = \frac{h}{p}$

He suggested that the wavelength of a particle was related to its momentum, p by the above equation.

When an electron changes its energy from one level to another, it either emits or absorbs a single electron. The energy of the photon hf is simply equal to the difference in energies between the two levels.

- $hf = E_1 - E_2$

NUCLEAR PHYSICS

When we calculate the amount of energy released in fission or fusion need to think about the masses of the particles involved. In a closed system the total amount of mass plus energy in a closed system remains constant.

- $E = mc^2$

Binding energy:
In nuclear fission when a massive nucleus splits it forms two smaller fragments. The products formed have greater binding energy that the original nucleus.

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In nuclear fusion when two light nuclei fuse, the final binding energy will be greater than the original value.

In nuclear processes nucleon number, proton number and energy are all conserved.
For example:

$$^{1}_{0}n + ^{235}_{92}U \longrightarrow ^{92}_{32}Kr + ^{141}_{56}Ba + 3\ ^{1}_{0}n$$

In both fission and fusion, unstable nuclei have become more stable. Energy is released.

The energy needed to pull a nucleus apart is called the binding energy of the nucleus.

RADIOACTIVITY

There are three types of ionising radiation produced by radioactive substance, α, β and λ rays. They all come from the nuclei of unstable atoms. Nuclei generally consist of protons and neutrons and if the balance between these two lies far to one side, the nucleus may emit one or other kind of radiation as a way of achieving stability.

α particles are helium nuclei, β particles are simply electrons and a λ ray is a form of electromagnetic radiation.

Radiation	Mass (relative to proton)	Charge (relative to proton charge, +e)	Speed
alpha particles	4	+2e	slow
beta particles	1/1840	-e	fast
gamma rays	0	0	speed of light

Because α radiation is highly ionising, it cannot penetrate very far into matter.

Alpha particles can be detected by a solid state detector or by a Geiger tube with a thin end window. With the source close to the detected, it can be shown that a single piece of paper is adequate to absorb all the alpha radiation, so it is not very penetrating.

Beta particles can be detected by using a Geiger tube. The source is placed close to the source and tube. Paper has little effect but a few centimetres of aluminium will completely absorb beta radiation.

Gamma rays are the least strongly ionising, so it makes them the most penetrating. Lead can be used to absorb gamma rays, but an infinite thickness of lead would be needed to completely absorb the radiation.

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Radioactive decay occurs within the nucleus of an atom. A nucleus emits radiation and the atom becomes an atom of a different substance. This is a spontaneous process, because we cannot predict for a particular nucleus when this will happen.

The unpredictability of nuclear decay, which is both a spontaneous and random process, means that count rates tend to fluctuate and we have to measure average quantities.

The decay constant λ is the probability that an individual nucleus will decay in a particular time interval.

The activity of a radioactive sample is the rate at which nuclei decay.

For a sample of N undecayed nuclei we have:

- $A = \lambda N$

The half life $t_{½}$ of a nuclide is the average time taken for half of the nuclei in a sample to decay.

A radio-isotope that decays rapidly has a short half life. Its decay constant must be high, since the probability of an individual nucleus decaying must be high. The half life and decay constant are inversely related.

- $\lambda = \frac{0.693}{t_{½}}$