Cambridge GCSE Notes
5054 Physics

Abrar Faiyaz Rahim, degrees pending

Contents

1 Motion, forces and energy

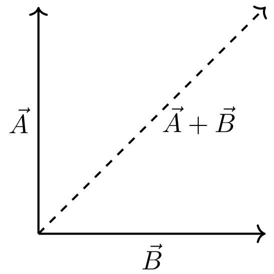
1.1 Physical quantities and measurement techniques

Lengths can be measured using measuring tapes, rulers and micrometers.

A measuring cylinder can be used to find the volume of an irregularly shaped object. A volume of liquid will first be taken in the measuring cylinder, which must fit the irregular object in question. The object will then be submerged into the liquid, and we will measure the change in volume reading of the liquid. For this case, note that $1\,\mathrm{cm}^3 = 1\,\mathrm{ml}$.

A scalar quantity has only a magnitude, and a vector quantity has magnitude and a direction related with that magnitude. Vector quantities will be denoted in this text as $\vec{x}$. Some scalar quantities are that of: distance, speed, time, mass, energy, and temperature. Some vector quantities follow: displacement, force, weight, velocity, acceleration, momentum, electric field strength and gravitational field strength.

Vectors are represented as arrows pointing in space. Those arrows have a direction, and a length, corresponding to the direction and magnitude of the quantity being represented by the arrows.



The above diagram shows two vectors: $\vec{A}$ and $\vec{B}$ and their resultant vector or their sum: $\vec{A}+\vec{B}$. To find the magnitude of their sum, or $\left|\vec{A}+\vec{B}\right|$, we can utilise the Pythagorean theorem:

$$\left|\vec{A}+\vec{B}\right| = \sqrt{\left|\vec{A}\right|^2 + \left|\vec{B}\right|^2}$$

1.2 Motion

Speed is the distance travelled by an object per unit time, and velocity is the change in displacement of an object per unit time. The displacement of an object is how far it is from a given origin point. This results in the following equation:

$$v = \frac{s}{t}$$

where s is displacement or distance, given the context, v is velocity or speed respectively and t is time taken to cause the corresponding change in displacement or to travel s distance.

The average speed of an object is given by the total distance it travelled over the total time it took:

$$\text{average speed} = \frac{\text{total distance travelled}}{\text{time taken}}$$

Acceleration is a vector which is the rate of change of velocity with respect to time, as seen in the equation:

$$\text{acceleration, } a = \frac{\Delta v}{\Delta t}$$

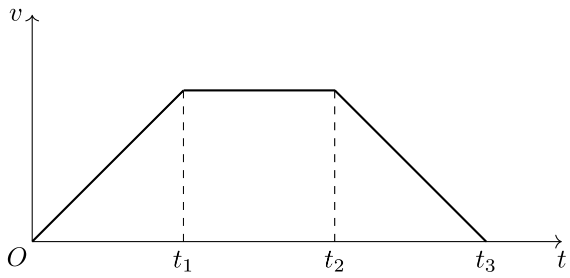
Uniform acceleration arises when the value of acceleration is unchanging. It causes a linear change in velocity with change in time, as seen in:

$$\Delta v = a(\Delta t)$$

A non-constant, i.e. changing value of acceleration results in a non-linear change in velocity, as seen by the same equation if the values of a is different for values of t.

A deceleration is simply negative acceleration, negative acceleration causes decrease in velocity. A deceleration of $9\,\mathrm{ms}^{-2}$ is equivalent to an acceleration of $-9\,\mathrm{ms}^{-2}$.

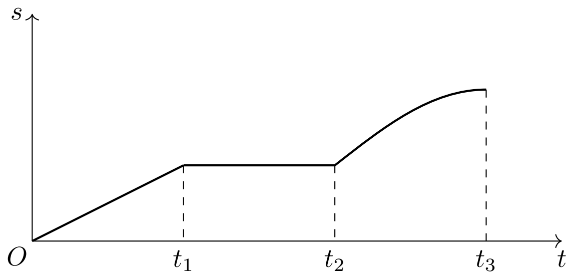
The values of speed, distance and velocity can all be plotted against time to see graphically, the relationships between all these variables.



velocity-time, v-t, graph.

In the above graph, a stopwatch is started at time, $t = 0\,\mathrm{s}$. The velocity of an object is measured at certain time intervals, using the data from which, the graph is drawn.

For $0 \leq t \leq t_1$, the graph shows a straight line. This means that the gradient of the curve must be constant. By definition, acceleration is the gradient of velocity with respect to time since it is the rate of change of velocity with respect to time. So a straight line in a v-t curve shows that acceleration is constant, i.e., uniform. Otherwise, the acceleration can be said to be non-uniform. For $t_1 \leq t \leq t_2$, the line is parallel to the horizontal axis. This means the gradient, a, equals 0. Note that, the area under a v-t graph gives distance or displacement, given context, since the product of the units of the axes, $(\mathrm{ms}^{-1})(\mathrm{s}) = \mathrm{m}$, gives the unit of distance. Lastly, $t_2 \leq t \leq t_3$ is a downward sloping line, meaning the acceleration is negative, and negative acceleration is decleration.



distance-time, s-t, graph.

In the above graph, the distance travelled by an object from time, $t = 0$ has been measured and plotted. Note that, the gradient of this curve is the speed of the object, and the area under it is nonsense.

Thus, for $0 \leq t \leq t_1$, the car travels with a constant positive speed and its distance travelled increases.

For $t_1 \leq t \leq t_2$, no more distance is travelled, meaning the object is stationary.

For $t_2 \leq t \leq t_3$, the object travels with a decreasing decreasing speed, meaning that the object is moving with a decreasing speed, i.e., it is decelerating.

For an object close to the surface of the earth, when they are in free fall, they are affected by a constant acceleration, $g = 9.8\,\mathrm{m/s^2}$.

1.3 Mass and weight

Mass is a measure of the quantity of an object at rest relative to the observer. It is this property of an object that resists change from its state of motion, be it rest or motion. This resistance of motion is called the inertia of that object, the measure of the stationary inertia of an object is its mass.

Gravitational field strength is a property unique to each gravitational field. It is the force each unit of mass experiences in the gravitational field, as follows:

$$g = \frac{W}{m}$$

where g is the gravitational field strength, in N/kg, W is the weight of an object, i.e., the force experienced by it due to gravity, and m is its mass.

A gravitational field is a region in space in which a mass experiences a force due to gravitational attraction.

1.4 Density

Density is the mass per unit volume of an object, as follows:

$$\rho = \frac{m}{V}$$

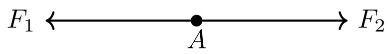
where ρ is the density and V is the volume of the object. To find the density of an irregularly shaped object, we can use the strategy discussed at the beginning of Section 1 and measure its mass, finally plugging those readings into the above formula.

1.5 Forces

1.5.1 Balanced and unbalanced forces

A force is simply a push or pull, or, more scientifically, a force is an acceleration on a mass. There are many kinds of force; weight, friction, drag, air resistance, tension (elastic), electrostatic, magnetic, thrust, contact etc.

Diagrams can be drawn to show the forces acting on an object:



The above diagram shows a particle A, which is experiencing forces in opposite directions, denoted by the arrows, F_1 and F_2. By the length of the arrows, we can say that the magnitudes of the forces is equal, i.e. $|F_1| = |F_2|$[1].

Newton's first law follows:

> An object either remains at rest or continues motion in a straight line at constant speed unless acted on by a resultant force.

A force causes an acceleration on a mass, this acceleration may change the magnitude of the object's velocity, i.e., its speed or it may change the direction of its velocity.

If there are multiple forces acting along the same axis, we will consider all the forces in one direction to be one sign, and consider the rest of the forces in the opposite direction to be an opposite sign. Consider an object has n forces acting to the right, and m forces acting to the left. Let's have the forces to the right have a positive sign, we must then have the forces to the left have a negative sign. The resultant of the forces on the object will then be:

$$(F_1 + F_2 + ... + F_n) - (F_1 + F_2 + ... + F_m)$$
$$\sum_{i=0}^{n} F_i - \sum_{k=0}^{m} F_k$$

Now, the resultant force, $\sum F$, on an object is the product of its mass and its acceleration:

$$\sum F = ma$$

Newton's third law follows:

> When object A exerts a force on B, then B exerts an equal opposite force on A.

This law describes pairs of forces of the same type acting on different objects.

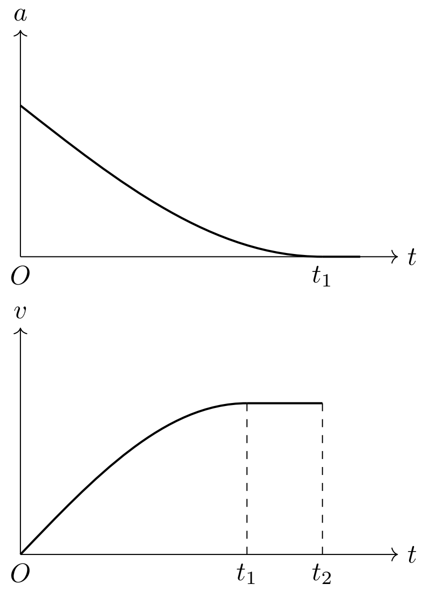
1.5.2 Friction

Friction is any force that impedes motion and produces heating.

In a perfect world, friction and such forces do not exist. Motion is not impeded. In such cases, forces cause objects to move with a constant acceleration, and this happens until or unless another resultant forces causes it to change. However, when friction or drag[2] is present, that constant acceleration is no longer constant, and it changes as the object moves, which may finally result in the object becoming stationary.

Let's consider the case of an object in free fall, where its motion is impeded by air particles. As it begins its free fall, its acceleration is maximum. As its motion continues, the resistive force against its motion increases and at a point these forces equal. At that point, acceleration of the object equals zero, the object continues its motion at a constant velocity, this is called the terminal velocity of the object. The following graphs illustrate this situation:

[1] $|\vec{x}|$ gives the magnitude of $\vec{x}$.
[2] Simply another form of friction.



To the left are the a-t and v-t graphs of an object in free fall which eventually reaches terminal velocity. Notice that by t_1, the acceleration of the object reaches 0, and so the velocity of the object also becomes constant t_1. For $t_1 \leq t \leq t_2$, the object travels at terminal velocity.

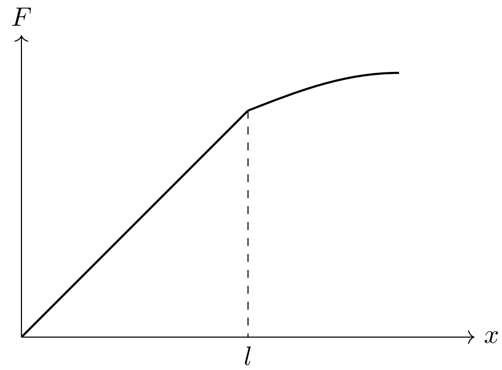
1.5.3 Elastic deformation

Forces may produce a change in size and shape of an object. Springs are objects which return to their original shape when deformed, this property of theirs is called elasticity.

The force required per unit extension is unique for each spring. Mathematically, a constant value is found, the spring constant, k.

$$k = \frac{F}{x}$$

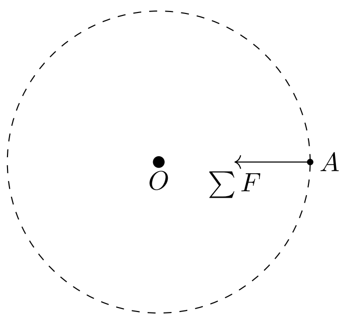
where F is the force applied on the spring and x is the extension of the spring. The force applied is also often called the load on a spring.



In the above graph, F on a string is plotted against its x. Note that the gradient of this curve is k, where $x \leq l$. l is the limit of proportionality of this spring, beyond which, k no longer applies.

1.5.4 Circular motion

For an object to be in an elliptic, circular or arc-like motion, the resultant force of the object and hence its acceleration must act normal to the arc of its motion, toward the centre of the circular path it is travelling.



Above is an example of object A travelling in a circular path around object O. The resultant force upon A which causes this motion is labelled as $\sum F$.

Here, four variables affect the motion of A, the radius of the circular motion, A's mass, speed and $\sum F$. Note that, speed increases if force increases, with mass and radius constant; radius decreases if force increases, with mass and speed constant; an increased mass requires an increased forcde to keep speed and radius constant.

1.5.5 Turning effect of forces

The moment of a force is its turning effect, i.e., how much the force makes something turn. Quantitatively:

$$\text{moment} = Fd$$

where d is the perpendicular distance of the force F from the pivot point of the object on which moment is being produced.

The principle of moments follows:

> For an object to be in equilibrium, its clockwise and anticlockwise moments must equal.

Mathematically,

$$F_1 d_1 + F_2 d_2 + ... + F_n d_n = F_1 d_1 + F_2 d_2 + ... + F_m d_m$$

where there are n clockwise moments and m anticlockwise moments.

1.5.6 Centre of gravity

Every irregular object has a point at which gravity acts on it. This is called the object's centre of gravity.

To find the centre of gravity of a plane lamina[3], we can use the following procedure:

1. Hang lamina from a certain point, use plumb line[4] to draw a line perpendicular to ground.
2. Hang lamina from seperate point, draw another line.
3. The point of intersection of these lines gives the centre of gravity of lamina.
4. A third line may be drawn to verify the found centre of gravity

1.6 Momentum

The momentum of an object is the product of its mass and velocity, as follows:

$$p = mv$$

where m is the mass v is the velocity and p is the momentum of the object.

An impulse is the product of the force and the time for which it acts:

$$\text{impulse} = F\Delta t$$

The product of the units of force and time, $(\text{kgm/s}^2)(\text{s}) = (\text{kgm/s})$, which is the unit of momentum. Hence, understand that:

$$F\Delta t = \Delta(mv) = \Delta p$$

hence,

$$F = \frac{\Delta p}{\Delta t}$$

1.7 Energy, work and power

1.7.1 Energy

Energy can be stored as kinetic, gravitational potential, chemical, elastic (strain), nuclear, electrostatic, internal, etc. Energy can be stored between different stores by means of mechanical, electrical work done or electromagnetic, sound waves.

The principle of conservation of energy follows:

[3] A flat shape, with uniform thickness but irregularity in shape.
[4] Mass suspended by a string, will always be perpendicular to ground.

> Energy can never be created nor destroyed, it is only converted from one form to another.

The kinetic energy of an object can be found by the following:

$$E_k = \frac{1}{2}mv^2$$

The unit of energy is the Joule (J), which is equivalent to (Nm).

The gravitational potential energy of an object comes from:

$$\Delta E_p = mg\Delta h$$

1.7.2 Work

Work done is simply energy transferred:

$$W = Fd$$

where W is the work done, F is the force applied and d is the distance across which it has been moved.

1.7.3 Energy resources

A renewable energy source is that which will not be depleted in the forseeable future, and a non-renewable one is the opposite. No matter the energy source, most of the time energy is released from the resource by means of heat, which is used to boil water. The steam formed has a high velocity and it travels through turbines, which spin as a result producing electric current. Where the steam is boiled is called the boiler, and the turbine is part of the generator from where electricity is produced.

Renewable resources may not always be available and will become depleted once they have been used. Such resources may also have detrimental environmental outcomes.

1.7.4 Efficiency

Efficiency is the ratio of the useful energy outputted by a process to the total energy inputted to the process. The same also applies for useful power output and total power input.

$$(\%)\text{ efficiency} = \frac{\text{useful energy/power output}}{\text{total energy/power input}} \times (100\%)$$

1.7.5 Power

Power is the rate of work done, or the rate of energy transferred. It comes down to:

$$P = \frac{W}{t} = \frac{\Delta E}{t}$$

Its unit is the Watt (W), which is equivalent to Joule per second.

1.8 Pressure

Pressure is the force per unit area:

$$p = \frac{F}{A}$$

where p is the pressure, F is the force, and A is the area on which it is applied.

With increase in force, pressure increases when area is constant. With constant force, pressure increases with decreasing area and the opposite applies for both cases..

In a liquid, the density and depth of it is directly related to the pressure of it. This can be shown in the following equation:

$$\Delta p = \rho g\Delta h$$

where Δh is the depth of the liquid from its surface and ρ is the density of the liquid.

2 Thermal physics

2.1 Kinetic particle model of matter

2.1.1 States of matter

Matter is composed of particles and can be found in three states: solid, liquid and gas. Their characteristics follow:

- Solids: Solids are rigid, and have a fixed shape and volume. They cannot be squashed.
- Liquids: Liquids have no rigidity, nor shape, in fact they take the shape of the container they are placed into. They are incompressible in that they cannot be squashed and hence have fixed volumes.
- Gases: Gases are not rigid, nor do they have a fixed shape, but they take the shape of their container. They are compressible and hence can be squashed. They may expand to take the shape of the container they were put into.

The temperature of matter dictates its state. Cooling reduces the kinetic energies of the particles getting them closer to solids and vice versa. The following diagram shows the changes of state of matter:

$$\text{Solid} \underset{\text{Freezing}}{\overset{\text{Melting}}{\rightleftharpoons}} \text{Liquid} \underset{\text{Condensing}}{\overset{\text{Boiling}}{\rightleftharpoons}} \text{Gas}$$

2.1.2 Particle model

All matter is made of particles, examples of which are ions, atoms molecules, electrons etc. The matter in their three states have these properties related to their particles:

- Solid: Have a regular arrangement of particles, which all have relatively low kinetic energy. Their movement consists only of vibration about fixed points. The hotter the solid, the faster that vibration.
- Liquid: The particles are not arranged in any pattern, and they are farther from each other than in solids. These particles can move by sliding around each other, while also vibrating. The hotter the liquid, the faster the vibrations of these particles.
- Gas: The particles in gases have are widely separated from one another, they are not in contact whatsoever but may collide amongst each other. The particles move freely about very energetically, bouncing off of each other and their container.

The higher the temperature of a particle, the higher their kinetic energy. The two are directly related. There is a temperature, $-273°\text{C}$, where the particles in matter are not moving at all and have zero kinetic energy.

In a gas, the particles are ever-moving and ever-colliding. For a gas in a container, there are three variables, its temperature T, its volume V and its pressure p. Note the following cases:

$$\text{Given constant } V,\ p \propto T.$$
$$\text{Given constant } p,\ V \propto T.$$
$$\text{Given constant } T,\ p \propto \tfrac{1}{V}\text{[5]}.$$

With variance in pressure and volume as a result of a varied temperature, the product of the first two variables will remain equal before and after the change in temperature. In other words:

$$p_1V_1 = p_2V_2$$

2.2 Thermal properties and temperature

2.2.1 Thermal expansion of solids, liquids and gases

Under heat, all three states of matter will undergo expansion, i.e., their volume will increase. This property is used in liquid in glass thermometers where the liquid expands according to the temperature it has been subjected to.

This expansion is a result of the particles in each state of matter gaining kinetic energy and moving about more intensely, causing themselves to push each other apart. Solids expand the least, liquids expand more than solids and gases expands the most per unit temperature increase.

[5] None of these three statements are concrete mathematically, these have been written to provide a sense of the relationships of the variables in a qualitative sense.

The temperature $-273\,^{\circ}\mathrm{C}$ has been mentioned before. This temperature is called absolute zero. It is from this temperature another scale for temperature is started, the Kelvin scale. To convert between the two scales:

$$T \text{ (in K)} = \theta \text{ (in } ^{\circ}\mathrm{C}) + 273$$

2.2.2 Specific heat capacity

An increase in the temperature of an object increases its internal energy and vice versa. This is because the average kinetic energies of all the particles in the object has increased.

The specific heat capacity of a material is the energy required per unit mass per unit temperature increase, it is a numerical value unique to each material and is denoted by c:

$$c = \frac{\Delta E}{m \Delta \theta}$$

where ΔE is the change in internal energy of the material, m is its mass and $\Delta\theta$ is the change in its temperature.

2.2.3 Melting, boiling and evaporation

Melting, freezing, boiling and condensation are all energy transfers without changes in temperature.

Every substance boils and melts at fixed temperature, for water the temperatures are $0\,^{\circ}\mathrm{C}$ and $100\,^{\circ}\mathrm{C}$ respectively.

Evaporation is the escape of more energetic particles from a surface of a liquid into gas. This occurs on the surface of the liquid below its boiling point. Evaporation rate is affected directly by temperature, surface area exposed to heat and movement of air over the body of liquid. In other words, the more the magnitude of these three variables, the faster the evaporation.

Latent heat is the energy required to change the state of a substance. During changes in state, the temperature of the substance is constant for some time before changing once again. At this constant temperature, not all particles of the substance have changed states and the substance is a mixture of its two states. During this time, energy is being absorbed by the substance to change its state. It is this energy that is the latent heat for that substance.

2.3 Transfers of thermal energy

2.3.1 Conduction

Heat is conducted through a non-metal as increased vibrations of particles at one end collides with the other end. As these collisions keep on happening, the kinetic energy of the particles in the substance increase steadily. In this case, non-metals are thermal insulators.

Metals have free (delocalised) electrons which can move about. When they are heated, not only do their particles vibrate more intensely, the electrons move about all over the metal. These electrons pass along heat to the extents of the metal. This is why metals conduct better than non-metals.

2.3.2 Convection

When one side of a fluid[6] is heated, the particles in that side gain kinetic energy and get further apart. As a result, the density of that region lowers. The hotter and hence less dense particles rises through the fluid, pushing the denser and cooler particles downward. These particles also become less dense while the particles previously pushed above are pushed back down. This cycle is called the convection current. This is what happens in pans and pots and stuff.

2.3.3 Radiation

Thermal energy may be transferred by infrared radiation, which is a form of electromagnetic wave. This form of radiation needs no medium to propagate. Infrared radiation is invisible to the naked eye and can be detected by our nerves.

Shiny white surfaces tend to reflect off all infrared radiation they are subjected to and hence they are the worst absorbers.

Matte black surfaces will absorb all infrared radiation they are subjected to and hence are the worst reflectors. As they are the best absorbers they are also the best emmitters.

[6] Liquid or gas.

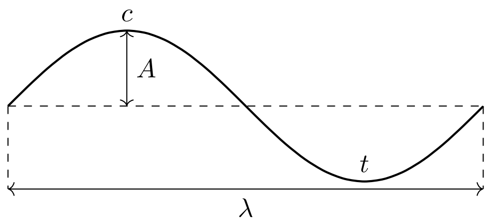
2.3.4 Consequences of thermal energy transfer

Insulators are used to maintain the internal temperature of buildings. Heaters are placed at the bottom of a room and cooling machines are placed at the top to set up convection currents respective to the densities of the particles undergoing temperature change.

3 Waves

3.1 General properties of waves

Waves are through which energy is transferred without transfer of matter.



Above is a diagram of a typical wave. It shows some characteristics of all waves. The wavelength of a wave is the distance between two adjacent identical points in the wave, denoted by λ. The amplitude of a wave is the maximum height from equilibrium position (the dotted line) of the wave, denoted by A. The highest and lowest points of a wave are called the waves crest and trough respectively, shown in the above diagram as c and t respectively. Every wave propagates, i.e., covers distance per unit time, known as its speed or the wave speed, denoted v. Never is there only one wave being produced, multiple waves are usually produced simultaneously. The crests and troughs of all these waves form lines called wavefronts.

Frequency, f is the number of wavelengths of a wave that pass a point per unit time. Its unit is Hertz (Hz), which is equivalent to s^{-1} (per second). The amplitude, A of the wave can also be said to be the maximum distance of a particle from the mean position.

Wave speed can be found using the following equation:

$$v = f\lambda$$

Waves can be of two types, transverse and longitudinal. The former is those where the direction of wave propagation is perpendicular/normal to the direction of particle oscillation. Water waves, electromagnetic waves and seismic secondary waves are all transverse waves. In the latter, direction of wave propagation is parallel to that of particle oscillation. Examples include sound waves and seismis primary waves.

When waves arrive at a plane surface, they are reflected. A change in speed of a wave causes its direction of propagation to change, which is known as refraction of the wave. When it travels through a gap, it is diffracted. Diffraction may also occur as a result of a wave passing beside an edge.

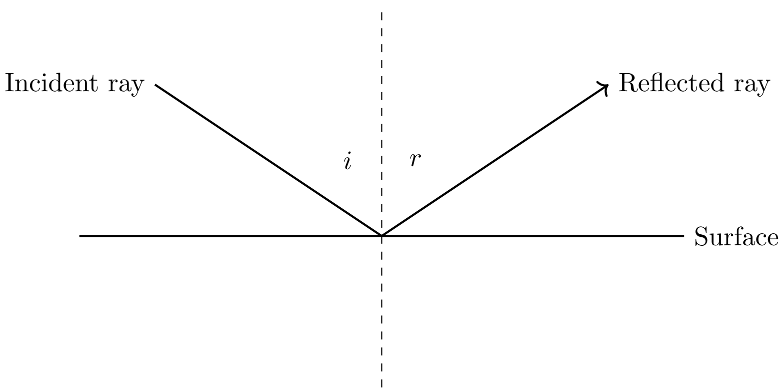
When waves pass through a barrier in which there is a gap whose width is greater than the wave's wavelength, diffraction's effect is not quite pronounced. The effect is most pronounced when the gap equals the wave's λ. When the gap is much smaller than the wave's wavelength, the wave does not pass through at all.

When waves pass by an edge, the angle of diffraction of the waves is directly related to the resulting angle of diffraction.

3.2 Light

3.2.1 Reflection of light

Reflection is the change of direction of a wave when it strikes a plane surface without passing through it. Light is reflected by shiny surfaces such as mirrors.



The normal of a surface is an imaginary line that is perpendicular to the surface. When waves are reflected, an angle of incidence is formed between the incident ray and the normal of the surface of reflection. This incidence angle is called i. The reflected ray of the wave also forms a reflected angle with the normal of the surface, denoted as r. In case of reflection $i = r$.

3.2.2 Refraction of light

In the case when the incident ray is not reflected off rather it passes into the surface, refraction occurs. The reflected ray is now called the refracted ray and the reflected angle the refracted angle. The extent of refraction depends on the material's refracting index, n.

The refractive index of a material can be found by:

$$n = \frac{\sin i}{\sin r} = \frac{c_i}{c_r}$$

where c_1 is the speed of wave in incidence medium and c_2 is that in refracted medium.

The critical angle of a material is that beyond which total internal reflection of a wave will occur and at which the incidence re-emergent ray is at $90°$ to the normal. Hence,

$$n = \frac{1}{\sin c}$$

where c is the critical angle.

Optical fibres consist of fibres whose interiors are lined with glass like substances. They are used to transmit information at light speed, as when light travels through these optical fibres, the angle of incidence of each ray is always greater than critical angle and hence no light is lost to refraction, no information is lost either.

3.2.3 Thin lenses

Lenses can be of two types: converging and diverging lenses.

TODO: Diagrams.

Understand that,

$$\text{linear magnification} = \frac{\text{image length}}{\text{object length}}$$

3.2.4 Dispersion of light

White light, when it passes through a glass prism, due to differences in its component colours, frequencies, wavelengths, will disperse into its 7 component colours. The seven component colours are violet, indigo, blue, yellow, orange and red, in sequence of decreasing frequency and increasing wavelength.

3.3 Electromagnetic spectrum

Electromagnetic waves are a waves which all have a speed of 3×10^8 m/s in vacuum. It is a spectrum of waves as each wave differs by its wavelength and frequency, the two being inversely related.

4 Space physics

4.1 Earth and the Solar System

4.1.1 The Earth

The Earth is a planet that orbits the Sun once in approximately 365 days. The orbit of the Earth is an ellipse which is approximately a circle. The Earth also rotates around its own tilted axis, and it completes one rotation every 24 hours. The Moon is a satellite of the Earth which takes approximately a month to complete its orbit around Earth. It takes approximately 500 seconds for light from the sun to reach the Earth.

The average orbital speed for a celestial body can be derived from that of speed:

$$v = \frac{2\pi r}{T}$$

where v is the average orbital speed, r is the radius of the orbit that has been plugged into the formula for circumference to find the orbit distance, and T is the time taken for one whole orbit.

4.1.2 The Solar System

The Solar System consists of one star, the Sun around which eight planets orbit. The names of the planets follow in order of increasing distance from the Sun:

1. Mercury.
2. Venus.
3. Earth.
4. Mars.
5. Jupiter.
6. Saturn.
7. Uranus.
8. Neptune.

There are also minor planets in orbit of the sun, these include dwarf planets such as Pluto. There is also an asteroid belt in between Mars and Jupiter, consisting of asteroids orbiting the Sun. All planets have bodies that orbit them, called their moons or satellites. Some bodies such as comets also exist which orbit the Sun in huge elliptical orbits.

The strength of the gravitational field at the surface of a planet depends on the mass of the planet itself. Around the planet, it is directly related to distance from the planet.

The Sun contains most of the mass of the Solar System and the strength of its gravitational field, at its surface is far greater than those of any planet. For a planet in orbit, it is the attractive force of this gravitational field that keeps it in orbit. However, with distance from the Sun, the strength of its gravitational field decreases as the distance from the Sun increases, the same hence applies for the planets' orbital speeds as with lower force there is a lower acceleration.

4.1.3 The Sun as a star

The Sun is a star of medium size, consisting mostly of hydrogen and helium, which radiates most of its energy in the infrared, visible and ultraviolet regions of the electromagnetic spectrum. Stars are powered by nuclear reactions that release energy, in stable ones the nuclear reactions involve the fusion of hydrogen into helium, shown in the following equation using nuclide notation:

$$^{1}_{1}\mathrm{H} + ^{1}_{1}\mathrm{H} \longrightarrow ^{2}_{2}\mathrm{He}$$

4.1.4 Stars

Galaxies are made up of many billions of stars. The Sun is a star in the galaxy known as the Milky Way. The other stars that consist the Milky Way are far farther from the Earth than the Sun is. Kilometres are not enough to measure these distances, the light-year is the unit of astronomical distance, which is the distance travelled by a ray of light in one year. That is:

$$(3.0 \times 10^8)(365)(24)(60)(60) \approx 9.4608 \times 10^{15}\text{m}$$

is one light-year.

Stars form from intersteller clouds of gas and dust that contain hydrogen called molecular clouds. A protostor is an interstellar cloud collapsing and increasing in temperature as a result of its internal gravitational attraction. A protostar becomes a stable star when the inward force of gravitational attraction is balanced by an outward force due to the high temperature in the centre of a star. All stars eventually run out of hydrogen, the fuel for the internal nuclear fusion reaction. Most stars expand to form red giants and more massive ones expand to form red supergiants when most of the hydrogen in the centre of a star has been converted to helium. A red giant from a less massive star forms a planetary nebula with a white dwarf at its centre. A red supergiant explodes as a supernova, forming a nebula containing hydrogen and new heavier elements, leaving behind a neutron star or a black hole at its centre. The nebula from a supernova may form new stars with planets that orbit them.

4.1.5 The Universe

The Milky Way is one of the many billions of galaxies making up the Universe and the diameter of the Milky Way is approximately $100000 = 10^6$ light-years. A redshift is the increase in the observed wavelength of the electromagnetic radiation emitted from receding stars and galaxies. The light from distant galaxies shows redshift and that the further away the galaxy, the greater the observed redshift and the faster the galaxy's speed is away from the Earth.

How does redshift provide evidence for the Big Bang Theory??????? HELP