National 5 Physics

Unit 1 – Waves & Radiation

Contents

In the next few pages there will be tables with knowledge that **must** be learned before the National 5 Physics exam. In the 1st box put a ✓ or ✗ to show your understanding. You can use the 2nd box to check your understanding at a later date.

Using this sheet **will** help you become more prepared for your final exam.

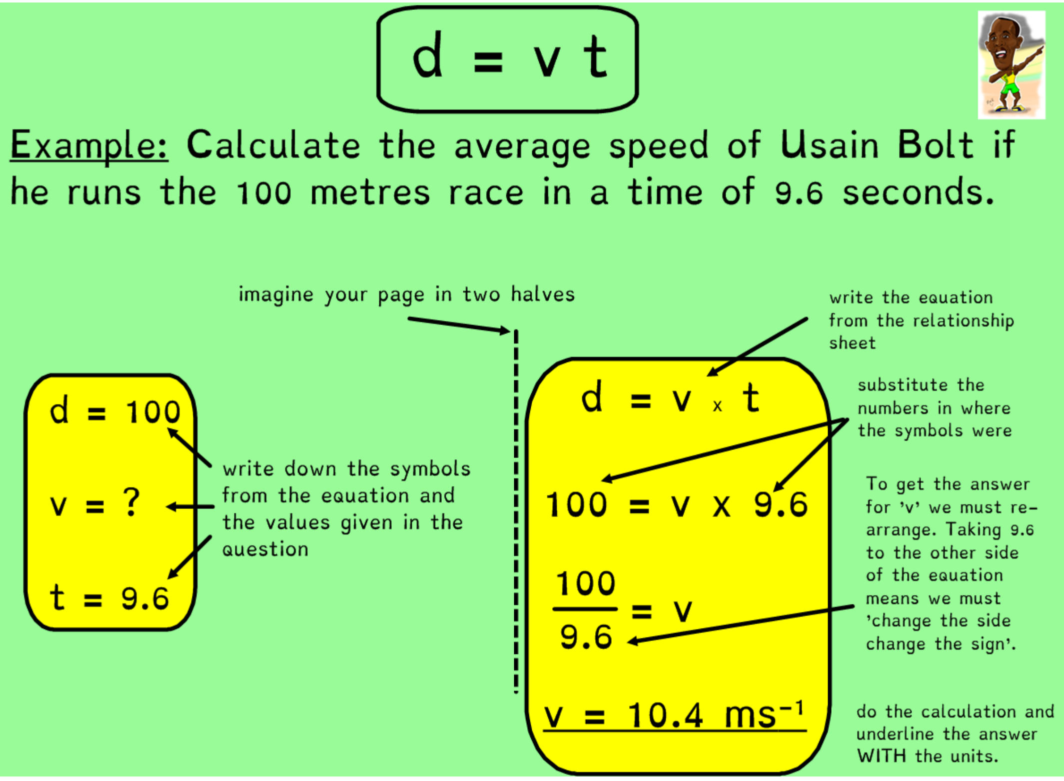
Use the extra space sections to include any additional information that you find when doing past paper questions/reading your notes etc…

Using the equations

When solving a calculation there are steps you can take to make it easier to gain as many marks as possible.

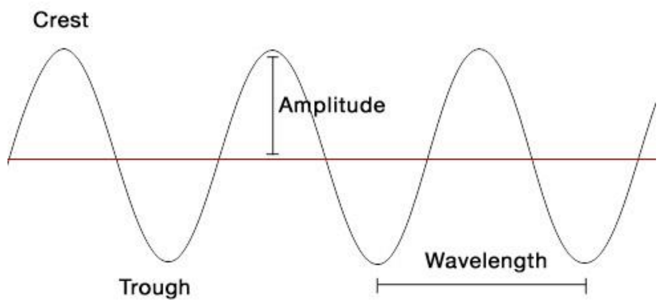
First, write down the information given in the question. When you have written all of the information the next step is to choose the correct equation from the relationship sheet (given in every assessment – you do not need to remember the equations!). Next is to write down the equation. Then substitute the value for each symbol. At this point you have achieved 2 marks out of 3, the final mark is for re-arranging the equation and using your calculator to get the correct answer, which must have the correct units and be rounded to 3 significant figures.

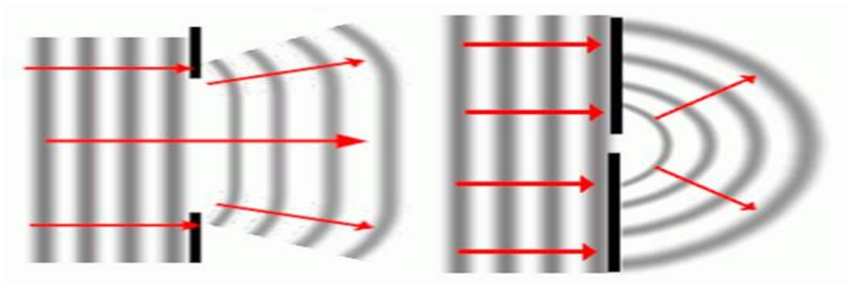
Example:



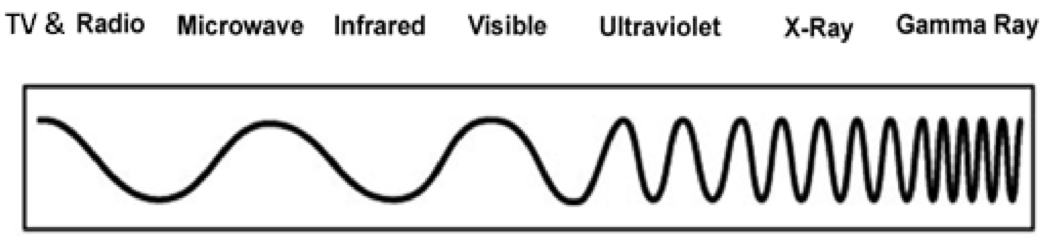
Extra space for additional information.

Section 1 – Wave parameters and behaviours

Energy can be transferred as waves.		
 <u>Frequency</u> is defined as the number of waves per second. <u>Amplitude</u> is the height from the centre to the crest/trough of a wave. <u>Period</u> is the time for one complete wave to pass a point. <u>Wavelength</u> is the length of one complete wave. <u>Wave speed</u> is the distance travelled by a wave in one second.		
The speed of a wave is calculated using the equation: $\mathbf{d = v\,t}$ where d = the distance measured in metres (m) and t = the time measured in seconds (s). v is the speed of the wave measured in metres per second (ms^{-1}).		
In a transverse wave the particles vibrate at **<u>90^{o}</u>** to the direction of travel of the wave. Examples of these waves are; all electromagnetic waves (radio waves etc..) and water waves.		
In longitudinal waves the particles vibrate **<u>along</u>** the direction of travel of the wave. Examples of these waves are sound waves.		
frequency = $\frac{1}{\text{period}}$ $\mathbf{f = \frac{1}{T}}$ where the frequency is measured in hertz (Hz) and the period is measured in seconds (s).		
speed = frequency x wavelength $\mathbf{v = f\lambda}$ where wavelength is measured in metres (m) and speed measured in metres per second (ms^{-1}).		
Diffraction occurs when waves pass an object and can bend around the object. If the wavelength is large then there will be more diffraction. This is why Radio waves diffract better than TV waves.		

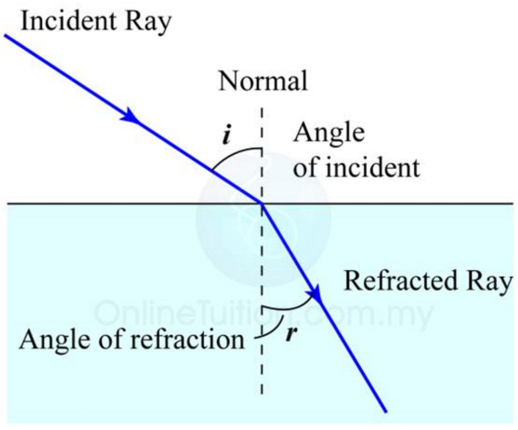
If the gap is larger than the wavelength there is a small amount of diffraction. If the gap is the same size as the gap there is a lot more diffraction. When drawing these diagrams the wavelength (distance between lines) must not change. This is shown in the diagrams below; 		
Extra space for additional information.		

Section 2 – Electromagnetic Spectrum

The Electromagnetic spectrum has 7 bands which are arranged in order. Below they are shown in order from largest wavelength to shortest wavelength.  Longest wavelength Shortest wavelength		
The order is **reversed** if they are arranged in order of largest frequency to smallest frequency. As the wavelength decreases the frequency increases.		
The **higher** the frequency the **greater** the energy. Gamma rays are the most dangerous as the have a high frequency and Radio and TV waves are the least dangerous as they have the lowest frequency.		

All Electromagnetic waves travel at 3×10^8 ms^{-1}. When asked to state the speed of any electromagnetic wave the units (ms^{-1}) must be written or <u>zero marks</u> will be given.		
<u>Radio and TV waves</u> are used in long distance communication. They are detected using an **<u>aerial</u>**.		
<u>Microwaves</u> are used in mobile phones and cooking. They are detected using an **<u>aerial</u>**.		
<u>Infrared</u> is emitted by all hot objects. They are detected using a **<u>photodiode</u>**.		
<u>Visible light</u> is used in lasers. They are detected by our **<u>eyes</u>** and **<u>photographic film</u>**.		
<u>Ultraviolet</u> is used to show up certain chemicals. They are detected using **<u>fluorescent materials</u>** and **<u>photographic film</u>**. Too much exposure can cause **<u>skin cancer</u>**.		
<u>X-rays</u> are used to examine broken bones and metal objects that are not easy to see. They are detected using **<u>photographic film</u>**. The **darker** the film the greater the levels of x-ray radiation present. Too much exposure can cause **<u>cells</u>** to change or be killed.		
<u>Gamma rays</u> are used in Nuclear power stations and in medicine. They are detected using a **<u>Geiger Muller tube</u>** and **<u>photographic film</u>**. They are very dangerous and can easily change and kill human **<u>cells</u>**.		
Extra space for additional information.		

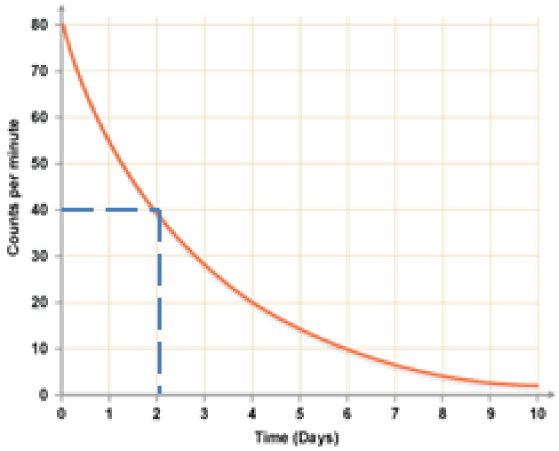
Section 3 – Light

Refraction is defined as the **<u>change in speed</u>** of light as it passes from one medium (material) to another.		
 i = angle of incidence r = angle of refraction As the light passes from air into the material it bends **<u>towards</u>** the normal. If the light passes from the material into the air it bends **<u>away</u> <u>from</u>** the normal.		
When drawing a refraction diagram the angles of incidence and refraction **<u>must</u>** be labelled. **<u>It is not good enough to simply put i and r.</u>**		
The angle of incidence and angle of refraction **<u>must</u>** be measured from the normal. It is always best to draw the normal line first before completing the path of the ray of light. The normal is **<u>always at 90°</u>** to the boundary of the two materials.		
Extra space for additional information.		

Section 4 – Nuclear radiation

An atom has three particles; protons, electrons and neutrons. Protons and neutrons are found in the nucleus while electrons orbit the nucleus.		
An alpha particle (α) is 2 protons and 2 neutrons or called a Helium nucleus.		
A Beta particle (β) is a fast moving electron which comes from the nucleus.		
A Gamma ray (γ) is not a particle but is a high energy electromagnetic wave.		
Alpha (α) is absorbed by a sheet of paper or a few cm of air.		
Beta (β) is absorbed by a few mm or aluminium or 1 metre of air.		
Gamma (γ) is absorbed by a few cm of lead or several metres of concrete.		
Ionisation is when a neutral atom gains or loses an electron.		
Alpha causes the greatest ionisation so has the largest ionisation density.		
Nuclear radiation can be used in medicine in power stations and in industry.		
In medicine, nuclear radiation is used to treat cancer using radiotherapy and to sterilise hospital equipment. It can do this because nuclear radiation can kill cells. Radioactive tracers can be injected/swallowed by the patient to examine organs in the body. This is done because the tracer can be detected easily and has a short half-life. Gamma radiation is used as alpha and beta would be absorbed by the body tissue.		
In power stations, nuclear radiation is used as when a nuclear fission reaction takes place large amounts of energy are released which can be used to generate electrical energy.		
In industry a leaking underground pipe can be detected by using a radioactive tracer to the liquid. A higher count-rate of gamma radiation will be detected at the leak than elsewhere.		
Nuclear radiation must be used safely. There are precautions that must be taken when handling it. These are; • Using tongs/gloves • Point away from body • Hold at arms length • Wash hands after use • Never put close to your eyes		
Background radiation is naturally occurring radiation from our surroundings.		

The total annual exposure of ionising radiation is made up of mostly background radiation but also some artificial (man-made radiation).		
Examples of natural background radiation are; • Radon gas • Rocks • Cosmic rays from space • Food and drink		
Examples of artificial (man-made) radiation are; • Medical i.e. radiotherapy, x-rays etc… • Nuclear waste from power stations		
Absorbed dose = $\frac{\text{Energy}}{\text{mass}}$ **D =** $\frac{\mathbf{E}}{\mathbf{m}}$ where absorbed dose is measured in Grays, Gy or JKg^{-1}.		
The absorbed dose is defined as the energy absorbed per unit mass of the absorbing material. 1 Gray = 1 Joule per Kilogram. This means that the smaller the mass of absorbing material the greater the absorbed dose.		
Equivalent dose = Absorbed dose x Radiation weighting factor **$H = D W_R$** where equivalent dose is measured in Sieverts, SV and W_R has no units. The radiation weighting factor takes into account the type of radiation and can be found in a table in the data sheet which is given for any assessment.		
The equivalent dose is a measure of the biological effect of radiation. In other words the risk of there being damage caused to the cells in your body. The greater the equivalent dose the greater the risk of cell damage.		
There are three ways to reduce the equivalent dose; • Use shielding • Limit time of exposure • Increase distance from the source		
The risk of biological harm depends on; • The absorbed dose • The type of radiation • The type of tissue exposed		
The average annual background radiation in the UK is 2.2 mSv.		

Safety limits are put in place to reduce the annual exposure of ionising radiation for places that use ionising radiation; Annual effective dose limit for radiation worker is 20 mSv. Annual effective dose limit for a member of the public is 1 mSv.		
To calculate the time a radiation worker can spend with a radioactive source the equivalent dose rate must be used. Equivalent dose rate = $\frac{\text{Equivalent dose}}{\text{time}}$ $\dot{H} = \frac{H}{t}$ where $\dot{H}$ is usually measured in Svh^{-1} (Sv per hour) but can be a different unit of time like days.		
Activity is defined as the number of decays per second. For this reason the time used in the calculation must be measured in <u>**SECONDS!**</u>		
The activity of any radioactive source decreases with time.		
Half-life is defined as the <u>**time taken**</u> for the <u>**activity**</u> of a radioactive source to half from its original value.		
A short half-life (a matter of hours) is desired in radioactive tracers so that the activity will decrease to a safe level in a short time. A longer half-life is desired in situations where the source is to be used over and over again.		
 Half-life can be calculated from a graph by observing the time taken for the activity to half. The initial activity was 80 and after 2 days the activity has halved to 40 so the <u>half-life is 2 days</u>. The half-life is the same value each time the activity is halved.		
Half-life can also be calculated using data. In questions like this the aim is to half the activity the correct number of times. There is no equation in half-life questions.		
Nuclear fission is when a nucleus of large mass splits into two nuclei of smaller mass with the release of energy.		
A chain reaction is when nuclear fission <u>**repeats**</u> itself over and over.		

Nuclear fusion is when two nuclei of small mass combine to form one nucleus of large mass with the release of energy.		
Nuclear fission produces a lot of radioactive waste compared to nuclear fusion. The waste must be stored safely as it has a long half-life which means it will be radioactive for a long time and can therefore cause damage to living things.		
Nuclear fission and nuclear fusion can be used in nuclear power stations to generate electrical energy. This happens in the nuclear reactor where the energy produced changes water into steam. The steam turns turbines which spin generators and generate electrical energy.		
The five main parts of a nuclear reactor are; • Fuel rods – Contains Uranium fuel • Moderator – Slows down **neutrons** • Control rods – Absorbs **neutrons** • Coolant – Cools down the reactor and changes water into steam to turn the turbines. • Containment vessel – Prevents radioactive materials escaping.		
In nuclear fusion reactors the main safety precaution is to prevent the plasma touching the walls of the reactor as the walls will melt. This is done by using powerful magnets.		
Advantages of nuclear power stations are; • Produce much more energy per kilogram than fossil fuels. • Produce no greenhouse gases.		
Disadvantages of nuclear power stations are; • Radioactive waste needs disposed of safely. • Risk of accidents. • Limited resources of Uranium.		
Extra space for additional information.		