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| **4.6 Waves** |  |  |  |
| *4.6.1 Waves in air, fluids and solids* |  |  |  |
| **4.6.1.1 Transverse and longitudinal waves** |  |  |  |
| 1. Waves may be either transverse or longitudinal.
2. The ripples on a water surface are an example of a transverse wave.
3. Longitudinal waves show areas of compression and rarefaction.
4. Sound waves travelling through air are longitudinal.
5. Students should be able to describe the difference between longitudinal and transverse waves.
6. Students should be able to describe evidence that, for both ripples on a water surface and sound waves in air, it is the wave and not the water or air itself that travels.
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| **4.6.1.2 Properties of waves** |  |  |  |
| 1. Students should be able to describe wave motion in terms of their amplitude, wavelength, frequency and period.
2. The amplitude of a wave is the maximum displacement of a point on a wave away from its undisturbed position.
3. The wavelength of a wave is the distance from a point on one wave to the equivalent point on the adjacent wave.
4. The frequency of a wave is the number of waves passing a point each second.
* $period= \frac{1}{frequency}$
* $T= \frac{1}{f}$

period, *T*, in seconds, sfrequency, *f*, in hertz, Hze) The wave speed is the speed at which the energy is transferred (or the wave moves) through the medium. |  |  |  |
| a) All waves obey the wave equation:* $wave speed=frequency x wavelength$
* $v=f x λ$

wave speed, *v*, in metres per second, m/sfrequency, *f*, in hertz, Hzwavelength, *λ*, in metres, mStudents should be able to:1. identify amplitude and wavelength from given diagrams
2. describe a method to measure the speed of sound waves in air
3. describe a method to measure the speed of ripples on a water surface.
4. (Physics only) Students should be able to show how changes in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related.
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| **Required practical activity 8:** make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements. |  |  |  |
| *4.6.2 Electromagnetic waves* |  |  |  |
| **4.6.2.1 Types of electromagnetic waves** |  |  |  |
| 1. Electromagnetic waves are transverse waves that transfer energy from the source of the waves to an absorber.
2. Electromagnetic waves form a continuous spectrum and all types of electromagnetic wave travel at the same velocity through a vacuum (space) or air.
3. The waves that form the electromagnetic spectrum are grouped in terms of their wavelength and their frequency. Going from long to short wavelength (or from low to high frequency) the groups are: radio, microwave, infrared, visible light (red to violet), ultraviolet, X-rays and gamma rays.

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| long wavelength short wavelength |
| radio waves | microwaves | infrared | visible light | ultraviolet | X-rays | gamma rays |
| low frequency high frequency |

d) Our eyes only detect visible light and so detect a limited range of electromagnetic waves.e) Our skin can detect temperature so we can detect infra-red waves.f) Students should be able to give examples that illustrate the transfer of energy by electromagnetic waves. |  |  |  |
| **4.6.2.2 Properties of electromagnetic waves 1** |  |  |  |
| 1. (HT only) Different substances may absorb, transmit, refract or reflect electromagnetic waves in ways that vary with wavelength.
2. (HT only) Some effects, for example refraction, are due to the difference in velocity of the waves in different substances.
3. Students should be able to construct ray diagrams to illustrate the refraction of a wave at the boundary between two different media.
4. (HT only) Students should be able to use wave front diagrams to explain refraction in terms of the change of speed that happens when a wave travels from one medium to a different medium.
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| **Required practical activity 9**: investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface. |  |  |  |
| **4.6.2.3 Properties of electromagnetic waves 2** |  |  |  |
| 1. (HT only) Radio waves can be produced by oscillations in electrical circuits.
2. (HT only) When radio waves are absorbed they may create an alternating current with the same frequency as the radio wave itself, so radio waves can themselves induce oscillations in an electrical circuit.
3. Changes in atoms and the nuclei of atoms can result in electromagnetic waves being generated or absorbed over a wide frequency range. Gamma rays originate from changes in the nucleus of an atom.
4. Ultraviolet waves, X-rays and gamma rays can have hazardous effects on human body tissue. The effects depend on the type of radiation and the size of the dose.
5. Radiation dose (in sieverts) is a measure of the risk of harm resulting from an exposure of the body to the radiation.
6. 1000 millisieverts (mSv) = 1 sievert (Sv)

Students will not be required to recall the unit of radiation dose.1. Students should be able to draw conclusions from given data about the risks and consequences of exposure to radiation.
2. Ultraviolet waves can cause skin to age prematurely and increase the risk of skin cancer.
3. X-rays and gamma rays are ionising radiation that can cause the mutation of genes and cancer.
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| **4.6.2.4 Uses and applications of electromagnetic waves** |  |  |  |
| 1. Electromagnetic waves have many practical applications. For example:
* radio waves – television and radio
* microwaves – satellite communications, cooking food
* infrared – electrical heaters, cooking food, infrared cameras
* visible light – fibre optic communications
* ultraviolet – energy efficient lamps, sun tanning
* X-rays and gamma rays – medical imaging and treatments.
1. (HT only) Students should be able to give brief explanations why each type of electromagnetic wave is suitable for the practical application.
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**PHYSICS EQUATIONS TO LEARN BY HEART**

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| **WAVES** |
|  | **Quantity** | **Unit** | **Equation** |
| *WAVES* | *23* | **v****f****λ** | velocityfrequencywavelength | metre per secondhertzmetre | m/sHzm | $$v=f x λ$$ |