S3 Physics

WAVES AND RADIATION

Study Guide

1.1 Introduction to Waves

At the end of the section you should be able to :

- ❑ 1 State that a wave transfers energy.
- ❑ 2 Carry out calculations involving the relationship between distance, time and speed in problems on water waves, sound waves, radio waves and light waves.
- ❑ 3 Use the following terms correctly in context: wave, frequency, wavelength, speed, amplitude, period.
- ❑ 4 State that the frequency of a wave is the number of waves which pass a particular point every second.
- ❑ 5 Carry out calculations involving the relationship between frequency and period.
- ❑ 6 State the difference between a transverse and longitudinal wave and give examples of each.
- ❑ 7 State that sound can pass through solids, liquids and gases.
- ❑ 8 State that sound cannot pass through a vacuum.
- ❑ 9 Give an example which shows that the speed of sound in air is less than the speed of light in air.
- ❑ 10 Describe a method for measuring the speed of sound in air using the relationship between distance, time and speed.
- ❑ 11 State that the speed of sound changes as it moves from one material to another.
- ❑ 12 Carry out calculations involving the speed of sound.
- ❑ 13 State that the higher the pitch of a sound the larger the frequency.
- ❑ 14 State that the louder the volume of a sound the greater the amplitude.

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- ❑ 15 Identify from oscilloscope traces the signal which would produce:
  (a) the louder sound
  (b) the higher frequency.

- ❑ 16 State that if two sounds are one octave apart, the frequency of one is double the other.

- ❑ 17 State that the frequency produced by a vibrating string can be increased by shortening the length of the string and increasing the tightness of the string.

- ❑ 18 State that the frequency produced by a vibrating air column can be increased by shortening the length of the air column.

- ❑ 19 State that the normal range of human hearing is from 20 hertz to 20,000 hertz.

- ❑ 20 State that high frequency sounds beyond the range of human hearing are called ultrasounds.

- ❑ 21 Give one example of a use of ultrasound in medicine.

- ❑ 22 Give one example of a non-medical use of ultrasound.

- ❑ 23 State that sound levels are measured in decibels.

- ❑ 24 Give two examples of noise pollution.

- ❑ 25 State that excessive noise can damage hearing.

- ❑ 26 State that hearing can be protected by ear protectors.

- ❑ 27 State that some ear protectors rely upon noise cancellation.

- ❑ 28 State that the output signal from an amplifier has the same frequency but a bigger amplitude than the input signal.

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1.1 Introduction to Waves

- ❑ 29 State the function of each of the three major components needed to amplify speech (microphone, amplifier, loudspeaker).
- ❑ 30 Explain why your recorded voice sounds different to you.
- ❑ 31 Describe a method of measuring the speed of sound in air, using the relationship between distance, time and speed.
- ❑ 32 Give an example which shows that the speed of light is greater than the speed of sound.
- ❑ 33 Carry out calculations involving the relationship between speed, wavelength and frequency for waves.
- ❑ 34 Explain the term diffraction in terms of waves and give examples of where it is useful.
- ❑ 35 Explain how the wavelength affects the diffraction of the wave.

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1.2 Electromagnetic Spectrum

At the end of the section you should be able to :

- ❑ 1 State in order of increasing wavelength the bands of the electromagnetic spectrum: gamma rays, X rays, ultraviolet, visible light, infrared, microwaves, TV and radio.

- ❑ 2 State sources and detectors of the different bands of the electromagnetic spectrum.

- ❑ 3 Give examples of applications for each band of the electromagnetic spectrum.

- ❑ 4 State that the higher the frequency of electromagnetic radiation the greater the energy of the wave.

- ❑ 5 State that all radiations in the electromagnetic spectrum travel at the speed of light.

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1.3 Light

At the end of the section you should be able to :

- ❑ 1 State that refraction is the change in the speed of light as it passes from one material to another.
- ❑ 2 Draw diagrams to show the change in direction with regards to the normal as light passes from air to glass and glass to air.
- ❑ 3 Use correctly in context the terms angle of incidence, angle of refraction and normal.
- ❑ 4 Describe and draw the shapes of converging and diverging lenses.
- ❑ 5 Describe the effect of a converging and a diverging lens on parallel rays of light.
- ❑ 6 State the meaning of long and short sight.
- ❑ 7 Explain the use of lenses to correct long and short sight.
- ❑ 8 State that light can be reflected.
- ❑ 9 Use correctly in context the terms: angle of incidence, angle of reflection and normal when a ray of light is reflected from a plane mirror.
- ❑ 10 Explain, with the aid of a diagram, what is meant by ‘the critical angle’.
- ❑ 11 Explain, with the aid of a diagram, what is meant by ‘total internal reflection’
- ❑ 12 Describe the principle of operation of an optical fibre transmission system.

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1.4 Introduction to Nuclear Radiation

At the end of the section you should be able to :

- ❑ 1 Describe a simple model of the atom which includes protons, neutrons and electrons.
- ❑ 2 State what is meant by an alpha particle, beta particle and gamma ray.
- ❑ 3 State that the energy from radiation may be absorbed in the medium through which it passes.
- ❑ 4 State the approximate range through air, and absorption of alpha, beta and gamma radiation.
- ❑ 5 Explain the term ionisation.
- ❑ 6 State that alpha particles produce much greater ionisation density than beta particles or gamma rays.
- ❑ 7 Identify natural sources of background radiation.
- ❑ 8 Identify artificial sources of background radiation.

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1.6 Dosimetry

At the end of the section you should be able to :

- ❑ 1 State that the absorbed dose *D* is the energy absorbed per unit mass of the absorbing material.

- ❑ 2 State that the gray, Gy, is the unit of absorbed dose and that one gray is one joule per kilogram.

- ❑ 3 Carry out calculations using the relationship D = E/m

- ❑ 4 State that the risk of biological harm from an exposure to radiation depends on:
  a) the absorbed dose
  b) the kind of radiation, eg α, β, slow neutron
  c) the body organs or tissue exposed.

- ❑ 5 State that a radiation weighting factor w_R is given to each kind of radiation as a measure of its biological effect.

- ❑ 6 State that the equivalent dose *H* is the product of *D* and w_R and is measured in sieverts, Sv.

- ❑ 7 Carry out calculations involving the relationship $H = D\, w_R$.

- ❑ 8 State that the equivalent dose rate $\dot{H}$ is the equivalent dose received in a given time.

- ❑ 9 Carry out calculations using the relationship $\dot{H} = H/t$.

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1.5 Activity, Half-life & Safety

At the end of the section you should be able to :

- ❑ 1 State that the activity of a radioactive source is measured in becquerels, Bq, where one becquerel is one decay per second.
- ❑ 2 Carry out calculations involving the relationship A = N/t
- ❑ 3 State that the activity of a radioactive source decreases with time.
- ❑ 4 State the meaning of the term ‘half-life’.
- ❑ 5 Describe the principles of a method for measuring the half-life of a radioactive source.
- ❑ 6 Carry out calculations to find the half-life of a radioactive isotope from appropriate data.
- ❑ 7 Describe the safety procedures necessary when handling radioactive substances.
- ❑ 8 State that the equivalent dose is reduced by shielding, by limiting the time of exposure or by increasing the distance from a source.
- ❑ 9 Identify the radioactive hazard sign and state where it should be displayed.

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1.7 Applications of Nuclear Radiation

At the end of the section you should be able to :

- ❑ 1 State that radiation can kill living cells or change the nature of living cells.
- ❑ 2 Describe medical uses of radiation based on the fact that radiation can destroy cells.
- ❑ 3 Describe uses of radiation based on the fact that radiation is easy to detect.
- ❑ 4 Describe the principles of the operation of a nuclear reactor in terms of fuel rods, moderator, control rods, coolant and containment vessel.
- ❑ 5 State the advantages and disadvantages of using nuclear power for the generation of electricity.
- ❑ 6 Describe the problems associated with the disposal and storage of radioactive waste.
- ❑ 7 Describe in simple terms the process of fission.
- ❑ 8 Explain in simple terms a chain reaction.
- ❑ 9 Describe in simple terms the process of fusion.
- ❑ 10 State that nuclear fusion is the reaction which occurs in the sun.