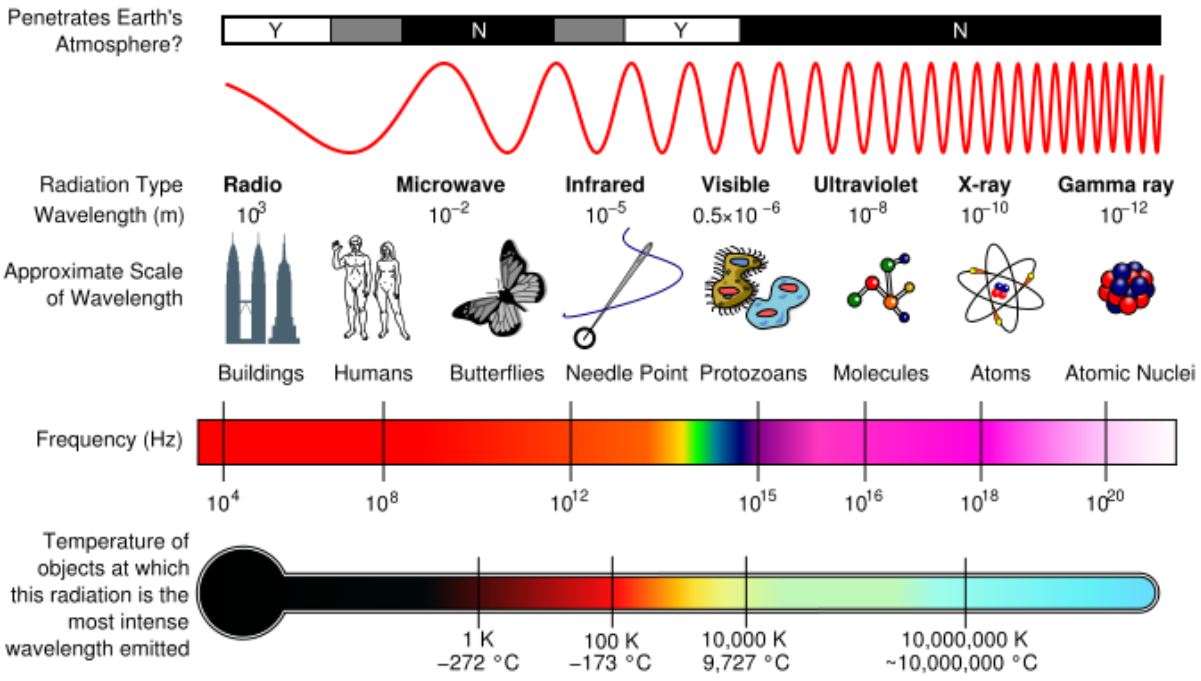
Grove Academy

National 5 Physics

Waves

Problems



Getting Started

Success involves doing many different kinds of problems which help improve your knowledge and understanding of the ideas in the course and your ability to solve problems.

In order to get started it is a good idea to look at a general method for tackling problems and then do some calculator exercises to become familiar with the function buttons on your calculator.

General Method for Solving Problems.

Any numerical problem in physics can be solved using the following steps:

- Read the question carefully.
- Find out exactly what is being asked.
- Extract the key data.
- Select the correct equation.
- Substitute the data into the equation to find the missing variable.
- Remember to give your answer the correct unit.

Helpful Hint

Always watch the units in a question - they may need to be converted before being put into an equation. e.g. 3 mA = 0.003 A = 3×10^{-3} A

6 km = 6 000 m = 6×10^{3} m

Example

How far does a cyclist travel in 26 seconds if he is travelling at a constant speed of 8 ms^{-1}?

Solution Read the question carefully. →

Find out exactly what is being asked. → Distance

Extract the key data. → time = 26 seconds
speed = 8 ms^{-1}

Select the correct equation. → distance = speed x time (1 mark)

Substitute data into the equation. → d = 8 x 26 (1 mark)

Remember to give your answer the correct unit. → = 208m (1 mark)

Usual layout

d	=	?	d	= v x t	
v	=	8 ms^{-1}		= 8 x 26	
t	=	26 s		= 208 m	

Final answer d = 208 m

Wave Parameters and behaviours

1. State what is meant by a wave?

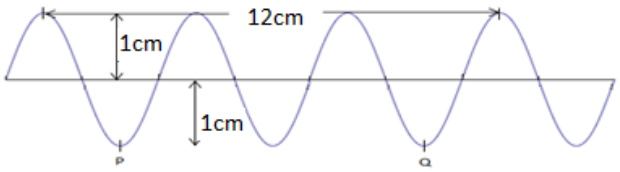
2. Copy and complete the following sentence.
   Waves transfer _____ from one place to another: they are created by _____.

3. a) Explain using a diagram, the difference between a transverse and longitudinal wave.
   b) What type of waves are the following:
      i) sound waves
      ii) water waves
      iii) light waves.

4. Explain using the particle model, why sound travels quicker in metals than it travels in gases.

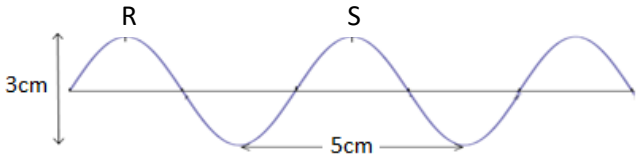
5. Explain why sound cannot travel through a vacuum.

6. Calculate the following quantities for this wave:



   a) wavelength
   b) amplitude
   c) the distance between the points marked P and Q

7. Here is a diagram of some water waves:



   a) Find the amplitude of the waves.
   b) What is the distance between the points marked R and S?

8. Calculate the wavelength of a wave of frequency 0.1 Hz and speed 5 ms^{-1}.

9. If the speed of a water wave is 0.6 ms^{-1} and the wavelength is 6 cm, calculate the frequency.

10. Some water waves in a canal travel straight along the canal at 0.5 ms^{-1} and have a wavelength of 2 metres. If you were standing on the bank, calculate how many waves would pass you in one second.

11. Forty waves are found to pass a point in 20 s. If the waves have a wavelength of 0.015 m, calculate their speed.

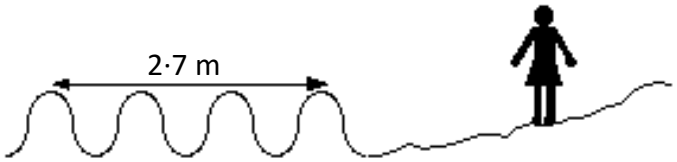
12. Wave A has a wavelength of 6 cm and a frequency of 50 Hz. Wave B travels 250 m in 1 minute 40 s. State which wave travels faster - and by how much?
    You must justify your answer

13. A swimming pool is to have a wave-making machine installed. The time taken for a wave to travel the length of the 50 m pool has to be 20 s and the wavelength has to be 4 m.
    a) Calculate the speed of the waves.
    b) Calculate the required frequency of the waves.

14. Waves of wavelength 5 cm travel 120 cm in one minute. Calculate:
    a) the speed of the waves.
    b) the frequency of the waves.

15. If waves break onto a beach once every 2 seconds and there is a distance of 4 metres between the wave crests, determine how fast the waves are travelling?

16. The diagram below represents water waves coming onto the shore.
    A girl standing on the shore counts 36 wave crests crashing onto the shore in 1 minute.



    Calculate the frequency, wavelength and speed of these waves.

17. Thunder is heard 20 seconds after a lightning flash. If the speed of sound is 340 ms^{-1}, how far away is the storm?

18. Explain why, during a thunderstorm, you see the lightning before you hear the thunder.

19. On a day when the speed of sound in air is 330 ms^{-1}, how long would sound take to travel a distance of 1.6 km?

20. During a thunderstorm, it is noticed that the time interval between the flash of lightning and the clap of thunder gets less. What does this tell you about the storm?

21. Ten pupils are standing on Calton Hill, looking at Edinburgh Castle. They measure the time difference between seeing the smoke from the one o'clock gun and hearing the bang. The measured times are 3.8 s, 4.2 s, 4.0 s, 3.8 s, 4.4 s, 3.8 s, 4.0 s, 4.2 s, 3.6 s and 4.2 s.

    a) Calculate the average time for the group.
    b) Calculate the distance from Edinburgh Castle to Calton Hill if the speed of sound is 330 ms^{-1}.

22. In a race, the runners are at different distances away from the starter. They will hear the starting horn at different times. Using the speed of sound as 340 ms^{-1}, calculate the time difference in hearing the horn for two runners who are 5 m and 15 m from the starter.

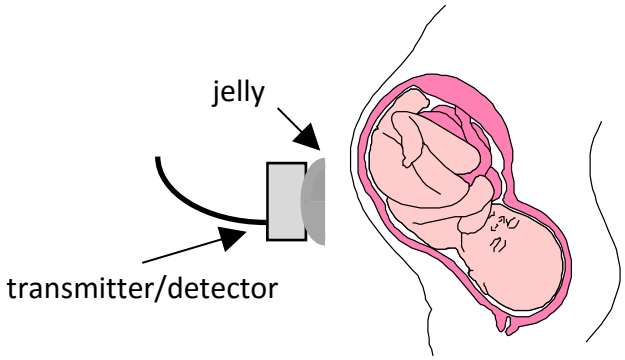
23. A boy is standing in front of a canyon wall. He shouts and hears the echo 0.24 s later. Take the speed of sound to be $340 ms^{-1}$.
    a) Calculate the total distance which is travelled by the sound.
    b) State how far from the wall the boy is standing?

24. A man shouts and hears the echo from a cliff 4 s later. Then he walks towards the cliff and tries again. This time he hears the echo after 2.5 s. If the speed of sound is $340 ms^{-1}$, calculate how far he has walked?

25. In a 100m sprint race the timers start timing when they hear the starter pistol and stop timing when they see the sprinters cross the finishing line.

    a) Does this method overestimate or underestimate their sprint times? Explain your answer.
    b) State how the accuracy of the timing could be improved?

26. An ultrasound pulse of frequency 8 MHz is transmitted into an expectant mother's womb and reflects from the baby's bottom. The pulse echo is detected 0·08 milliseconds after being transmitted. The speed of sound through the body tissue and fluid is 1 500 ms^{-1}.
    a) Determine how far the pulse travels?
    b) State how far from the transmitter is the baby's bottom?



    c) Another pulse is reflected from the baby's foot. If this reflected pulse is detected 0·15 milliseconds after being transmitted, determine how far from the transmitter is the baby's foot?

27. Explain what is meant by the diffraction of a wave.

28. Show, using diagrams, whether long wavelength waves or short wavelength waves are diffracted more passing a barrier.

Electromagnetic Spectrum

1. How far does light travel in 1 minute?

2. How long will it take a radio signal to travel from London to Edinburgh (a distance of 665 km)?

3. A radio station has a wavelength of 285m. What is its frequency?

4. Radio Clyde transmits at a frequency of 2927 kHz. Calculate its wavelength.

5. A solid state laser emits light which has a wavelength of 660nm (660×10^{-9}m). Calculate the frequency of the light emitted.

6. A pulse of light has a wavelength of 7×10^{-7}m. It travels through diamond for 8.2×10^{-12} s at a speed of 1.25×10^{8} ms^{-1}.

    a) Calculate the distance travelled by the light in the diamond.
    b) Calculate the frequency of the light.
    c) Calculate the distance the light would have travelled in air during the same time.

7. Peter sprained his ankle playing football. The physiotherapist uses infra-red radiation of wavelength 1.2×10^{-4} metres to heat the tissue in his ankle to help it heal.

Calculate the frequency of this radiation.

8. The ancient Egyptians used ultraviolet radiation from the Sun's rays to treat the skin complaint acne. Ultraviolet light is used today in hospital to treat acne. Calculate the wavelength of UV light of frequency $8{\cdot}8 \times 10^{16}$ Hz.

9. X-rays were discovered in 1895 by Wilhelm Rontgen. X-rays are now widely used in medicine and dentistry.

John is having an X-ray taken of one of his molars which is giving him pain. The dentist sets up the X-ray apparatus and stands behind a lead screen. The X-rays used have a frequency of 2×10^{17} Hz.

    a) Calculate the wavelength of these X-rays.
    b) How long will it take for these X-rays to travel 10 cm from the X-ray machine to John's tooth?

10. Read the passage below and use it to answer the questions that follow.

The Sun is a star 150 x10^6 km from Earth which produces enormous amounts of energy in the form of electromagnetic waves. We can detect the visible light from the Sun with our eyes, but we cannot detect the invisible ultraviolet light which also reaches Earth. Exposure to the ultraviolet light from the Sun can produce a change in the colouring of the skin which we call a sun tan.

There are three types of ultraviolet radiation. We are constantly exposed to UVA and we need this for healthy growth and to make vitamin D in our bodies. UVA light has wavelengths in the range 315 to 400 nm. UVB light has wavelengths in the range 280 to 315 nm.

Most of the UVB light from the Sun is removed by the layer of ozone in the atmosphere around the Earth. Scientists have found that there is a hole in the ozone layer which is allowing more UVB to reach us on the surface of Earth. UVB can cause a type of skin cancer called melanoma. The third type of UV light, with wavelengths in the range 200 to 280 nm, is called UVC .

People who are going to be exposed to the Sun for any length of time should protect their skin with sun tan cream. An extract from the back of a bottle of sun tan cream is given below.

> *Bronzage cream protects the skin from sun burn, premature skin ageing and long term damage to the internal structure of the skin by filtering out the harmful UVA/UVB rays from sunlight.*
> *Bronzage is water resistant even after 30 minutes of swimming.*

a) Calculate how long it takes for ultraviolet light to travel from the Sun to Earth.
b) Construct a table giving the wavelengths of UVA, UVB and UVC light.
c) Calculate the frequency of the shortest wavelength UVC light.
d) What type of UV light has a frequency of 7·5 x 10^{14} Hz?
e) What range of wavelengths does Bronzage sun tan cream block?

11. Copy and complete the following table.

Type of radiation	Approximate λ range (m)	Approximate frequency range (Hz)	Source	Detector
Gamma				
X-rays				
UV				
Visible light				
IR				
microwaves				
Radio waves				

12. Give two applications for each type of radiation.

Refraction

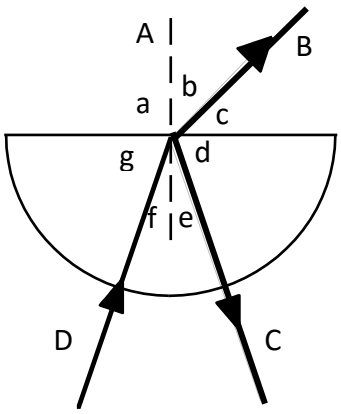
1. Explain the term ‘refraction’.

2. Give two uses of refraction of light.

3. Copy and complete the following sentences.

   When a light wave travels from air to glass, the wave refracts.
   The wave speed _____.
   The frequency _____ _____.
   The wavelength _____.
   The direction of the wave _____.

4. Identify the following in the diagram shown below.
   i. the incident ray
   ii. the reflected ray
   iii. the refracted ray
   iv. the normal
   v. the angle of incidence
   vi. the angle of refraction
   vii. the angle of reflection.



5. Copy and complete the following diagrams.