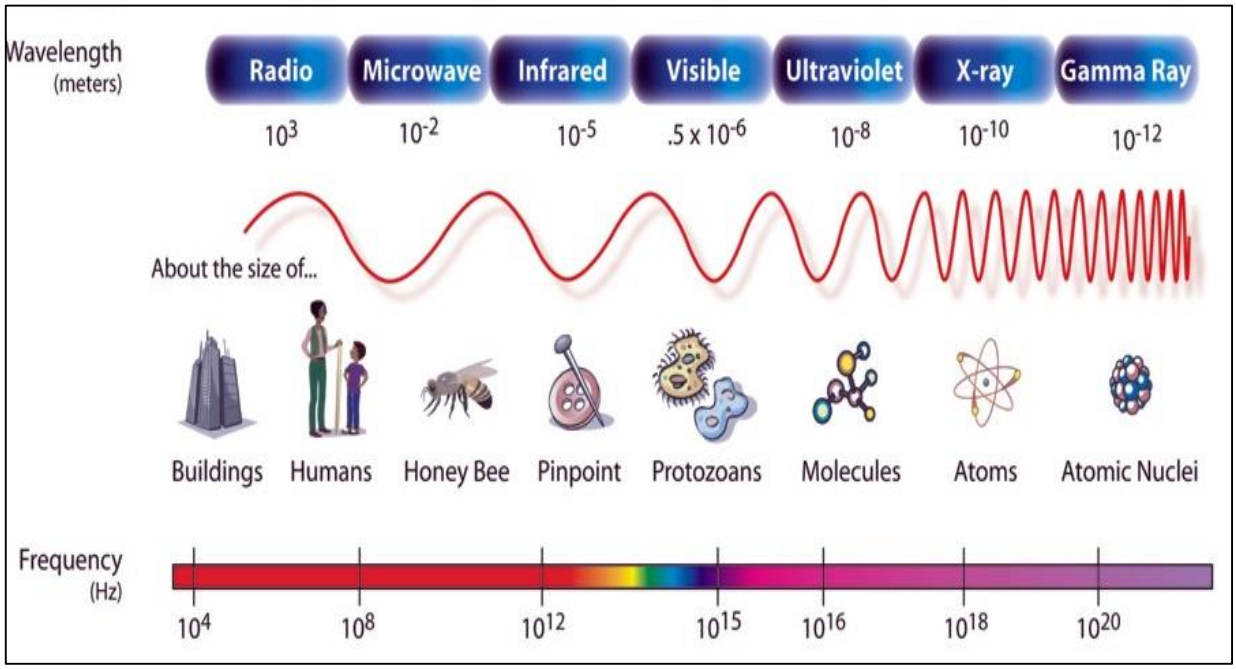
Grove Academy

National 4 Physics

Waves and Radiation

Problems



Wave Characteristics

1. Waves can either be **transverse** or **longitudinal.**
   a) State the difference between these waves.
   b) Give an example of each kind of wave.

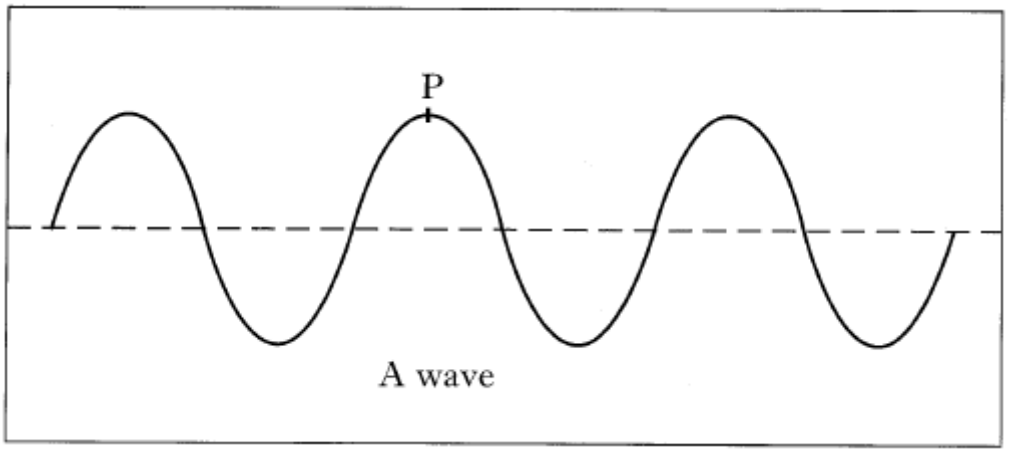
2. State what is meant by a **frequency** of 5 Hz.

3. A boy who is standing on a bridge over a river count 30 water waves passing under the bridge in one minute. Calculate the frequency of the water waves.

4. How long would it take for 100 water waves to hit the beach if the frequency of the waves is 2 Hz?

5. How many water waves would pass a point in 5 minutes if the frequency of the waves is 0.2 Hz?

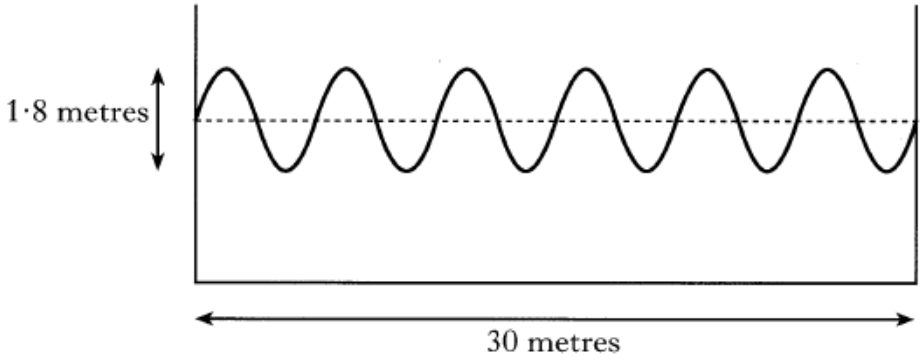
6. A diagram of a wave is shown below:



   a)
      i. Copy the diagram and mark on it a point which is exactly one wavelength from point P.
      ii. On your diagram draw a line to mark the amplitude.
   b) Some notes were taken by a physics student as shown below. The notes are incomplete.
      Use your knowledge to copy and complete the table:

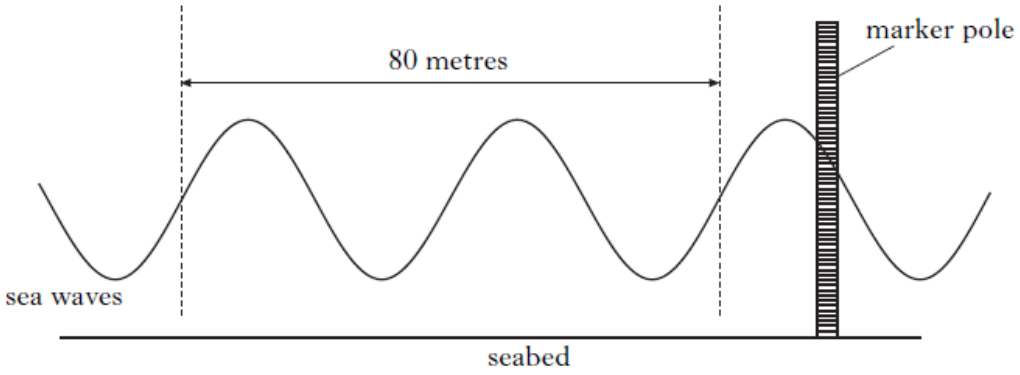
Quantity	Definition	Unit
Wavelength	The distance between the same point on two consecutive waves	
	Number of waves which pass a point in one second	
Speed		
Amplitude	Distance between the undisturbed position and either the crest or trough ofthe wave	

7. In a research laboratory, water waves are generated in a tank. During one test, the wave shown travels along the tank at 2.5 ms^{-1}.



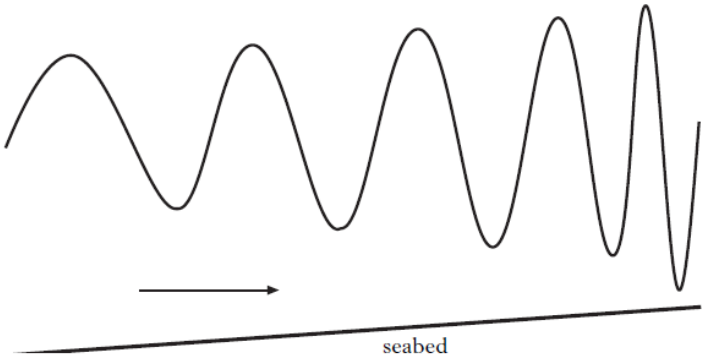
a) Calculate the amplitude of the wave shown.
b) Calculate the wavelength of the wave shown.
c) Calculate the frequency of the wave shown.

8. A surfer rides the waves near a beach.
a) The diagram shows a wave some distance from the beach.



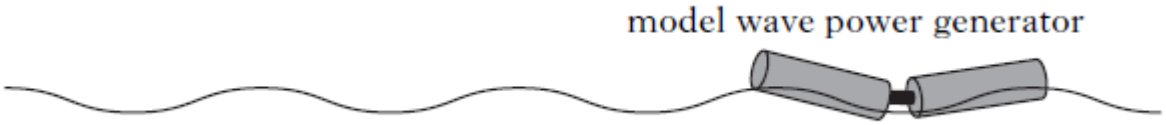
i. Using information from the diagram, calculate the wavelength of the wave.
ii. The time between one crest and the next crest passing the marker pole is 5 s.
Calculate the speed of the wave.
iii. Calculate the frequency of the wave.

b) The drawing below shows the changes in the wave as it approaches the beach:



i. State what happens to the wavelength as it approaches the beach.
ii. State what happens to the amplitude as it approaches the beach.

9. The diagram shows part of a water tank used to test a model wave power generator.



A wave power generator uses waves to generate electricity.

a)

i. A machine in the tank produces 20 waves in 10 seconds.
Calculate the frequency of the waves.

ii. The wavelength of the waves in the tank is 1.2 metres.
Calculate the speed of the waves in the tank.

b) The amplitude of the waves in the tank is 0.15 metres.
Calculate the maximum vertical distance the wave power generator moves through.

10. The River Severn in England is a tidal river. At certain times the tide does not rise gradually, but instead tidal waves travel along the river. Surfing in the waves is a popular activity.

a) One tidal wave travels 34 km along the river in a time of 2 and a half hours.
Calculate the average speed of the tidal wave in kmh^{-1}.

b) A surfer is gathering information about these tidal waves.

i. The surfer stands beside the river and counts 8 waves passing in a time of 10 seconds.
Calculate the frequency of these waves.

ii. As the waves move from the sea to the river, their wavelength decreases and their amplitude increases.
The drawing shows the waves in the sea.

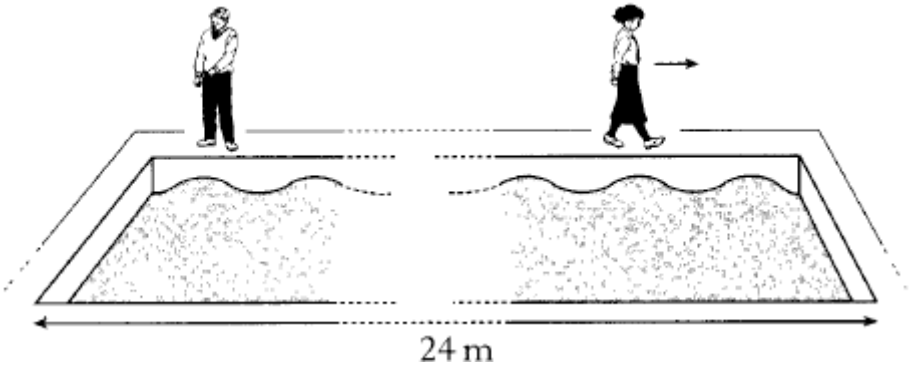
Sketch the waves as they would appear in the river.
You must clearly show differences in wavelength and amplitude in your sketch.

11. A wave has a wavelength of 4 m and a frequency of 2 Hz. Calculate its speed.

12. A wave with a frequency of 50 Hz is travelling at a speed of 0.5 ms^{-1}. Calculate its wavelength.

13. A wave with a wavelength of 20 m is travelling at 12 ms^{-1}. Calculate its frequency.

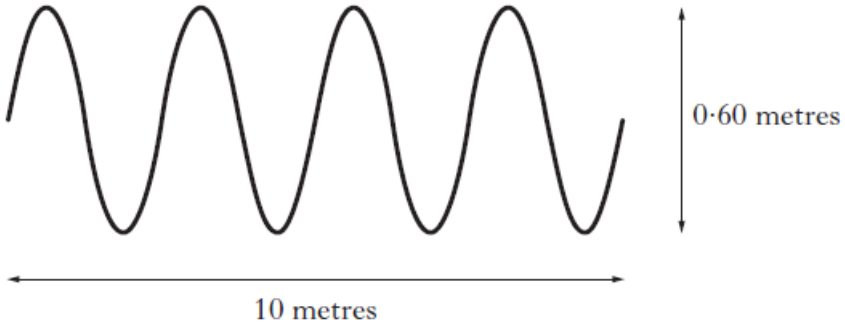
14. Two students watch the waves produced by a wave machine in a swimming pool.



One student walks beside the wave as it travels along the pool.
The wave goes from one end of the pool to the other in 20 s.
The length of the pool is 24 m.

a) Calculate the speed of the waves.
b) In the same time interval, the other student counts 5 waves going past the point where he is standing.
   Calculate the frequency of the waves.
c) The students note that there are 5 complete waves in the pool at any time.
   Calculate the wavelength of the waves.

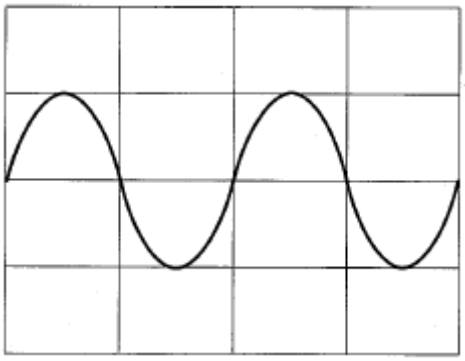
15. A teacher is carrying out a demonstration using a 'slinky spring' to show some of the properties of waves.
A simplified diagram of the wave produced is shown below.



a) Determine the amplitude of the waves.
b) The diagram shows the number of waves produced in 2 seconds. Calculate the frequency of the waves.
c) Calculate the wavelength of the waves.
d) Calculate the speed of the waves.

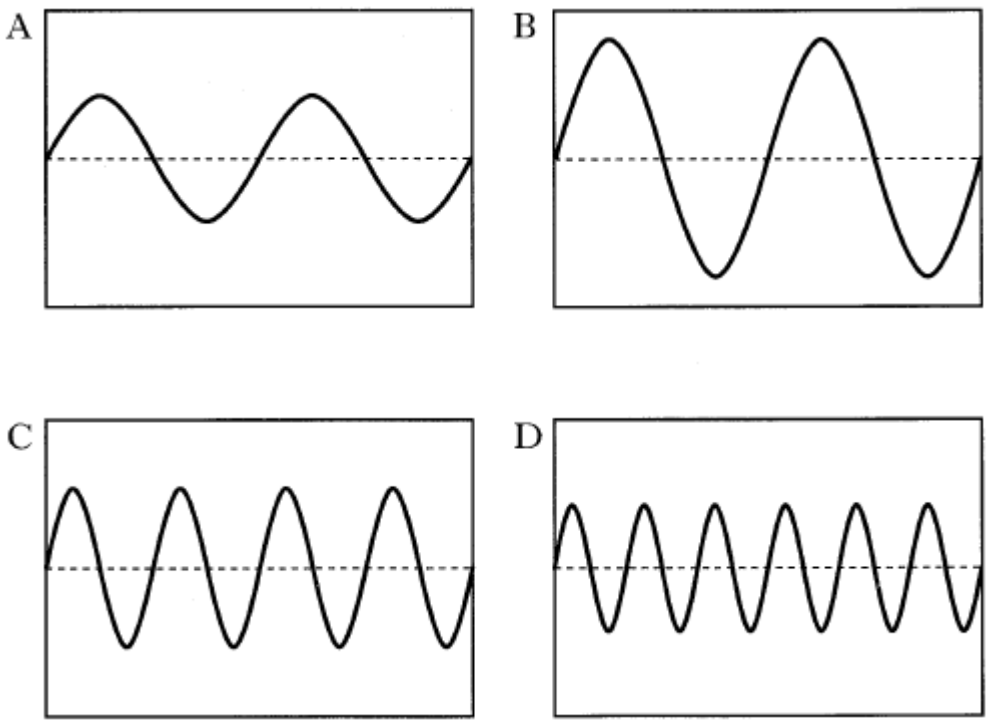
Sound

1. The diagram below shows a waveform of a sound wave which is picked up by a microphone on an oscilloscope screen.



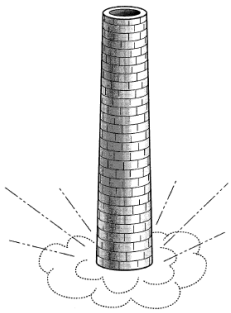
   a) Which property of the wave indicates how **loud** the sound is?
   b) Which property of the wave indicates how **high** the sound is?
   c) Redraw the original diagram and on **the same screen** draw what would be seen if a **quieter, higher** sound is made into the microphone.

2. Four different oscilloscopes are connected to four different microphones.
   Below are the waveforms shown on each oscilloscope screen:



   The controls on each screen are set on the same values.
   a) State which screen shows the highest pitched sound. Explain your answer.
   b) State which screen shows the loudest sound. Explain your answer.

3. A factory chimney is demolished using explosives.



A crowd of people watch from a safe distance. A person in the crowd hears the sound 2.5 s after seeing the explosion.

a) Explain why there is a delay between seeing the explosion and hearing the sound.
b) Calculate the distance between the chimney and the person in the crowd.
c) Why should a demolition worker who sets off the explosion wear ear protectors to reduce the sound level to below 80 dB?

4. A student uses a sound level meter to measure some sound levels.
The student records the results in the following table.

Source of sound	*Sound level* (decibels)
school bell at 1 metre	100
inside a classroom	60
normal conversation	50
whisper	20

a) Humans can only hear sounds above a certain sound level.
   i. What is the value of this sound in decibels?
   ii. When one source of sound is twice as loud as another, the sound level increases by 10 dB. Which of the **above sources** is twice as loud as a normal conversation?

b) The student measures the sound levels from earphones connected to an MP3 player.

Sound levels up to 102 dB are measured.
Explain why the student should reduce the sound level to below 80 dB before wearing the earphones.

c) The student now measure the range of sound frequencies that humans can hear.
   i. What is the name given to high frequency sounds beyond the range of human hearing?
   ii. Give **one** example of these high frequency sounds in medicine.

5. A camper on a mountain ridge sees a flash of lightning in the distance. He then hears thunder 20 s later.

a) Explain why there is a delay between the camper seeing the lightning and hearing the thunder.
b) Calculate the distance between the camper and the flash of lightning.
c) The camper later measures the time between seeing the lightning and hearing the thunder as 15 s. Explain why the time delay is now shorter.

6. A ship is anchored opposite a cliff as shown in figure 1. The ship's siren gives a short blast. A passenger on the ship hears the echo 5 s later.

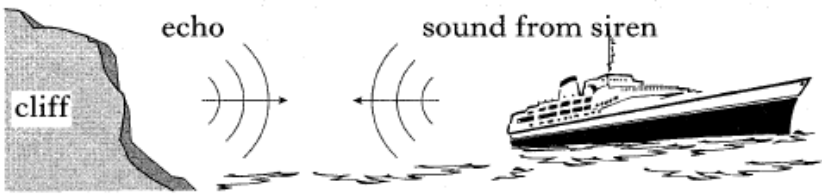


figure 1

a) Calculate how far the ship is from the cliff.

b) Figure 2 shows part of the display panel for the ship's siren. The pointer on the display shows the frequency of the sound produced by the siren.

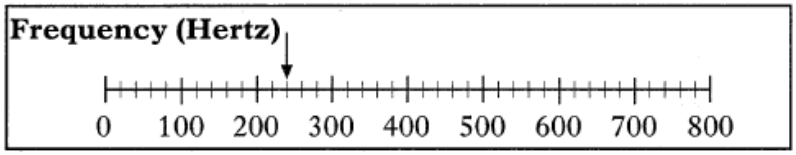


figure 2

i. What is the frequency of the sound from the siren?
ii. The frequency of the sound is increased to 700 Hz. Which of the following gives the time taken for the echo of this sound to reach the passenger?

A. Greater than 5 seconds
B. Less than 5 seconds
C. Equal to 5 seconds

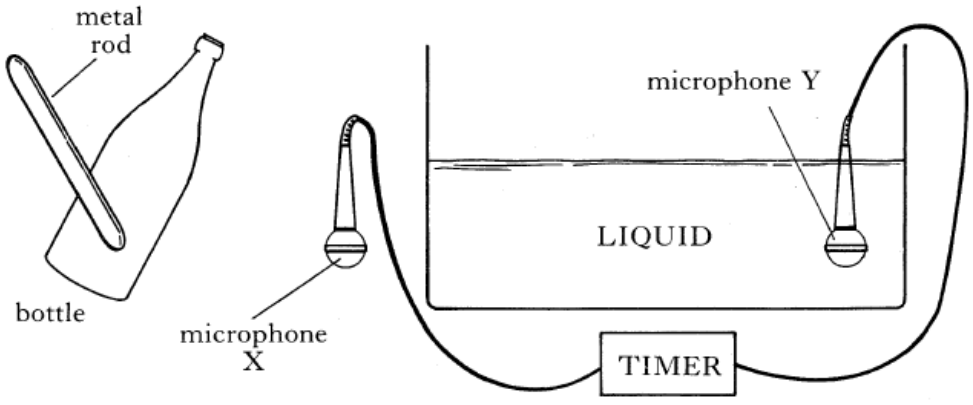
iii. Explain your answer to b) ii.

7. The table below lists the upper and lower frequency limits which apply to the hearing range of different animals.

Animal	*Frequency of lower limit of hearing (hertz)*	*Frequency of upper limit of hearing (hertz)*
Elephant	20	10 000
Finch	100	15 000
Cat	30	45 000
Dog	20	30 000
Human	20	17 000
Whale	40	80 000

a) What is the highest frequency which can be heard by a cat?
b) A dog whistle emits sound which can be heard by a dog but not by a human. Using information from the table, state **one** possible frequency of the sound emitted by a dog whistle.
c) Name two animals in the table, other than humans, which will not respond to ultrasound.
d) Choose the lowest frequency of sound which can be heard by a whale and calculate the wavelength of this sound in water.

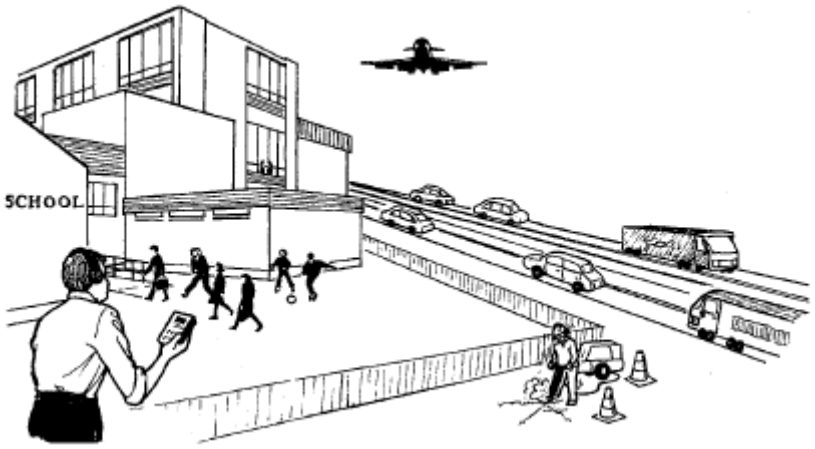
8. Scott tries to measure the speed of sound in a liquid. The equipment used is shown below.



The liquid is in a thin glass container. The bottle is hit and a pulse of sound is produced. When the sound reaches microphone X, the timer starts. When the sound pulse reaches microphone Y, the timer stops. The microphones have been adapted to work in a liquid.

a) What quantity, other than time, must be measured before the speed of sound in the liquid can be calculated?
b) Alan said the results of Scott's experiment will not be accurate.
How could the equipment be rearranged to obtain a more accurate value for the speed of sound in the liquid?

9. An Environmental Health Officer is measuring the level of noise pollution near a school.



a) From the picture, identify two sources of noise pollution.

b) Humans can only hear sounds above a certain **sound level**.
What is the value of this sound level?

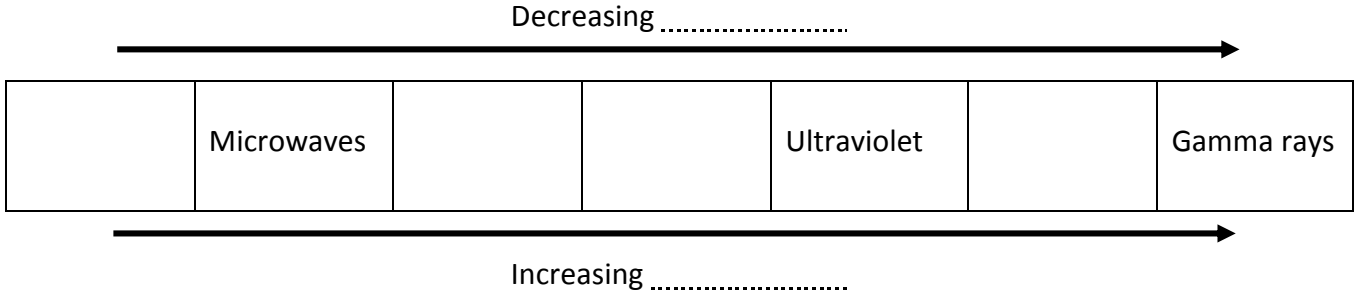
c) The Environmental Health Officer measures a sound level of 100 dB when a large lorry passes the school.

i. Why must the Environmental Health Officer wear ear protectors to reduce the sound level to below 80 dB?

ii. A student in a classroom measures the sound level at the same time as the Environmental Health Officer.
Explain whether the sound level measured by the student is higher or lower than the level measured by the Environmental Health Officer.

Electromagnetic Spectrum

1. Copy and complete the following diagram of the Electromagnetic Spectrum, filling in all the blanks:



2. What is the speed of all electromagnetic waves in air?

3. Are electromagnetic waves **transverse** or **longitudinal?**

4. Copy and complete the following table:

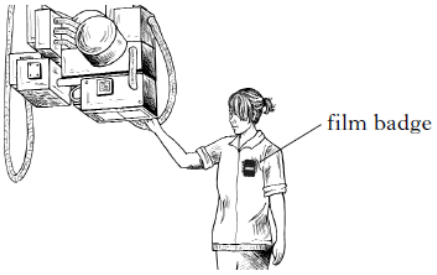
Member of Electromagnetic Spectrum	**Detector of Radiation**	**Application of Radiation**
Radio waves		
Microwaves		
Infrared		Thermal imaging
Visible Light		
Ultraviolet	Chemicals which fluoresce	
X-rays		
Gamma rays		

5. Read the following passage.

> In a hospital, a new digital X-ray imaging system is being used to replace photographic film. In the digital system, X-rays are detected by sensors and an image displayed on a computer screen.
>
> Photographic film, which contains silver, is expensive and hazardous chemicals are used to develop the film. The digital system is less expensive, does not use hazardous chemicals and the X-ray image is obtained in a shorter time.

a) Using information **given in the passage** state two advantages of a digital x-ray imaging system.

b) Hospital staff who operate x-ray machines wear film badges.



A film badge contains photographic film sealed in a plastic holder. Light cannot enter the film badge.

i. What effect do x-rays have on photographic film?

ii. Suggest a reason why hospital workers wear film badges.

6. A hospital technician is preparing medical equipment.

a) One of the instruments to be used is a digital thermometer. It detects heat radiation. State another name for heat radiation.

b) The technician takes an x-ray of a patient's chest.

i. What can be used to detect x-rays?

ii. Explain why the technician has to limit the time that the patient is exposed to x-rays.

c) The technician injects a source of gamma radiation into the patient, as a tracer, to diagnose a medical condition inside the patient. The tracer emits gamma radiation. A gamma camera scans and detects the gamma radiation.

i. Why is gamma used as a tracer?

ii. The half-life of a radioactive source is the time taken for its activity to reduce by half. The following table gives information about the half-life of different gamma sources.

Source of gamma radiation	*Half life*
Krypton 81	13 seconds
Technetium 99	6 hours
Iodine 125	60 days
Cobalt 57	270 days

A. Which of the sources above would be best for use as a tracer in this case?

B. Explain your answer.

7. Different types of radiation are used in medical procedures. X-rays are used to detect broken bones. Gamma radiation is used to kill cancerous cells.

a) Gamma radiation can be harmful.
   i. State two safety precautions needed when dealing with a source of gamma radiation.
   ii. State one other use of gamma radiation in medicine.

b) State one detector of x-rays.

c) Ultraviolet radiation has both advantages and disadvantages for health.
   i. State one advantage.
   ii. State one disadvantage.

d) Lasers have many applications in medicine and technology.
   i. State one medical use of lasers.
   ii. State one non-medical use of lasers.

8. Some chemicals fluoresce under certain conditions.

a) What is meant by the word 'fluoresce'?

b) Which of the following radiations would make a chemical fluoresce?

radio waves **infrared** **ultraviolet** **microwaves**

c) These chemicals are used on passports.

State one other use of these chemicals.

d) At an airport, hand luggage is passed through a scanner that uses a different kind of radiation. Name this type of radiation.

9. The electromagnetic spectrum is shown below:

radio & tv	microwaves	infrared	visible light	ultraviolet	X-rays	gamma rays

electromagnetic spectrum

Different types of waves in the spectrum are used in medicine.

a) What property do all electromagnetic waves have in common?

b) Describe one use of x-rays in medicine.

c) Gamma radiation is used as a tracer.
A tracer is a radioactive substance which is injected into the body.
The gamma radiation then given off by the body is monitored.
   i. Explain why gamma radiation is used rather than alpha or beta.
   ii. What is the unit for the activity of radiation?

d) Light can be produced by lasers.
Describe the use of a laser in **one** application in medicine.

10. Different types of radiation are used to detect and treat illnesses and injuries.
Four of these radiations are:

infrared **laser light** **ultraviolet** **x-rays**

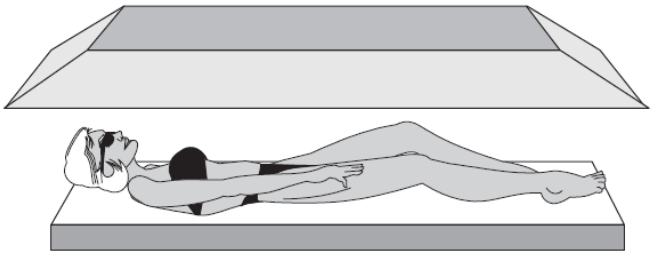
a) What type of radiation is used to treat skin conditions such as acne?

b)

   i. State one medical use of x-rays.
   ii. What can be used to detect x-rays?

c) Colour photographs called thermograms are used to find the temperature variation in a patient's body. Name the radiation used to make thermograms.

d)



Explain why people need to be protected from overexposure to ultraviolet radiation.

Nuclear Radiation

1. Name two artificial sources of background radiation.

2. Name two natural sources of background radiation.

3. Draw a simple diagram of an atom. Label all the particles and state what charge they have.

4. State what is meant by:
   a) An alpha particle
   b) A beta particle
   c) A gamma ray.

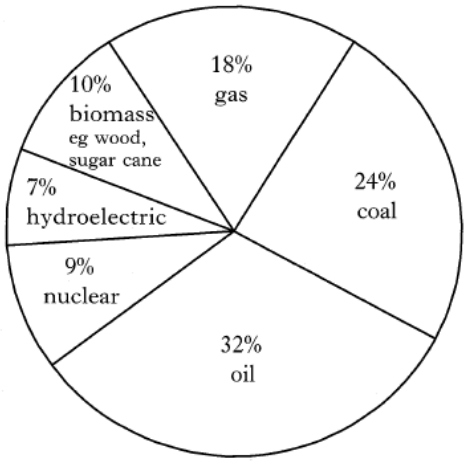
5. State two applications of nuclear radiation in:
   a) Medicine
   b) Industry

6. Describe briefly how electricity is produced in a nuclear power station.

7. State two advantages of nuclear power over traditional fossil-fuelled power stations.

8. State two disadvantages of nuclear power over traditional fossil-fuelled power stations.

9. The following pie chart shows the estimated use of the world's main energy sources for the year 2000.



   a) Use the names of the energy sources in the pie chart to complete the following table:

Fossil fuels	*Other energy sources*

   b) Use the pie chart to calculate the total percentage of energy supplied by fossil fuels.

   c) Why is it important to find sources of energy other than fossil fuels?

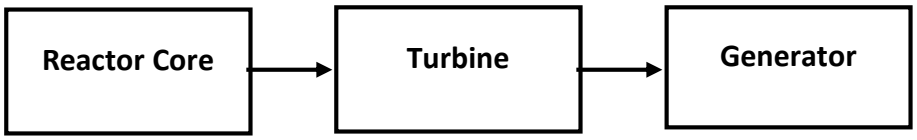
   d) Name one renewable source of energy not mentioned in the pie chart.

10. The following information relates to two power stations, a fossil fuel power station and a nuclear power station.

Fossil Fuel Power Station	**Nuclear Power Station**
Heat produced per kg of fuel – 4.5×10^7 J	Heat produced per kg of fuel – 4.4×10^{11} J
Waste produced per year (not radioactive) – 100 000 kg	Waste produced per year (radioactive) – 5 kg
Cooling water required – 550 kgs^{-1}	Cooling water required – 550 kgs^{-1}

a) Compare the **information given** for the two types of power station.
   i. State one advantage of generating electricity using each type of power station.
   ii. Using the information given, state where both types of power station are likely to be located. Explain your answer.

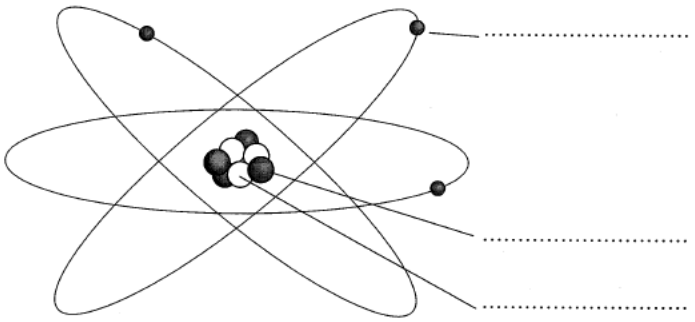
b) A simple block diagram of a nuclear power station is shown below:



State the energy transformation which takes place in:
   i. the reactor core
   ii. the generator.

11. Two students are revising for a Physics test.

a) One student draws a simple model of an atom.
Copy and complete the diagram, filling in the missing labels.



b) The students ask each other about nuclear radiation and safety.
State **two** safety precautions necessary when handling radioactive substances.