Waves & Radiation

Self Checks

DATA SHEET

Speed of light in materials

Material	*Speed* in $m\,s^{-1}$
Air	$3{\cdot}0 \times 10^8$
Carbon dioxide	$3{\cdot}0 \times 10^8$
Diamond	$1{\cdot}2 \times 10^8$
Glass	$2{\cdot}0 \times 10^8$
Glycerol	$2{\cdot}1 \times 10^8$
Water	$2{\cdot}3 \times 10^8$

Gravitational field strengths

	Gravitational field strength on the surface in $N\,kg^{-1}$
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in $J\,kg^{-1}$
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon Dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Iron	$2{\cdot}67 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in $J\,kg^{-1}$
Alcohol	$11{\cdot}2 \times 10^5$
Carbon Dioxide	$3{\cdot}77 \times 10^5$
Glycerol	$8{\cdot}30 \times 10^5$
Turpentine	$2{\cdot}90 \times 10^5$
Water	$22{\cdot}6 \times 10^5$

Speed of sound in materials

Material	*Speed* in $m\,s^{-1}$
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	*Specific heat capacity* in $J\,kg^{-1}\,°C^{-1}$
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

Melting and boiling points of materials

Material	*Melting point* in °C	*Boiling point* in °C
Alcohol	−98	65
Aluminium	660	2470
Copper	1077	2567
Glycerol	18	290
Lead	328	1737
Iron	1537	2737

Radiation weighting factors

Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3

S3
WAVES AND RADIATION
Self Checks

Introduction to Waves

1 Explain why, during a thunder storm, you see the lightning before you hear the thunder.

2. What is the speed of:-
(a) Sound in air (b) Light in air

3. What is the speed of sound in water if it travels 45km in 30s?

4. Describe a method for measuring the speed of sound in air.
You must include:-
- any apparatus used
- the measurements taken
- the equation used in the calculation

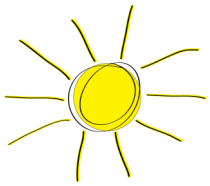
5. Explain why sounds cannot travel through a vacuum.

6. During a thunderstorm a boy hears the thunder 6s after he sees the lightning. How far away is the storm?

7. On a day when the speed of sound in air is 340ms^{-1} calculate how long it would take sound to travel a distance of 19.8km.

8. Change the following from the units they are given in to the standard units as required.
   a. 6 km into m
   b. 200 mm into m
   c. 660 nm into m
   d. 0.4 ms into s

9. What is the distance between the earth and the moon if it takes 1.2s for a radio signal transmitted from the surface of the moon to reach the earth?



10. Calculate how long it would take light to travel from the sun to the earth , a distance of 1.49 x 10 ^{11} m.

11. What quantity do waves transfer?

12. (a) If a train is 1.5 km from Whitecraigs station how long would it take for the sound to reach a man with his ear on the tracks if the sound was travelling through the tracks at 5050 ms^{-1}.

    (b) How much later will his friend hear the train if he listens to the sound travelling through the air?

13 (a) At the Olympics in the 100m final how long does it take for the sound of the starting pistol to reach the runner in lane 8 if the distance is 6m?

(b) To make the race fair , what is done to ensure all the athletes hear the gun at the same time?

14. An explosion in a science lab at Mearns Castle could be heard in St Ninian's 4.4s later.
If the speed of sound in air is 340ms^{-1} calculate the distance between the two schools.

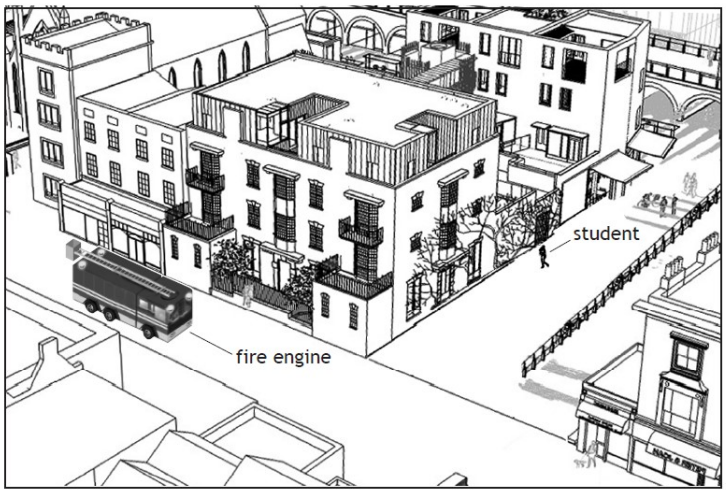
15. In a race the runners are at different distances away from the starter. They will hear the starting gun at different times. Using the speed of sound is 340ms^{-1} calculate the time difference in hearing the gun for two runners who are 5m away and 15m away.

16. Describe, with the aid of a diagram, the difference between a transverse and longitudinal wave,

17. Give an example of :-
(a) a transverse wave.
(b) a longitudinal wave.

18. Copy and complete the sentences below.
When waves meet the edge of a barrier they ____ around it.
This bending of the waves is called _____.
Waves with a longer wavelength diffract _____ than waves with a short wavelength.

19 A fire engine on its way to an emergency is travelling along a main street.
The siren on the fire engine is sounding. A student standing in a nearby street cannot see the fire engine but can hear the siren.



Use your knowledge of physics to comment on why the student can hear the siren even though the fire engine is not in view.

Wave Characteristics

20. What is meant by the **frequency** of a wave?

21. What units are used to measure **frequency**?

22. In each of the following cases calculate the frequency of the wave.

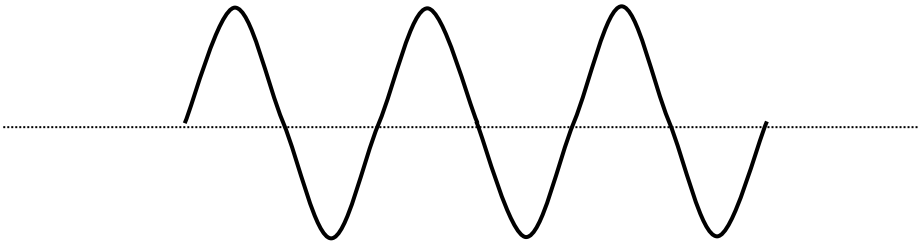
    a. 60 waves pass in 6 s

    b. 2 waves pass in 8 s

    c. 0.5 waves pass in 0.5s

    d. 180 waves pass in 3 minutes

23. A wine glass vibrates at 56 Hz. How many vibrations are produced in 10s?



24. Copy the diagram of the waveand on your diagram mark the following:

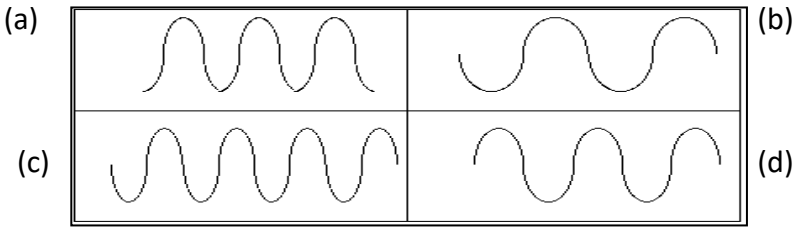
    (a) one wavelength, λ,

    (b) the amplitude

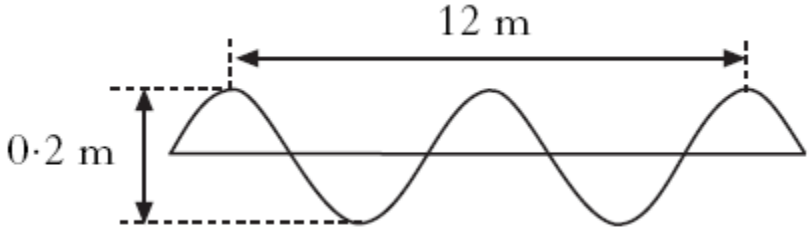
    (c) crest

    (d) a trough

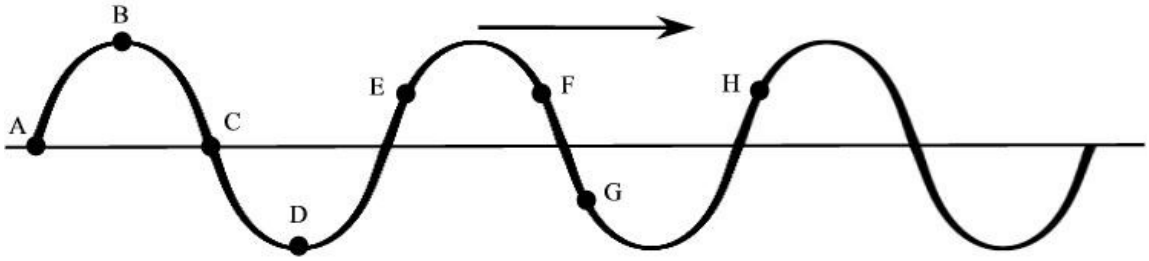
25. How many waves are shown in each of the diagrams?



26. Determine the wavelength and amplitude of the wave below.



27. The diagram below shows a wave on a spring. The arrow shows the direction in which the energy is being transferred.



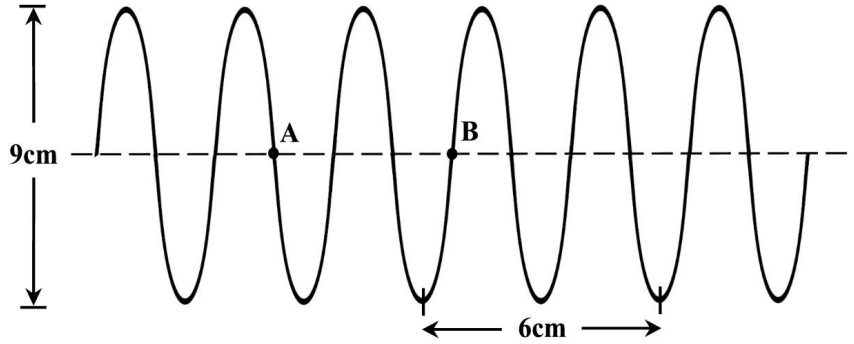
Use the letters A to H to indicate:

(a) A wave crest.
(b) A wave trough.
(c) Two points which are one wavelength apart.

Measure:

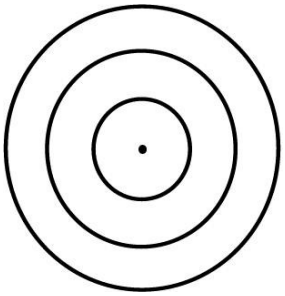
(d) The wavelength in millimetres.
(e) The amplitude in millimetres.
(f) Draw a sketch of the wave and mark the direction that point E on the spring is moving at this moment in time.

28. The wave below is produced in an experiment.



(a) What is the amplitude of the wave?
(b) What is the wavelength of the wave?
(c) What is the distance between points A and B?

29. A boy drops a pebble into a pool of water. A strobe light was used and showed this pattern 4s after the pebble hit the water. The wavelength of the wave is 100cm.



(a) How far do the waves travel in 4 s?
(b) Calculate the speed of the waves.

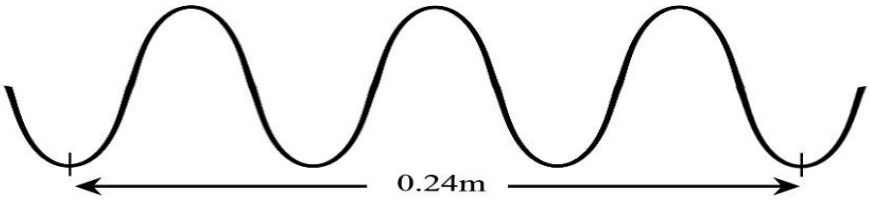
30. Change the following from the units they are given in to the standard units as required.

(a) 6 km into m (b) 200 mm into m

(c) 45 GHz into Hz (d) 0.4 kHz into Hz

Wave Equation

31. In the diagram below 150 waves pass a point in 1 minute.



Calculate

(a) The frequency of the wave (b) The wavelength of the wave

(c) The speed of the wave

32 Copy the table below and table below filling in the correct term, symbol and unit.

WAVE TERM	SYMBOL	UNIT	DEFINITION
			The number of waves passing a point every second
			From a point on a wave to the same point on the next wave
	v	ms^{-1}	

33. A wave generator at a leisure pool transmits 30 waves in a minute. The waves travel across the pool 24m pool in 12s. Calculate :

(a) The frequency of the wave .
(b) The speed of the waves

34. A wave has a wavelength of 11m and a frequency of 5 Hz. Calculate the speed of the wave.

35. A satellite sends microwaves to a ground station on earth. The microwaves have a wavelength of 60mm. Calculate the frequency of the waves emitted.

36. Different radio stations use different frequencies of radio wave to carry information from the radio transmitter to the radio receiver. Radio frequencies used for sound broadcasting are often measured in kilohertz (kHz) or megahertz (MHz).
Convert each of the following frequencies into hertz.

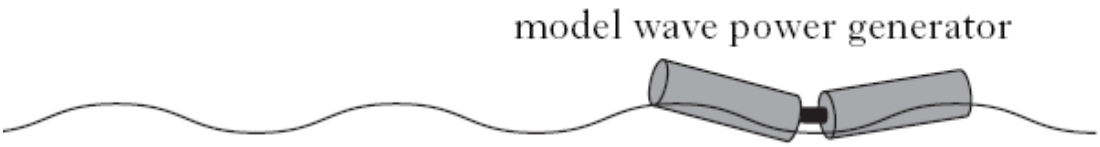
(*a*)	1215 kHz	(*b*)	810 kHz	(*c*)	548 kHz
(*d*)	88 MHz	(*e*)	97·6 MHz	(*f*)	850 MHz.

37. Calculate the frequency of middle C in music if the wavelength is 1.3m.

38. What is the frequency of Radio Clyde if it transmits at a wavelength of 102.49MHz?

39. Calculate the wavelength of the waves produced in air by a tuning fork producing a sound of 283Hz.

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



A wave generator uses waves to generate electricity.

(a) A machine in the tank produces 20 waves in 10 seconds.
Calculate the frequency of the waves.

(b) The wavelength of the waves in the tank is 1.2m
Calculate the speed of the waves in the tank.

(c) The amplitude of the waves in the tank is 0.15m.
Calculate the maximum vertical displacement the wave generator moves through.

41. A wave of wavelength 5cm travels 1.2m in 1 minute.

(a) What is the velocity of the wave ?
(b) What is the frequency of the wave?

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

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

(b) The surfer is gathering data about these tidal waves.
The surfer stands beside the river and counts 8 waves passing a point in a time of 10 seconds. Calculate the frequency of these waves.

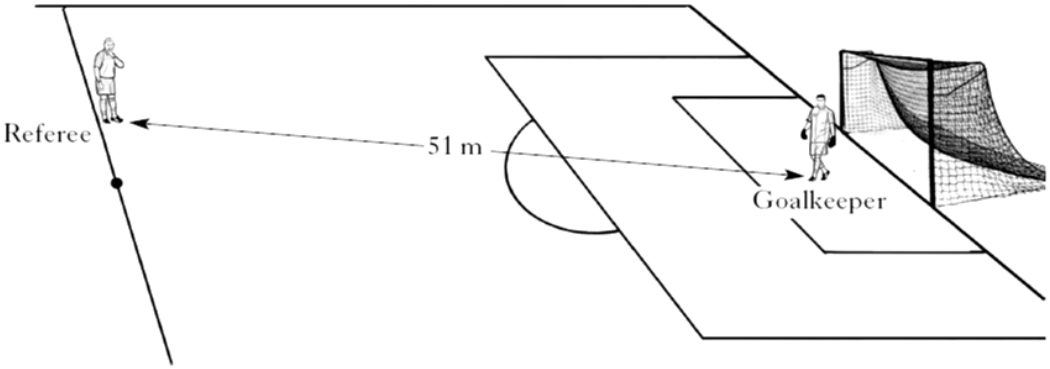
(c) As the waves move from the sea to the river, their wavelength decreases and their amplitude increases. The diagram above shows the waves in the sea.
Copy the sketch above and then below sketch the waves as they would appear in the river. You must clearly show both the differences to the wave.

43. 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*) How could the accuracy of the timing be improved?

44. At the kick-off in a football match, during the World Cup Finals, the referee blows his whistle. The whistle produces sound waves.

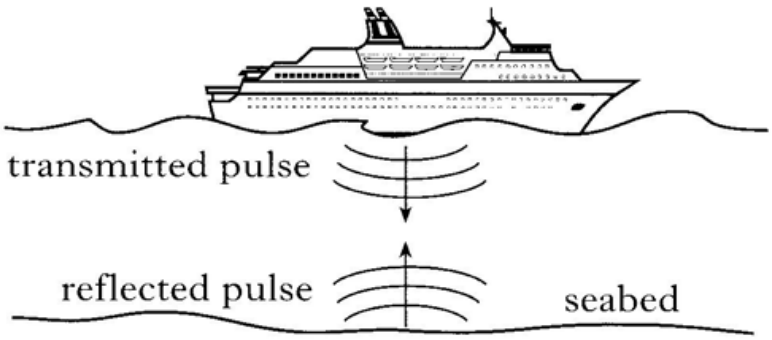


(a) Are sound waves transverse or longitudinal?

(b) Using information from the diagram and the data sheet, calculate the time taken for the sound waves to reach the goalkeeper.

(c) What is transferred by waves ?

45. The depth of the seabed is measured using pulses of ultrasound waves. The ultrasound waves are transmitted from a stationary ship. The waves are reflected from the sea bed as shown and are detected by the ship. The transmitted waves have a frequency of 30kHz.

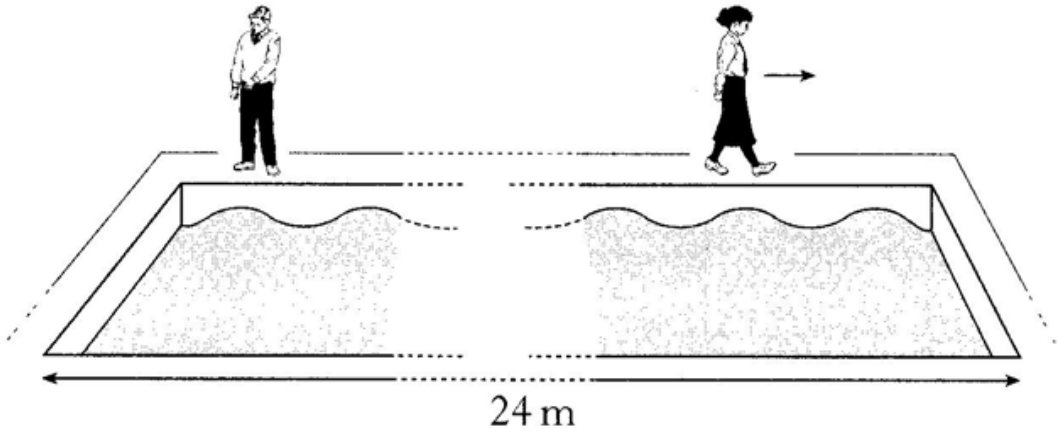


(a) One pulse of ultrasound waves is received back at the ship 0.2s after being sent out. Use the data sheet to find the speed of ultrasound in water.

(b) Calculate the depth of the seabed.

(c) Calculate the wavelength of the ultrasound waves in water.

46. Two students watch the waves produced by a waves machine at a swimming pool. One student walks beside a wave as it travel along the pool. The wave goes from one end of the pool to the other in 20s. The length of the pool is 24m .



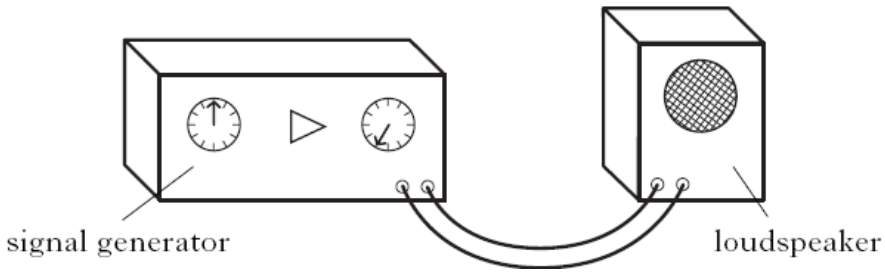
(a) Calculate the speed of the waves .

(b) In the same time interval, the other student counts 5 waves passing 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.

(d) Explain why 'distance divided by time' and 'frequency times wavelength' are equivalent for a wave

47. A signal generator is connected to a loud speaker which produces a sound waves of frequency 2 kHz.



(a) Calculate the wavelength of the sound wave in air.

(b) The loudspeaker is placed a distance of 10.2m from a wall. Calculate the time taken for the sound to return to the loudspeaker.

(c) The loudspeaker is now placed in a tank of carbon dioxide gas. The frequency remains unchanged at 2kHz.

What effect does this have on the wavelength of the sound? Explain your answer

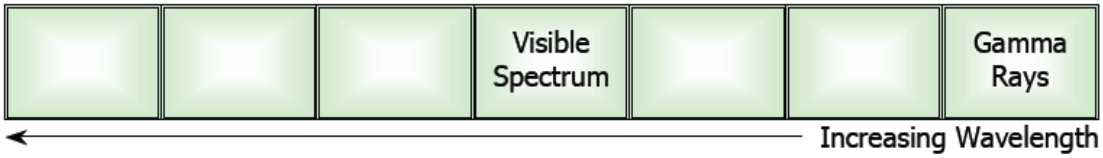
Electromagnetic Spectrum

1. Which member of the electromagnetic spectrum has:-

   (a) the highest frequency
   (b) the highest energy

2. (a) Copy the diagram of the electromagnetic spectrum and complete it with the following words:-

   Visible Light, Infrared, X-rays, Ultraviolet, Radio & TV,
   Gamma Rays and Microwaves.



   (b) Which of the radiations in the diagram has the lowest frequency.

3. What speed do all the waves in the electromagnetic spectrum travel at?

4. What frequency of light is emitted by a helium neon laser which has a wavelength of 632.8 nm?

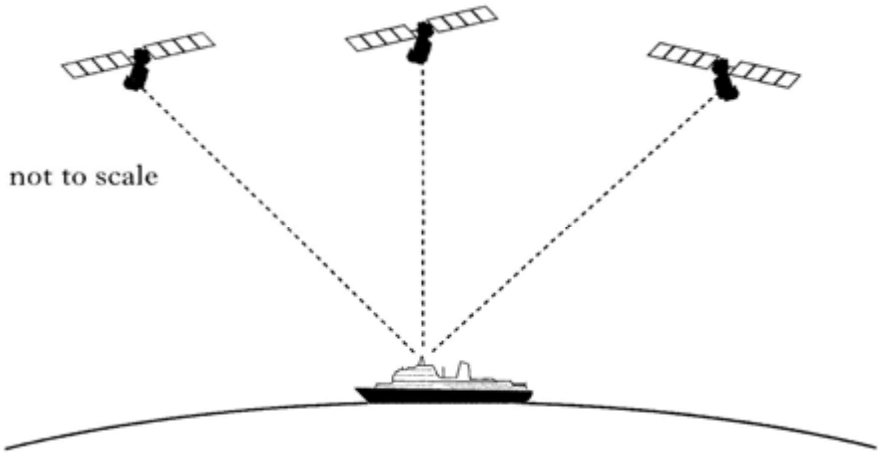
5. Copy and complete the table shown below giving examples of applications of each member of the electromagnetic spectrum.

TYPE OF RADIATION	Sources	Detectors
Radio & TV		
		CCD
Visible		CCD
Ultra Violet		CCD /Photodiode
		CCD
Gamma rays		

6. Name three types of radiation that are emitted from the sun.

7. Name three types of radiation that are emitted from electronic circuits.

8. A ship has a satellite navigation system. A receiver on the ship picks up signals from three global positioning satellites.



These satellites can transmit radio signals at three different frequencies, 1176MHz, 1228MHz and 1575MHz. The satellites orbit at a height of 20200km above the Earth's surface.

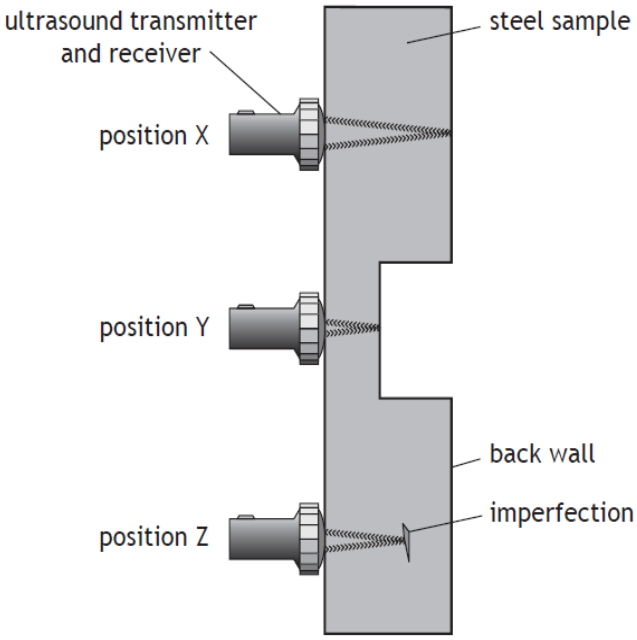
(a) (i) State the speed of the radio signals.

(ii) One of the satellites is directly above the ship.
Calculate the time taken for the signal from this satellite to reach the ship.

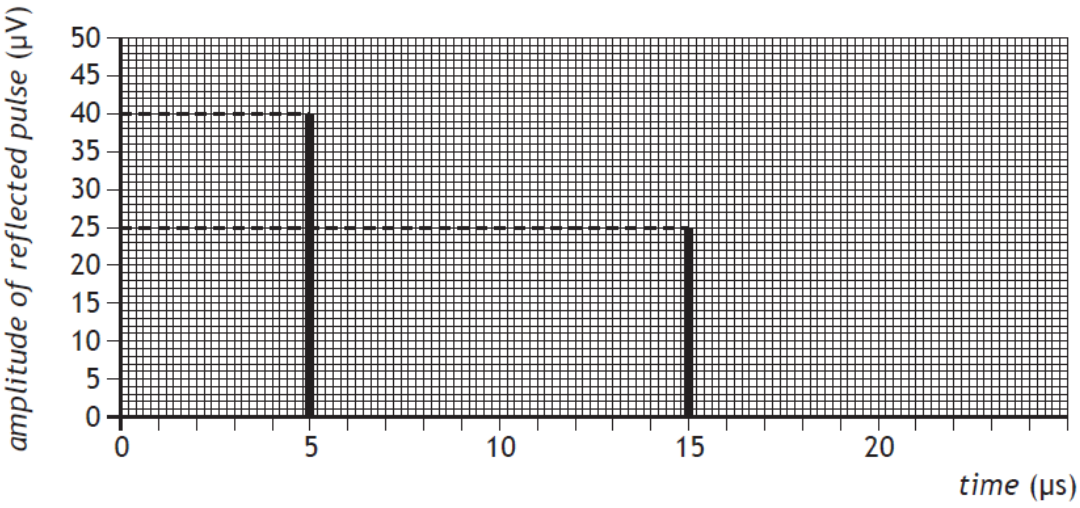
(iii) Calculate the wavelength of the 1228 MHz signal.

(b) State which of the three signals has the shortest wavelength.

9. A technician uses pulses of ultrasound (high frequency sound) to detect imperfections in a sample of steel. The pulses of ultrasound are transmitted into the steel. The speed of ultrasound in steel is 5200 m s^{-1}.
Where there are no imperfections, the pulses of ultrasound travel through the steel And are reflected by the back wall of the steel.
Where there are imperfections in the steel, the pulses of ultrasound are reflected by these imperfections. The reflected pulses return through the sample and are detected by the ultrasound receiver.
The technician transmits pulses of ultrasound into the steel at positions X, Y and Z as shown.



The times between the pulses being transmitted and received for positions X and Y are shown in the graph.



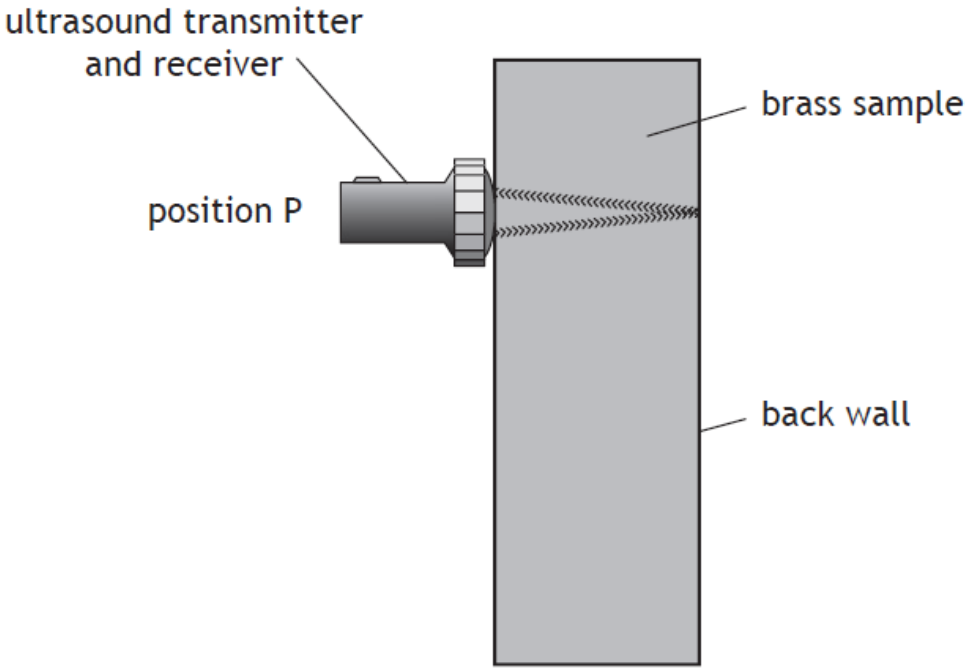
(a) (i) State the time taken between the pulse being transmitted and received at position X.

(ii) Calculate the thickness of the steel sample at position X.

(b) The ultrasound pulses used have a period of 4·0 μs.
(i) Show that the frequency of the ultrasound pulses is 2·5 × 105 Hz.

(ii) Calculate the wavelength of the ultrasound pulses in the steel sample.

(c) The technician replaces the steel sample with a brass sample.
The brass sample has the same thickness as the steel sample at position X.
The technician transmits pulses of ultrasound into the brass at position P as shown.



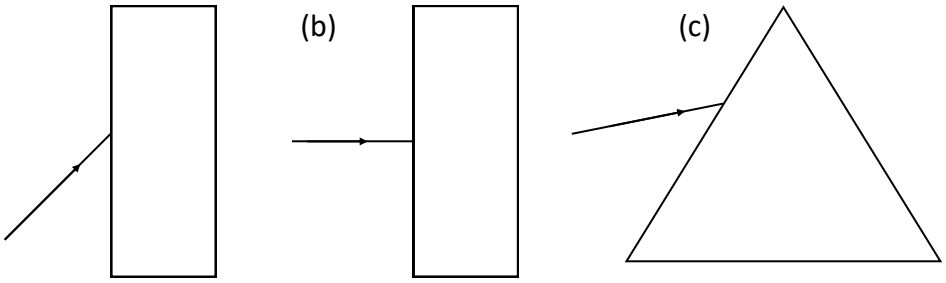
The time between the ultrasound pulse being transmitted and received at position P is greater than the time recorded at position X in the steel sample.
State whether the speed of ultrasound in brass is less than, equal to or greater than the speed of ultrasound in steel.
You **must** justify your answer.

Light

1. Explain what is meant by the term refraction.

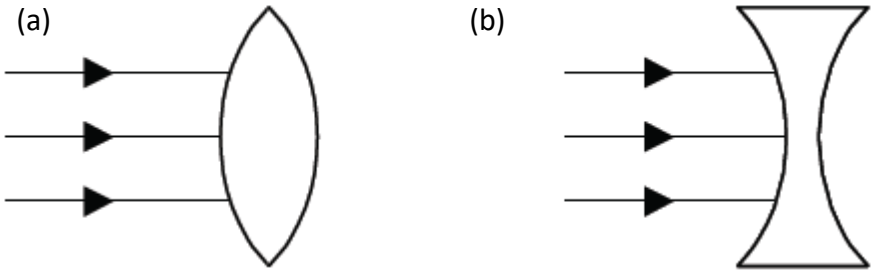
2. Copy and complete the three diagrams below showing the path of the ray of light until it leaves the block. Draw the normal on each diagram. Label the angle of incidence and the angle of refraction.

(a) (b) (c)



3. Copy and complete the two diagrams below to show how the light is refracted by each lens.

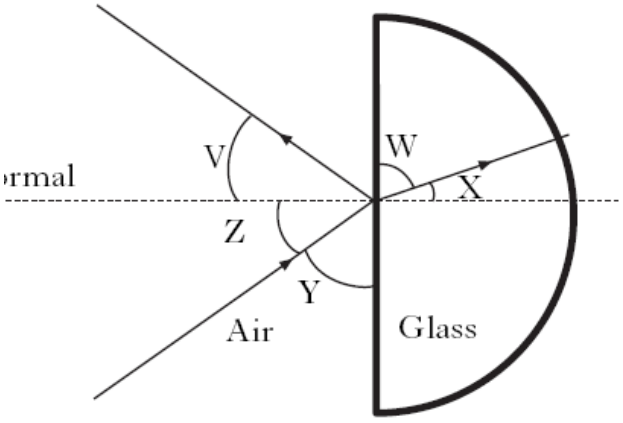
(a) (b)



(c) If the lens in part (a) was replaced by a thinner convex lens how would this affect the focal point of the lens

4. Copy and complete the sentences below inserting the correct word
When light passes from air into glass the ray of light changes direction **towards/away from** the normal.
When light passes from glass into air the ray of light changes direction **towards/away from** the normal.

5. Which letter on the diagram shows
(a) angle of incidence?
(b) angle of refraction?



6. During an experiment at St Ninian's a pupils measures the focal length of a convex lens. She uses the tree outside the window as the object.

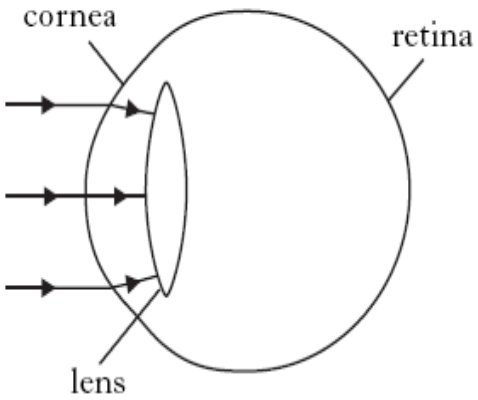
   (a) What other equipment would she require to carry out this experiment?
   (b) What measurements would she need to take?

7. A man wears glasses to correct short sightedness.
   (a) What shape is the lens?
   (b) Should the man wear his glasses to watch a movie or to read a magazine?
   (c) When the man was not wearing his glasses would the image be formed behind or in front of his retina?

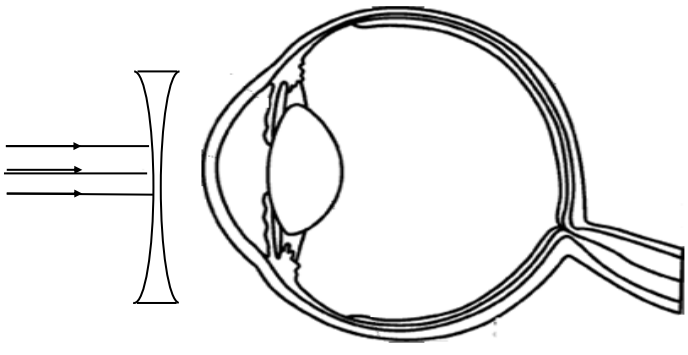
8. Copy the table below and fill in the blanks to give information about short and long sight.

SIGHT DEFECT	DESCRIPTION	LENS USED
Long Sight		
Short Sight		

9. Copy and complete the diagram below to show that the person suffers from short sight.



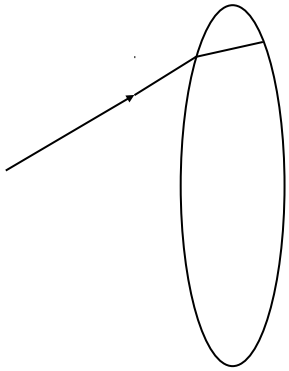
10. Copy and complete the diagram to show how the lens corrects short sight.



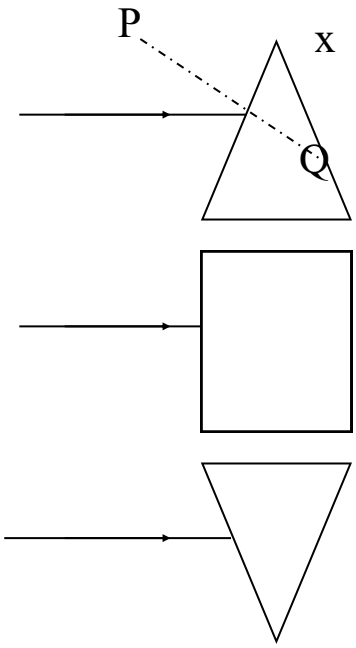
11. A long sighted person is prescribed glasses to correct their sight.

(a) State what is meant by long sight.

(b) Complete the diagram to show the path of the ray of light after it emerges



12. A student investigates the effect of glass shapes on rays of light.
The student places glass shapes in the path of three rays of red light as shown.



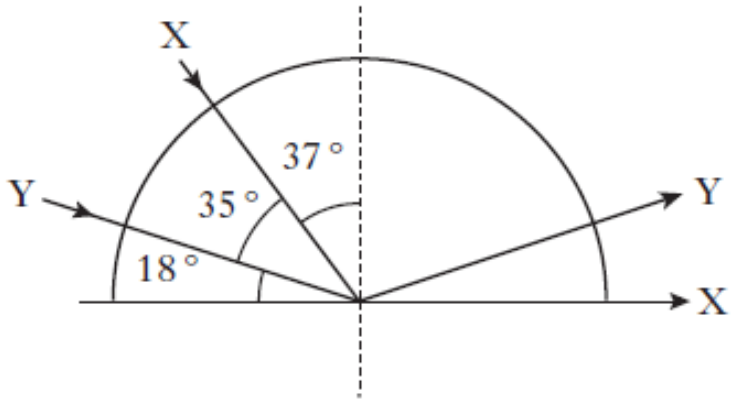
(a) The student has drawn line PQ on the diagram, what is the name of this line?

(b) Copy and complete the diagram to show the paths of the rays of light through and out of the three glass shapes.

(c) On your diagram, label one angle of incidence as *i* and one angle of refraction as *r.*

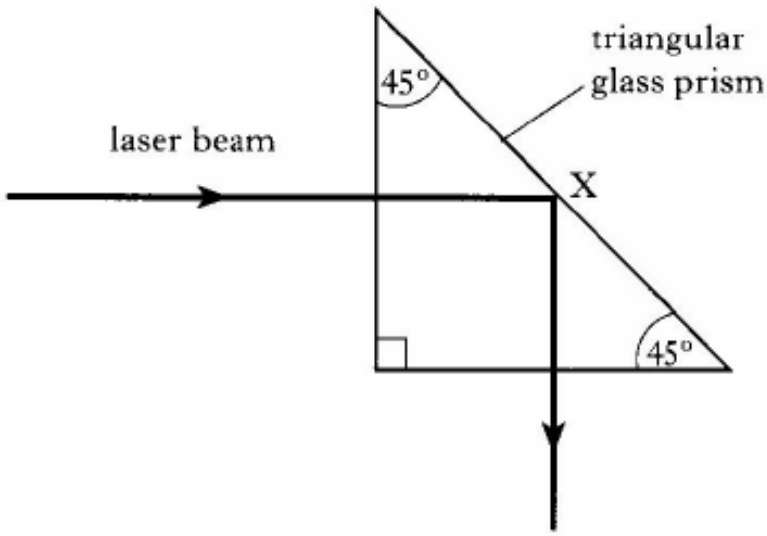
*(*d) Name the type of lens that would have a similar effect on the rays of light as the three glass shapes above.

13. The diagram shows two rays of red light X and Y passing through a block of glass



What is the critical angle of the material of the block?

14. A student aims a laser beam at a triangular glass prism as shown. The beam changes direction at X.



(a) Name the optical effect that occurs at point X.

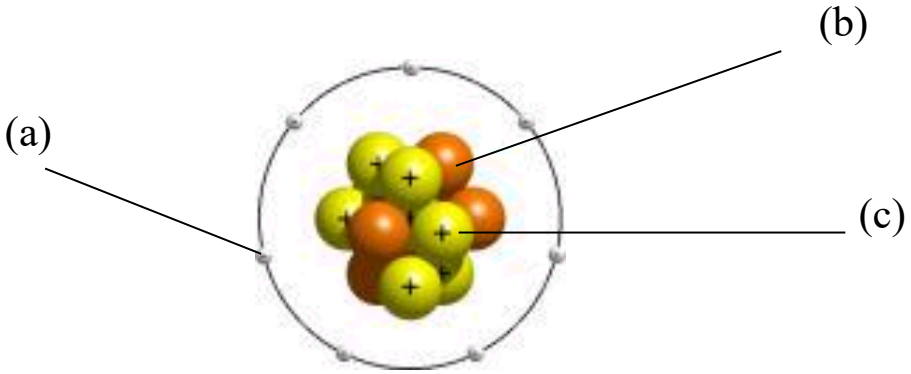
(b) Suggest a suitable value of the critical angle for the type of glass used for this prism.
You must explain your answer.

15. Explain, with the aid of a diagram, what is meant by 'total internal reflection'.

16. Give two applications that use optical fibres.

Introduction to Nuclear Radiation

1. Copy the diagram of the atom shown below and label a, b and c



2. Copy and complete the table below

Particle	charge
Proton	
Neutron	
electron	

3. Explain the term ionisation.

4. Give 2 natural sources of background radiation.

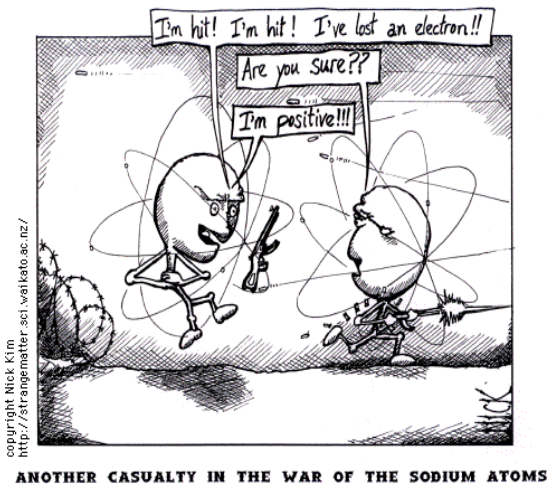
5. Give 2 man-made sources of background radiation.

6. A student makes the following statements about a carbon atom.

   I. The atom is made up only of protons and neutrons.
   II. The nucleus of the atom contains protons, neutrons and electrons.
   III. The nucleus of the atom contains only protons and neutrons.

Which of the statements is/are correct?

A I only
B II only
C III only
D I and II only
E I and III only



ANOTHER CASUALTY IN THE WAR OF THE SODIUM ATOMS

7. Describe three safety precautions that must be followed by workers when using radioactive materials.

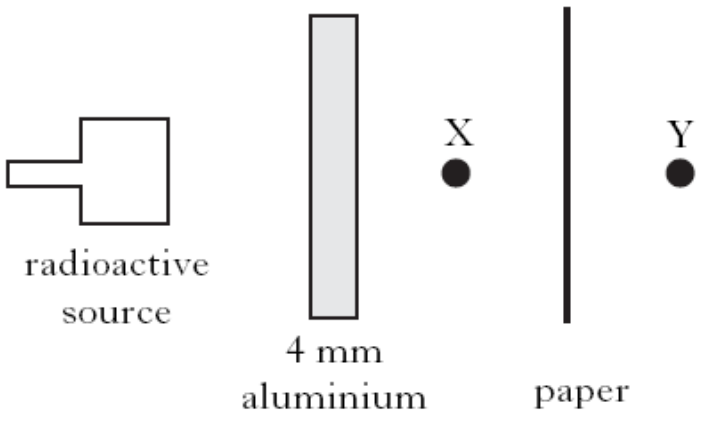
8. Which row in the table describes an alpha particle, a beta particle and a gamma ray?

	Alpha particle	Beta particle	Gamma Ray
A	neutron	helium nucleus	Electromagnetic radiation
B	helium nucleus	electron	Electromagnetic radiation
C	hydrogen nucleus	Electromagnetic radiation	electron
D	helium nucleus	Electromagnetic radiation	neutron
E	hydrogen nucleus	electron	Electromagnetic radiation

9. Copy and complete the following table.

Name of radiation	Symbol	What exactly is it?	Ionisation caused ?	Absorbed by?
Alpha			High	Piece of paper
	β			
Gamma				

10. A radioactive source emits α, β and γ radiation. Sheets of aluminium and paper are placed close to the source as shown. Determine which radiation will be detected at:



(a) X
(b) Y

Activity

1. What is meant by the activity of a radioactive source?

2. What units are used to measure activity of a radioactive source?

3. Convert the following to Becquerel's:
   (a) 2 kBq
   (b) 18 MBq

4. What is the activity of a source that has 210 decays in a minute?

5. For a particular source 1800 atoms decay in a time of 3 minutes. Calculate the activity of this source.

6. A radioactive source has 2400 atoms decay in a time of 2 minutes. Calculate the activity of this source.

7. What is the activity of a source that has 210 decays in a minute?

8. A source has an activity of 2.0 kBq. How many counts will be recorded from the source by a Geiger-Muller tube (and counter) in 30 seconds?

9. How long will it take a source with an activity of 1.8 MBq to have 8.1×10^8 radioactive decays?

Half Life

1. What is meant by the term half life?

2. Describe an experiment to measure the half life of a radioactive sources.
   Include
   (a) equipment used ,
   (b) reading taken
   (c) how these readings should be used.

3. A radioactive tracer has an initial activity of 48kBq. The source has a half life of 2 minutes and is left to decay for 10 minutes. What is the final activity of the source?

4. The initial activity of a radioactive isotope is 800 Bq. The sample has a half life of 4 minutes and is allowed to decay for 12 minutes. Calculate the final activity of the isotope.

5. A radioactive tracer has an activity of 160 MBq. The tracer has a half life of 5 hours and decays for 15 hours. What is its final activity?

6. A radionuclide has a half life of 300 years. If the original activity of a sample is 36Bq, calculate the time it takes to decay to 1/ 8th of its original value.

7. A radioactive source with a half life of 2.5 minutes decays for 20 minutes.
   The source has an initial activity of 256 kBq. Calculate the final activity of the source.

8. A sample of radioactive caesium has an initial activity of 2800 kBq. After 8 minutes its activity has dropped to 175 kBq.
   Use this information to calculate the half life of the source.

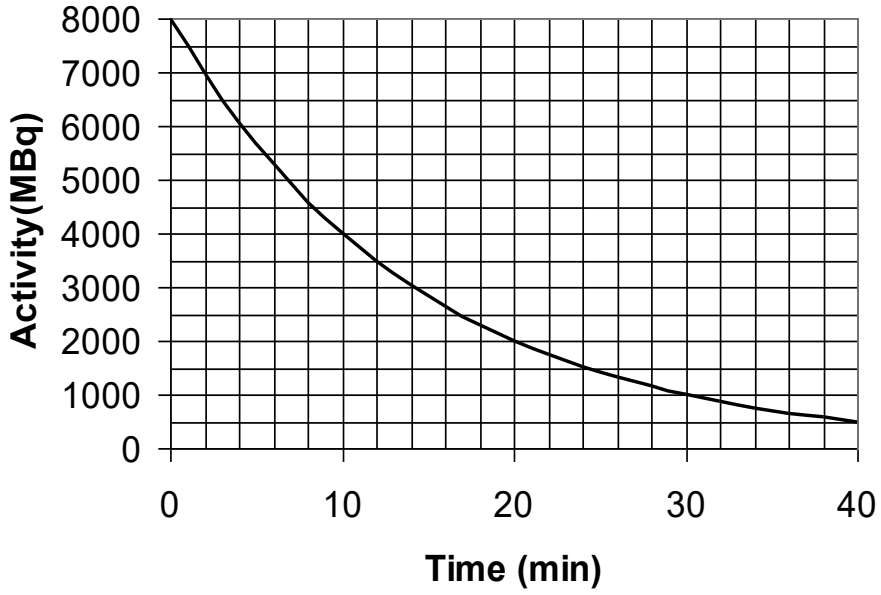
9. An isotope has a half-life of 70 s. How long does it take for the activity to fall to 1/32 of the starting value?

10. Radioactive uranium has an initial activity of 600 kBq. After 10 days its activity has dropped to 150 kBq. Use this information to calculate the half life of the source.

11. Calculate the initial activity of a radioactive source whose activity falls to 20 kBq in 16 minutes given that it has a half life of 2 minutes.

12. A radioactive rock decays for 48 hours and has a final activity of 480 kBq.
    What was its initial activity if its half life was 12 hours?

13. The graph below show the results achieved in an experiment carried out in St Ninian's High School. The source used was Protactinium – 234.



(a) Use the graph to calculate the half life of protactinium - 234.

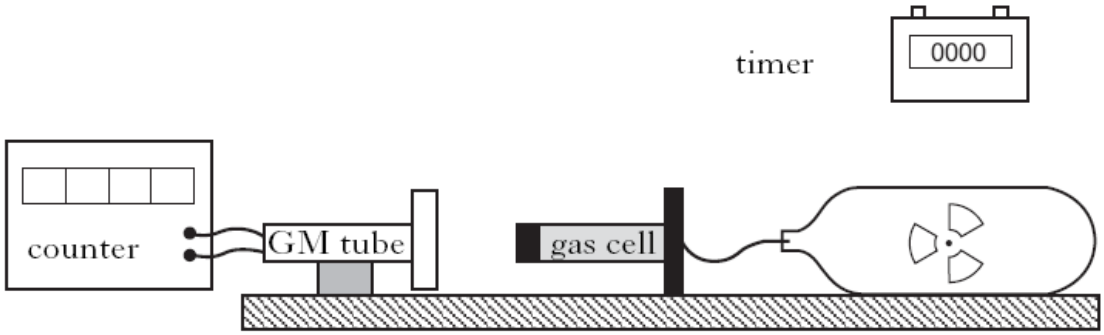
(b) What is meant by the term Half life.

14. Results taken in a second experiment with another source are shown in the table below, correction has been made for the background radiation.

Time (minutes)	0	2	4	6	8	10
Corrected Count Rate (per second)	72	45	28	18	12	8

Draw a graph of Corrected Count rate against Time, then use the graph to determine the half-life of the source.

15. An experiment is carried out in a laboratory to determine the half life of a radioactive source. A Geiger-Muller tube and counter are used to measure the background radiation over a period of 10 seconds. This is repeated several times and an average value of 4 counts in seconds is recorded. The apparatus shown is used to measure the count rate over a period of time. The readings are corrected for background radiation.



Time (minutes)	Corrected count rate
0	168
2	120
4	84
6	60
8	42
10	30
12	21

(a) Name two factors that affect the background radiation.

(b) Calculate the activity of the background radiation.

(c) Calculate the half-life of the radioactive source.

16. Carbon dating is used by scientists to tell the age of organic (formerly living) material. This method is based on knowing that the half-life of radioactive carbon is 5730 years.

(a) Explain what is meant by the statement "the half-life of radioactive carbon is 5730 years".

(b) What fraction of the original activity would be left after 17190 years?

(c) State the unit that is used for activity of a radioactive source.

Dosimetry

Use the table below to help with questions using Radiation Weighting factors

Type of radiation	w_r *(Radiation weighting factor)*
alpha	20
beta	1
gamma	1
fast neutrons	10
slow neutrons	3

1. Two nuclear power station worker absorbs 50J of energy of radiation.
   (a) Worker A has a mass of 55kg. Calculate his absorbed dose.
   (b) Worker B has a mass of 60 kg. Calculate his absorbed dose.
   (c) Who has the greater absorbed dose and why?

2. One Gray is equal to
   (a) one Becquerel per kilogram
   (b) one sievert per second
   (c) one joule per second
   (d) one sievert per kilogram
   (e) one joule per kilogram

3. A sample of tissue absorbs 1.8mJ of energy. Calculate the mass of the tissue if it receives an absorbed dose of 3 mGy.

4. A sample of tissue has a mass of 0.05 kg. The tissue is exposed to radiation and absorbs 0.1J of energy in 2 minutes. The absorbed dose is
   (a) 0.005 Gy
   (b) 0.1 Gy
   (c) 0.5 Gy
   (d) 2 Gy
   (e) 6 Gy

5. A medical technician absorbs 0.01J of fast neutrons to his finger of mass 0.1kg.
   Calculate his absorbed dose.

6. A nuclear power station worker absorbs 100J of energy of radiation, find his absorbed dose if his mass is 55 kg.

7. What does the radiation weighting factor for each radiation give us an indication of?

8. A medical physicist receives an absorbed dose of 20 mGy of alpha radiation.
   (a) Calculate the equivalent dose received by this worker.
   (b) If a second scientist of mass 50kg absorbs the same energy of alpha radiation. Calculate the absorbed dose.

9. An unknown material has an absorbed dose of 100μGy and gives an equivalent dose of 1mSv. Calculate the radiation weighting factor of this material.

10. A 50 kg person is exposed to radiation of energy 0.25J. The weighting factor for the radiation is 20.
   (a) Calculate the absorbed dose for this radiation
   (b) What is the equivalent dose

11. A technician working with an alpha source receives an absorbed dose of 20μGy. Calculate the total equivalent dose received by the technician

12. The risk of biological harm from radiation exposure depends on the absorbed dose and the type of radiation. Which other factor affects the risk of biological harm?

13. What are the legal limits of absorbed dose for :
   (a) The general public?
   (b) A worker in the nuclear industry?

14. Medical physicists working in a hospital are exposed to ionising radiations. State three methods employed to reduce/limit this radiation exposure?

15. Film badges are used in the nuclear industry as radiation detectors. Explain how a film badge can show the **type** and **level** of radiation exposure.

16. (a) Describe nuclear fusion.
   (b) Describe nuclear fission.
   (c) Which nuclear reaction takes place in the sun?
   (d) Which nuclear reaction takes place in a nuclear power station?

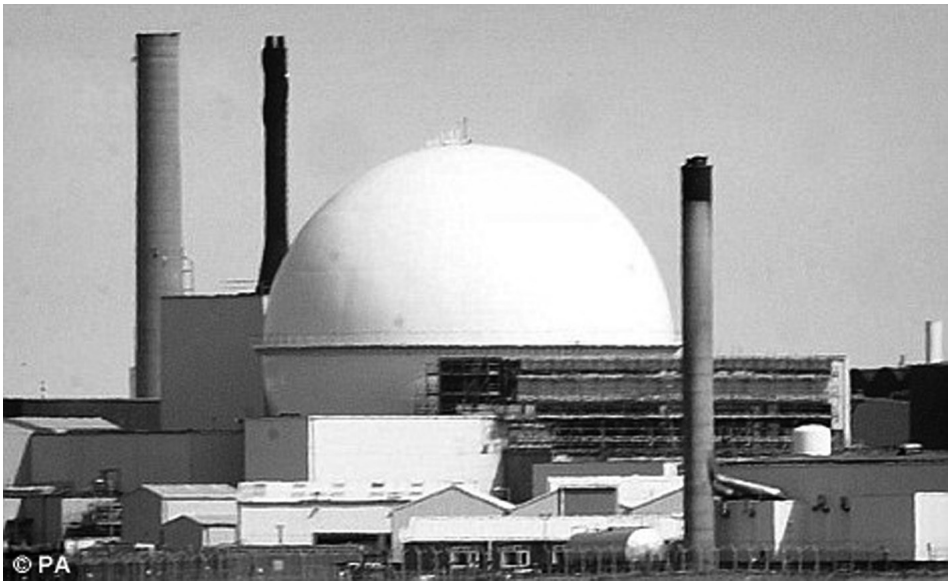
17. Environmental campaigners lobby against the construction of nuclear power stations.
   List the reasons why they are against using nuclear fuel to generate electrical energy.

18. List 3 sources of background radiation.

19. State and explain 2 disadvantages of using nuclear fuel to generate electricity.

20. State and explain 2 advantages of using nuclear fuel to generate electricity.

21. An aging nuclear power station is being dismantled .



(a) During the dismantling process a worker comes into contact with an object that emits 24000 alpha particles in five minutes. The worker's hand has a mass of 0.50 kg and absorbs 6 μJ of energy.

Calculate:
(i) the absorbed dose received by the worker's hand;
(ii) the equivalent dose received by the worker's hand;
(iii) the activity of the object.

(b) What type of nuclear reaction takes place in a nuclear power station's reactor?