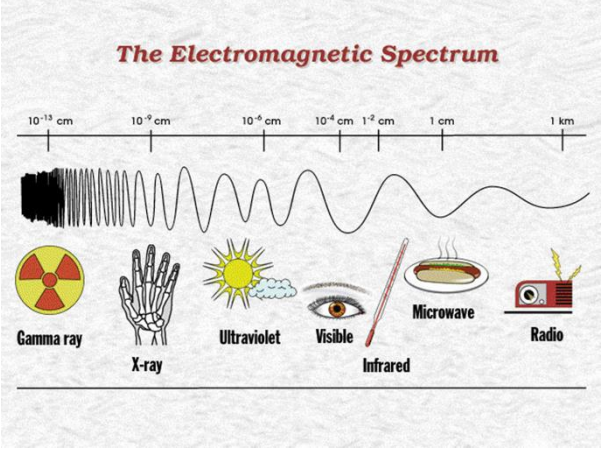
FLOREAT IUVENTUS

NATIONAL 5 PHYSICS

UNIT 2 — WAVES & RADIATION

WRITTEN QUESTIONS 2007—2019



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Applications of Radiation

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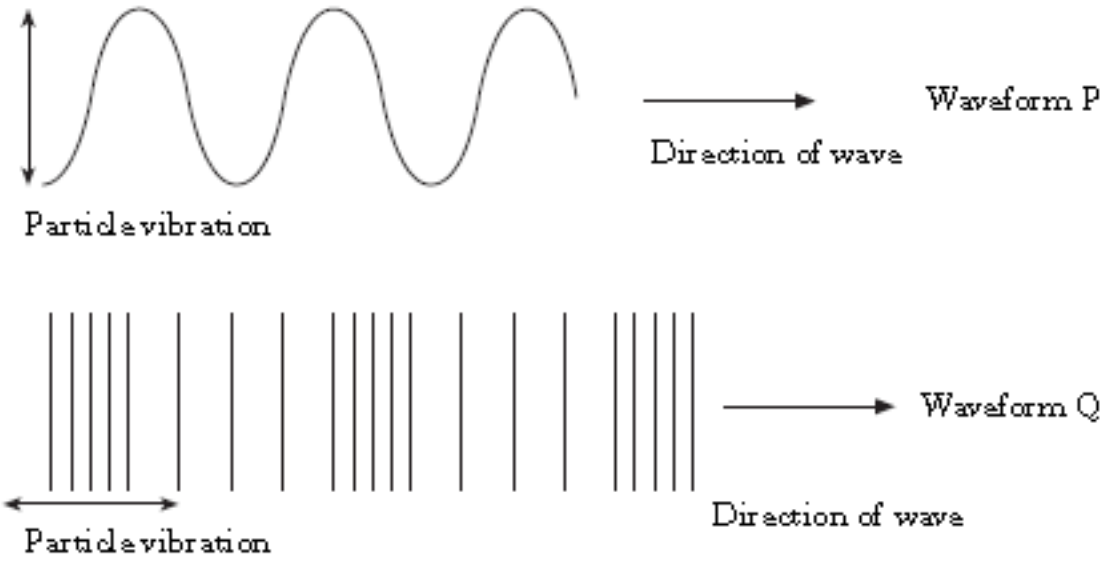
Introduction to Waves

2007 Q 28

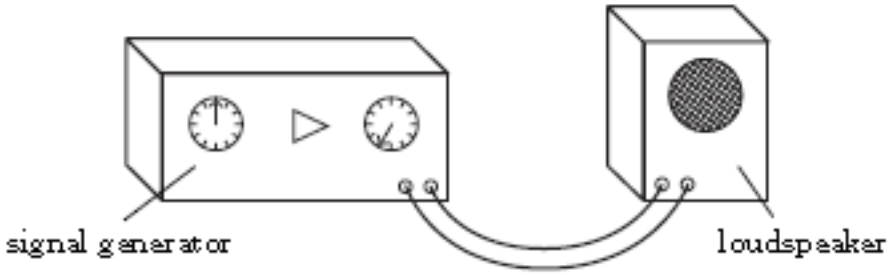
28. (*a*) Two types of waveform are shown.



(i) Which waveform represents a longitudinal wave? **1**

(ii) Which waveform represents a sound wave? **1**

(*b*) A signal generator is connected to a loudspeaker which produces a sound wave of frequency 2 kHz.



(i) Calculate the wavelength of the sound wave in air. **2**

(ii) The loudspeaker is placed a distance of 10·2 m from a wall. Calculate the time taken for the sound to return to the loudspeaker. **2**

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

What effect does this have on the wavelength of the sound?

Explain your answer. **2**

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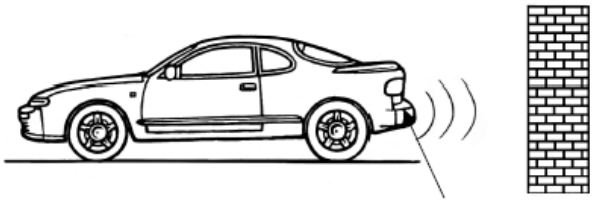
2009 Q 28 a,b

28. Parking sensors are fitted to the rear bumper of some cars. A buzzer emits audible beeps, which become more frequent as the car moves closer to an object.



Ultrasonic pulses are emitted from the rear of the car. Objects behind the car reflect the pulses, which are detected by sensors. Ultrasonic pulses travel at the speed of sound.

(*a*) The time between these pulses being sent and received is 2×10^{-3} s.

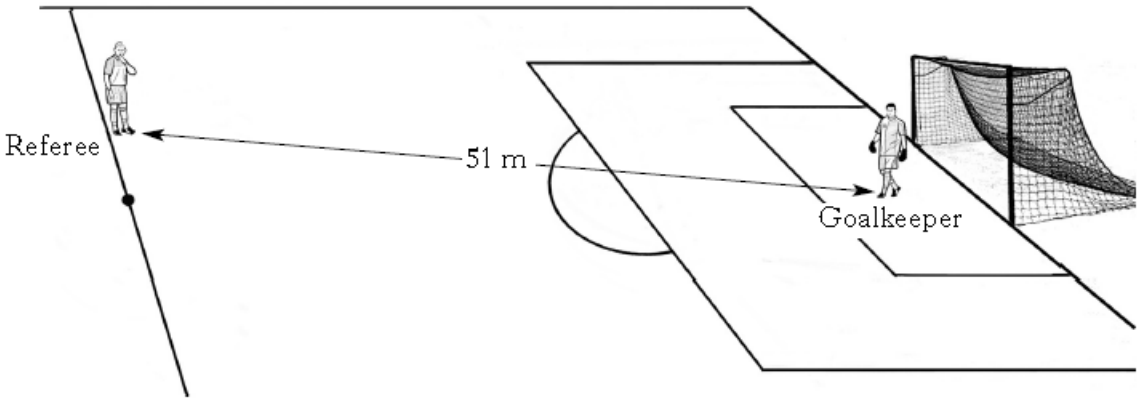
Calculate the distance between the object and the rear of the car. **3**

(*b*) At a certain distance, the buzzer beeps every 0·125 s.

Calculate the frequency of the beeps. **2**

2010 Q 27 a,b

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



(*a*) Using information from the diagram and the data sheet, calculate the time taken for the sound waves to reach the goalkeeper. **2**

(*b*) (i) Are sound waves transverse or longitudinal waves? **1**

(ii) Describe **two** differences between transverse and longitudinal waves. **2**

(iii) What is transferred by waves? **1**

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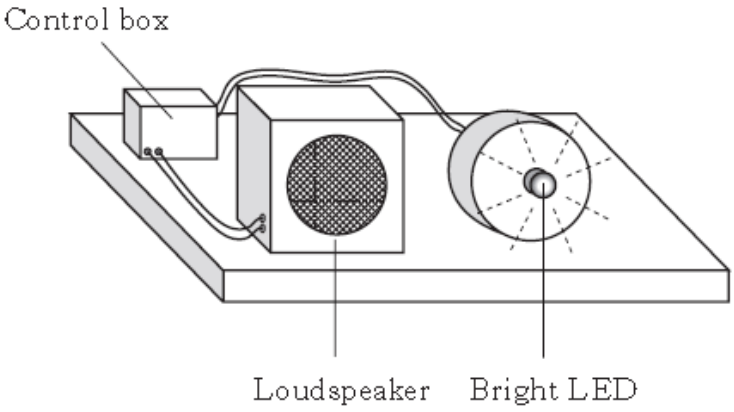
2012 Q 26 a

26. An apparatus used to measure the speed of sound consists of a bright LED which flashes every 0·5 s and a loudspeaker which beeps at **exactly the same time** as the LED flashes.



(*a*) A student standing beside the apparatus observes the beeps and flashes happening at exactly the same time.

Another student standing 88 m away does **not** observe them happening at the same time.

(i) Explain this observation. **1**

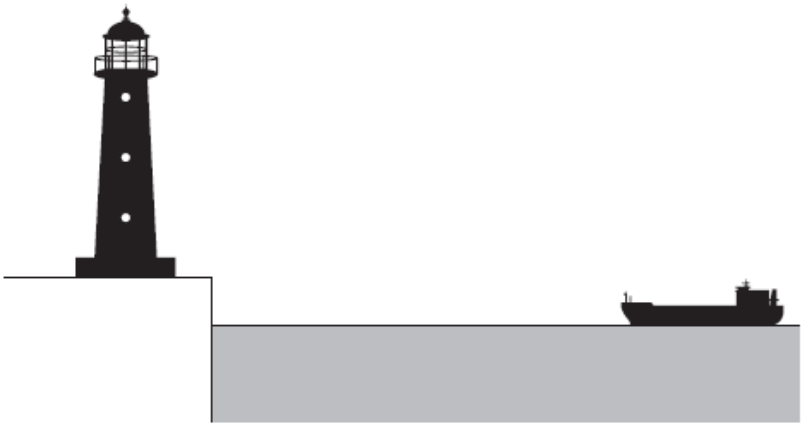
(ii) A third student 176 m away observes the beeps and flashes happening at exactly the same time.

Use this information to calculate a value for the speed of sound. **2**

2013 Q 29 c,d,e

29.(c) A lighthouse lamp flashes once every 7.45 seconds.
What is the name given to the time between each flash? **1**

(d) The lighthouse also uses a foghorn to alert ships.
A ship is at a distance of 2.04 km from the lighthouse.



Calculate the time taken for the sound to reach the ship. **2**

(e) Light waves are transverse waves. Sound waves are longitudinal waves.
Describe each type of wave in terms of vibrations. **2**

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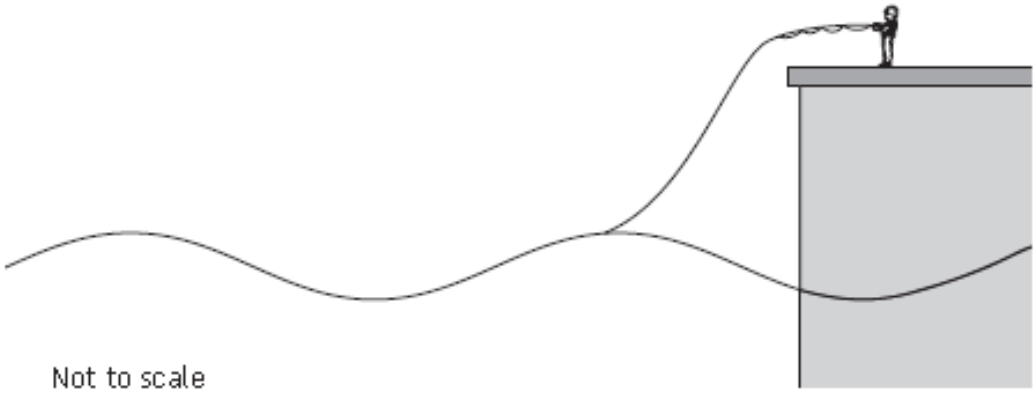
2014 Q 4 a

4. A student, fishing from a pier, counts four waves passing the end of the pier in 20 seconds. The student estimates that the wavelength of the waves is 12m.



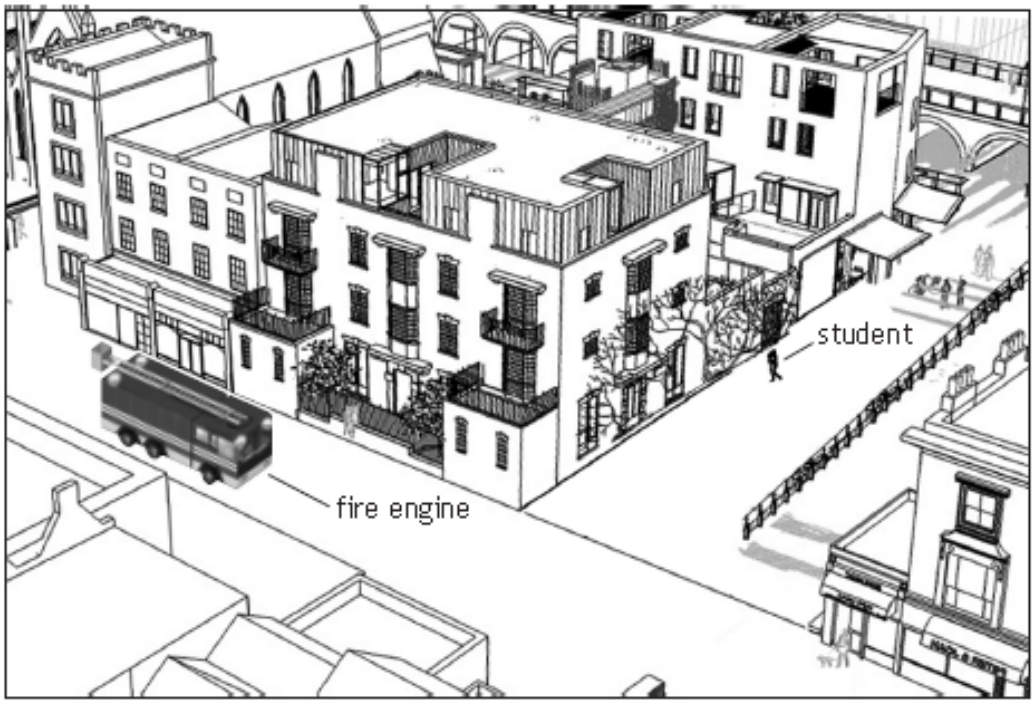
(a) Calculate the speed of the water waves. **4**

Space for working and answer

2014 Q 7

7. 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. **3**

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2015 Q 3 c

(c) The ultrasound pulses used have a period of 4·0 μs.

(i) Show that the frequency of the ultrasound pulses is $2{\cdot}5 \times 10^5$ Hz. **2**

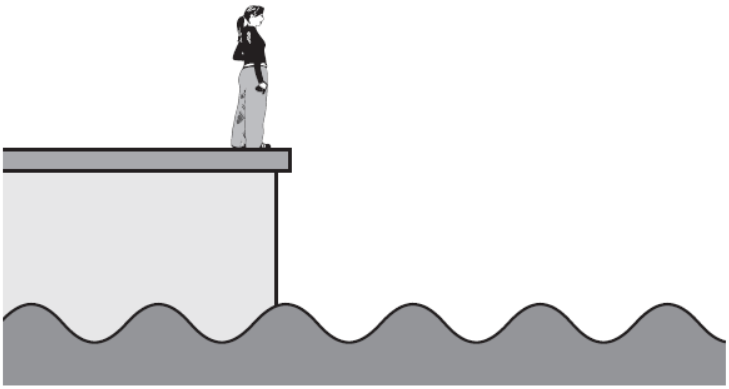
Space for working and answer

(ii) Calculate the wavelength of the ultrasound pulses in the steel sample. **3**

Space for working and answer

2017 Q 4

4. A student observes water waves entering a harbour.



(a) To determine the frequency of the waves, the student measures the time taken for a wave to pass a point at the harbour entrance.

The student measures this time to be 2·5 s

(i) Calculate the frequency of the waves. **3**

Space for working and answer

(ii) Suggest how the accuracy of the frequency determined by the student could be improved. **1**

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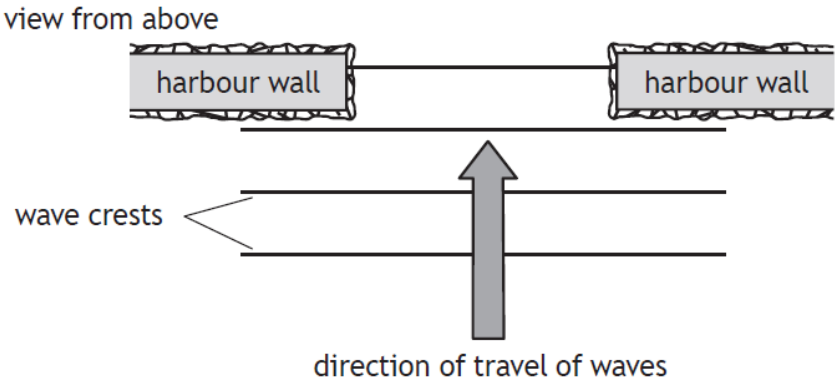
(b) The distance between one wave crest and the next crest is 8·0 m.

Calculate the velocity of the waves. **3**

Space for working and answer

(c) Waves travel towards the entrance of the harbour as shown.



Complete the diagram to show the pattern of wave crests inside the harbour. **2**

(An additional diagram, if required, can be found on *Page 28*)

(d) As the waves pass into the harbour the student observes that the amplitude of the waves decreases.

Explain this observation. **1**

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2018 Q 10

10. A student connects a mobile phone to a speaker wirelessly using a microwave signal.

not to scale

(a) The time taken for the microwave signal to travel from the mobile phone to the speaker is $2{\cdot}1 \times 10^{-8}$ s.

Calculate the distance between the mobile phone and the speaker. **3**

(b) Sound is a longitudinal wave.

The sound produced by the speaker is represented by the following diagram.

(i) State what is meant by the term *longitudinal wave*. **1**

(ii) Determine the wavelength of the sound wave. **1**

(iii) Calculate the frequency of the sound wave in air. **3**

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2019 Q 9 a, b

9. A lifeboat crew is made up of local volunteers. When there is an emergency they have to get to the lifeboat quickly.

The lifeboat crew members are alerted to an emergency using a pager.

Text messages are sent to the pager using radio waves.

(a) The radio waves have a frequency of 153 MHz.

Calculate the wavelength of the radio waves. **3**

(b) When the pager receives a message it beeps loudly and a light on the pager flashes.

A crew member holding the pager observes the beeps and the flashes happening at the same time.

A second crew member, who is 100 m away from the pager, also observes the beeps and the flashes.

Explain why the second crew member does not observe the beeps and the flashes happening at the same time. **2**

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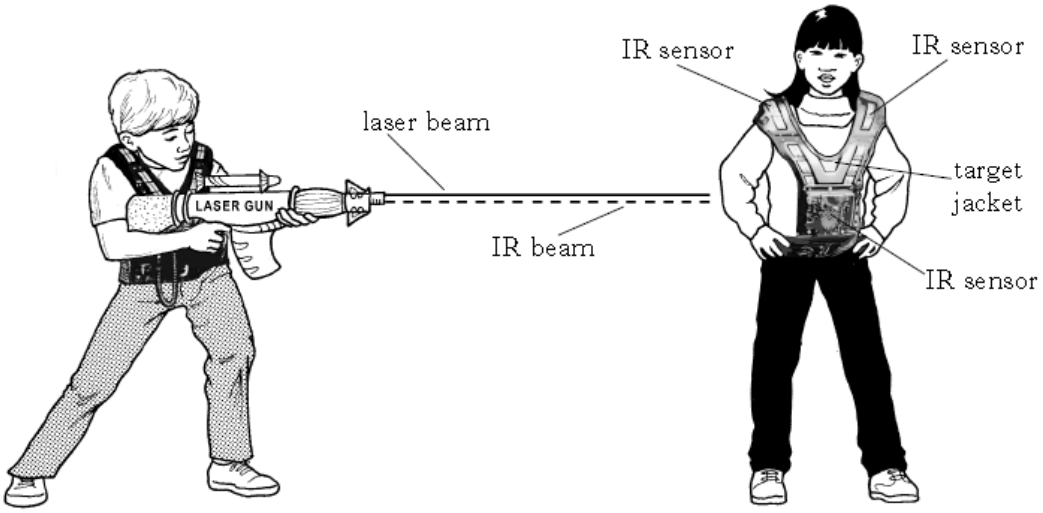
Electromagnetic Spectrum

2007 Q 25 a

Marks

25. A group of students visit a Laser Game Centre. The laser gun emits both a visible beam and an IR beam. Each target jacket contains three IR sensors.



(*a*) (i) What does the term IR stand for? **1**

(ii) Which of the two beams arrives at the target first?
You **must** explain your answer. **2**

2010 Q 28

28. A satellite sends microwaves to a ground station on Earth.

(*a*) The microwaves have a wavelength of 60 mm.

(i) Calculate the frequency of the waves. **2**

(ii) Determine the period of the waves. **2**

(*b*) The satellite sends radio waves along with the microwaves to the ground station. Will the radio waves be received by the ground station **before**, **after** or **at the same time** as the microwaves?

Explain your answer. **2**

(*c*) When the microwaves reach the ground station they are received by a curved reflector.

Explain why a curved reflector is used.

Your answer may include a diagram. **2**

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2011 Q 29 a

29. The Sun produces electromagnetic radiation. The electromagnetic spectrum is shown in order of increasing wavelength. Two radiations P and Q have been omitted.

Gamma rays	X rays	P	Visible light	Infra red	Q	Television and radio rays

Increasing wavelength

(*a*) (i) Identify radiations P and Q. **2**

(ii) The planet Neptune is $4{\cdot}50 \times 10^9$ km from the Sun. Calculate the time taken for radio waves from the Sun to reach Neptune. **2**

(iii) State what happens to the frequency of electromagnetic radiation as the wavelength increases. **1**

2014 Q 27 b

(*b*) Volunteers directing spectators use mobile phones for communication.

(i) A mobile phone uses microwaves of frequency 1200 MHz. Calculate the wavelength of these microwaves. **2**

(ii) A second mobile phone operates with a frequency of 1800 MHz. The signals from each phone travel the same distance.

How does the time taken for the signals from the second phone compare with the signals from the first phone? **1**

2016 Q 5

5. A Physics textbook contains the following statement.

"Electromagnetic waves can be sent out like ripples on a pond."

Using your knowledge of physics, comment on the similarities and/or differences between electromagnetic waves and the ripples on a pond. **3**

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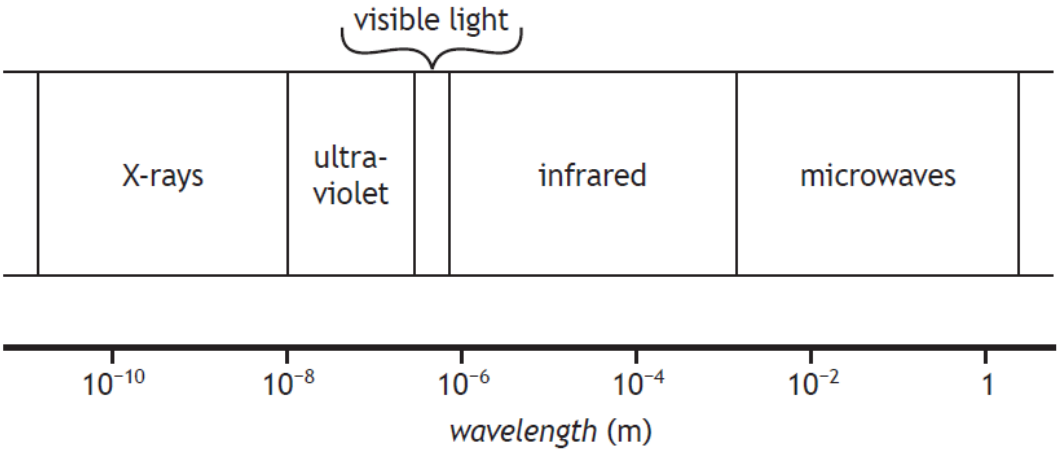
2016 Q 4

4. The diagram shows some parts of the electromagnetic spectrum in order of increasing wavelength.



(a) State a detector of infrared radiation. **1**

(b) State which radiation in the electromagnetic spectrum has a wavelength shorter than X-rays. **1**

(c) (i) An electromagnetic wave has a frequency of 1·2 GHz.

Show that the wavelength of this wave is 0·25 m. **2**

Space for working and answer

(ii) Identify the part of the spectrum that this wave belongs to. **1**

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2019 Q 10

10. Infrared and gamma rays are both members of a family of waves.

(a) State the name given to this family of waves. **1**

(b) State how the frequency of infrared compares to the frequency of gamma rays. **1**

(c) Some examples of sources and detectors of waves in this family are shown.

heater

radioactive waste

Geiger-Müller tube

fluorescent ink

black-bulb thermometer

LED

(i) From the examples shown, identify

(A) the detector of infrared **1**

(B) the source of gamma rays. **1**

(ii) Suggest one application for the waves that are detected using fluorescent ink. **1**

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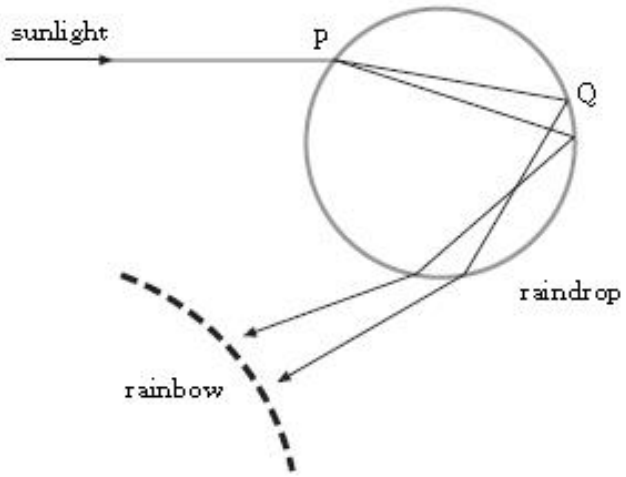
Light

2007 Q 27 a

Marks

27. When the sun shines during a shower of rain, a rainbow can sometimes be seen.

The diagram shows what happens to sunlight when it enters a raindrop.



(a) (i) Name the wave effect that happens at point P. **1**

(ii) Name the wave effect that happens at point Q. **1**

(iii) Which colour of the rainbow has the longest wavelength? **1**

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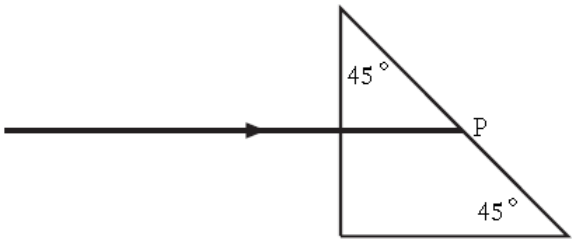
2008 Q 26 d

(*d*) The DVD player contains a laser.

Light from this laser enters a small glass prism as shown.



The glass has a critical angle of 40°.

(i) Explain what is meant by the term "critical angle". **1**

(ii) Copy and complete the diagram to show the path of the ray after it strikes point P. **2**

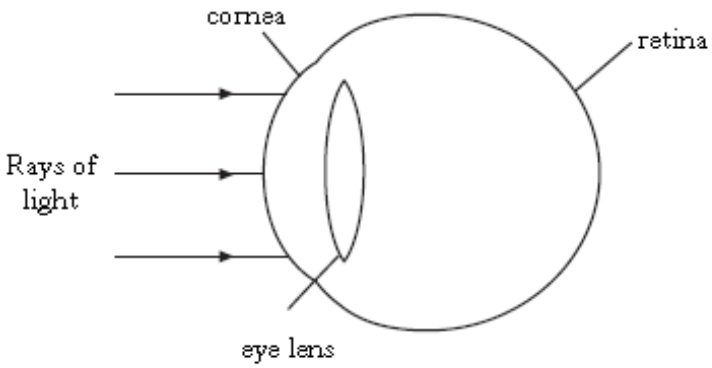
2009 Q 27

27. A student is short sighted.

(*a*) (i) What does the term "short sighted" mean? **1**

(ii) What type of lens is required to correct this eye defect? **1**

(*b*) In the eye, refraction of light occurs at both the cornea and the lens. Some eye defects can be corrected using a laser. Light from the laser is used to change the shape of the cornea.



(i) State what is meant by refraction of light. **1**

(ii) The laser emits light of wavelength 7×10^{-7} m.

Calculate the frequency of the light. **2**

(*c*) Lasers can be used in optical fibres for medical purposes.

(i) Copy and complete the path of the laser light along the optical fibre. **2**

(ii) Name the effect when the laser light hits the inside surface of the fibre. **1**

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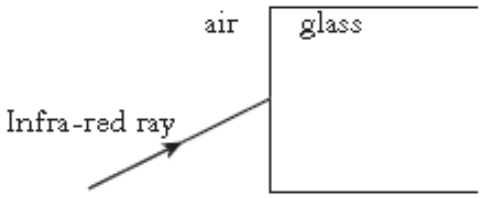
2012 Q 27 b,c

27. Optical fibres are used to carry internet data using infra-red radiation.

(*a*) Is the wavelength of infra-red radiation greater than, the same as, or less than the wavelength of visible light? **1**

(*b*) The diagram shows a view of an infra-red ray entering the end of a fibre.



Copy and complete the diagram to show the path of the infra-red ray as it enters the glass from air.

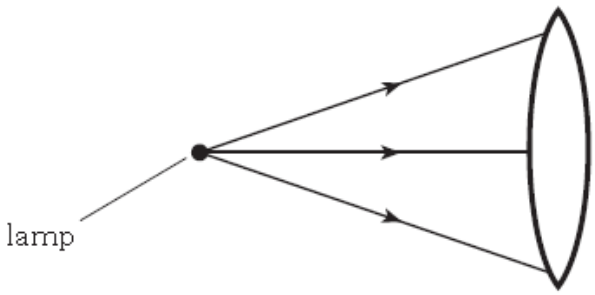
Indicate on your diagram the normal, the angle of incidence and the angle of refraction. **2**

(*c*) The diagram shows the path of the infra-red ray as it passes through a section of the fibre.

Name the effect shown. **1**

2013 Q 29 a

29. A lighthouse uses a converging lens to produce a beam of light.



(*a*) The lamp is placed at the focal point of the lens.

Copy and complete the diagram to show the paths of the light rays after they pass through the lens. **1**

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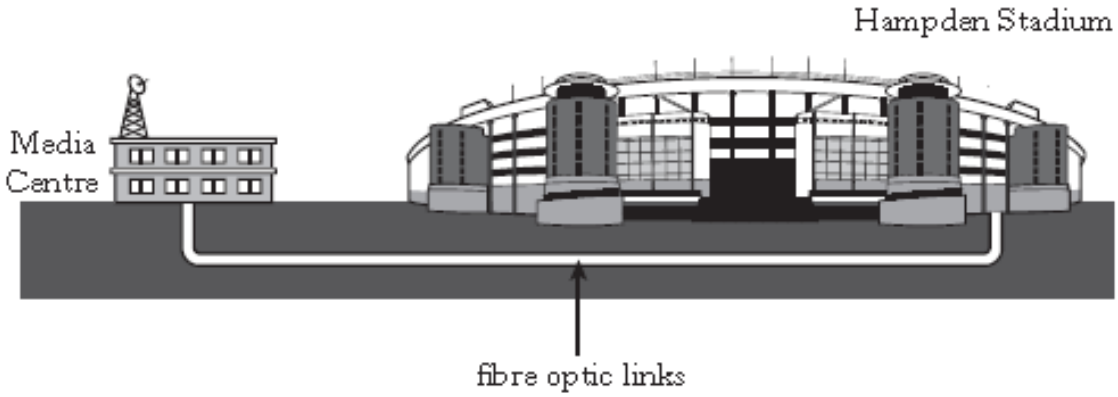
2014 Q 27 a

27. For the Commonwealth Games in Glasgow in 2014, fibre optic links will be used to carry TV signals from Hampden Stadium to the media centre.



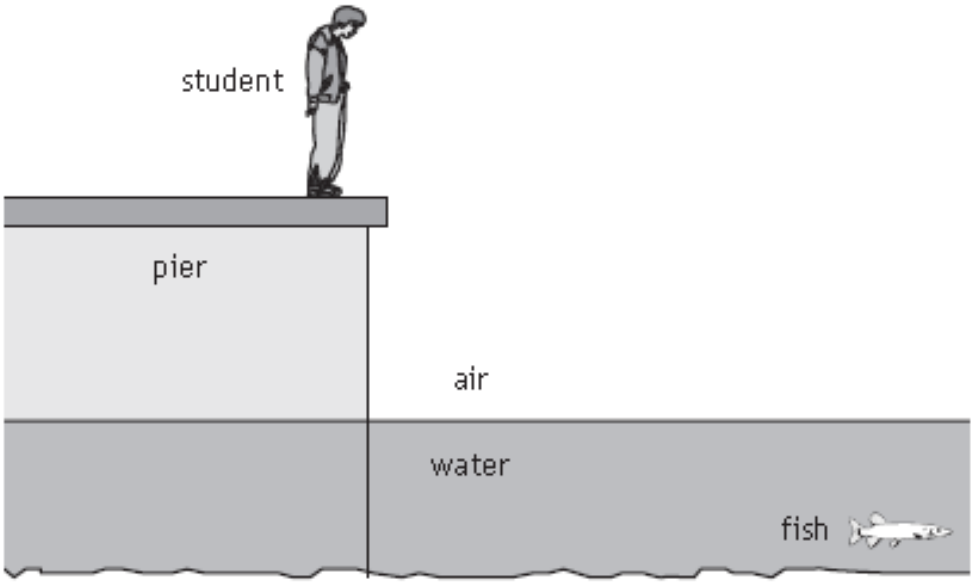
(*a*) The fibre optic link consists of a bundle of glass optical fibres.

(i) Name the effect used to transmit light through a glass optical fibre. **1**

(ii) The optical fibre has a length of 1·6 km. Calculate the minimum time taken for a light signal to travel along the fibre. **3**

2014 Q 4 b

(b) When looking down into the calm water behind the pier the student sees a fish.



Complete the diagram to show the path of a ray of light from the fish to the student.

You should include the normal in your diagram. **3**

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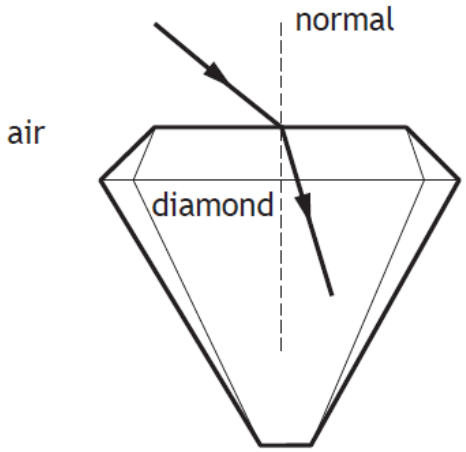
2015 Q 5 a,b,c

5. Diamonds are popular and sought after gemstones.

MARKS

Light is refracted as it enters and leaves a diamond.

The diagram shows a ray of light entering a diamond.



(a) On the diagram, label the angle of incidence *i* and the angle of refraction *r*. **1**

(b) State what happens to the speed of the light as it enters the diamond. **1**

(c) The optical density of a gemstone is a measure of its ability to refract light.

Gemstones of higher optical density cause more refraction.

A ray of light is directed into a gemstone at an angle of incidence of 45°.

The angle of refraction is then measured.

This is repeated for different gemstones.

Gemstone	*Angle of refraction*
A	24·3°
B	17·0°
C	27·3°
D	19·0°
E	25·5°

Diamond is known to have the highest optical density.

Identify which gemstone is most likely to be diamond. **1**

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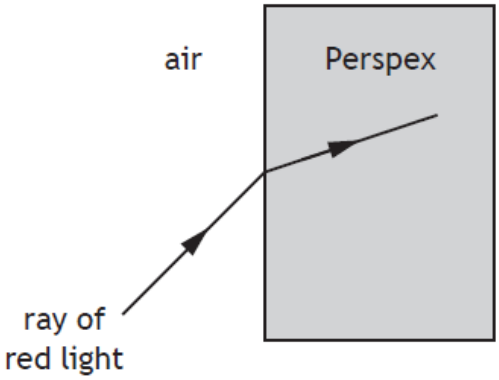
2016 Q 6

6. A student directs a ray of red light into a Perspex block to investigate refraction.



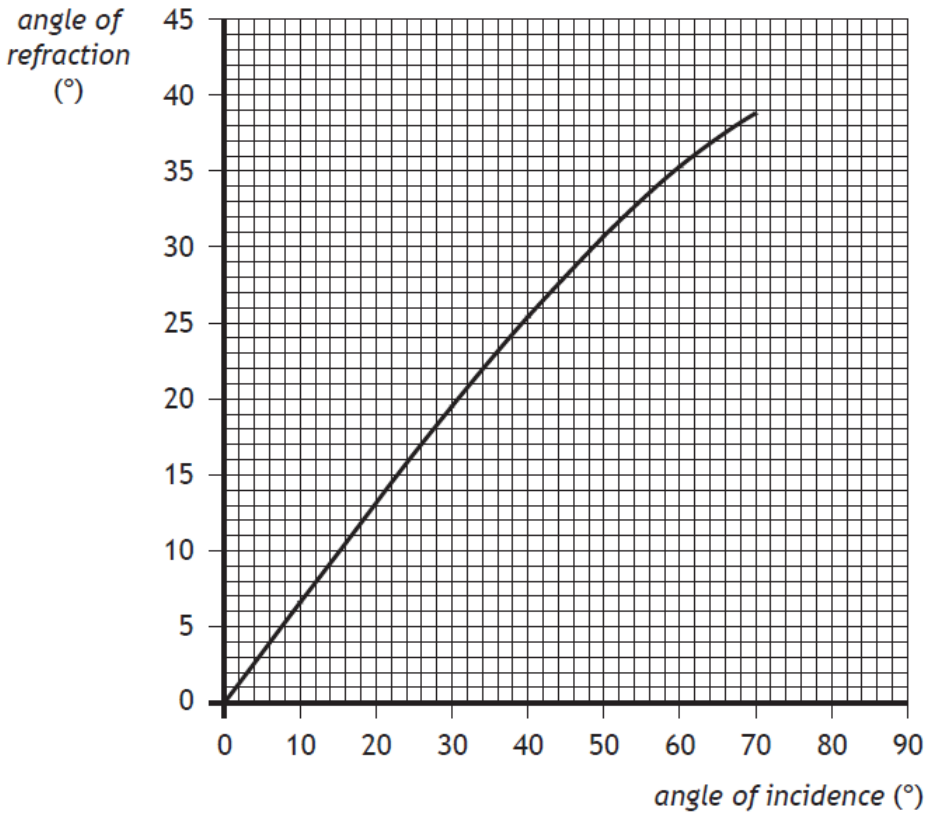
(a) On the diagram, draw and label:

(i) the normal; 1

(ii) the angle of incidence *i* and the angle of refraction *r*. 1

(An additional diagram, if required, can be found on *Page 33*)

(b) The student varies the angle of incidence and measures the corresponding angles of refraction. The results are plotted on a graph.



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2016 Q 6 continued

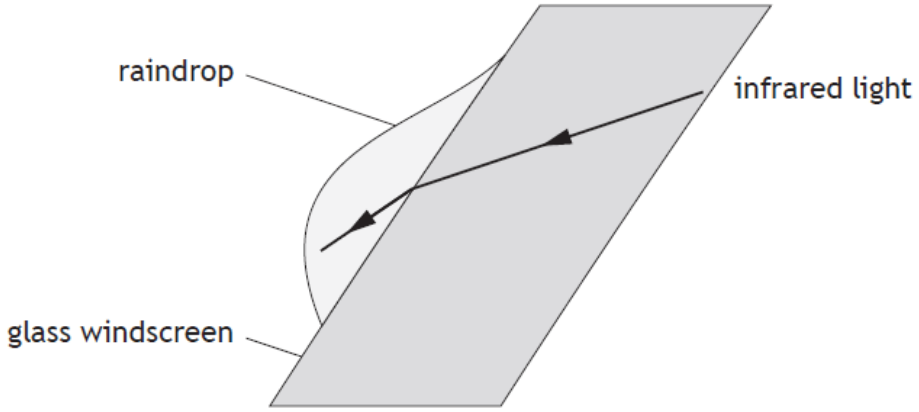
(i) Determine the angle of refraction when the angle of incidence is 12°. 1

(ii) Use the graph to predict the angle of refraction the student would obtain for an angle of incidence of 80°. 1

(c) Suggest why it would be good practice for the student to repeat the investigation a further three or four times. 1

2018 Q 11 c

(c) Some of the infrared light is refracted when travelling from the glass windscreen into a raindrop.



(i) On the diagram, draw and label:

(A) a normal; 1

(B) an angle of incidence i and an angle of refraction r. 1

(An additional diagram, if required, can be found on *page 44*.)

(ii) State whether the wavelength of the infrared light in the raindrop is less than, equal to or greater than the wavelength of the infrared light in the glass.

You **must** justify your answer. 2

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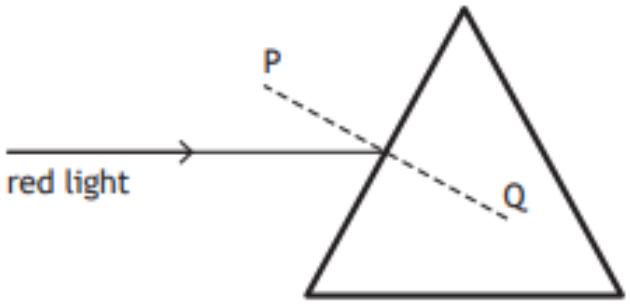
11. A student carries out an experiment to investigate the effect of different shaped glass blocks on the path of a ray of light.

(a) The student directs a ray of red light at a triangular glass block as shown.



(i) Complete the diagram above to show the path of the ray of red light through and out of the glass block. **2**

(An additional diagram, if required, can be found on *page 39*)

(ii) The diagram shows a dashed line PQ.

State the name given to this line. **1**

(iii) **On the diagram above**, label an angle of incidence *i*. **1**

(b) The student replaces the triangular glass block with a rectangular block made of the same material. The path of the ray of red light is as shown.

State whether the wavelength of the red light in this block is less than, the same as, or greater than the wavelength of the red light in the triangular glass block in (a).

Justify your answer. **2**

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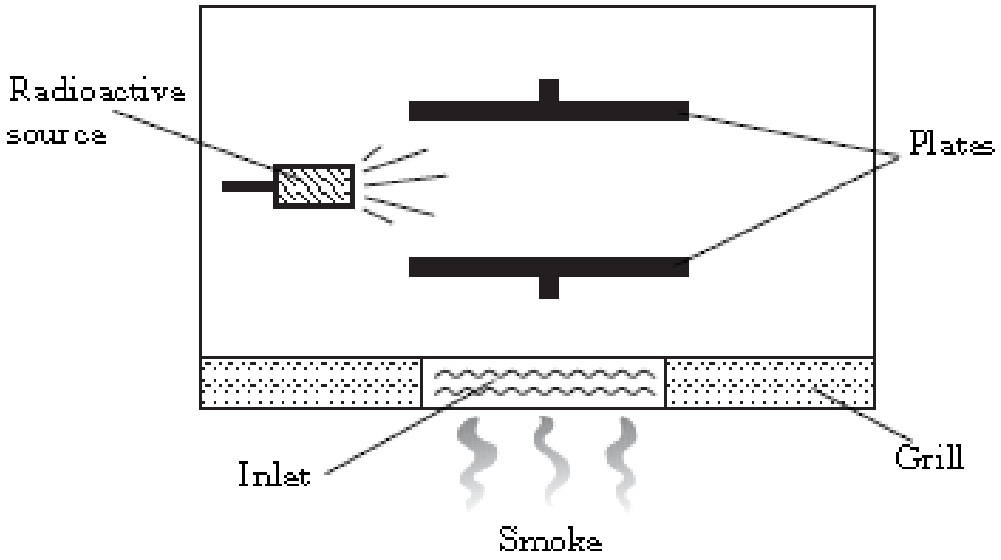
Introduction to Radiation

2007 Q 30 a

Marks

30. A simplified diagram of a smoke detector is shown. Radiation from the source causes ionisation of the air molecules between the plates. This produces a small current in a circuit. When smoke particles pass between the plates, the current decreases and a buzzer sounds.



(*a*) (i) What is meant by *ionisation*? **1**

(ii) Should the source be an alpha, beta or gamma emitter?
Explain your answer in terms of ionisation. **2**

(iii) A manufacturer is choosing a new source for its smoke detectors.
From the following information, select the most suitable source to use.
Explain your answer. **2**

Source	*Half-life* (years)	*Range* (metres)
W	1	0·05
X	10	2·0
Y	100	0·05
Z	1000	2·0

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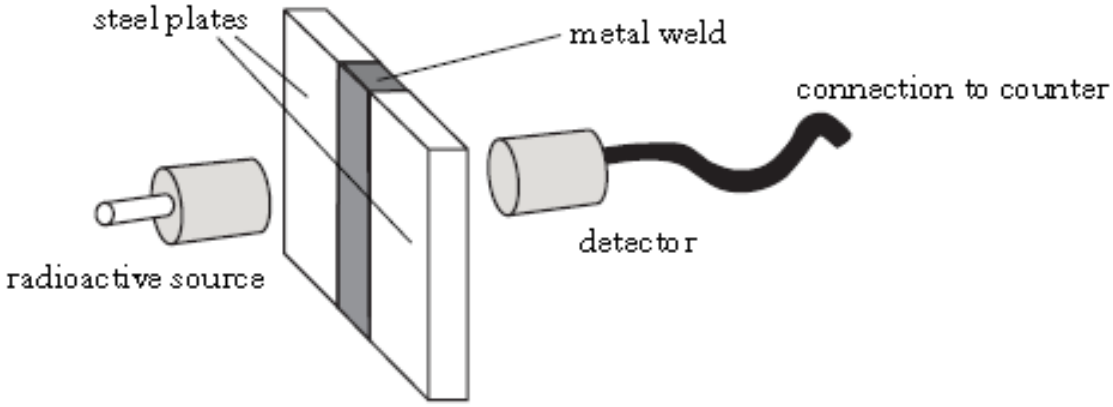
2008 Q 30

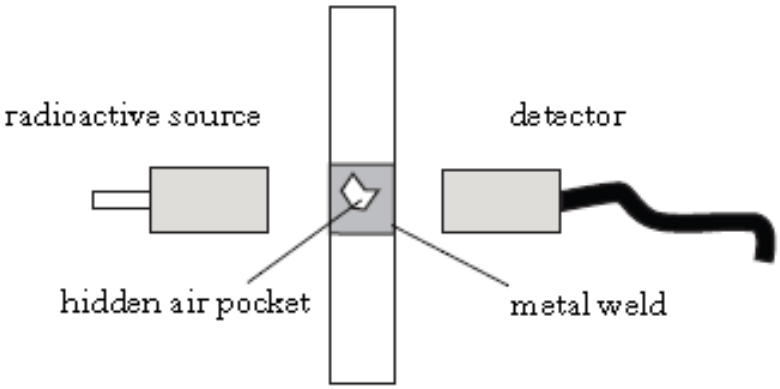
Marks

30. When welders join thick steel plates it is important that the joint is completely filled with metal. This ensures there are no air pockets in the metal weld, as this would weaken the joint.

One method of checking for air pockets is to use a radioactive source on one side of the joint. A detector placed as shown measures the count rate on the other side.



View from above



(*a*) The radioactive source and detector are moved along the weld. How would the count rate change when the detector moves over an air pocket?

Explain your answer. **2**

(*b*) Which of the radiations alpha, beta or gamma must be used?

Explain your answer. **2**

(*c*) X-rays are sometimes used to detect air pockets.

How does the wavelength of X-rays compare with gamma rays? **1**

(5)

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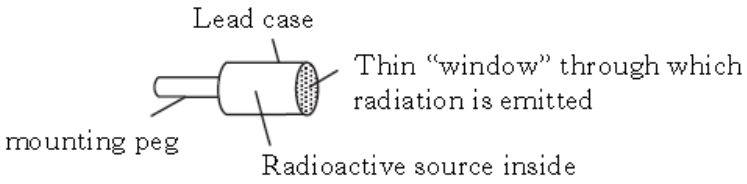
2009 Q 29 a

29. A radioactivity kit includes three radioactive sources each made up as shown.



Information about these sources is given in the table below.

	Radiation Emitted	*Radioactive Element*
Source 1	Alpha	Americium 241
Source 2	Beta	Strontium 90
Source 3	Gamma + Beta	Cobalt 60

(*a*) (i) Describe an experiment to show which is the alpha emitting source.

Your description must include:

- equipment used
- measurements taken
- an explanation of the results. **3**

(ii) The radioactive material in Source 3 emits both beta and gamma radiations. Describe how the window of the casing could be modified so that the beta radiation is stopped. **1**

2010 Q 29 a,b,e

29. In 1908 Ernest Rutherford conducted a series of experiments involving alpha particles.

(*a*) State what is meant by an alpha particle. **1**

(*b*) Alpha particles produce a greater ionisation density than beta particles or gamma rays. What is meant by the term *ionisation*? **1**

(*e*) Some sources emit alpha particles and are stored in lead cases despite the fact that alpha particles cannot penetrate paper. Suggest a possible reason for storing these sources using this method. **1**

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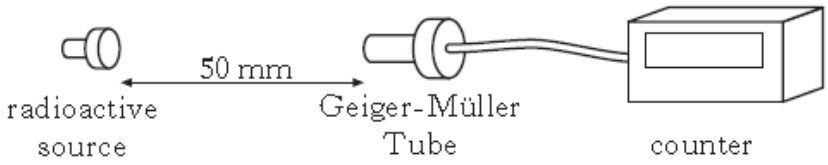
2011 Q 31 c,d,e,f

(*c*) Carbon-14 emits beta particles. What is a beta particle? **1**

(*d*) A radioactive source emits alpha particles. What is an alpha particle? **1**

(*e*) How does the ionisation density of alpha particles compare with that of beta particles? **1**

(*f*) (i) A student sets up an experiment as shown.



The student places a 3 mm sheet of aluminium between the radioactive source and the Geiger-Müller Tube. The count rate is observed to decrease and the student concludes that the radioactive material is emitting beta radiation.

Suggest **one** reason why her conclusion may be incorrect. **1**

(ii) State **two** safety precautions that the student must observe when handling radioactive sources. **2**

2014 Q 29 b,c

(*b*) The worker wears a badge containing photographic film.

Explain how this can indicate if the worker has been exposed to radiation. **1**

(*c*) X-rays can cause ionisation.

Explain what is meant by *ionisation*. **1**

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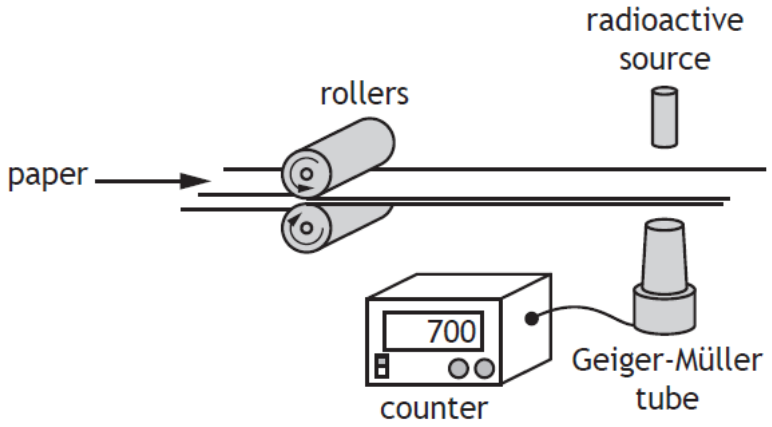
2015 Q 6 a,b

6. A paper mill uses a radioactive source in a system to monitor the thickness of paper. MARKS



Radiation passing through the paper is detected by the Geiger-Müller tube. The count rate is displayed on the counter as shown. The radioactive source has a half-life that allows the system to run continuously.

(a) State what happens to the count rate if the thickness of the paper decreases. **1**

(b) The following radioactive sources are available.

Radioactive Source	*Half-life*	*Radiation emitted*
W	600 years	alpha
X	50 years	beta
Y	4 hours	beta
Z	350 years	gamma

(i) State which radioactive source should be used.

You **must** explain your answer. **3**

2017 Q 5

5. Alpha, beta and gamma are types of nuclear radiation, which have a range of properties and effects.

Using your knowledge of physics, comment on the similarities and/or differences between these types of nuclear radiation. **3**

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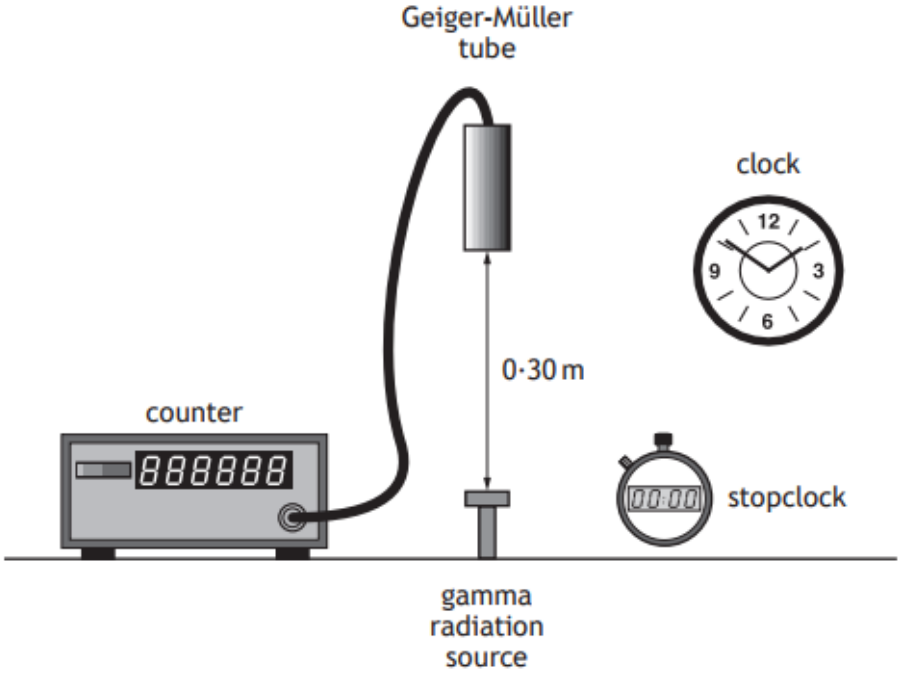
2018 Q 13 a

13. A technician carries out an experiment, using the apparatus shown, to determine the half-life of a gamma radiation source.



(a) Before carrying out the experiment the technician measures the background count rate.

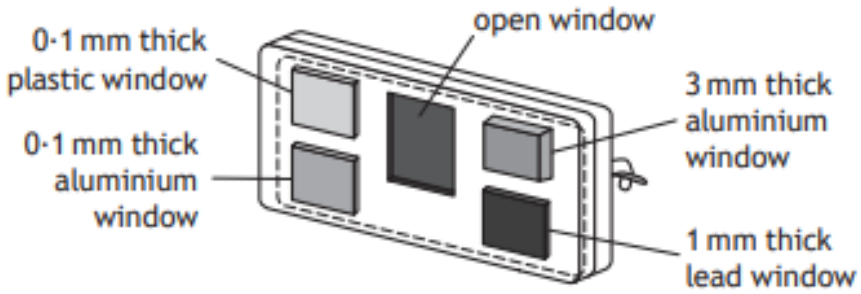
(i) Explain why this measurement is made. **1**

(ii) State a source of background radiation. **1**

2019 Q 12 d

(d) The technician wears a film badge to monitor exposure to radiation.

The film badge contains a piece of photographic film behind windows of different materials.



Explain how this badge is used to determine the type of radiation the technician has been exposed to. **2**

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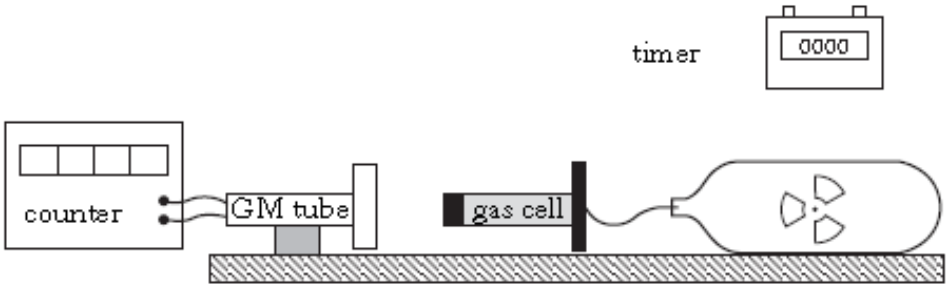
Activity, Half Life & Safety

2007 Q 31

Marks

31. An experiment is carried out in a laboratory to determine the half-life of a radioactive source. A Geiger-Müller 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 10 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 count rate. **2**

(*b*) Calculate the activity of the background radiation. **2**

(*c*) Calculate the half-life of the radioactive source. **2**

(6)

2008 Q 31 a,b,c

31. Gold-198 is a radioactive source that is used to trace factory waste which may cause river pollution.

A small quantity of the radioactive gold is added into the waste as it enters the river. Scanning the river using radiation detectors allows scientists to trace where the waste has travelled.

Gold-198 has a half-life of 2·7 days.

(*a*) What is meant by the term "half-life"? **1**

(*b*) A sample of Gold-198 has an activity of 64 kBq when first obtained by the scientists.

Calculate the activity after 13·5 days. **2**

(*c*) Describe two precautions taken by the scientists to reduce the equivalent dose they receive while using radioactive sources. **2**

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2009 Q 29 b

(*b*) Strontium 90 has a half life of 28 years. Calculate how many years it takes for the activity to decrease to 1/16th of its original value. **2**

2010 Q 29 c,d

(*c*) A radioactive source emits alpha particles and has a half-life of 2·5 hours. The source has an initial activity of 4·8 kBq.

Calculate the time taken for its activity to decrease to 300 Bq. **2**

(*d*) Calculate the number of decays in the sample in two minutes, when the activity of the source is 1·2 kBq. **2**

2011 Q 31 a,b

31. It is possible to determine the age of a prehistoric wooden boat by measuring the activity of radioactive carbon-14.

The activity of a piece of wood from the boat is 300 μBq.

(*a*) How many atoms of carbon-14 decay in 1 day? **2**

(*b*) When the boat was carved, the activity of the piece of wood was 2400 μBq due to carbon-14 atoms. The half-life of carbon-14 is 5730 years. Calculate the age of the boat. **2**

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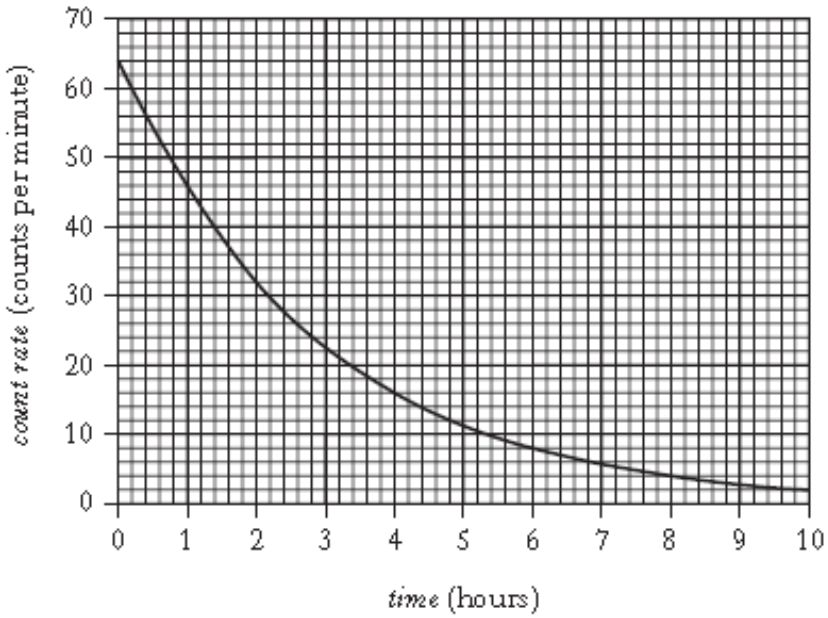
2012 Q 29 a

29. A technician checks the count rate of a radioactive source. A graph of count rate against time for the source is shown. The count rate has been corrected for background radiation.



(*a*) Use the graph to determine the half-life of the source. **2**

2013 Q 30 c

(*c*) In another medical procedure, a radioactive chemical is injected into a patient.

The chemical is prepared by the technician from a source which has an activity of 320 MBq.

The source has a half-life of 6 hours.

Calculate the activity of the source 18 hours later. **2**

2014 Q 30 d

(*d*) Radioactive caesium is a waste product of the fission reaction.

Caesium has a half-life of 30 years.

(i) A caesium sample was removed from the reactor on 1 January 1954. On 1 January 2014 the activity of the sample was 4×10^{12} Bq. Calculate the activity of the sample on 1 January 1954. **2**

(ii) Calculate how many nuclei would decay during a 5 minute period when the sample has an activity of 4×10^{12} Bq. **2**

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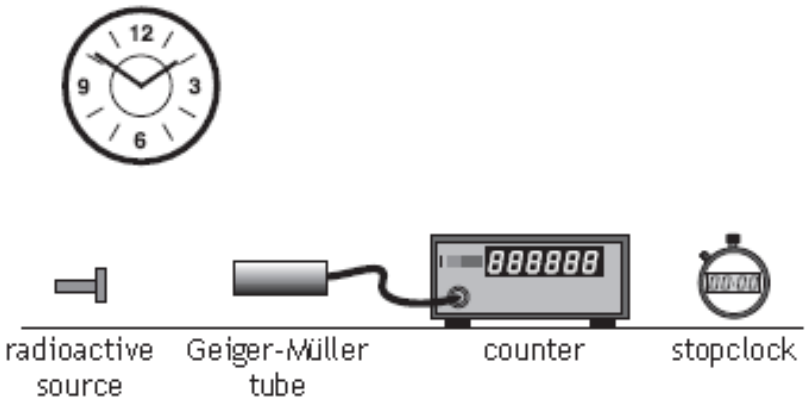
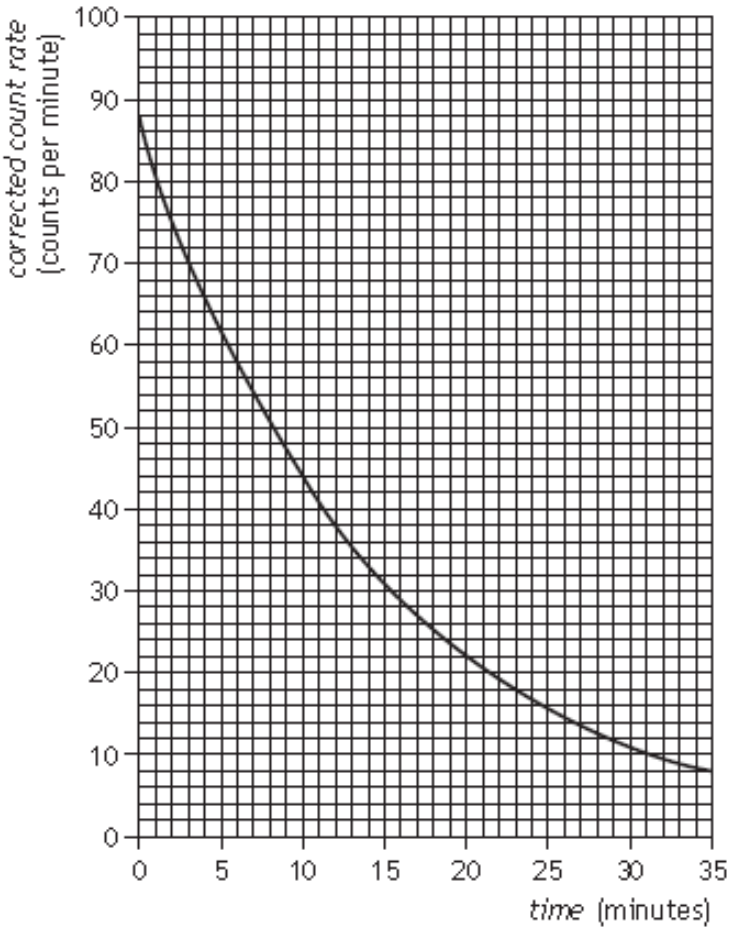
2014 Q 6

6. A technician carries out an experiment, using the apparatus shown, to determine the half-life of a radioactive source.



(a) State what is meant by the term *half-life*. **1**

(b) The technician displays the data obtained from the experiment in the graph below.



(i) Describe how the apparatus could be used to obtain the experimental data required to produce this graph. **3**

(ii) Use information from the graph to determine the half-life of the radioactive source. **1**

(iii) Determine the corrected count rate after 40 minutes. **2**

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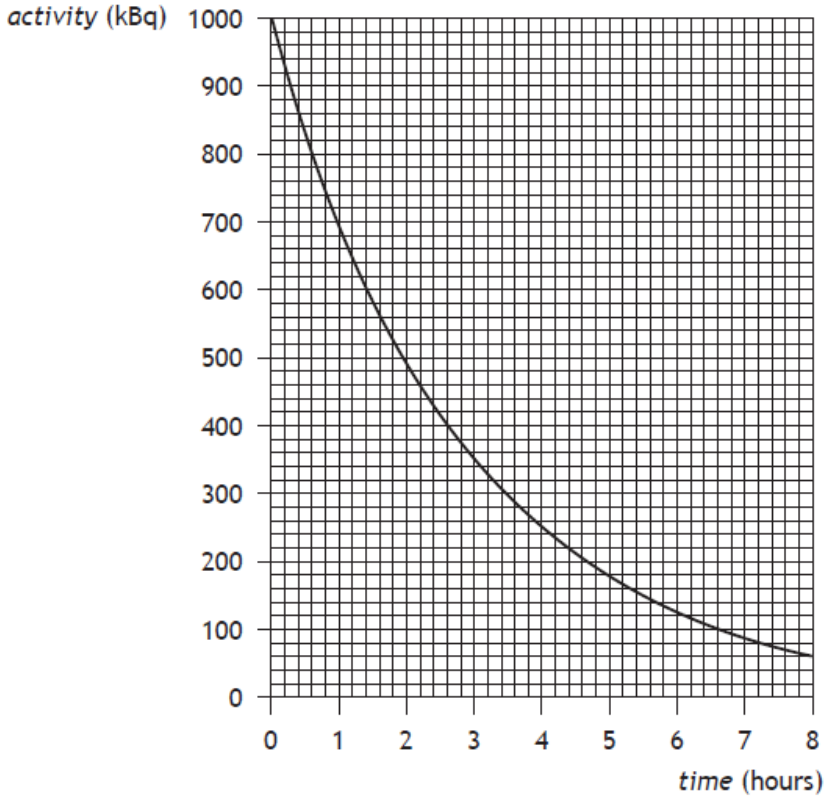
2015 Q 6 c

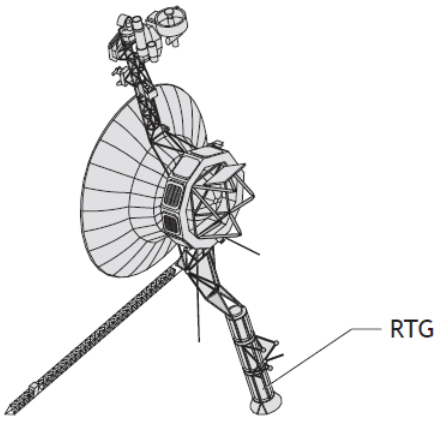
(c) The graph below shows how the activity of another radioactive source varies with time.



Determine the half-life of this radioactive source. 1

2016 Q 7 a

7. A spacecraft uses a radioisotope thermoelectric generator (RTG) as a power source.



The RTG transforms the heat released by the radioactive decay of plutonium–238 into electrical energy.

(a) In 15 minutes, $7{\cdot}92 \times 10^{18}$ nuclei of plutonium-238 decay.

Calculate the activity of the plutonium-238. 3

Space for working and answer

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2016 Q 8 b

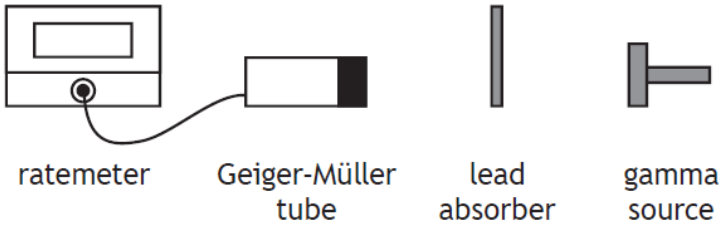
(b) The beta source used during testing has a half-life of 36 hours.

The initial activity of the beta source is 12 kBq.

Determine the activity of the source 144 hours later. 3

2017 Q 6 a,b

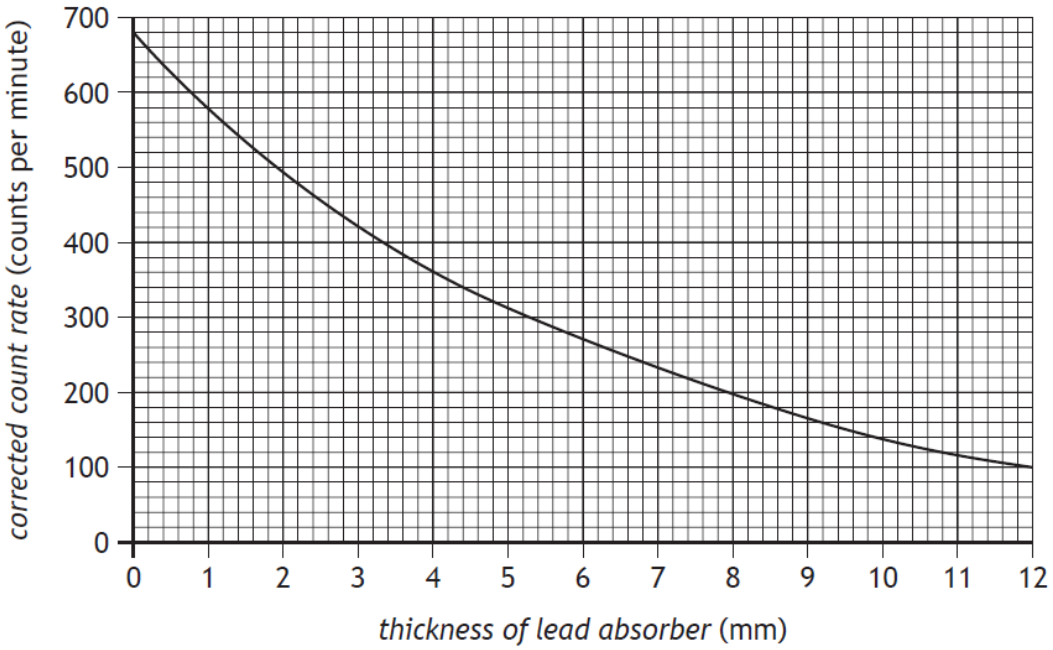
6. A technician uses the apparatus shown to investigate the effect of shielding gamma radiation with lead.



Gamma radiation passing through a lead absorber is detected by a Geiger-Müller tube. The count rate is displayed on the ratemeter.

The count rates for a range of different thicknesses of lead absorber are recorded.

Using these results the technician produces a graph of corrected count rate against thickness of lead absorber as shown.



(a) State what additional measurement the technician must have made in order to determine the corrected count rate. 1

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2017 Q 6 a,b continued

(b) The half-value thickness of a material is the thickness of material required to reduce the corrected count rate from a source by half.

(i) Using the graph, determine the half-value thickness of lead for this source of gamma radiation. **1**

(ii) Determine the thickness of lead required to reduce the corrected count rate to one eighth of its initial value. **2**

Space for working and answer

(iii) The technician suggests repeating the experiment with aluminium absorbers instead of lead absorbers.

Predict how the half-value thickness of aluminium would compare to the half-value thickness of lead for this source. **1**

2017 Q 7 a

7. Nuclear reactions are used to generate electrical energy in a nuclear power station.

(a) The fuel for the power station is in the form of pellets, containing uranium-235.

A fuel pellet has an activity of 80 kBq.

State what is meant by an *activity of 80 kBq*. **1**

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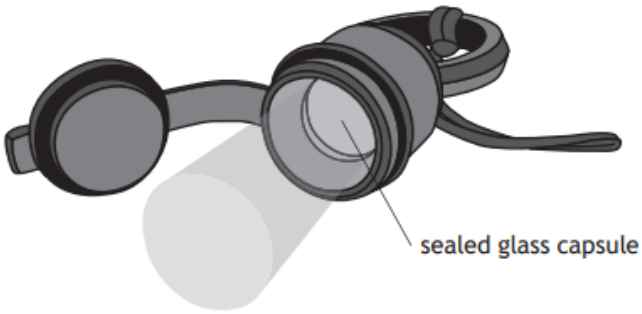
2018 Q 12 b

12. A tritium torch includes a sealed glass capsule containing radioactive tritium gas.



Beta particles emitted by the tritium gas are absorbed by a coating on the inside of the glass capsule.

The coating then emits visible light.

(a) State what is meant by a *beta particle*. **1**

(b) The half-life of tritium gas is 12·3 years.

The manufacturer states that the torch will work effectively for 15 years.

Explain why the torch will be less effective after this time. **2**

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2018 Q 13 b,c

13. (continued) MARKS

(b) The technician's results are shown in the table.

Time (minutes)	*Corrected count rate* (counts per minute)
0	680
20	428
40	270
60	170
80	107
100	68

(i) Using the graph paper below, draw a graph of these results. **3**

(ii) Use your graph to determine the half-life of the gamma radiation source. **1**

(c) The technician repeats the experiment with an alpha radiation source.

(i) Suggest a change the technician must make to the experimental set-up to determine the half-life of the alpha radiation source.

Justify your answer. **2**

(ii) During the first 15 s of the experiment the alpha radiation source has an average activity of 520 Bq.

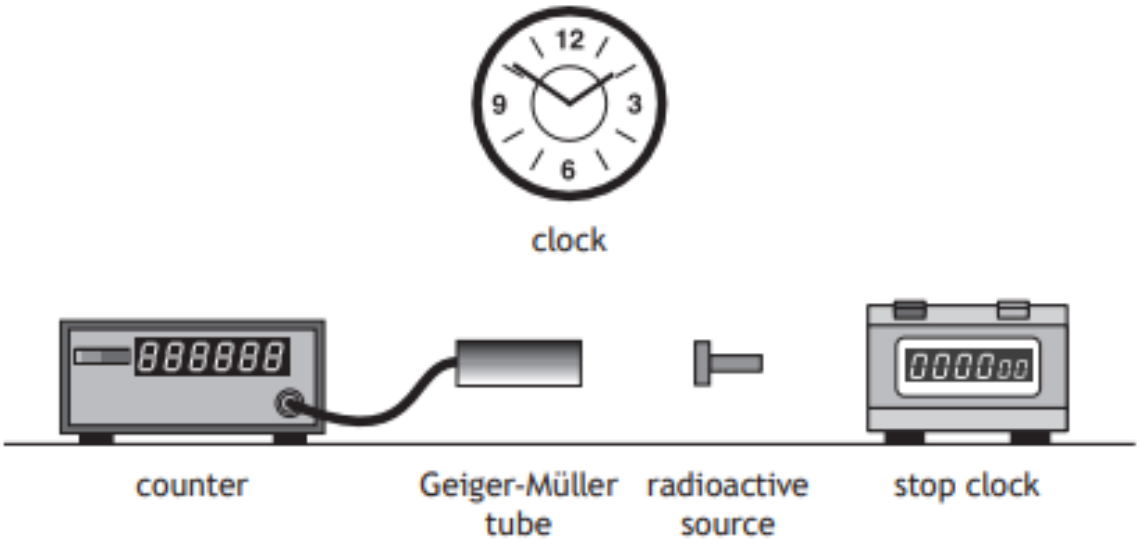
Calculate the number of nuclear disintegrations that occur in the source in the first 15 s of the experiment. **3**

Space for working and answer

Return to Contents Page

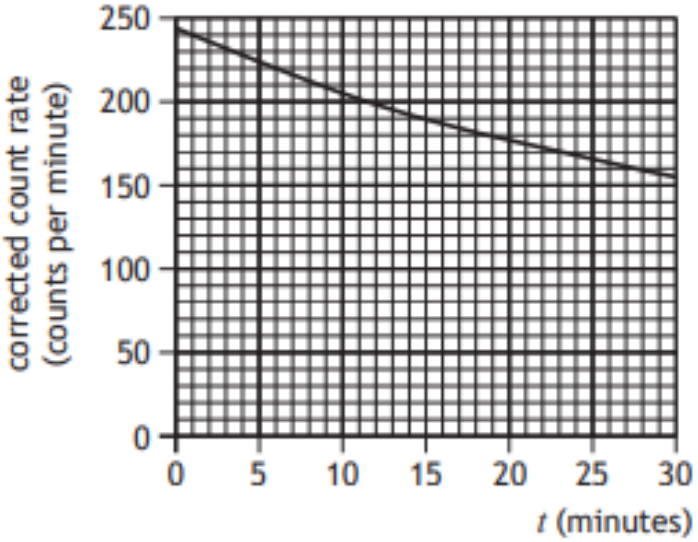
2019 Q 12 a, b

12. A technician carries out an experiment, using the apparatus shown, to determine the half-life of a radioactive source.



(a) Describe how the apparatus can be used to determine the half-life of the radioactive source. **3**

(b) The technician carries out the experiment over a period of 30 minutes, and displays the data obtained in a graph as shown.



Suggest an improvement that the technician could make to the procedure to more easily determine a value for the half-life of this source. **1**

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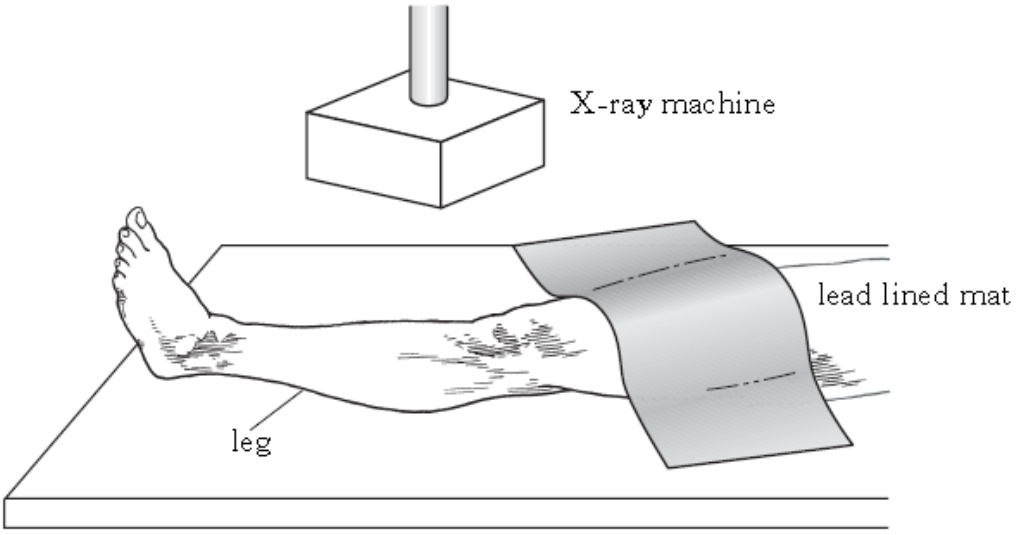
Dosimetry

2007 Q 29

29. A football player injures his leg while playing in a match.



In hospital the player has three X-rays, each producing an absorbed dose of 50 μGy.

(*a*) The mass of the player's leg is 6 kg. Calculate the energy absorbed by the leg from the X-rays. **2**

(*b*) Why is the rest of the player's leg covered with a lead lined mat? **1**

(*c*) Apart from absorbed dose, name **one** other factor that contributes to biological harm. **1**

2008 Q 31 d

(*d*) A scientist receives an absorbed dose of 10 mGy of alpha radiation.

(i) Calculate the equivalent dose received. **2**

(ii) 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? **1**

(8)

2009 Q 29 c

(*c*) (i) A technician working with Source 1 receives an absorbed dose of 20 μGy of alpha particles. Calculate the total equivalent dose received by the technician. **2**

(ii) Describe two ways in which the technician could reduce his absorbed dose. **2**

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2012 Q 30 a

30. An ageing nuclear power station is being dismantled.

(*a*) During the dismantling process a worker comes into contact with an object that emits 24 000 alpha particles in five minutes. The worker's hand has a mass of 0·50 kg and absorbs 6·0 μJ of energy.

Calculate:

(i) the absorbed dose received by the worker's hand; **2**

(ii) the equivalent dose received by the worker's hand; **2**

(iii) the activity of the object. **2**

2013 Q 30 a,b

30. A hospital radiographer calculates the equivalent dose of radiation absorbed by a patient. This is done by multiplying the absorbed dose by a radiation weighting factor.

(*a*) State what is meant by a radiation weighting factor. **1**

(*b*) During a scan of the patient's brain, the absorbed dose is measured as 1·5 mGy. The mass of the brain is 1·4 kg.

Calculate the energy absorbed by the brain during the scan. **2**

2017 Q 6 c

(c) When working with the radioactive source the technician is exposed to an equivalent dose rate of $2{\cdot}5 \times 10^{-6}$ Sv h^{-1}.

The annual equivalent dose limit for the technician is 20 mSv.

Calculate the maximum number of hours the technician may work with this source without exceeding this limit. **3**

Space for working and answer

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2014 Q 8 a

8. An airport worker passes suitcases through an X-ray machine.

(a) The worker has a mass of 80·0 kg and on a particular day absorbs 7·2 mJ of energy from the X-ray machine.

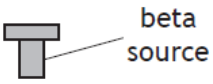
(i) Calculate the absorbed dose received by the worker. **3**

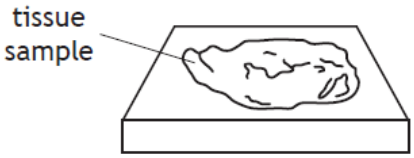
(ii) Calculate the equivalent dose received by the worker. **3**

2016 Q 8 a

8. During medical testing a beta source is used to irradiate a sample of tissue of mass 0·50 kg from a distance of 0·10 m.

The sample absorbs $9{\cdot}6 \times 10^{-5}$ J of energy from the beta source.





(a) (i) Calculate the absorbed dose received by the sample. 3

Space for working and answer

(ii) Calculate the equivalent dose received by the sample. 3

Space for working and answer

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2017 Q 6 c

(c) When working with the radioactive source the technician is exposed to an equivalent dose rate of $2{\cdot}5 \times 10^{-6}\,\text{Sv}\,\text{h}^{-1}$.

The annual equivalent dose limit for the technician is 20 mSv.

Calculate the maximum number of hours the technician may work with this source without exceeding this limit. **3**

2018 Q 12 c

(c) During the manufacturing process a glass capsule cracks and a worker receives an absorbed dose of 0·40 mGy throughout their body from the tritium gas.

The mass of the worker is 85 kg.

(i) Calculate the energy of the radiation absorbed by the worker. 3

(ii) Calculate the equivalent dose received by the worker. 3

2019 Q 12 c

(c) In a second experiment, the technician absorbs 1·2 μJ of energy throughout their body from a radioactive source.

The mass of the technician is 80·0 kg.

(i) Calculate the absorbed dose received by the technician. 3

(ii) During the experiment, the technician receives an equivalent dose of $4{\cdot}5 \times 10^{-8}$ Sv.

Calculate the radiation weighting factor of this source. 3

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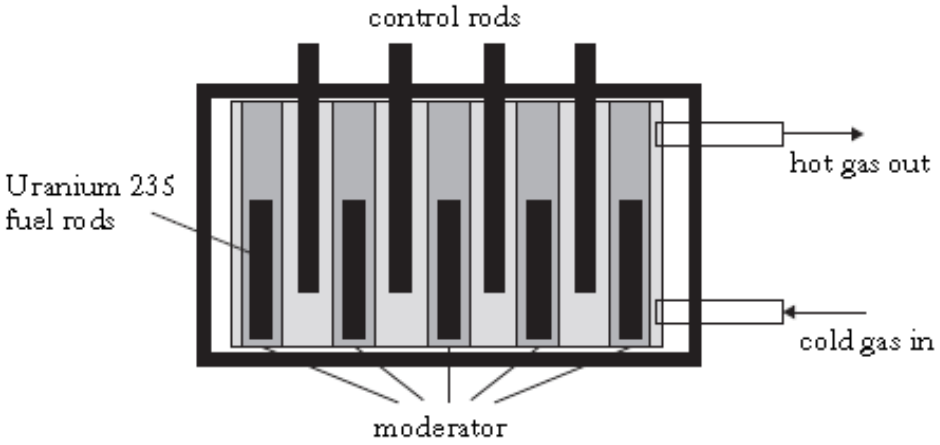
Applications of Radiation

2010 Q 30

30. Many countries use nuclear reactors to produce energy. A diagram of the core of a nuclear reactor is shown.



(*a*) State the purpose of:

(i) the moderator; **1**

(ii) the control rods. **1**

(*b*) One nuclear fission reaction produces $2{\cdot}9 \times 10^{-11}$ J of energy. The power output of the reactor is 1·4 GW. How many fission reactions are produced in one hour? **3**

(*c*) State **one advantage** and **one disadvantage** of using nuclear power for the generation of electricity. **2**

2012 Q 30 b,c

(*b*) In a nuclear reactor, state the purpose of:

(i) the moderator; 1

(ii) the containment vessel. 1

(*c*) What type of nuclear reaction takes place in a nuclear power station' s reactor? 1

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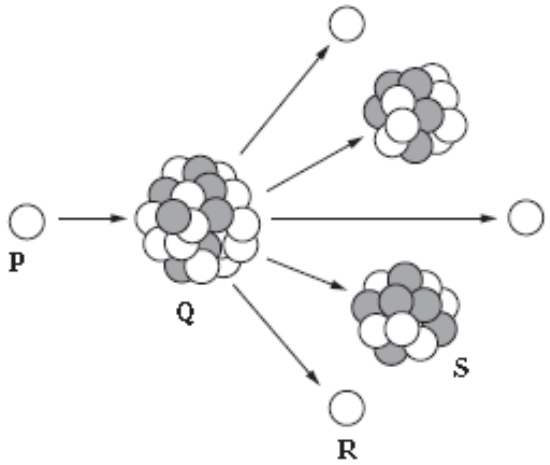
2013 Q 31

31. (*a*) A student is researching information on nuclear reactors.

The following diagram is found on a website.

It illustrates a type of reaction that takes place in a reactor.



(i) What type of nuclear reaction is shown in the diagram? **1**

(ii) The labels have been omitted at positions **P**, **Q**, **R** and **S** on the diagram.

State clearly what each of these labels should be. **2**

(*b*) Name the part of the reactor whose function is to prevent release of radiation beyond the reactor. **1**

(*c*) Disposal of some types of radioactive waste from nuclear reactors is particularly difficult.

Give a reason for this difficulty. **1**

(*d*) Electricity can be generated using fossil fuels or nuclear fuel.

State one advantage of using nuclear fuel. **1**

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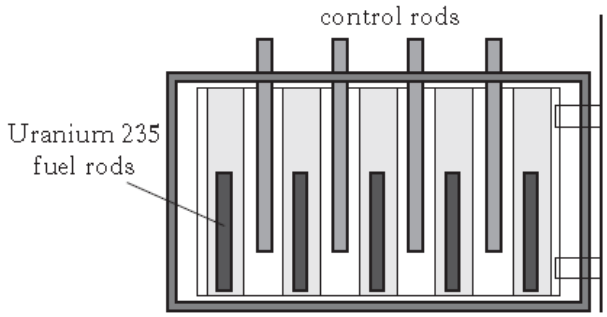
2014 Q 30 a

30. A nuclear reactor in a submarine uses uranium fuel rods. During a chain reaction uranium nuclei undergo nuclear fissions in the reactor.



(*a*) The reactor is fitted with boron control rods.

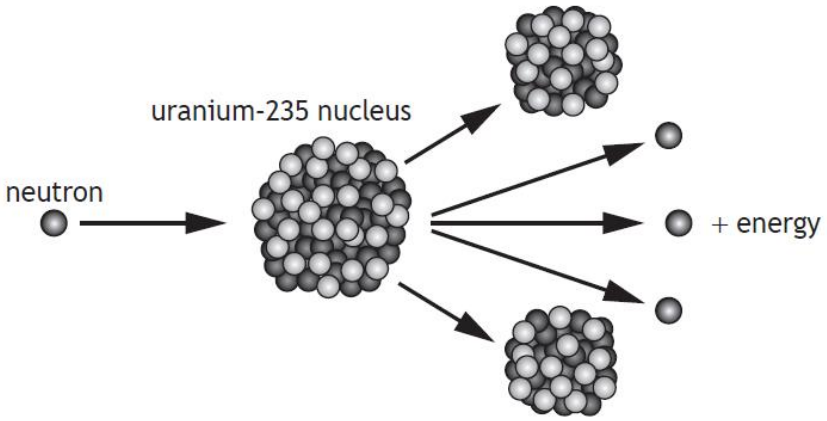
These can be lowered into the reactor.

What effect does this have on the chain reaction?

You **must** explain your answer. 2

2017 Q 7 b,c

(b) In a nuclear reaction a uranium-235 nucleus is split by a neutron to produce two smaller nuclei, three neutrons, and energy.



(i) Explain how a single reaction can lead to the continuous generation of energy. **2**

(ii) One nuclear reaction releases $3{\cdot}2 \times 10^{-11}$ J.

In the reactor, $3{\cdot}0 \times 10^{21}$ reactions occur each minute.

Determine the maximum power output of the reactor. **4**

Space for working and answer

(c) The nuclear reactor produces waste that emits nuclear radiation.

State a use of nuclear radiation. **1**

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13. A physics teacher makes the following statement.

'Instead of nuclear fission, perhaps one day nuclear fusion will become a practical source of generating energy.'

Using your knowledge of physics, comment on the similarities and/or differences between using nuclear fission and nuclear fusion to generate energy. **3**

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