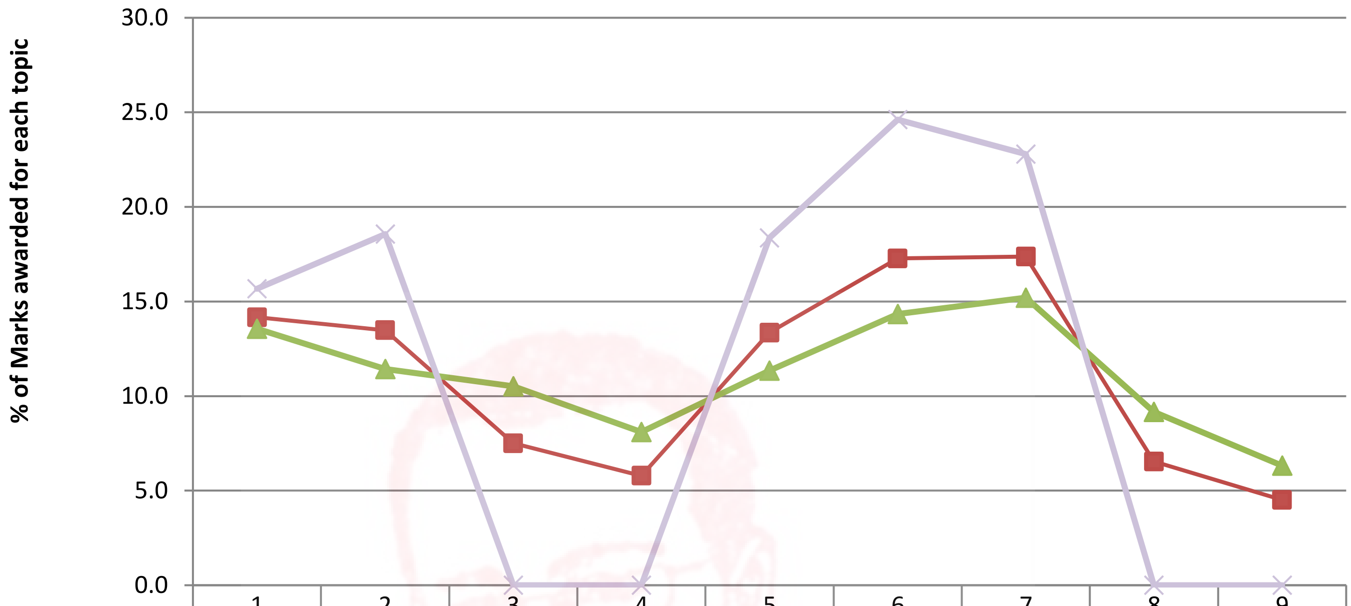
Name

iG Phx 6 EQ 14w to 02w P3 4Students 297marks

For these stats only papers 3 (which after 2016 became paper 4) and paper 6 were used to examine the topics.

iG Phx CIE 0625 PAPERS 3 and 6

Percentage of all WEIGHTED marks awarded for P3 & 6 each topic from s2002 to w2014 (red squares) and % of Paper 3 marks (green triangles) and paper 6 (purple crosses)

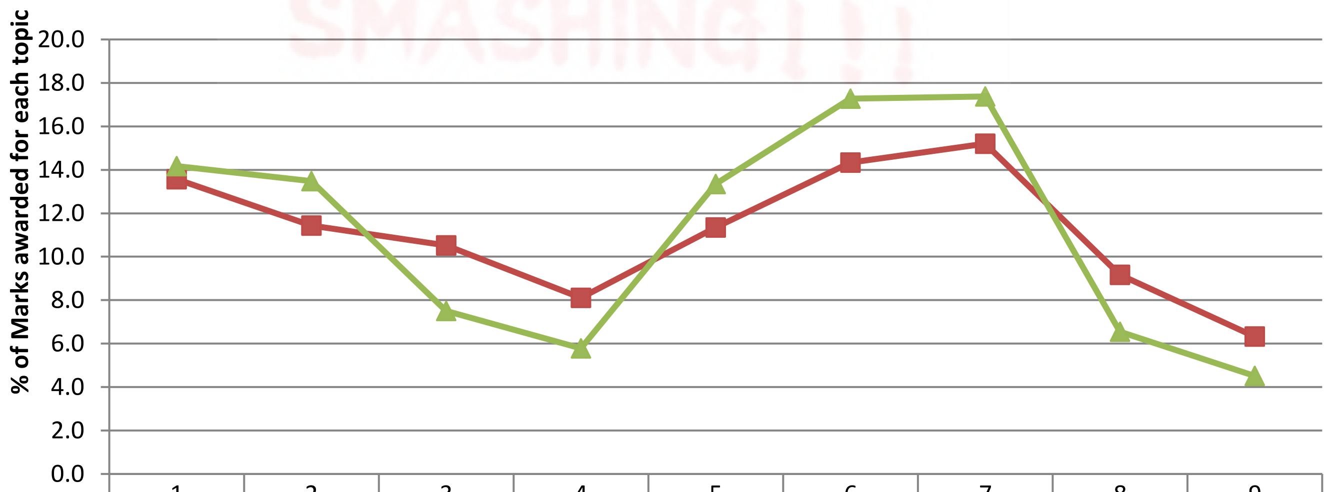


	1	2	3	4	5	6	7	8	9
PhxBoth P3&6	14.2	13.5	7.5	5.8	13.4	17.3	17.4	6.5	4.5
PhxP3	13.6	11.4	10.5	8.1	11.3	14.3	15.2	9.2	6.3
PhxP6	15.7	18.6	0.0	0.0	18.4	24.6	22.8	0.0	0.0

Papers 3 and 6 Topic Number

PAPER 3

Percentage of all marks awarded for each topic from s2002 to w2014 in Paper 3 (red squares) and marks per topic for papers 3 and 6 (green triangles)



	1	2	3	4	5	6	7	8	9
ALL P3 %	13.6	11.4	10.5	8.1	11.3	14.3	15.2	9.2	6.3
P3 & 6	14.2	13.5	7.5	5.8	13.4	17.3	17.4	6.5	4.5

Paper 3 Topic Number

Papers covered in this sample

	1st Paper	Last Paper	Marks/ paper	Theor. All Papers	Actual All Marks	Difference	Difference %	Weight per paper	Weight per mark
Paper 3	2002w	2014w	80	2000	2072	72	3.6	50	0.63
Paper 6	2002s	2015w	40	1120	1040	-80	-7.1	20	0.50

There are a few missing:

Got all Paper 31s (except 2014w Paper 31), and got 2014w 33

So papers in time zones 2 and 3 are not covered.

All topics ranked by frequency of marks in exams (P3 and 6 only)

Topic	PhxBoth P3&6	PhxP3	PhxP6
7	17.4	15.2	22.8
6	17.3	14.3	24.6
1	14.2	13.6	15.7
2	13.5	11.4	18.6
5	13.4	11.3	18.4
3	7.5	10.5	0.0
8	6.5	9.2	0.0
4	5.8	8.1	0.0
9	4.5	6.3	0.0

Other statistics that might be of interest:

	Topics:	1	2	3	4	5	6	7	8	9
P3/4 marks	2072	281	237	218	168	235	297	315	190	131
P3/4 %		13.6	11.4	10.5	8.1	11.3	14.3	15.2	9.2	6.3
P6	1040	163	193	0	0	191	256	237	0	0
P6 %		15.7	18.6	0.0	0.0	18.4	24.6	22.8	0.0	0.0
Total Marks (WIEGHTED)	1815	257	245	136	105	242	314	315	119	82
% of Marks (Weighted)	1815	14.2	13.5	7.5	5.8	13.4	17.3	17.4	6.5	4.5
# of Questions		63	64	35	16	63	74	70	26	20
Average marks per Q		**4.1**	**3.8**	**3.9**	**6.6**	**3.8**	**4.2**	**4.5**	**4.6**	**4.1**

Final note:

My iG and IB chemistry papers were broken down more carefully than these were, so there may be a mark or two in the wrong topic especially in topics 3 to 5, but if you learnt or taught these topics in sequence than you shouldn't have a problem with seeing material from an earlier topic.

Defining the Topics: Why not use the units given in the syllabus?

Artificial topics have been created for the physics syllabus by me so that each topic is roughly the same size. Topics go in syllabus order. I have decided to use the number of marks allocated in previous exams to each syllabus point to determine how many go into each topic.

1. General physics

Topic 1

1.1 Length and time
1.2 Motion
1.3 Mass and weight
1.4 Density

Topic 2

1.5 Forces
1.6 Momentum (Extended candidates only)

Topic 3

1.7 Energy, work and power
1.8 Pressure

2. Thermal physics

Topic 4

2.1 Simple kinetic molecular model of matter

Topic 5

2.2 Thermal properties and temperature
2.3 Thermal processes

3. Properties of waves, including light and sound

Topic 6

3.1 General wave properties
3.2 Light
3.3 Electromagnetic spectrum
3.4 Sound

4. Electricity and magnetism

Topic 7

4.1 Simple phenomena of magnetism
4.2 Electrical quantities
4.3 Electric circuits
4.4 Digital electronics (Extended candidates only)
4.5 Dangers of electricity

Topic 8

4.6 Electromagnetic effects

5. Atomic physics

Topic 9

5.1 The nuclear atom
5.2 Radioactivity

8 **(a)** Draw a straight line from each quantity on the left-hand side to a speed on the right-hand side which is typical for that quantity.

	30 m/s
speed of sound in gas	300 m/s
	3000 m/s
speed of sound in solid	30 000 m/s
	300 000 m/s

[2]

(b) Explain why sound waves are described as *longitudinal*.

....

.... [2]

(c) Fig. 8.1 shows how the displacement of air molecules, at an instant of time, varies with distance along the path of a sound wave.

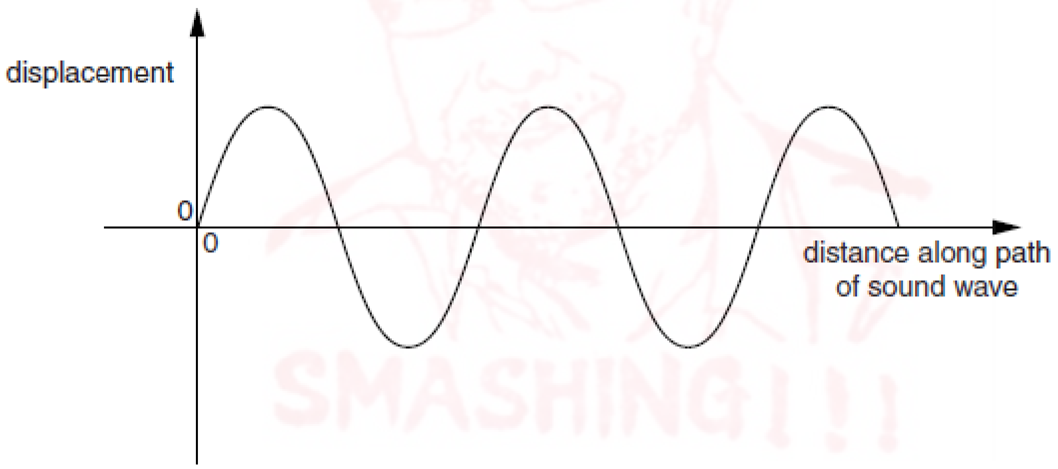


Fig. 8.1

(i) On Fig. 8.1, sketch two cycles of a sound wave that has a shorter wavelength **and** a greater amplitude. [2]

(ii) State **two** changes in the sound heard from this wave compared with the original wave.

1. ....

2. ....

[2]

[Total: 8]

7 **(a)** Fig. 7.1 shows the surface of water in a tank.

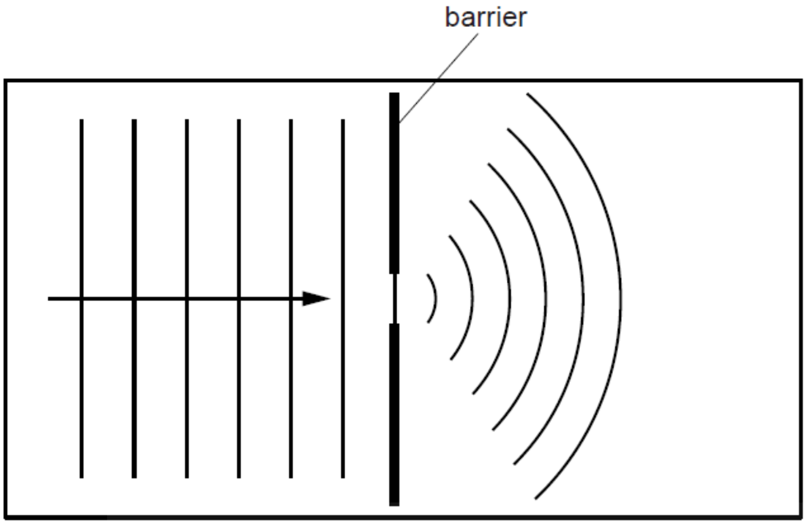


Fig. 7.1

Straight wavefronts are produced at the left-hand end of the tank and travel towards a gap in a barrier. Curved wavefronts travel away from the gap.

(i) Name the process that causes the wavefronts to spread out at the gap.

.... [1]

(ii) Suggest a cause of the reduced spacing of the wavefronts to the right of the barrier.

.... [1]

(iii) State how the pattern of wavefronts to the right of the barrier changes when the gap is made narrower.

.... [1]

(b) Fig. 7.2 shows a wave travelling, in the direction of the arrow, along a rope.

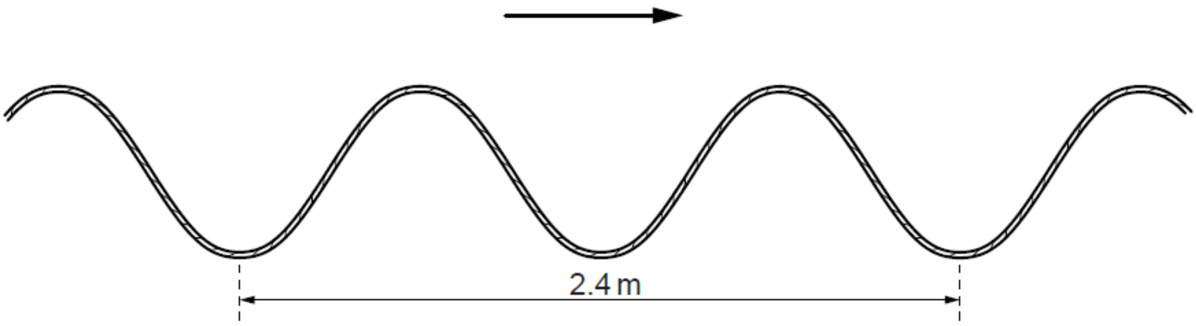


Fig. 7.2

(i) Explain why the wave shown in Fig. 7.2 is described as a *transverse* wave.

....

.... [1]

(ii) The speed of the wave along the rope is 3.2 m / s.

Calculate the frequency of the wave.

frequency = ... [3]

[Total: 7]

7 Fig. 7.1 shows the principal axis PQ of a converging lens and the centre line XY of the lens.

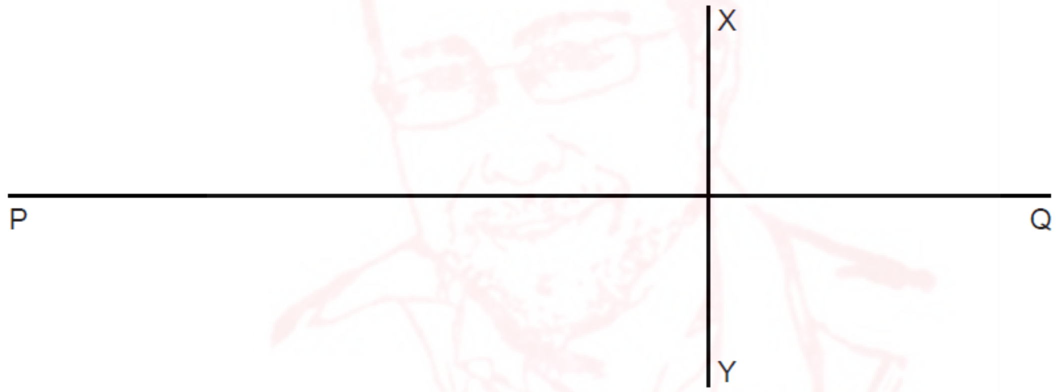


Fig. 7.1

An object 2.0 cm high is placed 2.0 cm to the left of the lens. The converging lens has a focal length of 3.0 cm.

(a) On Fig. 7.1, draw a full-scale diagram to find the distance of the image from the lens, and the height of the image.

distance of image from the lens = ...

height of image = ...
[5]

(b) State and explain whether the image in **(a)** is real or virtual.

....

....[1]

[Total: 6]

8 **(a)** State the range of frequencies of sound which can be heard by a healthy human ear.

.... [1]

(b) Compressions and rarefactions occur along the path of sound waves.

State, in terms of the behaviour of molecules, what is meant by

(i) a *compression*,

....

....

(ii) a *rarefaction*.

....

....

[2]

(c) State the effect on what is heard by a listener when there is

(i) an increase in the amplitude of a sound,

.... [1]

(ii) a decrease in the wavelength of a sound.

.... [1]

(d) A student carries out an experiment to find the speed of sound in air.

He stands facing a high cliff and shouts. He hears the echo 1.9 s later.

He then walks 250 m further away from the cliff and shouts again, hearing the echo 3.5 s later.

Calculate the speed of sound given by this experiment.

speed = ... [3]

[Total: 8]

8 **(a)** A ray of light in air travels across a flat boundary into glass. The angle of incidence is 51°. The angle of refraction is 29°.

(i) In the space below, draw a labelled diagram to illustrate this information. [3]

(ii) Calculate the refractive index of the glass.

refractive index = ... [2]

(b) A ray of light in glass travels towards a flat boundary with air. The angle of incidence is 51°. This ray does not emerge into the air.

State and explain what happens to this ray.

....

....

....

.... [2]

[Total: 7]

6 **(a)** Fig. 6.1 shows the position of layers of air, at one moment, as a sound wave of constant frequency passes through the air. Compressions are labelled C. Rarefactions are labelled R.

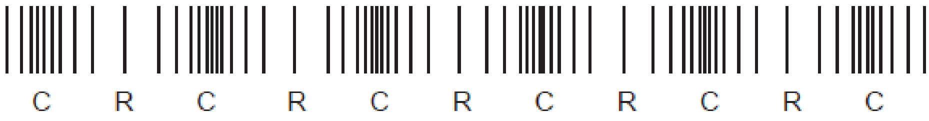


Fig. 6.1

(i) State how Fig. 6.1 would change if

1. the sound had a higher frequency,

....[1]

2. the sound were louder.

....

....

....[2]

(ii) On Fig. 6.1, draw a line marked with arrows at each end to show the wavelength of the sound. [1]

(b) In an experiment to measure the speed of sound in steel, a steel pipe of length 200 m is struck at one end with a hammer. A microphone at the other end of the pipe is connected to an accurate timer. The timer records a delay of 0.544 s between the arrival of the sound transmitted by the steel pipe and the sound transmitted by the air in the pipe.

The speed of sound in air is 343 m / s. Calculate the speed of sound in steel.

speed of sound in steel = ...[3]

[Total: 7]

7 (a) Fig. 7.1 shows a ray of monochromatic red light, in air, incident on a glass block at an angle of incidence of 50°.

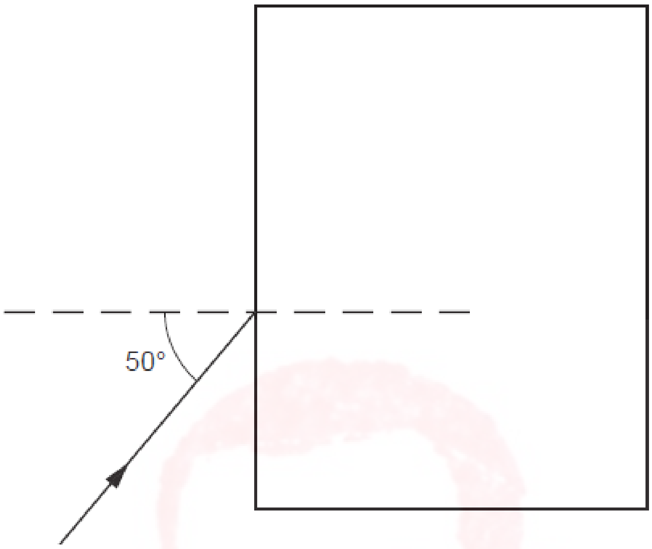


Fig. 7.1

(i) State what is meant by *monochromatic* light.

....[1]

(ii) For this red ray the refractive index of the glass is 1.52. Calculate the angle of refraction for the ray.

angle of refraction = ...[2]

(iii) Without measuring angles, use a ruler to draw the approximate path of the ray in the glass block and emerging from the block. [2]

(b) The red ray in Fig. 7.1 is replaced by a ray of monochromatic violet light. For this violet ray the refractive index of the glass is 1.54. The speed of light in air is 3.00×10^8 m/s.

(i) Calculate the speed of the violet light in the glass block.

speed = ...[2]

(ii) Use a ruler to draw the approximate path of this violet ray in the glass block and emerging from the block. Make sure this path is separated from the path drawn for the red light in **(a)(iii)**. Mark both parts of this path with the letter V. [2]

[Total: 9]

7 **(a)** The speed of light in air is known to be 3.0×10^8 m/s.

Outline how you would use a refraction experiment to deduce the speed of light in glass. You may draw a diagram if it helps to clarify your answer.

....

....

....

....

....

....[4]

(b) A tsunami is a giant water wave. It may be caused by an earthquake below the ocean.

Waves from a certain tsunami have a wavelength of 1.9×10^5 m and a speed of 240 m/s.

(i) Calculate the frequency of the tsunami waves.

frequency = ...[2]

(ii) The shock wave from the earthquake travels at 2.5×10^3 m/s.

The centre of the earthquake is 6.0×10^5 m from the coast of a country.

Calculate how much warning of the arrival of the tsunami at the coast is given by the earth tremor felt at the coast.

warning time = ...[4]

[Total: 10]

8 **(a)** Fig. 8.1 shows a section of an optical fibre. It consists of a fibre of denser transparent material, coated with a layer of a less dense transparent material.

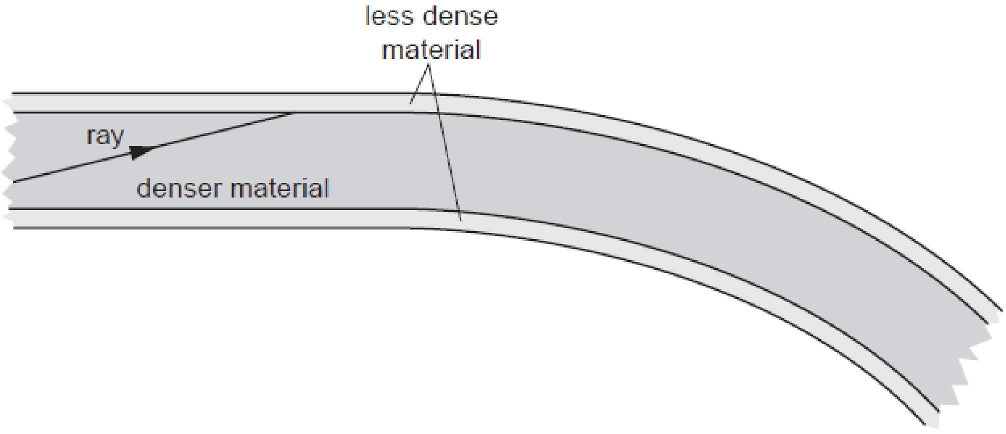


Fig. 8.1

One ray within the fibre has been started for you on Fig. 8.1.

(i) State and explain what happens to the ray already drawn, after it reaches the boundary between the materials.

....

....

....[2]

(ii) On Fig. 8.1, carefully continue the ray until it reaches the end of the section of optical fibre. [1]

(b) Fibre-optic cables are sometimes used to carry out internal examinations on the human stomach.

(i) Suggest one reason why the cable is made of thousands of very thin optical fibres.

....

....

....[1]

(ii) Describe briefly how the inside of the stomach is illuminated.

....

....

....[1]

(iii) Describe briefly how the light from the stomach is transferred to the detecting equipment outside the body.

....

....

....[1]

[Total: 6]

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7 **(a)** The speed of light in air is known to be 3.0×10^8 m / s.

Outline how you would use a refraction experiment to deduce the speed of light in glass. You may draw a diagram if it helps to clarify your answer.

....

....

....

....

....

....[4]

(b) A tsunami is a giant water wave. It may be caused by an earthquake below the ocean.

Waves from a certain tsunami have a wavelength of 1.9×10^5 m and a speed of 240 m / s.

(i) Calculate the frequency of the tsunami waves.

frequency = ...[2]

(ii) The shock wave from the earthquake travels at 2.5×10^3 m / s.

The centre of the earthquake is 6.0×10^5 m from the coast of a country.

Calculate how much warning of the arrival of the tsunami at the coast is given by the earth tremor felt at the coast.

warning time = ...[4]

[Total: 10]

7 **(a)** The following list contains the names of types of energy transfer by means of waves.

γ-rays, infra-red, radio/TV/microwaves, sound, visible light, X-rays

(i) Which one of these is **not** a type of electromagnetic wave?

.... [1]

(ii) State the nature of the wave you have named in **(a)(i)**.

.... [1]

(iii) The remaining names in the list are all regions of the electromagnetic spectrum, but one region is missing.

Name the missing region.

.... [1]

(b) A television station emits waves with a frequency of 2.5×10^8 Hz. Electromagnetic waves travel at a speed of 3.0×10^8 m/s.

Calculate the wavelength of the waves emitted by this television station. State the equation you use.

wavelength = ... [3]

[Total: 6]

6 Fig. 6.1 shows part of the path of a ray of light PQ travelling in an optical fibre.

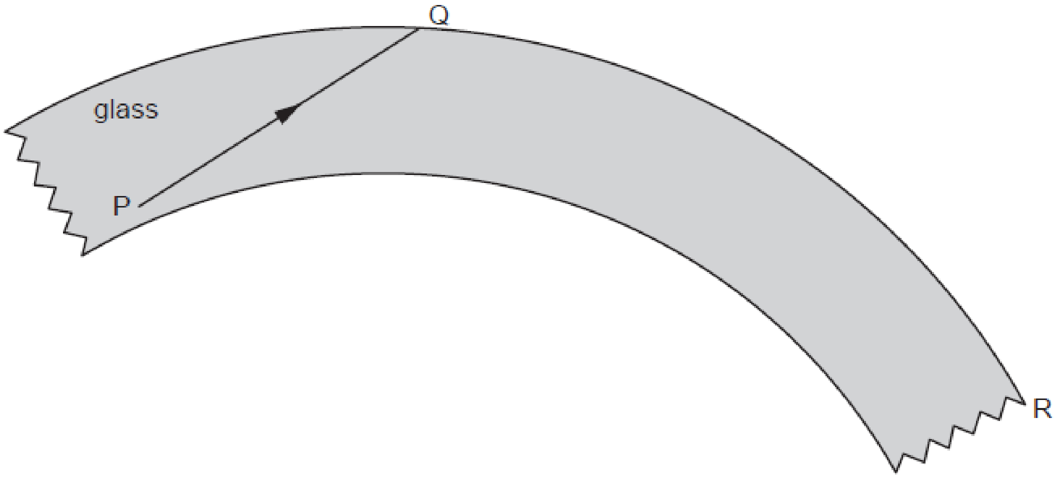


Fig. 6.1

PQ undergoes total internal reflection at Q.

(a) Explain what is meant by *total internal reflection*, and state the conditions under which it occurs.

....

....

....

....

.... [3]

(b) Carefully complete the path of the ray of light, until it reaches the end R of the optical fibre. [2]

[Total: 5]

6 Some plane waves travel on the surface of water in a tank. They pass from a region of deep water into a region of shallow water. Fig. 6.1 shows what the waves look like from above.

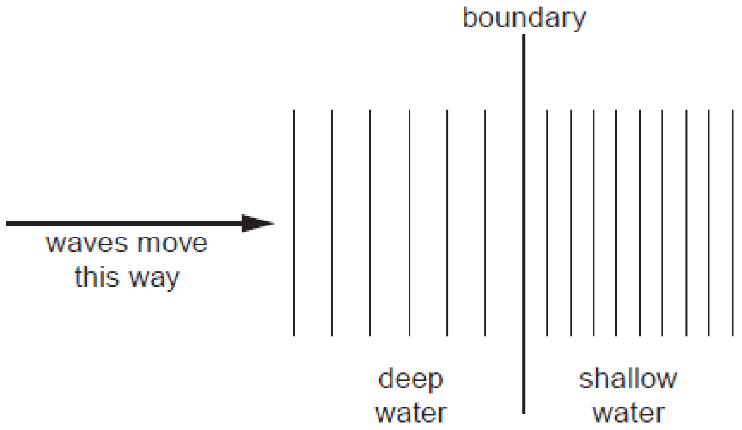


Fig. 6.1

(a) State what happens at the boundary, if anything, to

(i) the frequency of the waves,

.... [1]

(ii) the speed of the waves,

.... [1]

(iii) the wavelength of the waves.

.... [1]

(b) The waves have a speed of 0.12 m/s in the deep water. Wave crests are 0.08 m apart in the deep water.

Calculate the frequency of the source producing the waves. State the equation that you use.

frequency = ... [3]

(c) Fig. 6.2 shows identical waves moving towards the boundary at an angle.

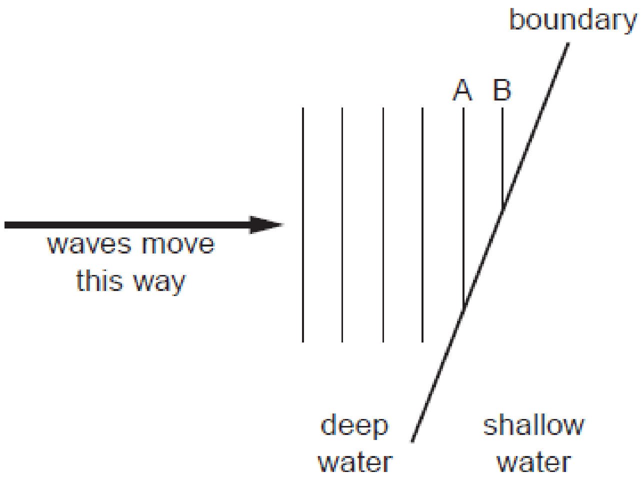


Fig. 6.2

On Fig. 6.2, draw carefully the remainder of waves A and B, plus the two previous waves which reached the shallow water. You will need to use your ruler to do this. [3]

[Total: 9]

7 During a thunderstorm, thunder and lightning are produced at the same time.

(a) A person is some distance away from the storm.

Explain why the person sees the lightning before hearing the thunder.

....

....

.... [1]

(b) A scientist in a laboratory made the following measurements during a thunderstorm.

time from start of storm / minutes	0.0	2.0	4.0	6.0	8.0	10.0
time between seeing lightning and hearing thunder / s	3.6	2.4	1.6	2.4	3.5	4.4

Fig. 7.1

(i) How many minutes after the storm started did it reach its closest point to the laboratory?

.... [1]

(ii) How can you tell that the storm was never immediately over the laboratory?

.... [1]

(iii) When the storm started, it was immediately above a village 1200 m from the laboratory.

Using this information and information from Fig. 7.1, calculate the speed of sound.

speed of sound = ... [2]

(iv) State the assumption you made when you calculated your answer to **(b)(iii)**.

.... [1]

(c) Some waves are longitudinal; some waves are transverse.

Some waves are electromagnetic; some waves are mechanical.

Put ticks (✓) in the table below to indicate which of these descriptions apply to the light waves of the lightning and the sound waves of the thunder.

	light waves	sound waves
longitudinal		
transverse		
electromagnetic		
mechanical		

[3]

[Total: 9]

8 Fig. 8.1 shows a thin converging lens. The two principal foci are shown.

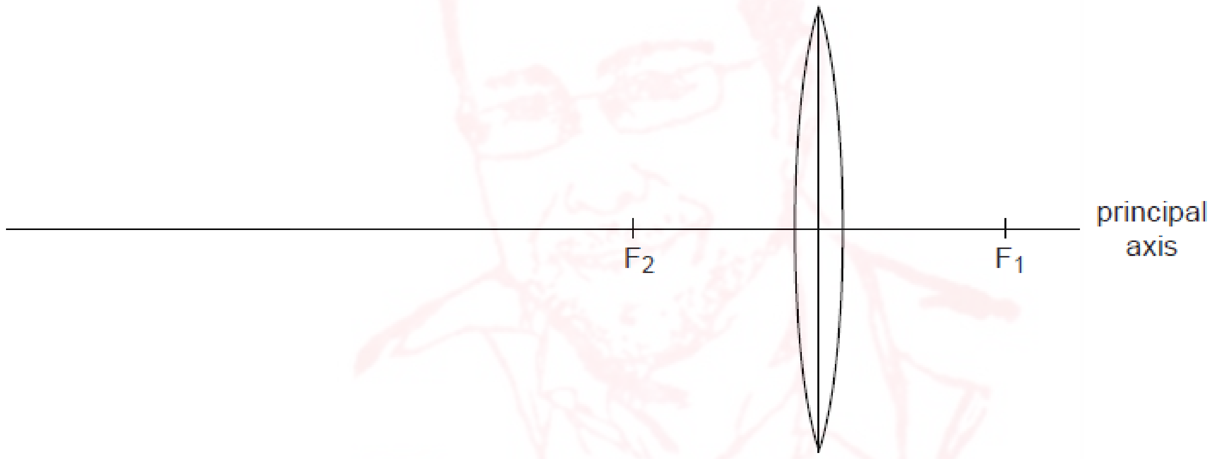


Fig. 8.1

A vertical object, 2 cm tall, is to be positioned to the left of the lens, with one end on the principal axis.

On Fig. 8.1,

(a) draw the object in a position which will produce a virtual image, labelling the object with the letter O, [1]

(b) draw two rays showing how the virtual image is formed, [2]

(c) draw in the image, labelling it with the letter I. [1]

[Total: 4]

Q# 16/_iG Phx/2009/s/Paper 31/ www.SmashingScience.org

8 In an optics lesson, a Physics student traces the paths of three rays of light near the boundary between medium A and air. The student uses a protractor to measure the various angles.

Fig. 8.1 illustrates the three measurements.

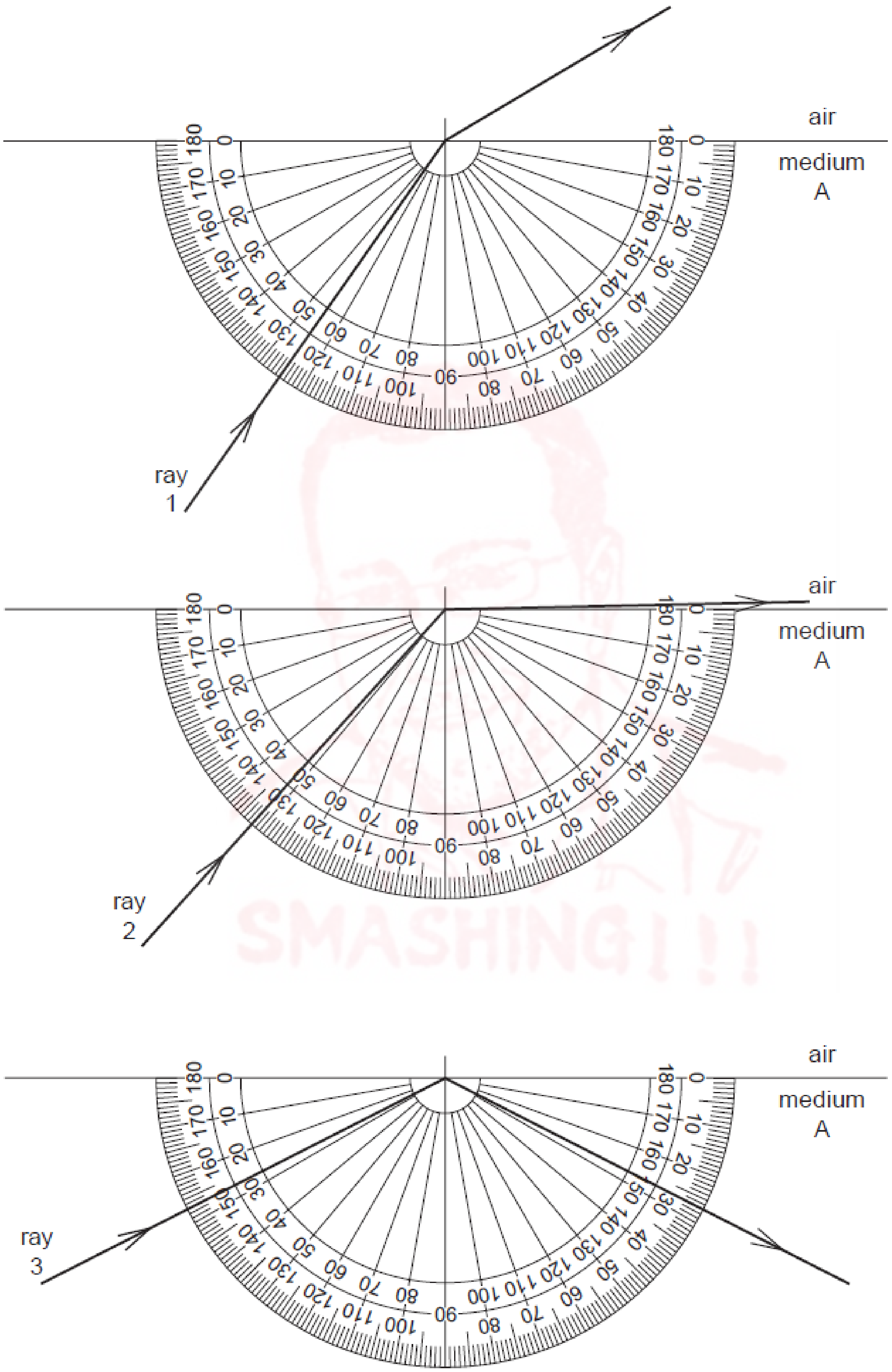


Fig. 8.1

(a) State which is the optically denser medium, A or air, and how you can tell this.

....

.... [1]

(b) State in which medium the light travels the faster, and how you know this.

....

.... [1]

(c) State the critical angle of medium A.

.... [1]

(d) State the full name for what is happening to ray 3.

.... [1]

(e) The refractive index of medium A is 1.49.

Calculate the value of the angle of refraction of ray 1, showing all your working.

angle of refraction = ... [2]

(f) The speed of light in air is 3.0×10^8 m/s.

Calculate the speed of light in medium A, showing all your working.

speed of light = ... [2]

[Total: 8]

7 Fig. 7.1 shows a scale drawing of plane waves approaching a gap in a barrier.

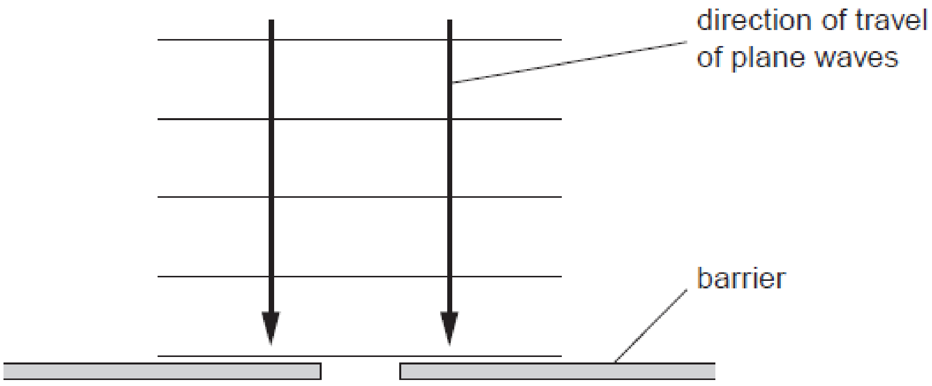


Fig. 7.1

(a) On Fig. 7.1, draw in the pattern of the waves after they have passed the gap. [3]

(b) The waves approaching the barrier have a wavelength of 2.5 cm and a speed of 20 cm/s. Calculate the frequency of the waves.

frequency = ... [2]

(c) State the frequency of the diffracted waves.

.... [1]

[Total: 6]

6 Fig. 6.1 shows two rays of monochromatic light, one entering the prism along the normal DE and the second one along PQ.

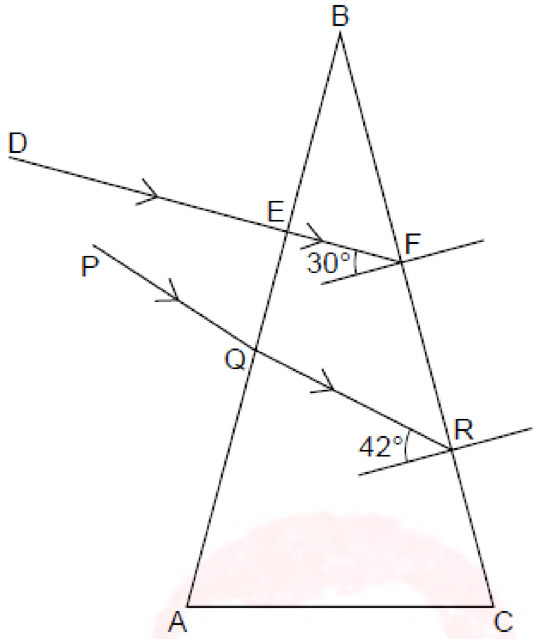


Fig. 6.1

(a) State what is meant by *monochromatic* light.

.... [1]

(b) The refractive index of the glass of the prism is 1.49. The ray EF is refracted at F. Use information from Fig. 6.1 to calculate the angle of refraction at F.

angle of refraction = ... [3]

(c) On Fig. 6.1, draw in the refracted ray, starting from F. [1]

(d) State how the refraction, starting at F, would be different if the monochromatic ray were replaced by a ray of white light.

.... [1]

(e) The critical angle for the glass of the prism is just over 42°. State the approximate angle of refraction for the ray striking BC at R.

.... [1]

(f) Another monochromatic ray, not shown in Fig. 6.1, passes through the prism and strikes BC at an angle of incidence of 50°. State what happens to this ray at the point where it strikes BC.

.... [1]

[Total: 8]

6 Fig. 6.1 shows an object, the tip of which is labelled O, placed near a lens L.

The two principal foci of the lens are F_1 and F_2.

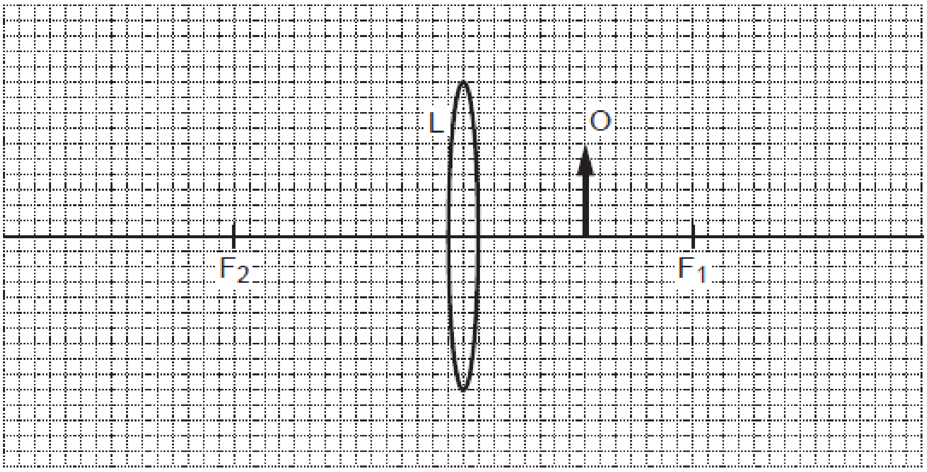


Fig. 6.1

(a) On Fig. 6.1, draw the paths of two rays from the tip of the object so that they pass through the lens and continue beyond.

Complete the diagram to locate the image of the tip of the object. Draw in the whole image and label it I. [3]

(b) Describe image I.

....

....

....

.... [3]

[Total: 6]

7 Fig. 7.1 and Fig. 7.2 show wavefronts of light approaching a plane mirror and a rectangular glass block, respectively.

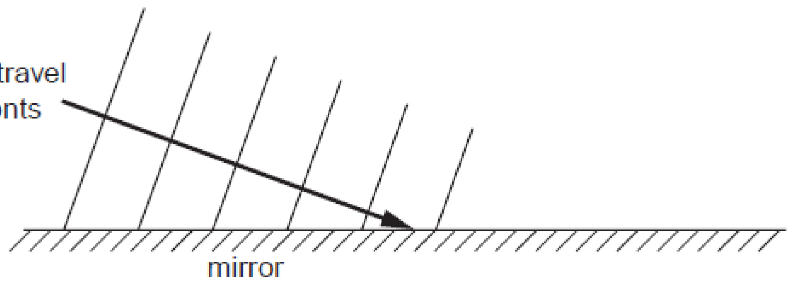


Fig. 7.1

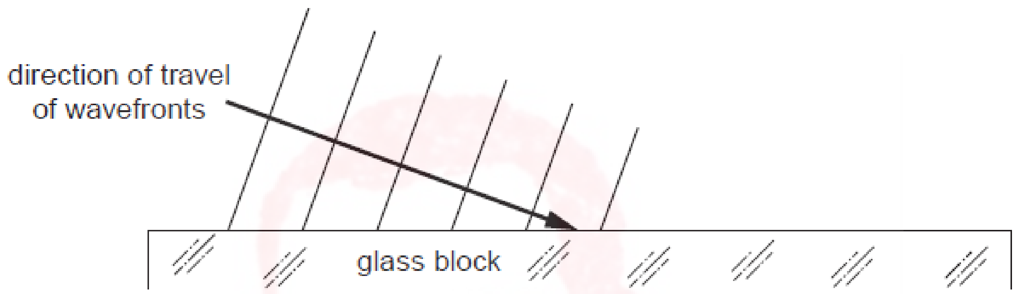


Fig. 7.2

(a) On Fig. 7.1 and on Fig. 7.2 draw wavefronts to show what happens after the waves strike the surface. [4]

(b) In Fig. 7.2, the waves approaching the block have a speed of 3.0×10^8 m/s and an angle of incidence of 70°. The refractive index of the glass of the block is 1.5.

(i) Calculate the speed of light waves in the block.

speed = ... [2]

(ii) Calculate the angle of refraction in the block.

angle = ... [2]

[Total: 8]

7 **(a)** In the space below, draw a diagram to represent a sound wave.

On your diagram, mark and label

(i) **two** consecutive compressions and **two** consecutive rarefactions,

(ii) the wavelength of the wave.

[3]

(b) Fig. 7.1 shows part of the electromagnetic spectrum.

Fig. 7.1

(i) On Fig. 7.1, label the positions of γ-rays, visible light waves and radio waves. [1]

(ii) State which of the three types of wave in **(i)** has the lowest frequency.

.... [1]

(iii) State the approximate value of the speed in air of radio waves.

.... [1]

[Total: 6]

6 Virtual images may be formed by both plane mirrors and by convex lenses.

Fig. 6.1 shows a plane mirror and a convex lens.

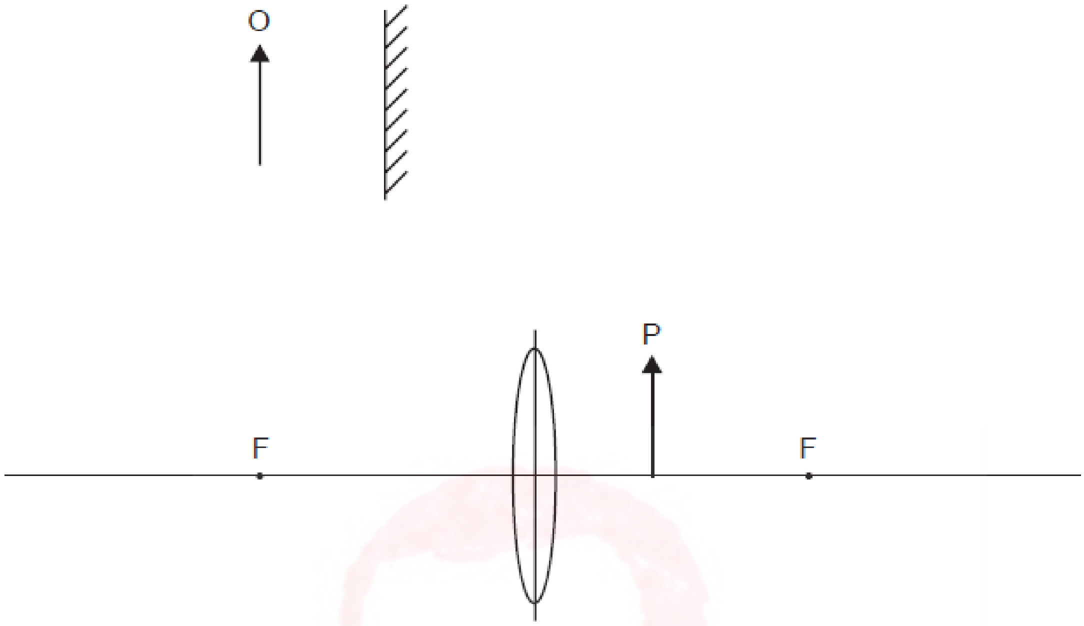


Fig. 6.1

(a) On Fig. 6.1, draw rays to locate the approximate positions of the images of the tops of the two arrow objects O and P.
Label the images. [5]

(b) Both images are virtual.

(i) What is meant by a *virtual image*?

.... [1]

(ii) State **one** other similarity between the two images.

.... [1]

(iii) State **one** difference between the two images.

.... [1]

[Total: 8]

7 Two students are asked to determine the speed of sound in air on the school playing fields.

(a) List the apparatus they need.

....

....

.... [1]

(b) List the readings that the students need to take.

....

....

.... [1]

(c) State how the speed of sound is calculated from the readings.

.... [1]

(d) State one precaution that could be taken to improve the accuracy of the value obtained.

....

.... [1]

(e) The table gives some speeds.

speed/ m/s	speed of sound in air	speed of sound in water
10		
100		
1000		
10 000		

Place a tick in the table to show the speed which is closest to

(i) the speed of sound in air,

(ii) the speed of sound in water.

[2]

[Total: 6]

6 Fig. 6.1 shows a rectangular glass block ABCD.

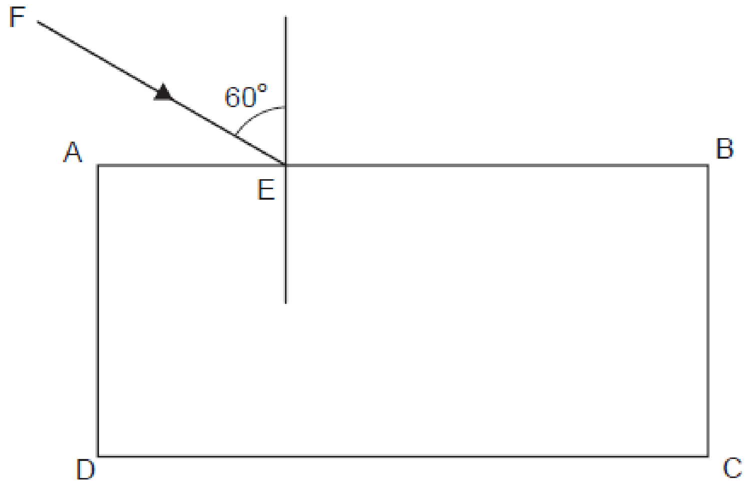


Fig. 6.1

(a) The ray FE is partly reflected and partly refracted at E.

(i) On Fig. 6.1, draw in the approximate path of the refracted ray, within and beyond the block. Label the ray *refracted ray*. [1]

(ii) On Fig. 6.1, draw in the path of the reflected ray. Label the ray *reflected ray*. [1]

(b) A second ray, almost parallel to AE, strikes the block at E and is partly refracted at an angle of refraction of 43°.

(i) State an approximate value for the angle of incidence at E.

.... [1]

(ii) State an approximate value for the critical angle for the light in the glass block.

.... [1]

(iii) Calculate an approximate value for the refractive index of the glass of the block.

refractive index = ... [2]

(c) The speed of the light along ray FE is 3.0×10^8 m/s. Calculate the speed of the refracted light in the glass block.

speed = ... [2]

[Total: 8]

7 Fig. 7.1 is a drawing of a student's attempt to show the diffraction pattern of water waves that have passed through a narrow gap in a barrier.

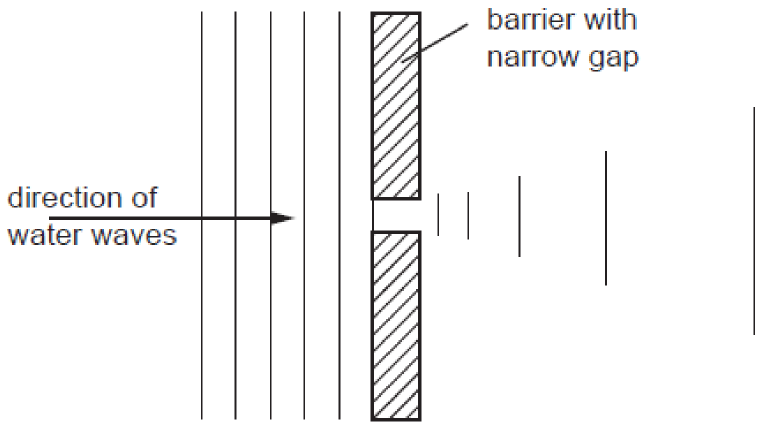


Fig. 7.1

(a) State two things that are wrong with the wave pattern shown to the right of the barrier.

1. ....

2. ....[2]

(b) In the space below, sketch the wave pattern when the gap in the barrier is made five times wider.

[2]

(c) The waves approaching the barrier have a wavelength of 1.2 cm and a frequency of 8.0 Hz.
Calculate the speed of the water waves.

speed = ...[2]

6 Fig. 6.1 shows a ray of light, from the top of an object PQ, passing through two glass prisms.

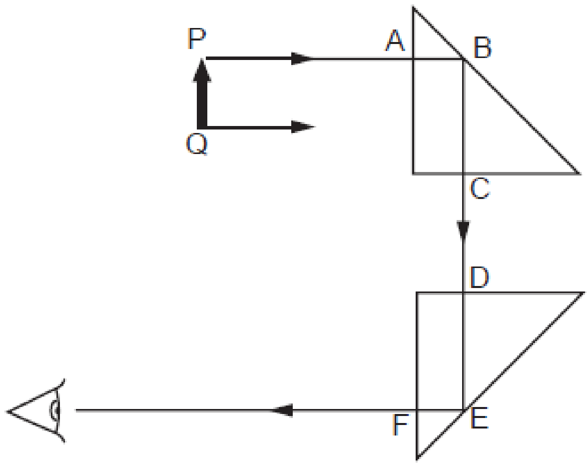


Fig. 6.1

(a) Complete the path through the two prisms of the ray shown leaving Q. [1]

(b) A person looking into the lower prism, at the position indicated by the eye symbol, sees an image of PQ.
State the properties of this image.

....[2]

(c) Explain why there is no change in direction of the ray from P at points A, C, D and F.

....

....[1]

(d) The speed of light as it travels from P to A is 3×10^8 m/s and the refractive index of the prism glass is 1.5.
Calculate the speed of light in the prism.

speed = ...[2]

(e) Explain why the ray AB reflects through 90° at B and does not pass out of the prism at B.

....

....

....[2]

7 Fig. 7.1 shows how the air pressure at one instant varies with distance along the path of a continuous sound wave.

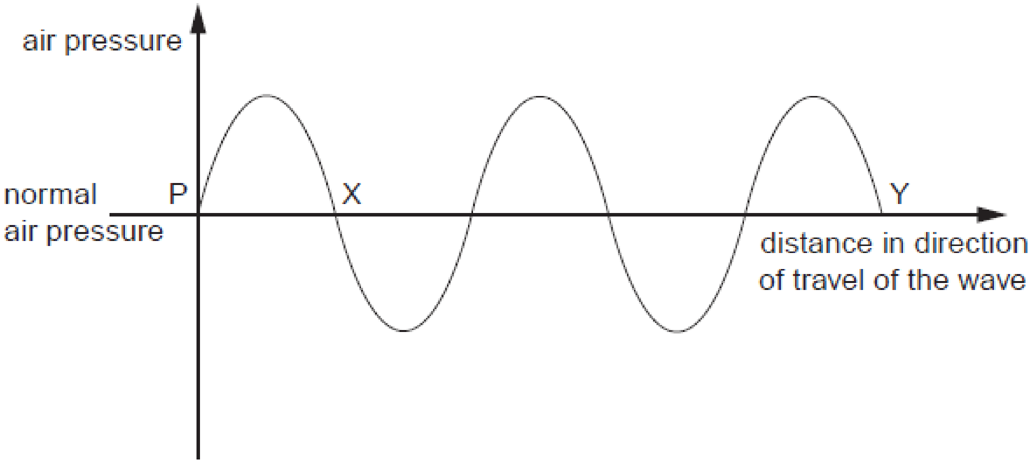


Fig. 7.1

(a) What type of waves are sound waves?

....[1]

(b) On Fig. 7.1, mark on the axis PY

(i) one point C where there is a compression in the wave, [1]

(ii) one point R where there is a rarefaction in the wave. [1]

(c) Describe the motion of a group of air particles situated on the path of the wave shown in Fig. 7.1.

....

....

....[2]

(d) The sound wave shown has speed of 340 m/s and a frequency of 200 Hz. Calculate the distance represented by PX on Fig. 7.1.

distance = ...[2]

6 Fig. 6.1 shows white light incident at P on a glass prism. Only the refracted red ray PQ is shown in the prism.

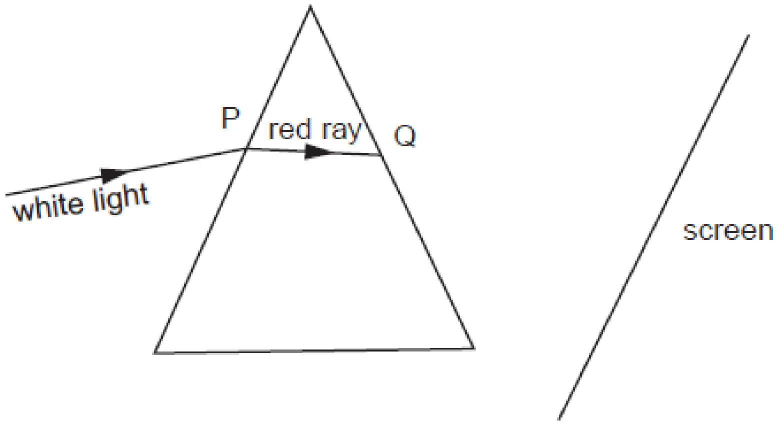


Fig. 6.1

(a) On Fig. 6.1, draw rays to complete the path of the red ray and the whole path of the violet ray up to the point where they hit the screen. Label the violet ray. [3]

(b) The angle of incidence of the white light is increased to 40°. The refractive index of the glass for the red light is 1.52.
Calculate the angle of refraction at P for the red light.

angle of refraction = ...[3]

(c) State the approximate speed of

(i) the white light incident at P, speed = ...[1]

(ii) the red light after it leaves the prism at Q. speed = ...[1]

6 Fig. 6.1 shows the path of a sound wave from a source X.

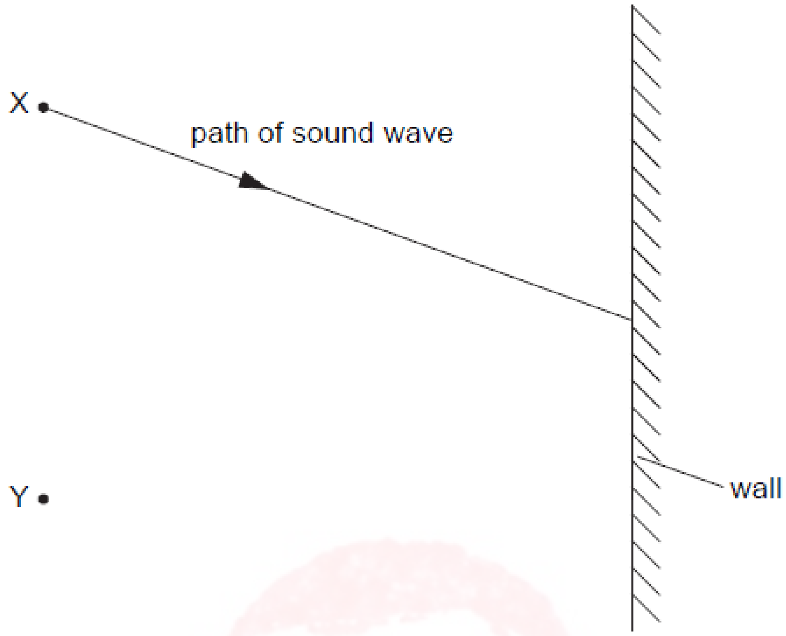


Fig. 6.1

(a) State why a person standing at point Y hears an echo.

.... [1]

(b) The frequency of the sound wave leaving X is 400 Hz. State the frequency of the sound wave reaching Y.

frequency = ... [1]

(c) The speed of the sound wave leaving X is 330 m/s. Calculate the wavelength of these sound waves.

wavelength = ... [2]

(d) Sound waves are longitudinal waves.

State what is meant by the term *longitudinal*.

....

.... [1]

7 **(a)** Fig. 7.1 shows two rays of light from a point O on an object. These rays are incident on a plane mirror.

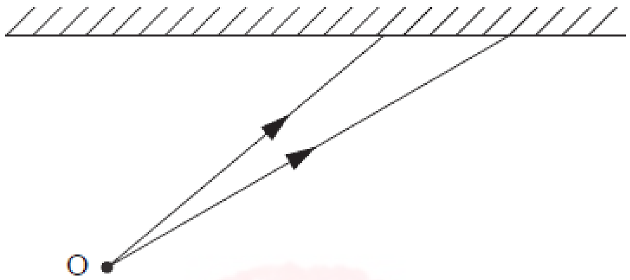


Fig. 7.1

(i) On Fig. 7.1, continue the paths of the two rays after they reach the mirror. Hence locate the image of the object O. Label the image I. [2]

(ii) Describe the nature of the image I.

....

.... [2]

(b) Fig. 7.2 is drawn to scale. It shows an object PQ and a convex lens.

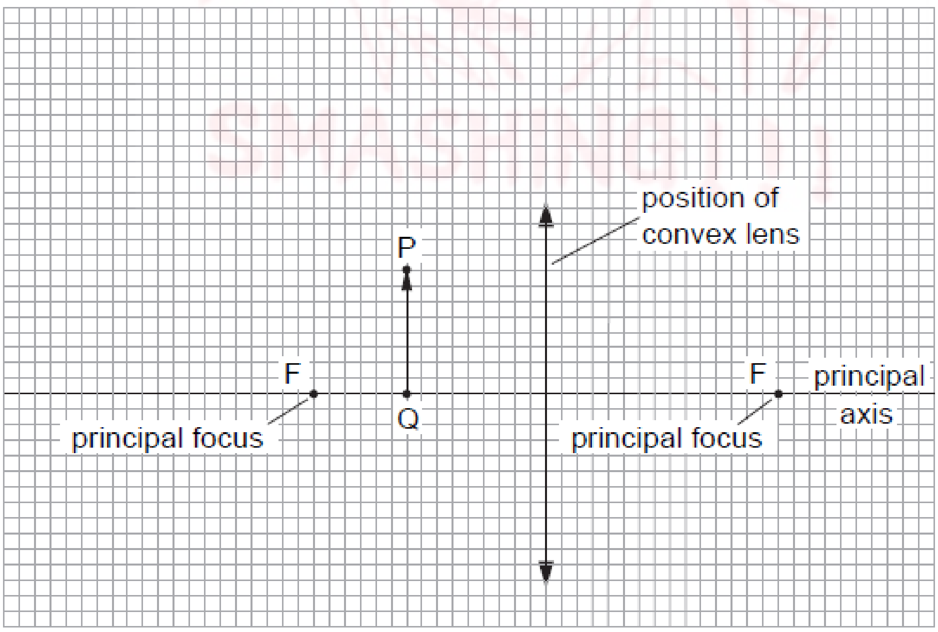


Fig. 7.2

(i) On Fig. 7.2, draw two rays from the top of the object P that pass through the lens. Use these rays to locate the top of the image. Label this point T. [3]

(ii) On Fig. 7.2, draw an eye symbol to show the position from which the image T should be viewed. [1]

Q# 31/ iG Phx/2005/s/ www.SmashingScience.org

7 Fig. 7.1 shows the parts of the electromagnetic spectrum.

γ-rays and X-rays	ultra-violet	visible	infra-red	radio waves

Fig. 7.1

(a) Name one type of radiation that has

(i) a higher frequency than ultra-violet,

.... [1]

(ii) a longer wavelength than visible light.

.... [1]

(b) Some γ-rays emitted from a radioactive source have a speed in air of 3.0×10^8 m/s and a wavelength of 1.0×10^{-12} m.

Calculate the frequency of the γ-rays.

frequency = ... [2]

(c) State the approximate speed of infra-red waves in air.

.... [1]

6 Fig. 6.1 shows a ray of light OPQ passing through a semi-circular glass block.

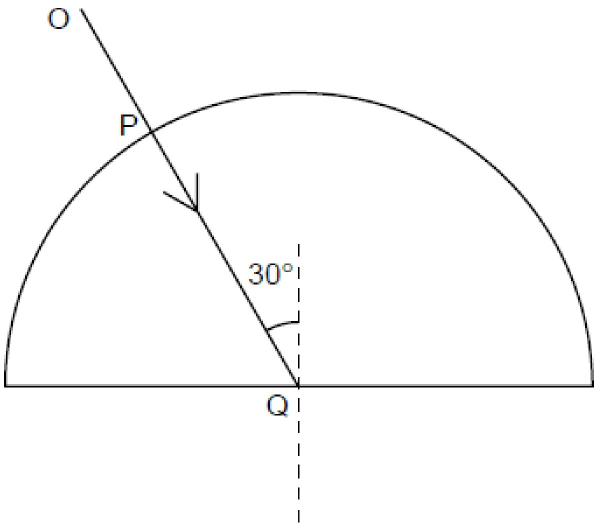


Fig. 6.1

(a) Explain why there is no change in the direction of the ray at P.

....

.... [1]

(b) State the changes, if any, that occur to the speed, wavelength and frequency of the light as it enters the glass block.

....

....

.... [2]

(c) At Q some of the light in ray OPQ is reflected and some is refracted.

On Fig. 6.1, draw in the approximate positions of the reflected ray and the refracted ray. Label these rays. [2]

(d) The refractive index for light passing from glass to air is 0.67.

Calculate the angle of refraction of the ray that is refracted at Q into air.

angle = ... [3]

6 Fig. 6.1 shows an optical fibre. XY is a ray of light passing along the fibre.

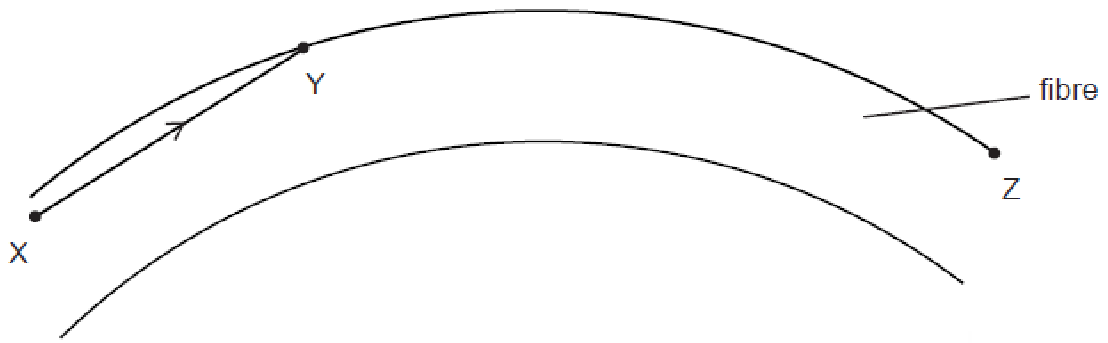


Fig. 6.1

(a) On Fig. 6.1, continue the ray XY until it passes Z. [1]

(b) Explain why the ray does **not** leave the fibre at Y.

....

....

....[2]

(c) The light in the optical fibre has a wavelength of 3.2×10^{-7} m and is travelling at a speed of 1.9×10^{8} m/s.

(i) Calculate the frequency of the light.

frequency = ……………………...

(ii) The speed of light in air is 3.0×10^{8} m/s.
Calculate the refractive index of the material from which the fibre is made.

refractive index = ……………………...

[4]

8 Fig. 8.1 shows plane waves passing through a gap in a barrier that is approximately equal to the wavelength of the waves.

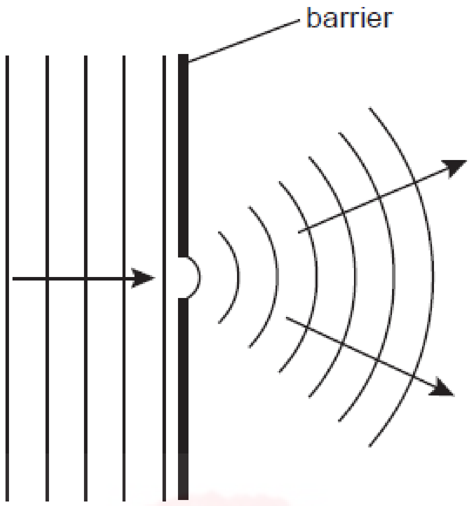


Fig. 8.1

(a) What is the name given to the wave property shown in Fig. 8.1?

....[1]

(b) In the space below, carefully draw the pattern that would be obtained if the gap were increased to six times the wavelength of the waves. [4]

(c) The effect in Fig. 8.1 is often shown using water waves on the surface of a tank of water. These are transverse waves. Explain what is meant by a *transverse* wave.

....

....

....[2]

6 Fig. 6.1 shows a ray PQ of blue light incident on the side of a rectangular glass block.

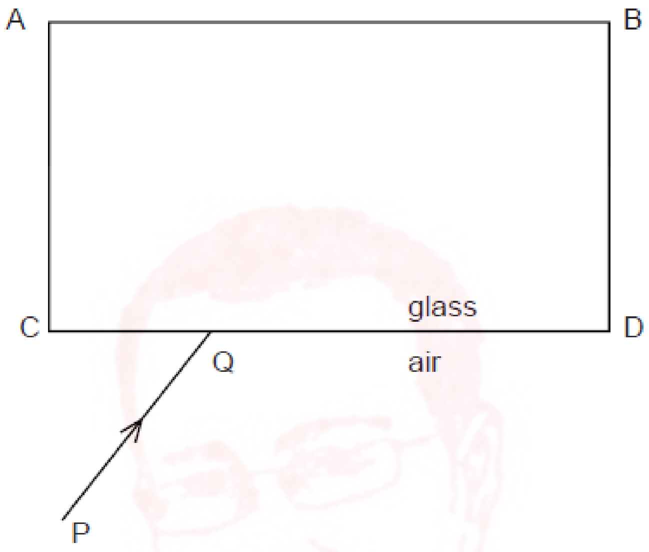


Fig. 6.1

(a) **(i)** By drawing on Fig. 6.1, continue the ray PQ through and beyond the block.

(ii) Mark the angle of incidence at CD with the letter *i* and the angle of refraction at CD with the letter *r*.

[3]

(b) The speed of light in air is 3.0×10^8 m/s and the speed of light in glass is 2.0×10^8 m/s.

(i) Write down a formula that gives the refractive index of glass in terms of the speeds of light in air and glass.

refractive index =

(ii) Use this formula to calculate the refractive index of glass.

refractive index = ...

[2]

(c) The frequency of the blue light in ray PQ is 6.0×10^{14} Hz.
Calculate the wavelength of this light in air.

wavelength = ...[2]

7 Fig. 7.1 shows the cone of a loudspeaker that is producing sound waves in air.
At any given moment, a series of compressions and rarefactions exist along the line XY.

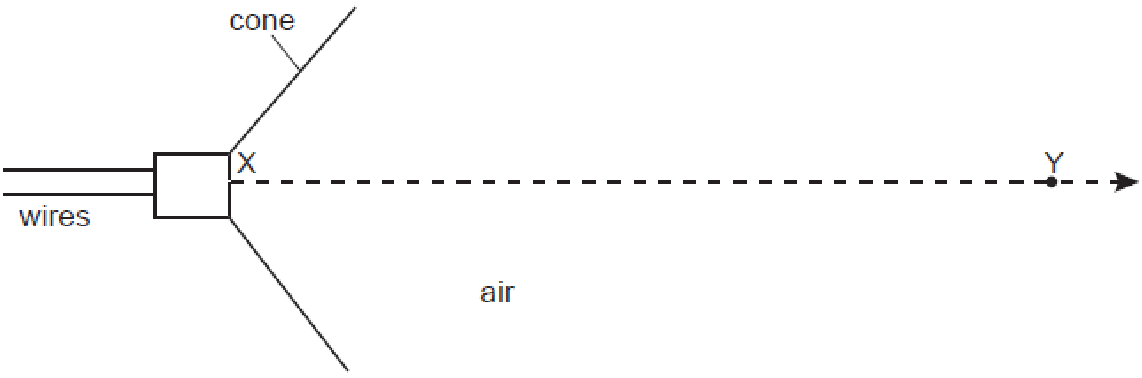


Fig. 7.1

(a) On Fig. 7.1, use the letter C to mark **three** compressions and the letter R to mark **three** rarefactions along XY. [1]

(b) Explain what is meant by

(i) a *compression*,

....

....

(ii) a *rarefaction*.

....

....

[2]

(c) A sound wave is a longitudinal wave. With reference to the sound wave travelling along XY in Fig. 7.1, explain what is meant by a *longitudinal* wave.

....

....[2]

(d) There is a large vertical wall 50 m in front of the loudspeaker. The wall reflects the sound waves.
The speed of sound in air is 340 m/s.
Calculate the time taken for the sound waves to travel from X to the wall and to return to X.

time = ...[2]

6 Fig. 6.1 shows the diffraction of waves by a narrow gap.

P is a wavefront that has passed through the gap.

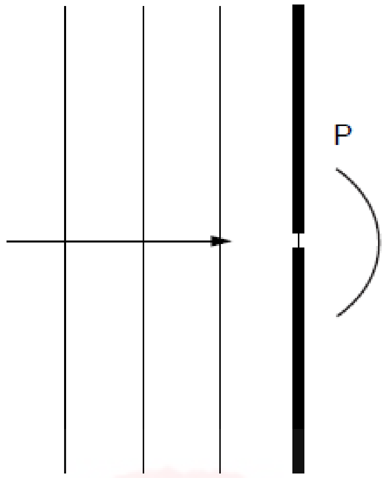


Fig. 6.1

(a) On Fig. 6.1, draw three more wavefronts to the right of the gap. [3]

(b) The waves travel towards the gap at a speed of 3×10^{8} m/s and have a frequency of 5×10^{14} Hz. Calculate the wavelength of these waves.

wavelength = ... [3]

7 Fig. 7.1 is drawn to full scale. The focal length of the lens is 5.0 cm.

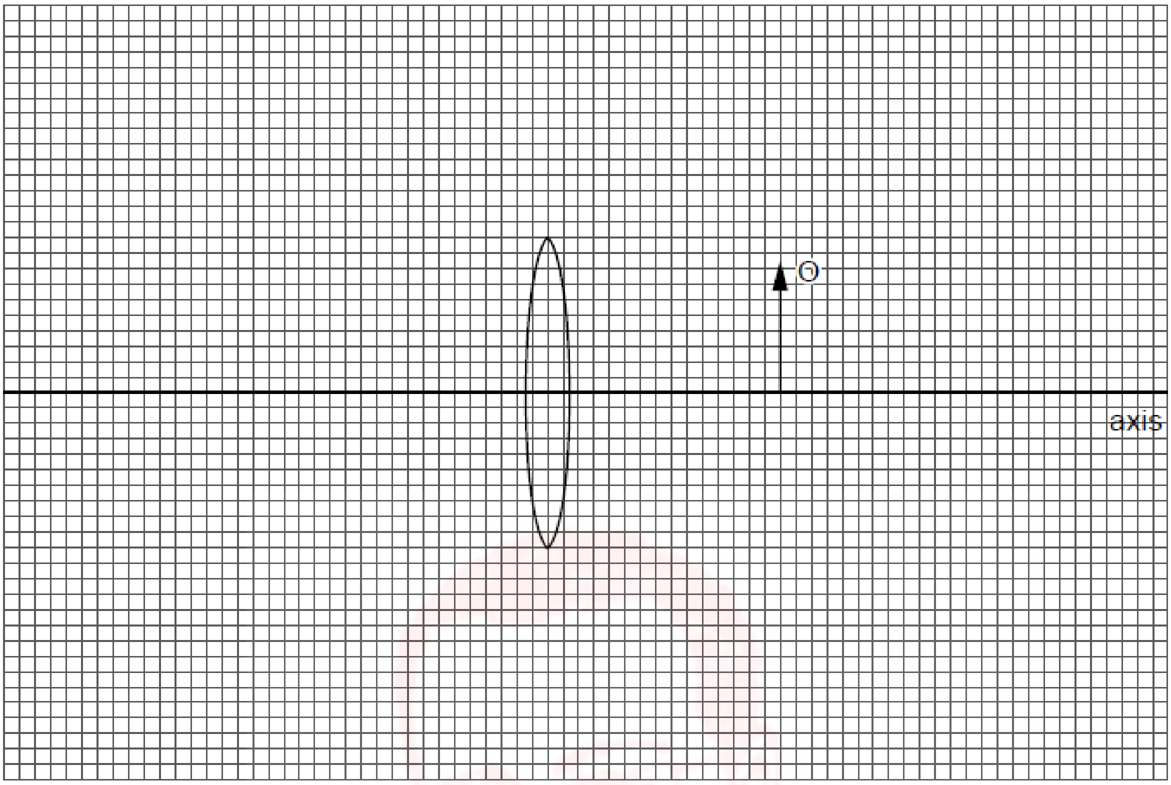


Fig. 7.1

(a) On Fig. 7.1, mark each principal focus of the lens with a dot and the letter F. [2]

(b) On Fig. 7.1, draw **two** rays from the tip of the object O that appear to pass through the tip of the image. [2]

(c) On Fig. 7.1, draw the image and label it with the letter I. [1]

(d) Explain why the base of the image lies on the axis.

....

.... [1]

(e) State a practical use of a convex lens when used as shown in Fig. 7.1.

.... [1]

7 In a thunderstorm, both light and sound waves are generated at the same time.

(a) How fast does the light travel towards an observer?

speed = ... [1]

(b) Explain why the sound waves always reach the observer after the light waves.

....[1]

(c) The speed of sound waves in air may be determined by experiment using a source that generates light waves and sound waves at the same time.

(i) Draw a labelled diagram of the arrangement of suitable apparatus for the experiment.

(ii) State the readings you would take.

....

....

....

(iii) Explain how you would calculate the speed of sound in air from your readings.

....

....

[4]

6 Fig. 6.1 shows wavefronts of light crossing the edge of a glass block from air into glass.

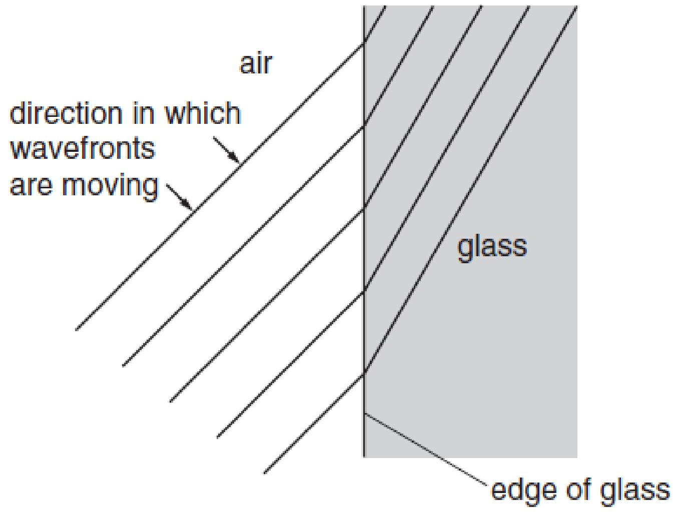


Fig. 6.1

(a) On Fig. 6.1

(i) draw in an incident ray, a normal and a refracted ray that meet at the same point on the edge of the glass block,

(ii) label the angle of incidence and the angle of refraction,

(iii) measure the two angles and record their values.

angle of incidence = ...

angle of refraction = ...

[4]

(b) Calculate the refractive index of the glass.

refractive index = ...[3]

5 (a) Fig. 5.1 shows the air pressure variation along a sound wave.

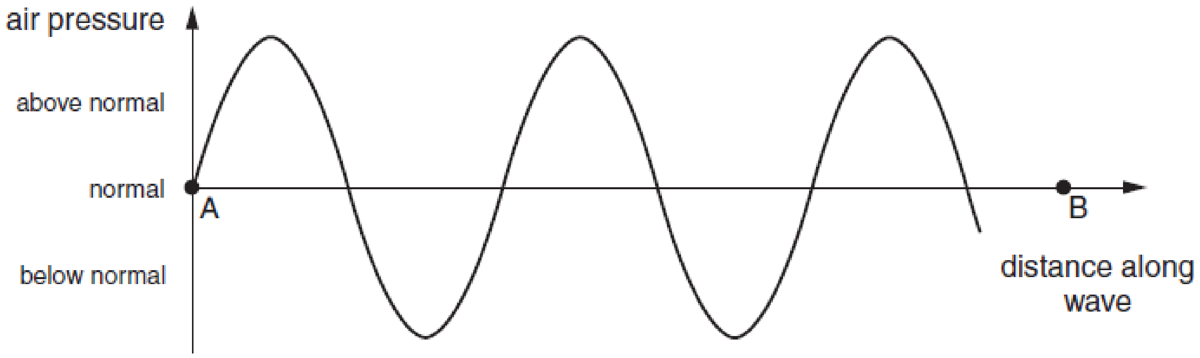


Fig. 5.1

(i) On AB in Fig. 5.1, mark one point of compression with a dot and the letter C and the next point of rarefaction with a dot and the letter R.

(ii) In terms of the wavelength, what is the distance along the wave between a compression and the next rarefaction?

....

[3]

(b) A sound wave travels through air at a speed of 340 m/s. Calculate the frequency of a sound wave of wavelength 1.3 m.

frequency = ... [2]

6 (a) Fig. 6.1 shows the results of an experiment to find the critical angle for light in a semi-circular glass block.

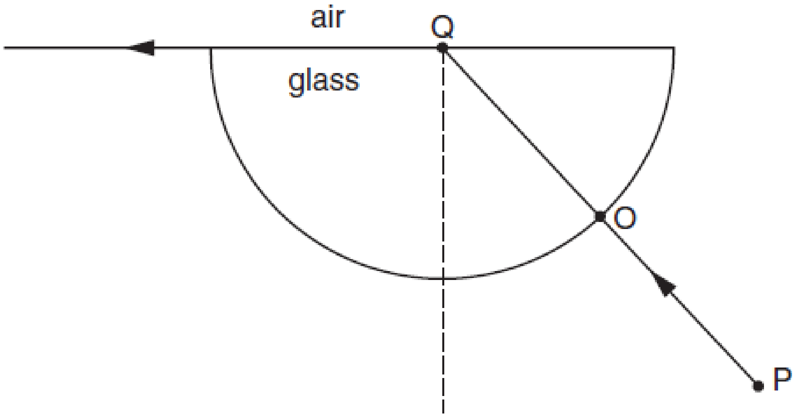


Fig. 6.1

The ray of light PO hits the glass at O at an angle of incidence of 0°.
Q is the centre of the straight side of the block.

(i) Measure the critical angle of the glass from Fig. 6.1.

critical angle = ...

(ii) Explain what is meant by the *critical angle* of the light in the glass.

....

....

....

[3]

(b) Fig. 6.2 shows another ray passing through the same block.

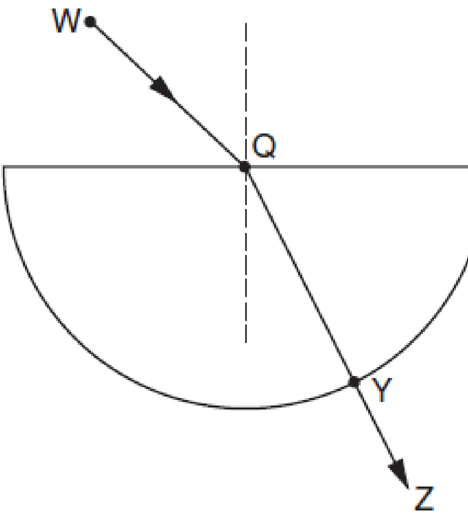


Fig. 6.2

The speed of the light between W and Q is 3.0×10^8 m/s. The speed of the light between Q and Y is 2.0×10^8 m/s.

(i) State the speed of the light between Y and Z.

speed = ...

(ii) Write down an expression, in terms of the speeds of the light, that may be used to find the refractive index of the glass. Determine the value of the refractive index.

refractive index = ...

(iii) Explain why there is no change of direction of ray QY as it passes out of the glass.

....

(iv) What happens to the wavelength of the light as it passes out of the glass?

....

[5]

Mark Scheme

Q# 1/ iG Phx/2014/s/Paper 31/ www.SmashingScience.org

8	(a)		speed of sound in gas: 300 m/s	B1
			speed of sound in solid: 3000 m/s	B1
	(b)		particles/molecules/atoms oscillate/vibrate OR pressure variation/compressions/rarefactions/displacements move	B1
			in the direction of travel (of the wave/sound)	B1
	(c)	(i)	two complete wavelengths/cycles with shorter wavelength	B1
			wave drawn has greater amplitude	B1
		(ii)	higher frequency/pitch	B1
			louder/higher volume	B1
				[Total: 8]

Q# 2/ iG Phx/2013/w/Paper 3/ www.SmashingScience.org

7	(a)	(i)	diffraction	B1
		(ii)	waves travel slow(er)/water is shallow(er)	B1
		(iii)	angular spread of wavefronts increases o.w.t.t.e. OR amplitude of waves is smaller	B1
	(b)	(i)	oscillation/up and down motion (of rope) is at right angles to the direction of the wave OR motion of rope/particles is at right angles to the direction of the wave	B1
		(ii)	$\lambda = 2.4/2 = 1.2$ m $v = f\lambda$ in any form OR ($f =$) v/λ OR 3.2/1.2 2.7 Hz OR $t = 2.4/3.2$ $f = 2 \times 3.2/2.4$ 2.7 Hz	C1 C1 A1 (C1) (C1) (A1)
				[Total: 7]

Q# 3/ iG Phx/2013/s/Paper 31/ www.SmashingScience.org

7	(a)	two of: ray <u>through</u> centre of lens undeviated ray parallel to axis refracted to right hand focus rays through left hand focus refracted parallel to axis	B2
		rays extrapolated to a point	B1
		accuracy marks: image 6 cm from lens image 6 cm high	B1 B1
	(b)	image is virtual/not real <u>AND</u> cannot be seen on screen OR no rays come from (position of) image	B1
			[Total 6]

Q# 4/ iG Phx/2013/s/Paper 31/ www.SmashingScience.org

8	(a)		15–25 Hz to 15 000–25000 Hz / 15–25 kHz	B1
	(b)	(i)	(region) where air layers/molecules/particles are pushed together/moved together/ closer (than normal) OR (region) where (air) pressure raised/air (more) compressed/more dense	B1
		(ii)	(region) where air layers/molecules are pushed apart/far(ther) apart (than normal) OR (region) where (air) pressure reduced/air expanded	B1
	(c)	(i)	(sound is) loud(er) OR volume (of sound is) increased	B1
		(ii)	sound has a higher frequency/pitch OR higher note (heard)	B1
	(d)		3.5 – 1.9 OR 1.6 (s) seen OR $v = 2d/1.9$	C1
			250 × 2 OR 500 (m) seen OR $v = (2d + 500)/3.5$	C1
			(speed = 500 / 1.6 =) 312.5 m/s at least 2 sig. figs	A1
				[Total 8]

Q# 5/ iG Phx/2012/s/Paper 31/ www.SmashingScience.org

8	(a)	(i)	Diagram to show – boundary, normal and ray bending towards normal	B1
			Angle of incidence labelled i or 51°	B1
			Angle of refraction labelled r or 29°	B1
		(ii)	n = sin i / sin r OR n = sin 51 / sin 29	C1
			n = 1.603 at least 2 s.f. *Unit penalty applies	A1
	(b)		Ray is totally internally reflected / undergoes TIR	B1
			Angle of incidence is more than / equal to the critical angle (of the glass)	B1
			OR	
			Ray travels along the boundary	(B1)
			Angle of incidence = critical angle (of the glass)	(B1)
			OR	
			Critical angle calculated as 38.6° ecf from **(a)(ii)**	(B1)
			Angle of incidence greater than critical angle (of the glass)	(B1)

Q# 6/ iG Phx/2011/w/Paper 31/ www.SmashingScience.org

6 (a) (i) 1. compressions and/or rarefactions closer together
OR more compressions and/or rarefactions — B1
ignore wavelength shorter

2. layers closer together at compressions — B1
layers farther apart at rarefactions — B1
OR
compressions narrower — (B1)
rarefactions wider — (B1)
ignore wavelength shorter ignore 'amplitude greater' ignore 'maximum displacement greater'

(ii) distance between 2 compressions or 2 rarefactions shown with reasonable accuracy — B1

(b) time taken by sound in air = 200 / 343 = 0.583 s — C1
time taken by sound in steel = 0.583 – 0.544 = 0.039 s — C1
5128 m/s — A1 [7]

Q# 7/ iG Phx/2011/w/Paper 31/ www.SmashingScience.org

7 (a) (i) light of a single wavelength / frequency ignore 'one colour' — B1

(ii) $n = \sin i/\sin r$ OR $1.52 = \sin 50/\sin r$ OR $\sin r = \sin 50/1.52$ — C1
30.26° at least 2 s.f. — A1

(iii) ray closer to normal in block — B1
ray parallel to incident ray emerging from block — B1

(b) (i) $n = v_A/v_G$ OR $n = 1.54/v_G$ OR $v_G = 3 \times 10^8/1.54$ — C1
1.948×10^8 m/s — B1

(ii) ray with smaller angle of refraction than red in block i.e. violet ray under red ray — B1
emerging ray parallel to incident ray — B1 [9]

Q# 8/ iG Phx/2011/s/Paper 31/ www.SmashingScience.org

7 (a) idea of fine ray/beam shone into (glass) block / pins appropriately placed shown in diagram or described — B1
angles i & r or C measured OR correct i & r or C marked on diagram — B1
$\sin i/\sin r$ OR $\sin r/\sin i$ OR $1/\sin C$ OR $\sin C$ — B1
n = speed in air/speed in glass OR $c/v = \sin i/\sin r$ OR $n = 1/\sin C$ OR $c/v = 1/\sin C$ — B1

(b) (i) $v = f\lambda$ OR $240/1.9 \times 10^5$ OR $T=d/s$ AND $f=1/T$ — B1
0.00126 Hz OR 0.0013 Hz NOT 0.0012 Hz
ignore more than 3 s.f. accept s^{-1} — A1

(ii) distance = speed × time in any form accept $s = 2d/t$ — C1
(time for tremor =) 240 (s) or 4 mins also gives first C1 — C1
(time for tsunami =) 2500 (s) or 41 mins 40 s also gives first C1 — C1
(warning time =) 2260 (s) or 37 mins 40 s — A1 [10]

Q# 9/_iG Phx/2011/s/Paper 31/ www.SmashingScience.org

8	(a)	(i)	total (internal) reflection OR reflection but no refraction/doesn't emerge	B1	
			angle (of incidence} > critical angle	B1	
		(ii)	initial reflection + 0 or 1 further reflection only, not at lower surface must be straight and reach within 1cm of end	B1	
	(b)	(i)	bends easily/less likely to break (ignore stronger) OR smaller pixels/ more detail/greater resolution/see smaller objects/wider field of view	B1	
		(ii)	light travels down/along/through fibres	B1	
		(iii)	light/image returns up/along/through fibres ignore cameras	B1	[6]

Q# 10/_iG Phx/2011/s/Paper 31/ www.SmashingScience.org

7	(a)		idea of fine ray/beam shone into (glass) block / pins appropriately placed shown in diagram or described	B1	
			angles i & r or C measured OR correct i & r or C marked on diagram	B1	
			sin$i$/sin$r$ OR sin$r$/sin$i$ OR 1/sin$C$ OR sin$C$	B1	
			n = speed in air/speed in glass OR c/v = sin$i$/sin$r$ OR n = 1/sin$C$ OR c/v = 1/sin$C$	B1	
	(b)	(i)	$v = f\lambda$ OR $240/1.9 \times 10^5$ OR $T=d/s$ AND $f=1/T$	B1	
			0.00126 Hz OR 0.0013 Hz NOT 0.0012 Hz ignore more than 3 s.f. accept s^{-1}	A1	
		(ii)	distance = speed × time in any form accept $s = 2d/t$	C1	
			(time for tremor =) 240 (s) or 4 mins also gives first C1	C1	
			(time for tsunami =) 2500 (s) or 41 mins 40 s also gives first C1	C1	
			(warning time =) 2260 (s) or 37 mins 40 s	A1	[10]

Q# 11/_iG Phx/2010/w/Paper 31/ www.SmashingScience.org

7	(a)	(i)	sound	B1
		(ii)	particle OR mechanical OR compression OR longitudinal OR matter wave	B1
		(iii)	ultra violet/uv	B1
	(b)		$v = f\lambda$ OR $\lambda = v/f$	B1
			$3.0 \times 10^8/2.5 \times 10^8$ OR $3.0 \times 10^8 = 2.5 \times 10^8\ \lambda$	C1
			1.2 m	A1
				[Total: 6]

Q# 12/_iG Phx/2010/w/Paper 31/ www.SmashingScience.org

6	(a)	incident ray in (more) dense medium angle of incidence greater than critical angle/42° no light refracted reflected with $i = r$	any 3	B1 × 3
	(b)	reflection at Q only, no further reflections (allow B1 only, if there is one further reflection at lower surface) (give B0 for more than one further reflection)		B2 **[Total: 5]**

Q# 13/ iG Phx/2010/s/Paper 31/ www.SmashingScience.org

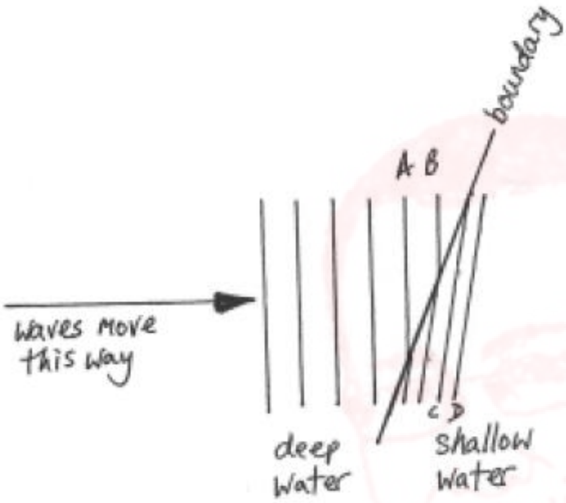
6 (a) (i) same / unchanged / nothing B1

(ii) reduced / slows down B1

(iii) reduced B1

(b) v = fλ in any form or in words [not numbers]
OR f =1/T in any form or in words [not numbers] B1
0.12 = f × 0.08 OR T = 0.08 / 0.12 C1
1.5 Hz / cycles per sec / c.p.s. / per s
[only 2 marks if B1 mark above not scored] A1

(c)



(ignore length of waves)
waves bending in correct direction (be generous) M1
A and B correct by eye, straight and parallel A1
C and D parallel to A and B by eye A1 [9]

Q# 14/ iG Phx/2010/s/Paper 31/ www.SmashingScience.org

7 (a) idea of light travelling (much) faster than sound B1

(b) (i) 4.0 (min) B1

(ii) always a (measurable) time difference / never zero time difference
Ignore time would be less B1

(iii) distance/time in any form, symbols, words, numbers OR 1200/3.6 C1
333.3 m/s to 2 or more sig figs A1

(iv) idea of light travelling instantaneously OR no wind
OR idea of lightning at ground level OR no obstruction to sound
Ignore echoes B1

Q# 15/_iG Phx/2009/w/Paper 31/ www.SmashingScience.org

8 (a)	2 cm (by eye) vertical object somewhere between F_2 and lens (condone no O, if clear)	B1	
(b)	any two standard rays correctly drawn (no extrapolation needed)	B1	
	correct rays extrapolated back to intersect	B1	
	virtual image drawn at candidate's intersection of extrapolated rays (condone no I, if clear)	B1	
			[4]

Q# 16/_iG Phx/2009/s/Paper 31/ www.SmashingScience.org

8 (a)	medium A because angle in air is bigger OR angle in A is smaller OR refracts / bends away from normal / angle of refraction greater than angle of incidence / total internal reflection only occurs in denser medium	B1	
(b)	air: light travels faster in less dense medium OR air: air is less dense / rarer	B1	
(c)	42°–43°	B1	
(d)	total internal reflection	B1	
(e)	*n = sin i / sin r* OR *n = sin r / sin i* OR 1.49 = *sin i / sin 35*	C1	
	(allow 1.49 or refractive index instead of *n* in any of above)		
	58.719° to at least 2 s.f. Allow 58.71°	A1	
(f)	*n = speed in air / speed in medium* in any arrangement		
	OR 1.49 = 3.0×10^8 / speed in medium A	C1	
	2.01343×10^8 m/s to at least 2 s.f.	A1	[8]

Q# 17/_iG Phx/2008/w/Paper 31/ www.SmashingScience.org

7 (a)	clear attempt at arcs of circles, at least 3	B1	
	same wavelength as incoming waves, by eye (ignore shape ignore distance to first wave)	B1	
	centre of curvature of arcs at centre of gap, by eye	B1	
(b)	speed/wavelength or 20/2.5 or v = fλ	C1	
	8 Hz or 8 s^{-1} or 8 waves/second	A1	
(c)	his **(b)** or "the same"	B1	[6]

Q# 18/_iG Phx/2008/w/Paper 31/ www.SmashingScience.org

6	(a)	light of one colour/frequency/wavelength	B1	
	(b)	n = sin*r*/sin*i* OR n = sin*i*/sin*r* in any form sin*r*/sin30 = 1.49 OR sin*r* = 1.49 × sin30 48.0° – 48.2°	C1 C1 A1	
	(c)	ray at angle >30° and <60° to normal, by eye, correct way **NO** e.c.f. Ignore any angles or labelling	B1	
	(d)	colours/spectrum would appear OR range of angles (ignore "rainbow") OR dispersion OR ray splits up	B1	
	(e)	90° approx (accept any value 80° to 90°)	B1	
	(f)	(totally internally) reflected OR T.I.R. ignore not refracted	B1	[8]

Q# 19/_iG Phx/2008/s/ www.SmashingScience.org

6	(a)	(for all rays, ignore any arrows, -1 for each incorrect extra ray) correct ray through F_1 ± 1mm on axis) correct ray through F_2 ± 1mm on axis) any 2 ray through lens centre ± 1mm on axis) image drawn between his intersection and axis	B1, B1 B1
	(b)	virtual upright/erect magnified/enlarged further (from lens) any 3	B1 × 3 [6]

Q# 20/_iG Phx/2008/s/ www.SmashingScience.org

7	(a)		(condone discontinuities at boundaries)	
			mirror:	
			equally spaced reflected waves, approx. same spacing as incident (by eye) IGNORE reflected waves to left of arrowhead	B1
			correct angle to surface, by eye	B1
			block:	
			reduced wavelength in block ACCEPT refracted waves to left of arrowhead	B1
			at sensible angle of refraction CONDONE reflected waves shown as well as refracted	B1
	(b)	(i)	3×10^8/speed in glass = 1.5 2×10^8 m/s	C1 A1
		(ii)	sin70°/sin*r* = 1.5 38.7895° to 2 or more sig figs	C1 A1
				[8]

Q# 21/_iG Phx/2007/w/Paper 3/ www.SmashingScience.org

7	(a)	(i)	diagram showing compressions and rarefactions (could be either spaced vertical lines or dots, or coil or sine wave) 2C's and 2R's in approx correct place	 B1 B1
		(ii)	wavelength correctly marked, by eye	B1
	(b)	(i)	all 3 in correct positions	B1
		(ii)	radio (waves)	B1
		(iii)	3×10^8 m/s	B1
				[Total: 6]

Q# 22/_iG Phx/2007/w/Paper 3/ www.SmashingScience.org

6	(a)	mirror:	2 reflected rays approx correct projected back to approx correct labelled image note: images may be dots or lines	M1 A1
		lens:	ray through F, correct by eye ray <u>through</u> centre OR ray through other F, correct by eye projected back to approx correct (labelled) image	M1 M1 A1
	(b)	(i)	not produced by real rays crossing OR cannot be caught on a screen OR rays appear to come from image	 B1
		(ii)	upright/right way up/erect c.a.o.	B1
		(iii)	lens image enlarged AND mirror image same size c.a.o. OR (different) size OR (different) distance OR different side	 B1
				[Total: 8]

Q# 23/_iG Phx/2007/s/ www.SmashingScience.org

7	(a)	source of sound (e.g. gun/hooter), tape (100 m), stopwatch NOT clock, metre rule (unless lab method)	B1	[1]
	(b)	distance <u>and</u> time between "flash and bang" (must be clear)	B1	[1]
	(c)	distance/time OR d/t OR 2d/t	B1	[1]
	(d)	further apart/more accurate timer/repeat/any other	B1	[1]
	(e)	speed of sound in air, tick 100	B1	
		speed of sound in water, tick 1000	B1	[2]
				[Total: 6]

Q# 24/_iG Phx/2007/s/ www.SmashingScience.org

6	(a)	(i)	refracted ray, angle < i, emergent ray approx parallel to incident	B1	
		(ii)	reflected ray at equal angle to incident, by eye	B1	[2]
	(b)	(i)	88–90°	B1	[1]
		(ii)	43° c.a.o.	B1	[1]
		(iii)	n = sin (his90°)/sin (his43°)	C1	
			1.466 or 1.47 or 1.5 c.a.o. any no s.f. ⩾ 2	A1	[2]
	(c)		n or his 1.5 = speed in air/speed in glass e.c.f.	C1	
			speed in glass = 2(.0) × 10^8 m/s e.c.f. any no s.f. ⩾ 2	A1	[2]
					[Total: 8]

Q# 25/_iG Phx/2006/w/Paper 3/ www.SmashingScience.org

7	(a)	straight not circular or WTTE waves not same wavelength/same distance apart waves should extend into shadow area (more) any 2	B2	[2]
	(b)	diagram showing large flat piece with circular edges (ignore any wavelength changes) but straight part must be (very) nearly equal to slit width	M1 A1	[2]
	(c)	speed = 1.2 x 8 = 9.6 cm/s	C1 A1	[2]
				[Total: 6]

Q# 26/_iG Phx/2006/w/Paper 3/ www.SmashingScience.org

6	(a)	completed path	B1	[1]
	(b)	any two correct, -1 each incorrect virtual, inverted, same size as object	B2	[2]
	(c)	angle of incidence zero/at right angles/along normal	B1	[1]
	(d)	1.5 = Va/Vg = 3x 10^8/Vg Vg = 2 x 10^8 m/s	C1 A1	[2]
	(e)	angle of incidence = 45°, so angle of reflection = 45°, so ray turns through 90° OR angle i> angle c so totally internally reflects	B1 B1	[2]
				[Total: 8]

Q# 27/_iG Phx/2006/s/ www.SmashingScience.org

7	(a)	Longitudinal or pressure waves	B1	1
	(b)	a correct C marked	B1	
		a correct R marked	B1	2
	(c)	oscillation/vibration/backwards and forwards	M1	
		along PY (consider pressure waves as alternative)	A1	2
	(d)	wavelength = 340/200	C1	
		PX(= λ/2) = 0.85 m	A1	2
				[7]

Q# 28/_iG Phx/2006/s/ www.SmashingScience.org

6	(a)	red ray refracted away from normal	B1	
		violet ray refracted more than red ray in prism	B1	
		violet ray further refracted from red ray to screen	B1	3
	(b)	1.52 = sin 40°/sin r	M1	
		sin r = sin 40°/ 1.52 (= 0.423)	C1	
		r = 25°	A1	3
	(c) (i)	3 x 10^8 m/s	A1	
	(ii)	same as (i)	A1	2
				[8]

Q# 29/_iG Phx/2005/w/Paper 3/ www.SmashingScience.org

6	(a)	Sound reflects off wall	B1	[1]
	(b)	400 Hz	B1	[1]
	(c)	λ = v/f or = 330/400	C1	
		= 0.83 m	A1	[2]
	(d)	vibration/oscillation along line of/direction of wave	B1	[1]
				Total [5]

Q# 30/_iG Phx/2005/w/Paper 3/ www.SmashingScience.org

7	(a) (i)	two approximately correct reflections	B1	
		evidence of projecting back to image or use of equal distance from the mirror, object and image	B1	
	(ii)	virtual	B1	
		any one of upright, same size, same distance from mirror	B1	[4]
	(b) (i)	ray 1 correct	B1	
		ray 2 correct	B1	
		image correctly located	B1	
	(ii)	eye symbol to right of lens	B1	[4]
				Total [8]

Q# 31/_iG Phx/2005/s/ www.SmashingScience.org

7	(a)	(i)	x-rays or gamma rays	B1	
		(ii)	infra red or radio	B1	2
	(b)		$f = v/\lambda$ or $3 \times 10^8 / 1 \times 10^{-12}$	C1	
			$= 3 \times 10^{20}$ Hz	A1	2
	(c)		3×10^8 m/s	1	1 [5]

Q# 32/_iG Phx/2005/s/ www.SmashingScience.org

6	(a)	along normal or angle i = 0 so angle r = 0	B1	1
	(b)	speed reduced, wavelength reduced, frequency unchanged		
		any two correct scores one mark	B1	
		third correct scores second mark	B1	2
	(c)	reflected at 30°	B1	
		refracted at > 30°	B1	2
	(d)	sin 30°/sin r = 0.67	C1	
		sin r = sin 30°/0.67	C1	
		r = 48°	A1	3 [8]

Q# 33/_iG Phx/2004/w/Paper 3/ www.SmashingScience.org

6	(a)		expect two internal reflections at sensible angles	1	1
	(b)		angle of incidence at Y greater than critical angle	1	
			total internal reflection occurs	1	2
	(c)	(i)	frequency= velocity/wavelength or $1.9 \times 10^8/3.2 \times 10^{-7}$	1	
			$= 5.9 \times 10^{14}$Hz	1	
		(ii)	refractive index = 3/1.9 or 1.9/3	1	
			= 1.58 (no e.c.f.)	1	4
					(7)

Q# 34/_iG Phx/2004/w/Paper 3/ www.SmashingScience.org

8	(a)	diffraction	1	1
	(b)	plane waves in front of gap	1	
		curved end effect shown, reasonable curves	1	
		wavelength constant throughout and approximately same as in Fig. 8.1	1	
		good quality i.e. end effect starts at correct points	1	4
	(c)	particles/water oscillate/vibrate/move up and down	1	
		at right angles to wave direction	1	2
				(7)

Q# 35/_iG Phx/2004/s/ www.SmashingScience.org

6	(a)	(i)	Refraction at Q approx. correct, ray emerge from AB parallel PQ	B1	
		(ii)	Angle of incidence correctly marked	B1	
			Angle of refraction correctly marked	B1	
			(can score even if incorrect / no refraction shown)		3
	(b)	(i)	Refractive index = speed in air / speed in glass	B1	
		(ii)	Refractive index = $(3 \times 10^8 / 2 \times 10^8) = 1.5$	B1	2
	(c)	(i)	Wavelength = v/f or $3 \times 10^8 / 6 \times 10^{14}$	C1	
			Wavelength = 5×10^{-7} m	A1	2
					[7]

Q# 36/_iG Phx/2004/s/ www.SmashingScience.org

7	(a)		C,R,C,R,C,R marked (or v.v.) along XY	B1	1
	(b)	(i)	Above normal / high air pressure or particles close together	B1	
		(ii)	Below normal / low pressure or particles further apart	B1	2
	(c)		Oscillation / vibration of particles / molecules (or particles / molecules move to and fro)	B1	
			Oscillation is along XY	B1	2
	(d)		Time = distance / speed or (2x) 50/340	C1	
			Time = 0.29 s	A1	2

Q# 37/_iG Phx/2003/w/Paper 3/ www.SmashingScience.org

6	(a)	3 more roughly circular	B1	
		all drawn clearly circular, stop (well) clear of barrier and centred on slit	B1	
		wavelength constant throughout, both sides of barrier	B1	3
	(b)	wavelength – speed/frequency in any form	C1	
		values substituted correctly	C1	
		answer 6 x 10 m	A1	3
				[6]

Q# 38/_iG Phx/2003/w/Paper 3/ www.SmashingScience.org

7	(a)	two dots, marked F, each 5.0 cm from the lens	A2	2
	(b)	each correct ray one mark	M2	2
	(c)	correct image, labeled I	A1	1
	(d)	rays pass along the axis undeviated/object distance same for all object/rays meet at same distance on image/image distance same for all image	B1	1
	(e)	magnifying glass/eyepiece of telescope or microscope	B1	1
				[7]

Q# 39/_iG Phx/2003/s/ www.SmashingScience.org

7	(a)		value 3 x 10 m/s	A1	1
	(b)		speed of light (much) greater than speed of sound or value for sound	A1	1
	(c)	(i)	source and receiver arrangement	C1	
			with detail and labels	A1	
		(ii)	distance between source and receiver	B1	
			time between flash and bang	B1	
		(iii)	speed = distance/time	B1	max 4
					[6]

Q# 40/_iG Phx/2003/s/ www.SmashingScience.org

6	(a)	(i)	incident ray, refracted ray and normal drawn	C1	
			all correct and meeting at a point	A1	
		(ii)	angle of incidence and refraction correctly identified	B1	
		(iii)	values correct within agreed limits	B1	4
	(b)		use of sini/sinr	C1	
			correct substitution from candidates values	C1	
			value correct within agreed limits from candidate's values	A1	3
					[7]

Q# 41/_iG Phx/2002/w/Paper 3/ www.SmashingScience.org

5 a(i) C marked vertically under/at any peak (including on axis)		B1	
R marked on NEXT trough (either way)	2	B1	
(ii) half a wavelength	1	B1	3
b f = v/w or 340/1.3		C1	
= 260 Hz*	2	A1	2
		QT	5

Q# 42/_iG Phx/2002/w/Paper 3/ www.SmashingScience.org

6 a(i) 43° ±1°	1	A1	
(ii) angle r for this ray is 90°		B1	
or marked c → angle c is angle i (in denser medium) ~~(giving angle r = 90°)~~	2	B1	3
b(i) 3 x 10⁸ m/s*	1	A1	
(ii) speed in air/speed in medium		M1	
= 1.5 (no up for °)	2	A1	
(iii) angle i = 0°/ along normal / at 90° to surface	1	B1	
(iv) increased/more/larger	1	B1	5
		QT	8