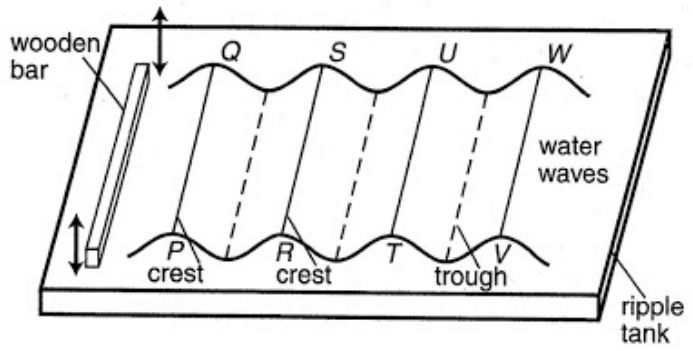
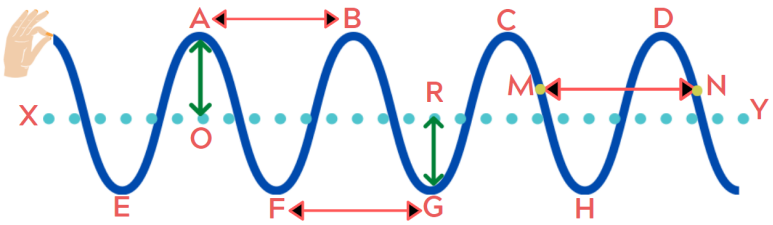
GENERAL WAVE PROPERTIES

- Waves transfer energy without transferring matter.
- Waves are produced by vibrating ropes and springs and water waves.



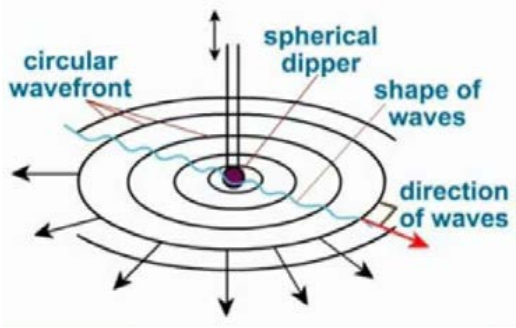
Example: Water waves are produced in labs by oscillating paddle in shallow water.

TRANSVERSE WAVE



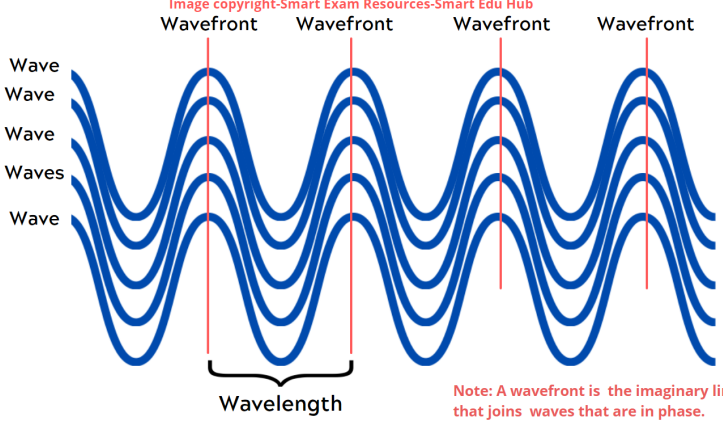
Example: Water waves on a vibrating rope tied at one end

COMPLETE WAVE: One crest and one trough together form one complete wave.
CREST:A, B, C and D are called as the crests
TROUGH: E,F,G,and H are called as the troughs
MEAN POSITION: XY
AMPLITUDE: DISTANCE OA and RG
WAVELENGTH: DISTANCE AB, FG, MN
FREQUENCY: 4.5 Hz because 4.5 waves are passing a fixed point per second.



Wavefronts:The expanding circles formed when a stone is dropped are known as wave fronts

WAVES, WAVEFRONTS AND WAVELENGTHS



Note: A wavefront is the imaginary line that joins waves that are in phase.

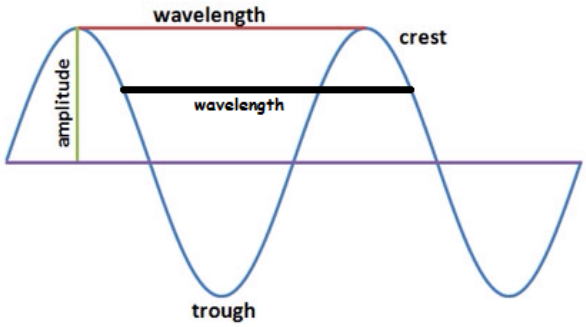
Difference between transverse waves and longitudinal waves

	LONGITUDINAL WAVE	TRANSVERSE WAVE
1	It has compressions AND rarefactions	It has crests and troughs
2	The vibrations are parallel to direction of travel of the wave energy OR the compressions move in direction of travel of wave energy	The vibrations travel perpendicular to the direction of travel of the wave energy.
3	Examples: Sound waves, waves on a slinky spring and seismic P-waves.	Electromagnetic radiations, Seismic S-waves and water waves

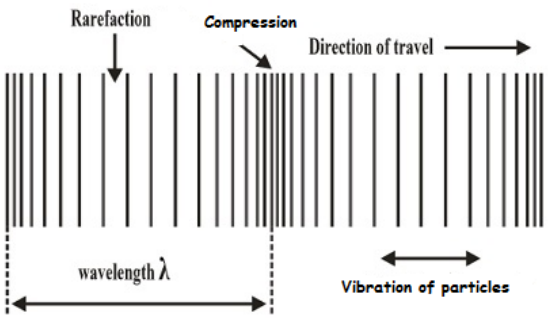
---

Wavelength , amplitude of transverse waves:

Amplitude: It is the maximum displacement of a wave from its rest position.
Wavelength: It is the distance between two consecutive crests or two consecutive troughs or any two points in phase.
Frequency: It is the number of complete vibrations per unit time.
Amplitude: It is the maximum displacement of a wave from its rest position



Transverse Wave



Longitudinal wave

FOLLOWING ARE DIFFERENT WAYS OF DRAWING LONGITUDINAL WAVES

Note: Longitudinal waves are also called as pressure waves because they have regions of low pressure when molecules are furthest apart and regions of high pressure where molecules are the closest. as shown below.

DIAGRAM :1

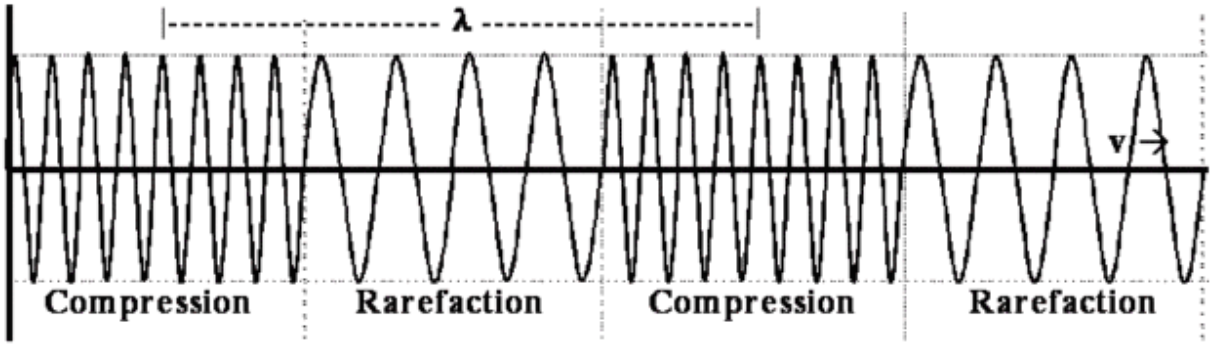


DIAGRAM :2

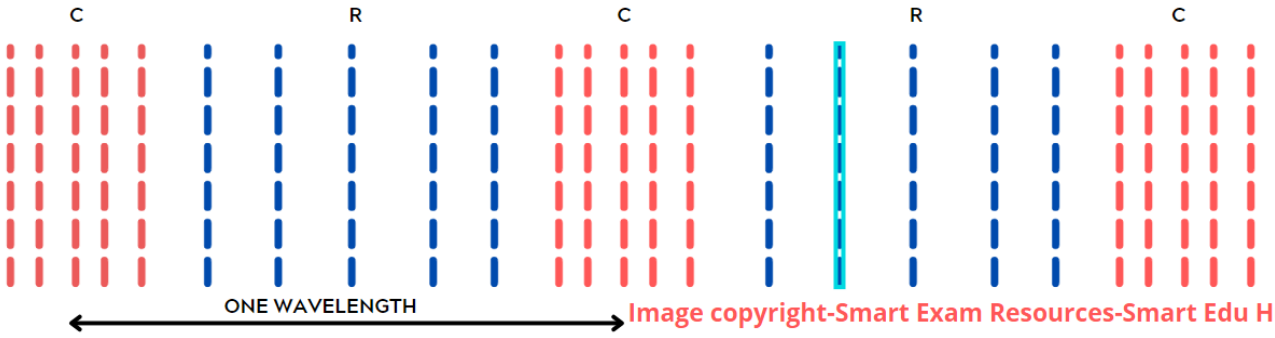


DIAGRAM :3

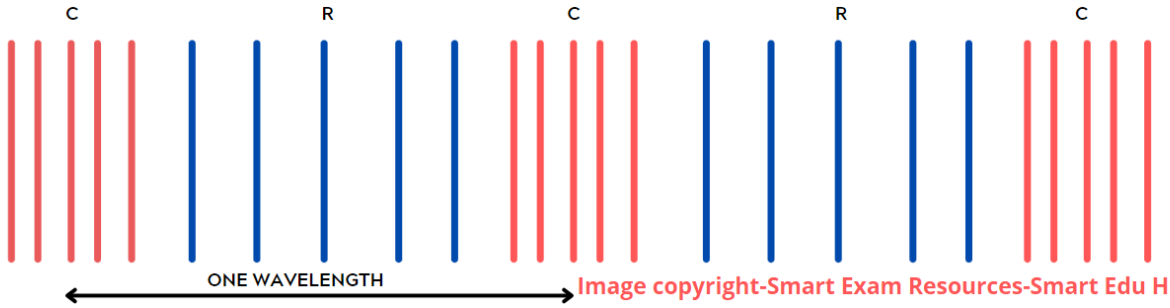
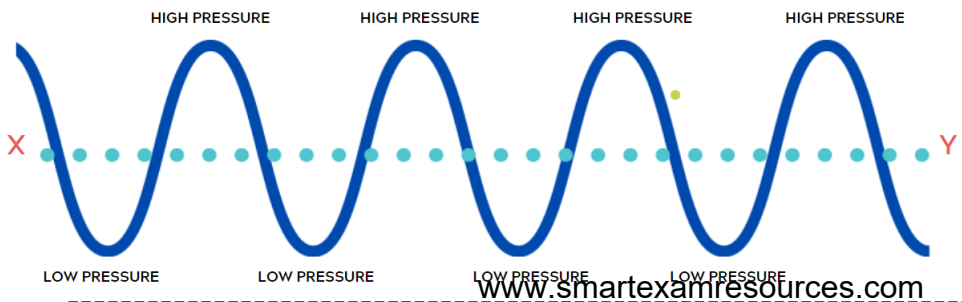


DIAGRAM :4



Speed of waves(v):

It is the distance travelled by a wave crest or a wave trough every second.

Note:

Speed of sound in air is 340m/s and in vacuum is 343m/s .

Speed of sound in water and steel: The acceptable values as per the markschemes are in the range " 1 and 9.9 x10^3m/s.

Formula for speed $v = f\lambda$

where; v = speed

f= frequency

$\lambda = wavelength$

Numerical:

(b) (i) The electromagnetic waves used in a microwave oven have a frequency of 2.45×10^9 Hz. The speed of the waves is 3.00×10^8 m/s.

Calculate the wavelength of the waves.

Solution:

$v = f\lambda$

$3.00 \times 10^8 = 2.45 \times 10^9 \times \lambda$

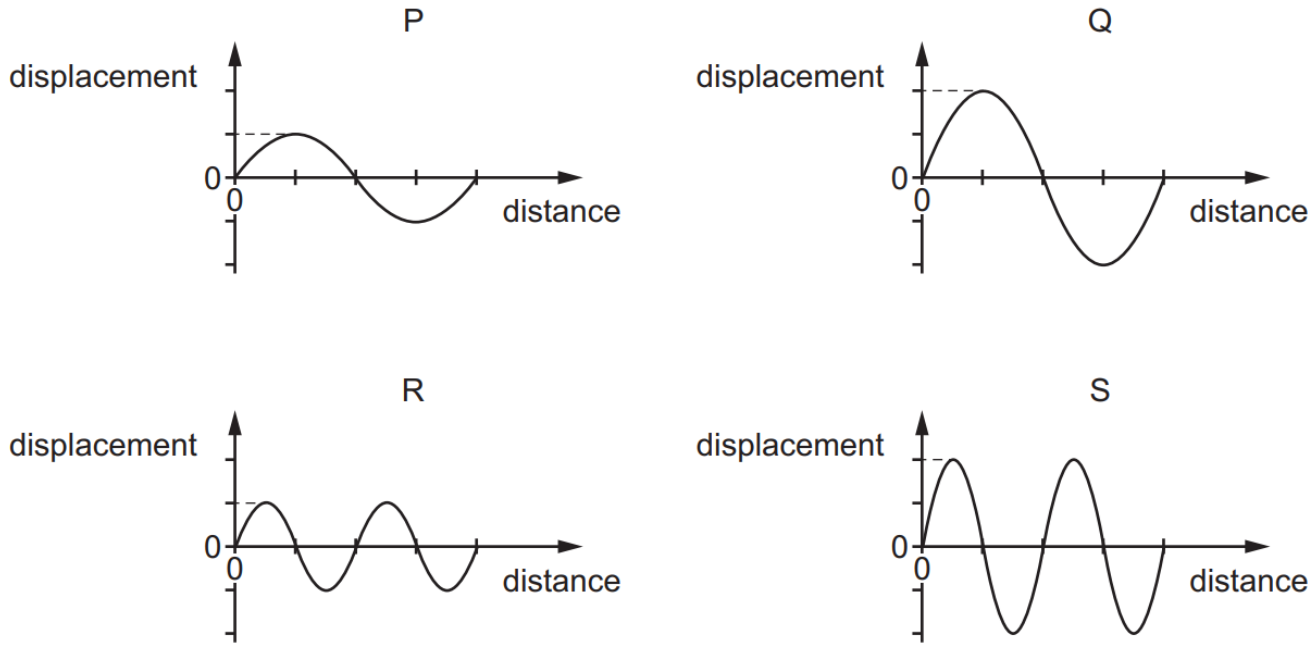
$\lambda = \frac{3\ x\ 10^8}{2.45\ x\ 10^9} = 1.22 \times 10^{-1}\text{m} = 0.12\text{m}$

Application based questions:

MCQ:

The diagram shows four waves drawn to the same scale.

0625/12/O/N/14-Q16-ANS: A



Which statement is correct?

A The amplitude of wave P is the same as the amplitude of wave R.

B The amplitude of wave S is double the amplitude of wave Q.

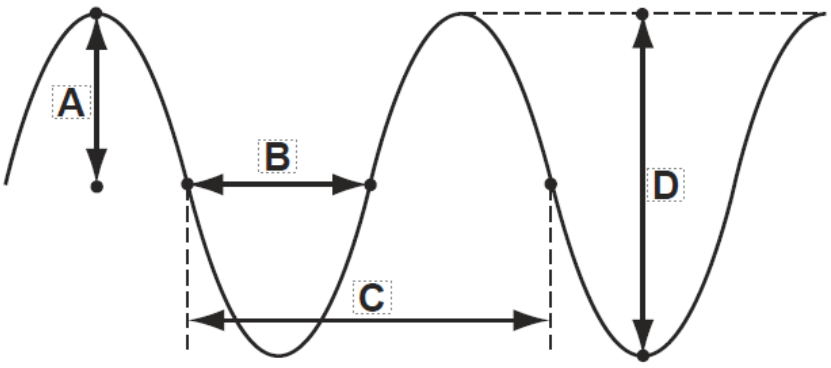
C The wavelength of wave Q is double the wavelength of wave P.

D The wavelength of wave S is the same as the wavelength of wave Q.

The drawing shows a wave.

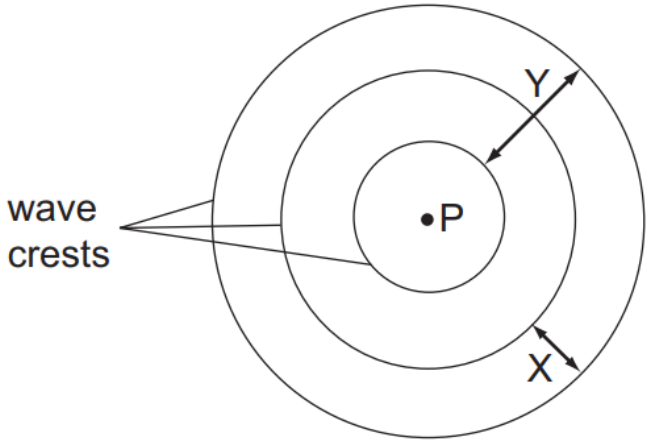
Which labelled distance is the wavelength?

0625/01/M/J/05-Q20-ANS:C



A vertical stick is dipped up and down in water at P. In two seconds, three wave crests are produced on the surface of the water.

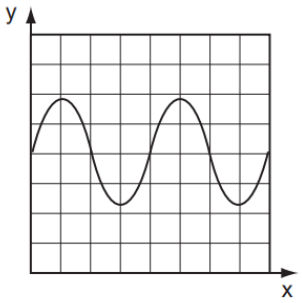
0625/01/M/J/04 -Q21-ANS:C



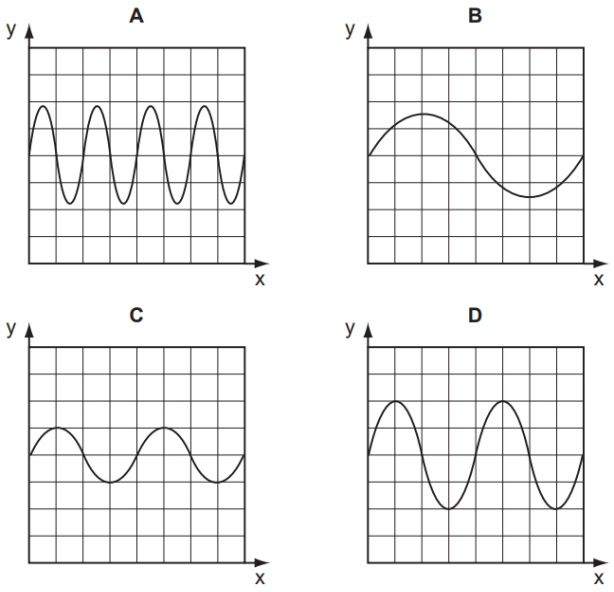
Which statement is true?
A Distance X is the amplitude of the waves.
B Distance Y is the wavelength of the waves.
C Each circle represents a wavefront.
D The frequency of the waves is 3Hz.

The graph represents a sound wave. The horizontal (x) axis represents time

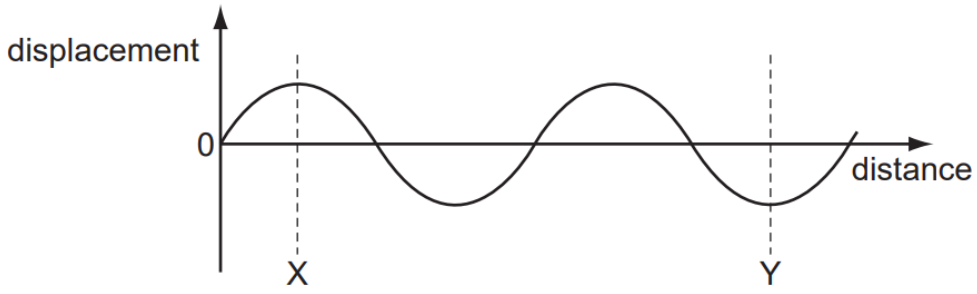
0625/01/O/N/07-Q25-ANS:A



The frequency of the sound is increased.
The graphs below are shown to the same scale. Which graph represents the new sound wave?



The diagram represents a wave. 0625_s13_ms_11-Q20-ANS:C



How many wavelengths are there between X and Y?

A $\frac{2}{3}$ **B** 1 **C** $1\frac{1}{2}$ **D** 3

YOU MAY WRITE THE EXPLANATIONS FOR YOUR MCQS' HERE:

EXTENDED THEORY QUESTIONS:

The end of the strip is pulled down and released, so that the strip vibrates. X and Z are the extreme positions of the end of the strip during this vibration. Y is the mid-position.

Explain what is meant by

(i) the frequency of vibration of the strip,

.....

.....

(ii) the amplitude of vibration of the end of the strip.

.....

.....[2]

MARKSCHEME:

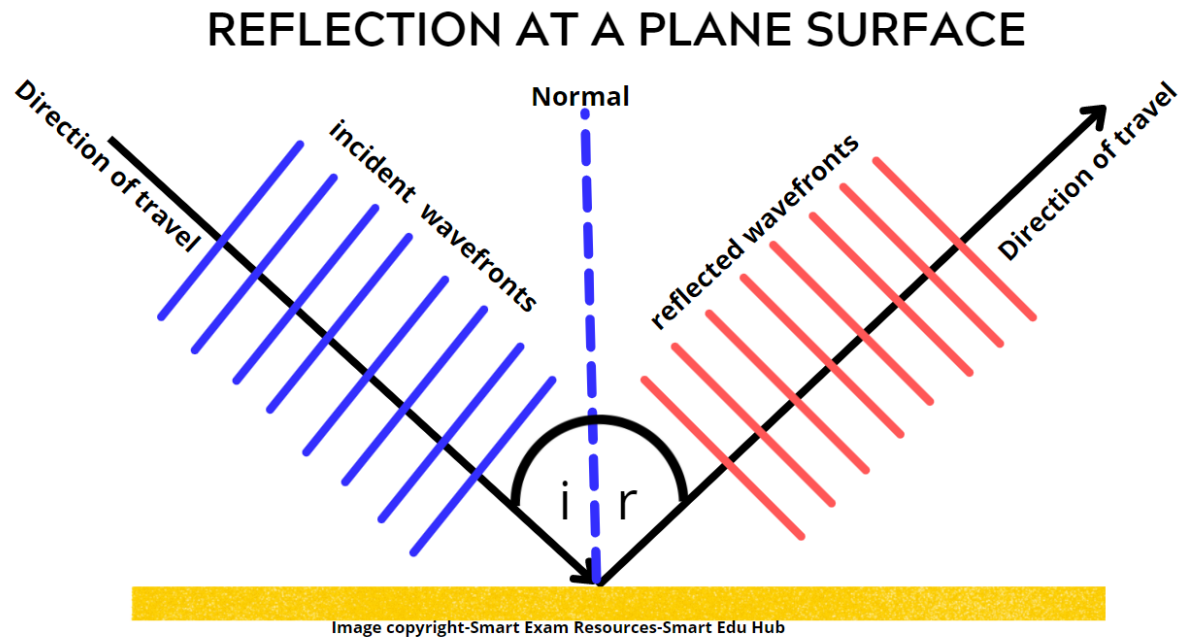
(a) (i) (number of complete) vibrations (of the strip) per second/unit time B1

(ii) maximum displacement of end of strip from mid-position

OR XY OR ZY OR XZ ÷ 2

Reflection, refraction and diffraction of waves

REFLECTION:



When wavefronts are incident at an angle to a plane surface:

- Angle of incidence will always be equal to the angle of reflection
- The reflected wavefronts will be parallel to each other
- The wavelength, frequency and the speed of the wavefronts all remain unchanged after reflection

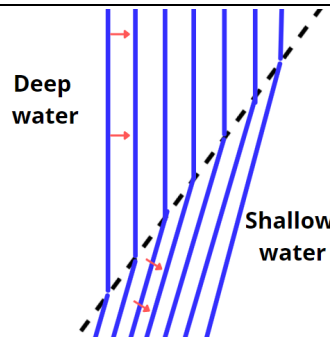
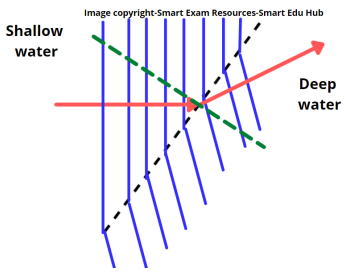
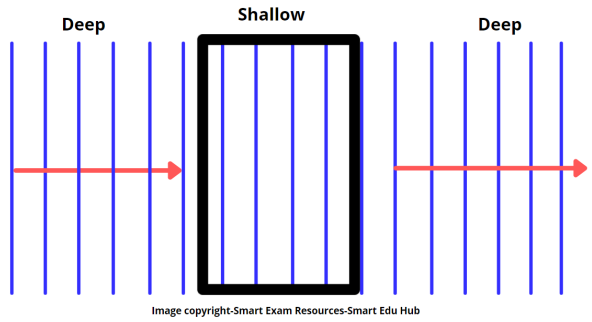
- After refection, a wave has the same speed, frequency and wavelength as before.
- Only the direction of the wave changes.

Refraction

Definition: Refraction is the change in the direction of the waves at the boundary when they travel from one medium to another.

Water waves refract if the depth changes.

for example when water waves travel from deep water to shallow water, they refract.

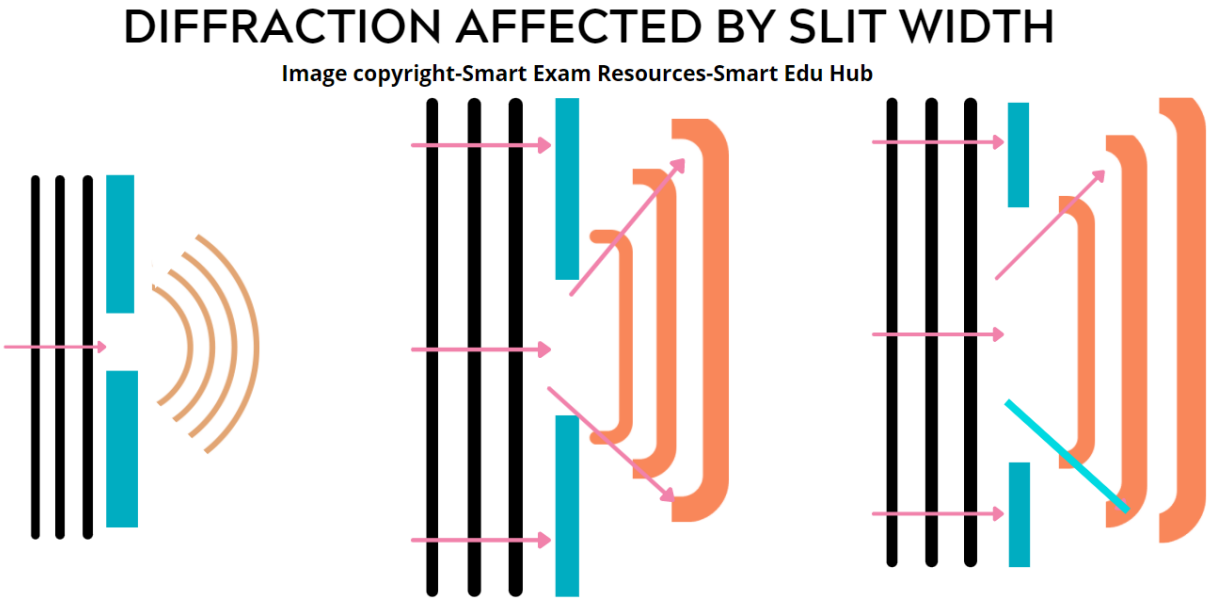
Medium	Effect
	Waves bend towards the boundary when water waves travel from deep water to shallow water. Their speed and wavelength decreases. Their frequency is unchanged.
	Waves bend away from the boundary when water waves travel from shallow water to deep water. Their speed and wavelength increases Their frequency is unchanged.
	If the waves strike the boundary an angle of incidence= 0^0,then there is no refraction. The speed and the wavelength and frequency changes as explained above depending on whether waves travel from shallow to dep or deep to shallow water.

Note:

- **If the waves meet the boundary between deep and shallow water at an angle , then the direction of the waves changes.**
- **Speed of waves does not change during reflection and diffraction.**
- **Speed of waves changes during refraction**

Diffraction:

Diffraction is the spreading of waves when they pass through a gap or move past an obstacle.



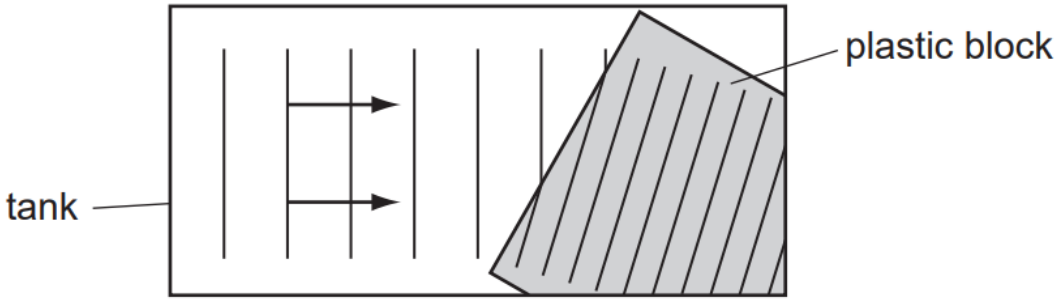
The wavelength, frequency, period and speed are the same before and after diffraction.

Note:

- The narrower the gap , the more the waves spread out (greater diffraction)
- The wider the gap, the less the waves spread out(the lesser is the diffraction.
- Maximum diffraction happens when the gap width is equal to the wavelength of the waves.
- Wavelength, frequency period and speed stay the same on diffraction.

APPLICATION BASED QUESTIONS
MCQ:

1] Water waves in a tank pass over a thin plastic block as shown



What happens to the waves as they reach the plastic block?

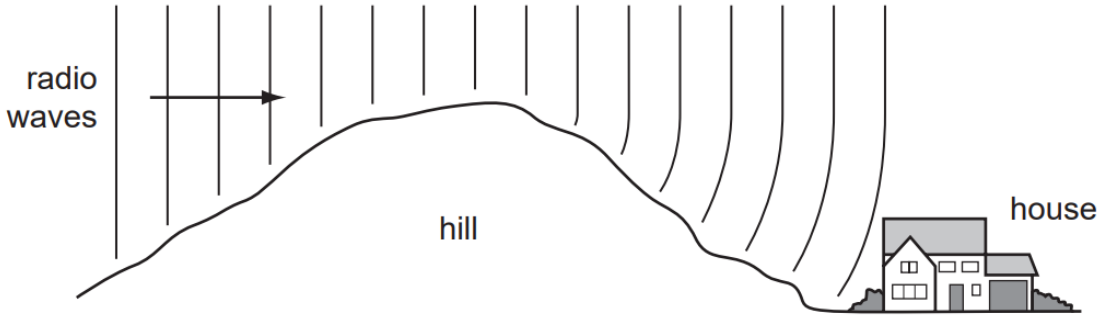
A They are diffracted because they slow down.

B They are diffracted because they speed up.

C They are refracted because they slow down.

D They are refracted because they speed up

2] Radio waves are received at a house at the bottom of a hill



The waves reach the house because the hill has caused them to be

A diffracted.

B radiated.

C reflected.

D refracted.

3]

21 A boy throws a small stone into a pond. Waves spread out from where the stone hits the water and travel to the side of the pond.

0625/12/O/N/13

The boy notices that eight waves reach the side of the pond in a time of 5.0 s.

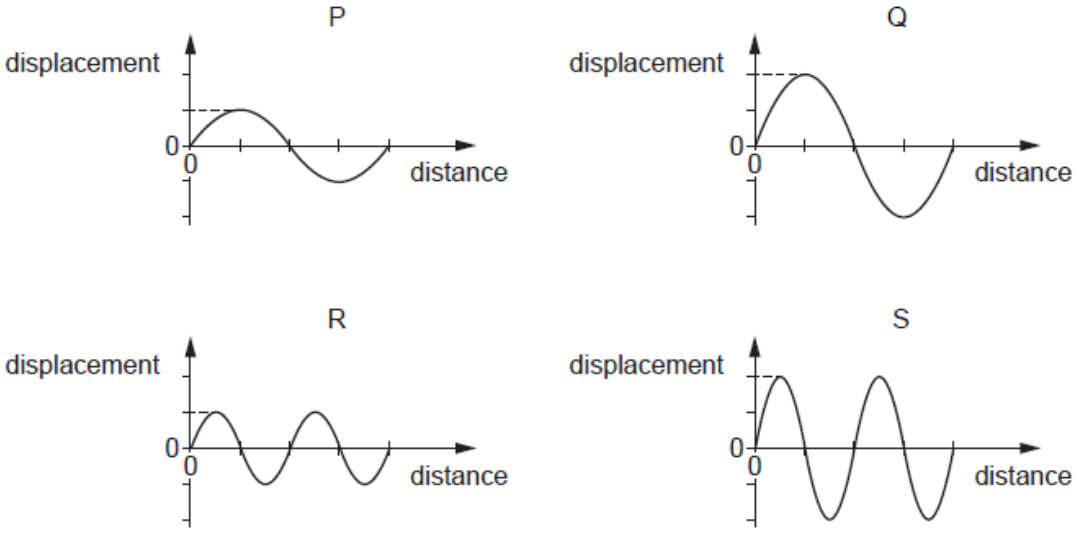
What is the frequency of the waves?

A 0.20 Hz **B** 0.63 Hz **C** 1.6 Hz **D** 40 Hz

4]

16 The diagram shows four waves drawn to the same scale.

0625/12/O/N/14



Which statement is correct?

A The amplitude of wave P is the same as the amplitude of wave R.

B The amplitude of wave S is double the amplitude of wave Q.

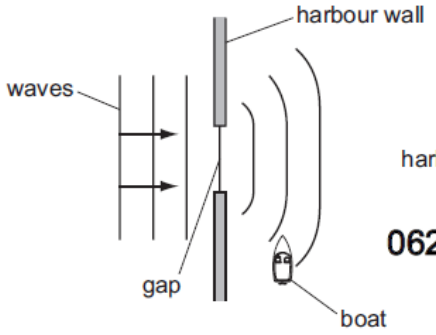
C The wavelength of wave Q is double the wavelength of wave P.

D The wavelength of wave S is the same as the wavelength of wave Q.

5]

26 The diagram shows water waves passing through a gap in a harbour wall. The waves curve round the wall and reach a small boat in the harbour.

0625/13/M/J/12



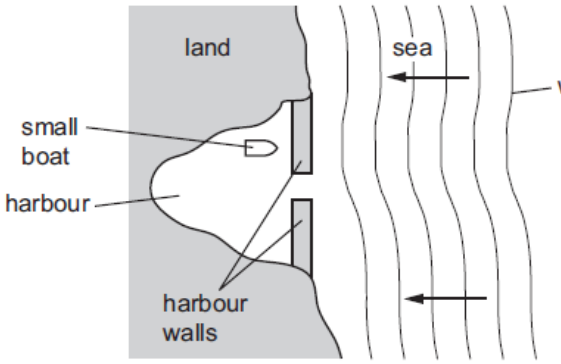
0625/11/M/J/13

What is the name of this curving effect, and how can the gap be changed so that the waves are less likely to reach the boat?

	name of effect	change to the gap
A	diffraction	make the gap slightly bigger
B	diffraction	make the gap slightly smaller
C	refraction	make the gap slightly bigger
D	refraction	make the gap slightly smaller

6]

19 A small boat in a harbour is protected from waves on the sea by harbour walls.



0625/11/M/J/14

Some waves can curve round the harbour walls and reach the boat.

What is the name of this effect?

A diffraction

B dispersion

C reflection

D refraction

MARKSCHEME:
1-C
2-A
3-C
4-A
5-B
6-A

EXTENDED THEORY QUESTIONS

This wave pattern is wrong because:[2]

1. The wave fronts have been drawn straight whereas they should have been circular.
2. The wavelengths have not been drawn with the same wavelength(They are not the same distance apart)
3. Waves should have entered more in the shadow area

APPLICATION BASED QUESTIONS-EXTENDED THEORY

(a) Underline the most appropriate value below for the speed of sound in water. [1]

1.5 m / s 15 m / s 150 m / s 1 500 m / s 15 000 m / s

(b) Sound travels in water as a series of compressions and rarefactions.

Describe what is meant by a compression and by a rarefaction.

compression .....

.....

rarefaction .....

.....[2]

MARKSCHEME:

(a) 1500 m/ s underlined/ indicated B1

(b) compression: closer together AND rarefaction: further apart B1

compression: particles / molecules /wavefronts closer together/ low pressure

AND rarefaction: particles / molecules /wavefronts further apart/high pressure B1

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

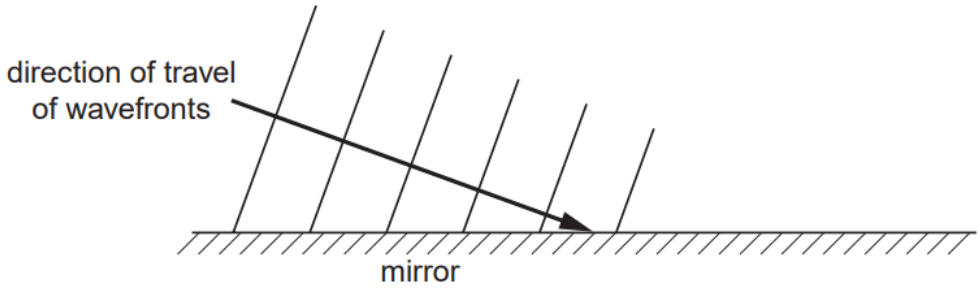


Fig. 7.1

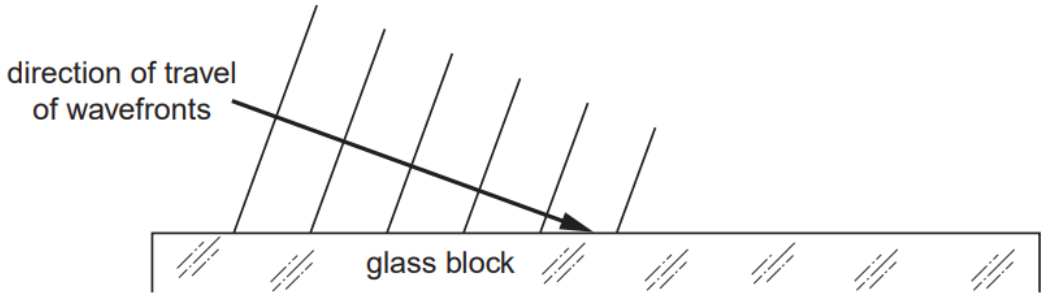


Fig. 7.2

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

MARKSCHEME:

(a) (condone discontinuities at boundaries)mirror: equally spaced reflected waves, approx. same spacing as incident (by eye) B1 IGNORE reflected waves to left of arrowhead

correct angle to surface, by eye B1

block: reduced wavelength in block B1

ACCEPT refracted waves to left of arrowhead at sensible angle of refraction B1

CONDONE reflected waves shown as well as refracted

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.

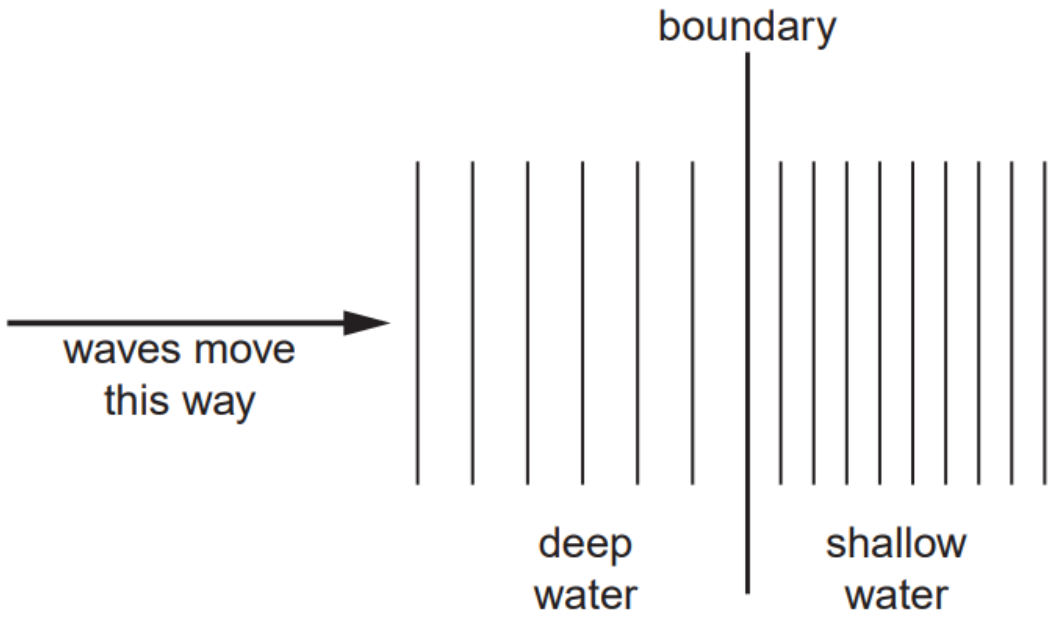


Fig. 6.1

(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.

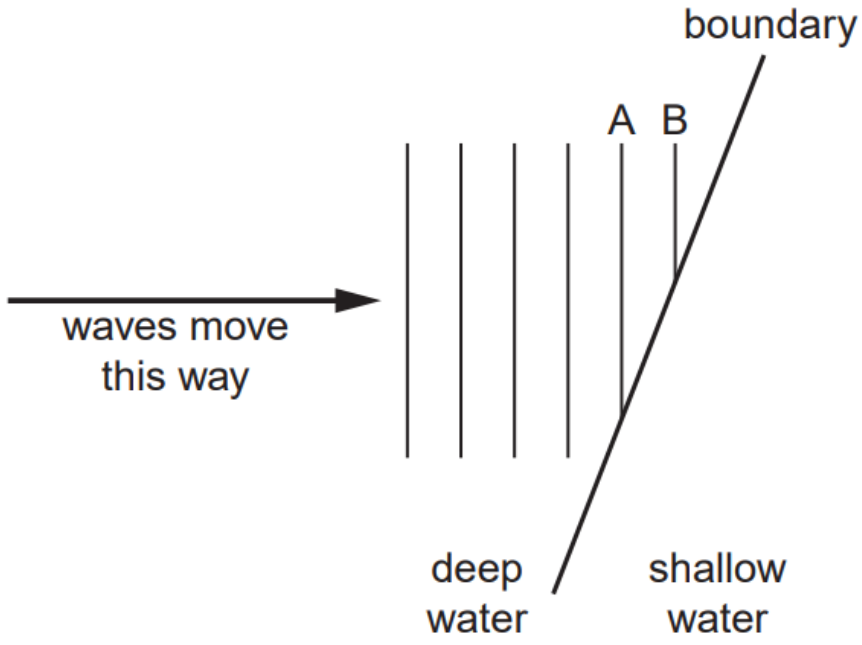


Fig. 6.2

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]

MARKSCHEME:

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

(ii) reduced / slows down B1

(iii) reduced B1

(b) $v = f\lambda$ in any form or in words [not numbers]

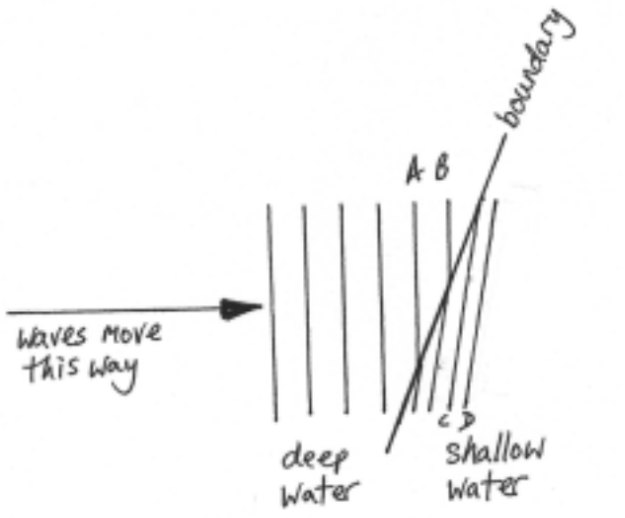
OR $f = 1/T$ in any form or in words [not numbers] B1

$0.12 = f \times 0.08$ 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]

(a) A wave passes along the surface of the water in a ripple tank. Describe the motion of a molecule on the surface as the wave passes.

.....

..... [1]

(b) Fig. 7.1 shows a view from above of water waves approaching a narrow gap in a barrier.

The water on both sides of the barrier has the same depth.

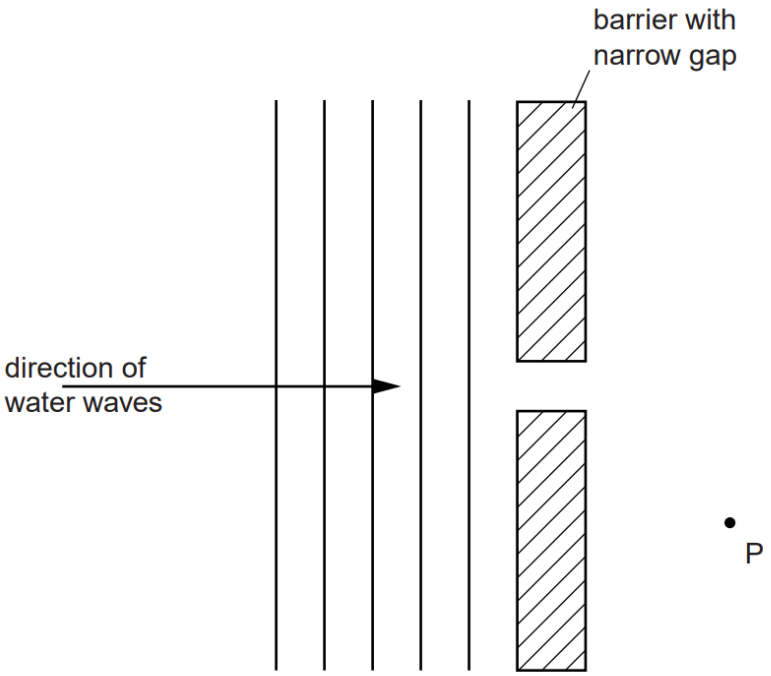


Fig. 7.1

(i) On Fig. 7.1, sketch the pattern of waves in the region to the right of the barrier. [2]

(ii) State the process by which waves arrive at point P to the right of the barrier.

.....[1]

(c) The waves approaching the barrier in Fig. 7.1 have a wavelength of 1.4 cm and travel at a speed of 12 cm / s.

Calculate the frequency of the waves.

frequency = ... [2]

[Total: 6]

MARKSCHEME:

(a) (Molecule) moves up and down / rises and falls OR oscillates perpendicular to direction of wave OR describes a circle B1

(b) (i) At least 3 circular arcs, angular spread greater than 90° (symmetrically above and below slit B1

Centre of arcs at centre of slit and with same spacing (by eye) as incident

waves B1

(ii) Diffraction B1

(c) $v = f \times \lambda$ OR $12 = f \times 1.4$ OR $f = v / \lambda$ OR $f = 12 / 1.4$ C1

f = 8.57 Hz / per s / waves or vibrations per s A1

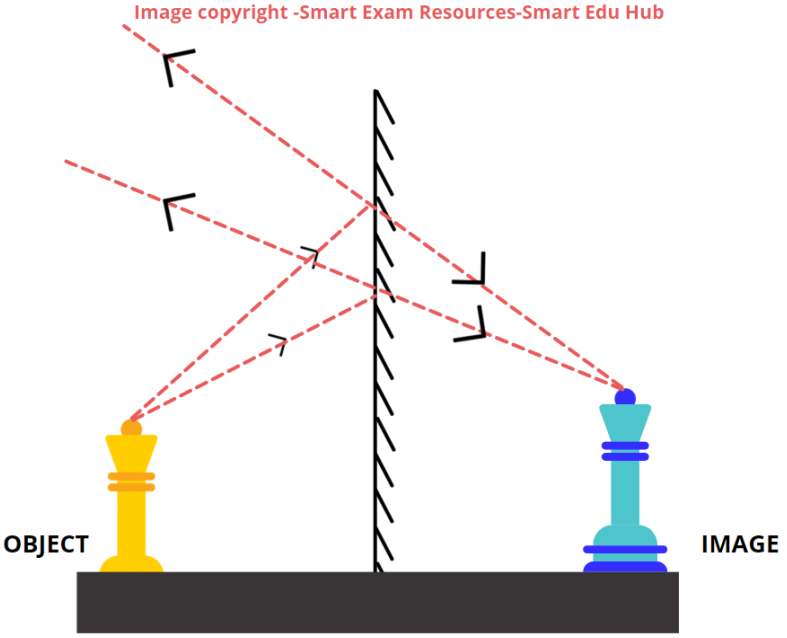
at least 2 s.f.

[Total: 6]

LIGHT

FORMATION OF IMAGE BY A PLANE MIRROR

VIRTUAL IMAGE IN A PLANE MIRROR



Properties of image formed in a plane mirror:

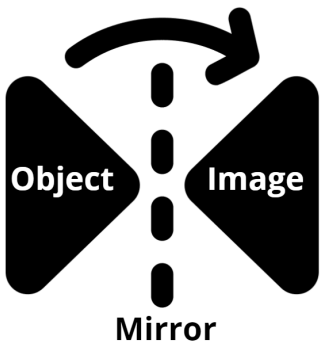
- **It is laterally inverted**
- **It is the same shape and size as the object**
- **It is the same distance behind the mirror as the object is in front of it**
- **It is virtual as it is formed by rays that appear to meet**

Why the image formed in the plane mirror is virtual.

This is because the image is formed by rays that appear to meet behind the mirror. In reality the rays bounce off the mirror.

Why the image formed in the plane said to be laterally inverted?

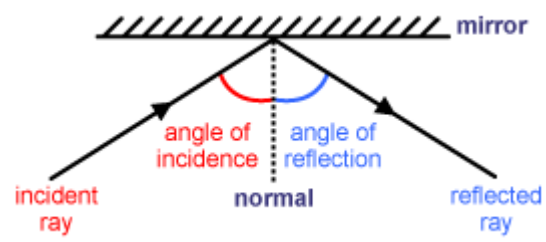
LATERALLY INVERTED IMAGE



This is because the right side of the object appears to be the image's left side and vice-versa

---

Laws of reflection:

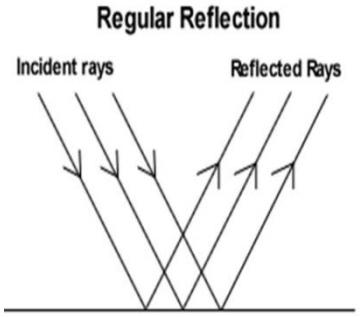


- The angle of incidence=angle of reflection ($\angle i = \angle r$
- The incident ray , the reflected ray and the normal ray line on the same plane.

Angle of incidence: It is the angle between the incident ray and the normal.
Angle of reflection: It is the angle between the reflected ray and the normal.
Normal: The straight line at 90^0 to the reflecting surface is called as the normal.

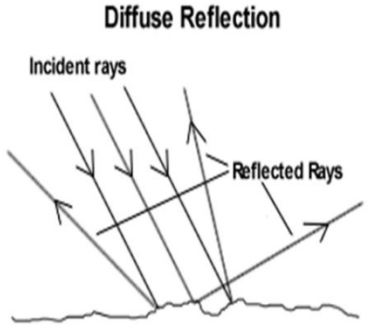
Types of reflection:

There are two types of reflections:



- Regular reflection: When reflection is produced by very smooth surfaces and the reflected rays all leave the surface parallel to each other.
- Example: Images formed by a plane mirror, still water, a gleam off the polished floor, stainless steel, glass.

==========



- Irregular reflection (Diffuse reflection): When reflection is produced by rough surfaces and the reflected rays all leave the surface in many different directions.
- Example: Images formed by a wooden tables, blankets, walls etc.

Real and a virtual image:

	Real image	Virtual image
Definition	A real image is formed by rays of light meeting Or A real image can be formed on the screen. Or A real image is formed on the opposite side of the lens from the object	A virtual image is an image that is not produced by real rays crossing each other Or A virtual image cannot be caught on a screen. Or In an virtual image , the rays appear to come from the image
Nature	A real image is always inverted	It is always upright
Examples	Image formed on a cinema screen, image formed on the retina of the eye	Image formed by the plane mirror, magnifying glass

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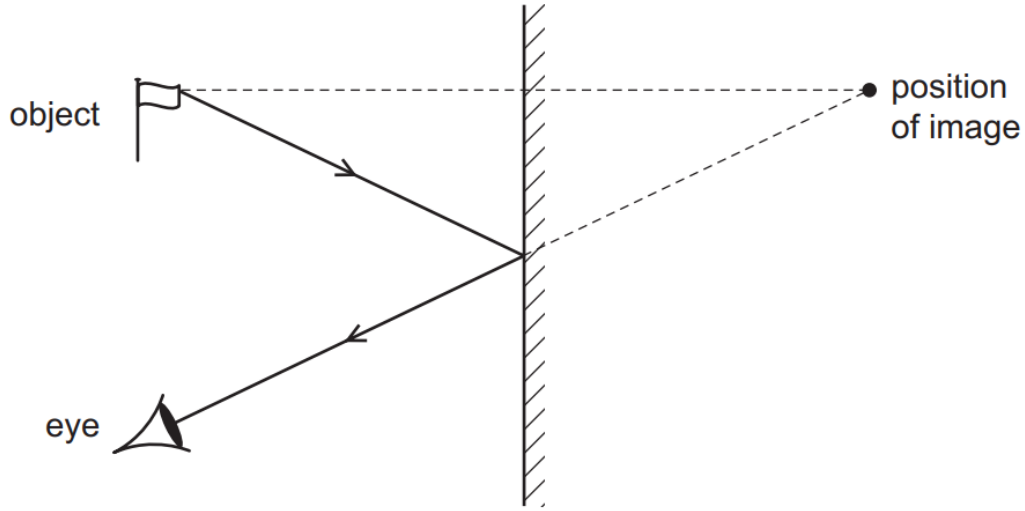
APPLICATION BASED QUESTIONS

MCQ:

ANSWER:C

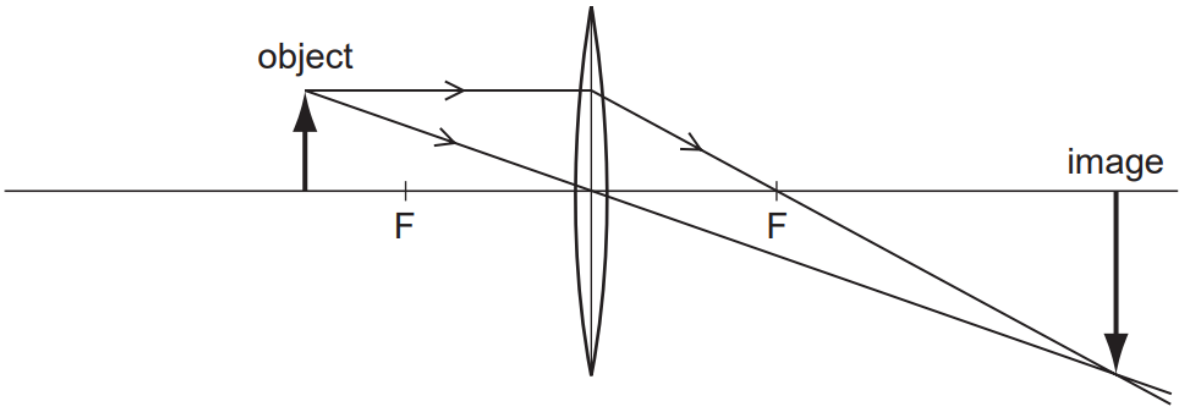
1] The image formed by a plane mirror is upright.



What are the other characteristics of the image?

	laterally inverted (left to right)	magnified (larger than the object)	virtual
A	no	yes	yes
B	yes	no	no
C	yes	no	yes
D	yes	yes	no

2] A thin converging lens forms an image. **ANSWER:C**



What is the nature of this image and can it be formed on a screen?

	nature of image	can be formed on a screen?
A	not real	no
B	not real	yes
C	real	no
D	real	yes

3] A girl writes the word **LEFT** on a piece of card.

ANSWER: B

She looks at the image of this card, made by reflection by a plane mirror.

What does she see?

A

B

C

D

4] The diagram shows the image of a clock in a plane mirror.

ANSWER:C

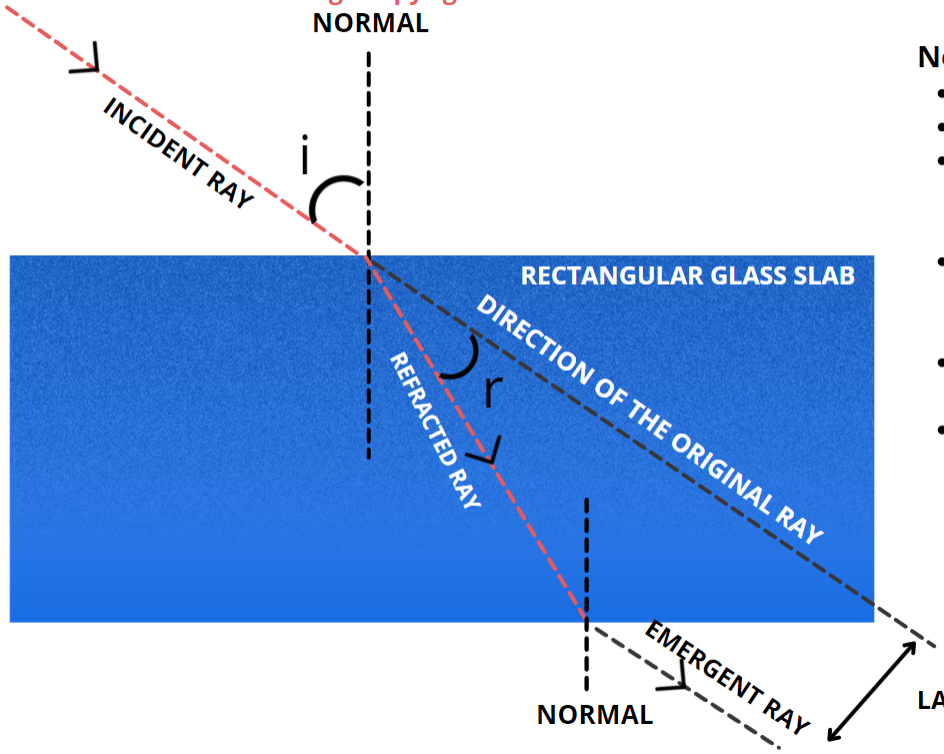
What time is shown?

A 02:25 **B** 02:35 **C** 09:25 **D** 09:35

REFRACTION OF LIGHT

REFRACTION OF LIGHT THROUGH A PARALLEL SIDED TRANSPARENT BLOCK

REFRACTION OF LIGHT THROUGH A GLASS SLAB



Note:

- i=angle of incidence
- r=angle of refraction
- The angle of incidence is the angle between the incident ray and the normal.
- The angle of refrcation is the angle between the refracted ray and the normal.
- The incident ray is always parallel to the emergent ray.
- The incident ray always bends towards the normal while travelling from a rarer medium to a denser medium and vice versa

1.When a ray of light enters from a rarer medium (Example air) to a denser medium (say glass),, it bends towards the normal. The speed of light decreases.

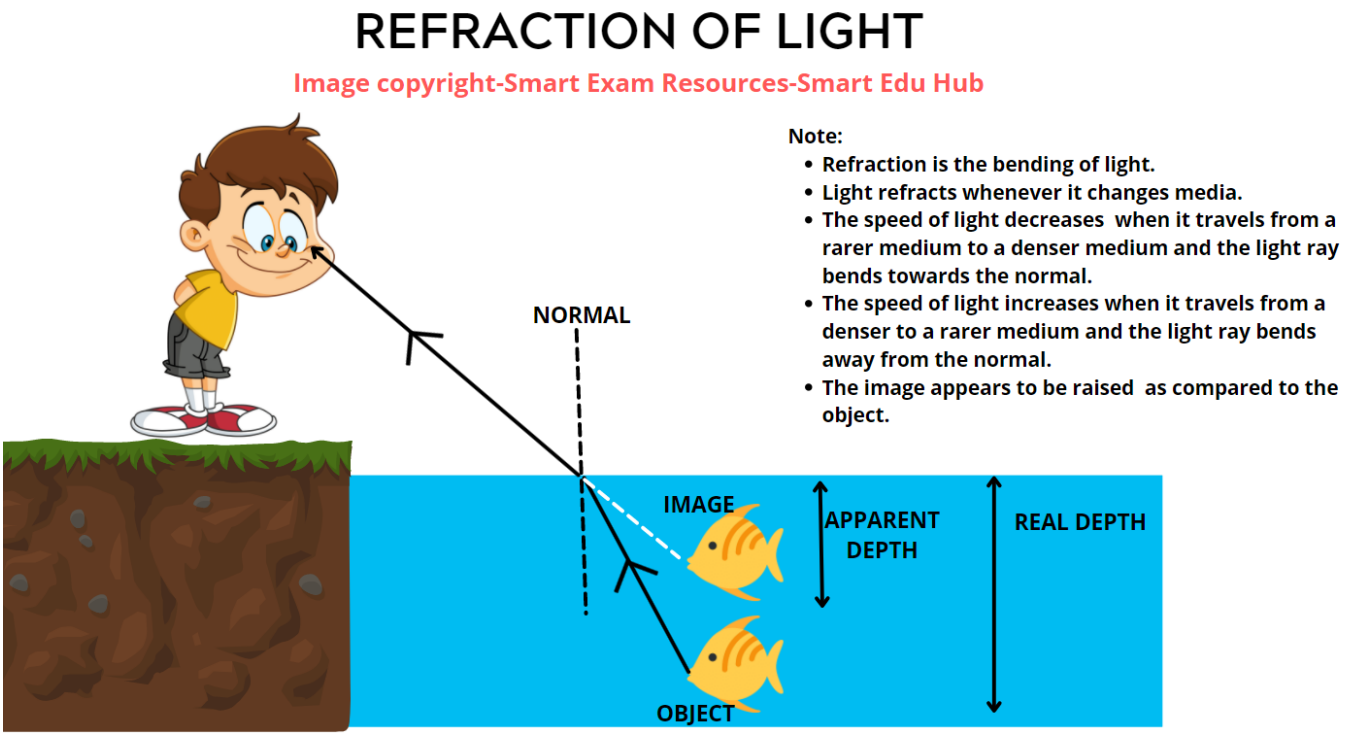
2. When a ray of light enters from a denser medium(say glass) to a rarer medium (for example air) the ray of light bends away from the normal. The speed of light increases.

Note:

- The angle between the incident ray and the normal is the angle of incidence.
- The angle between the refracted ray and the normal is the angle of refraction.
- The angle between the normal and the emergent ray is the angle of emergence.
- The angle of emergence is always equal to the angle of incidence.

==========

REAL DEPTH AND APPARAENT DEPTH:



Light gets refracted when it changes medium. Hence the position of an object appears to be raised compared to the actual position

1. The distance between the water surface and the object is the real depth.
2. The distance between the water surface and the image is the apparent depth.

REFRACTIVE INDEX:

The refractive index is defined as: $\eta = \frac{\textit{The speed of light in the air}}{\textit{The speed of light in a medium}}$

==========

For light travelling from a rarer medium to a denser medium = =

$\eta = \frac{Sini}{sinr}$

==========

CRITICAL ANGLE AND TOTAL INTERNAL REFLECTION:

REFRACTION IN A SEMICIRCULAR GLASS SLAB

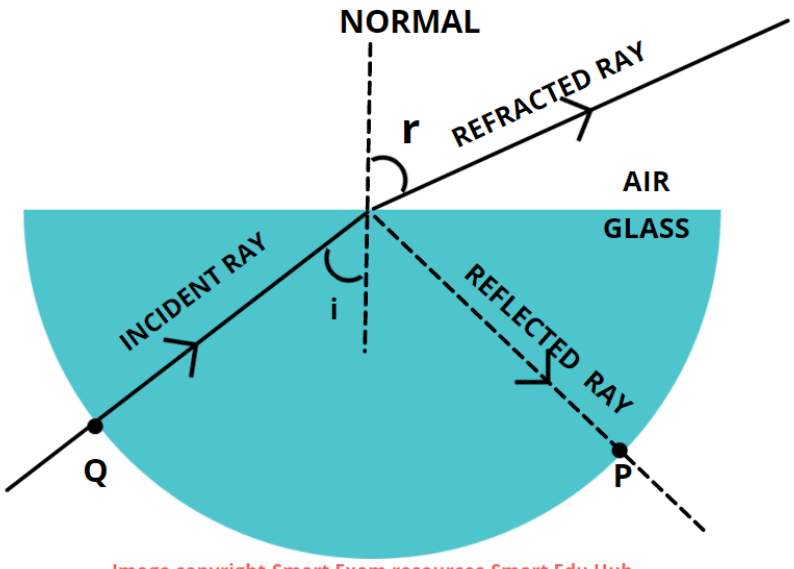


Fig.A

Note:

- **Refraction does not happen at the curved edges because; for instance, at point Q, the incident ray hits the normal and similarly at point Q, the reflected ray travels along the normal at that point. Hence light ray will never bend at such curved surfaces when it travels along the normal.**
- **The refracted ray bends away from the normal when it travels from a denser to a rarer medium and vice-versa.**

FIGURE A:When a ray travels from a denser medium to a rarer medium, the ray of light refracts away from the normal.

CRITICAL ANGLE AND TOTAL INTERNAL REFLECTION:

FIGURE B: At a particular angle of incidence, the refracted ray emerges along the boundary of the two surfaces. Here the angle of refraction is equal to 90^0.

Hence , The critical angle is that angle of incidence for which the angle of refraction is 90^0.

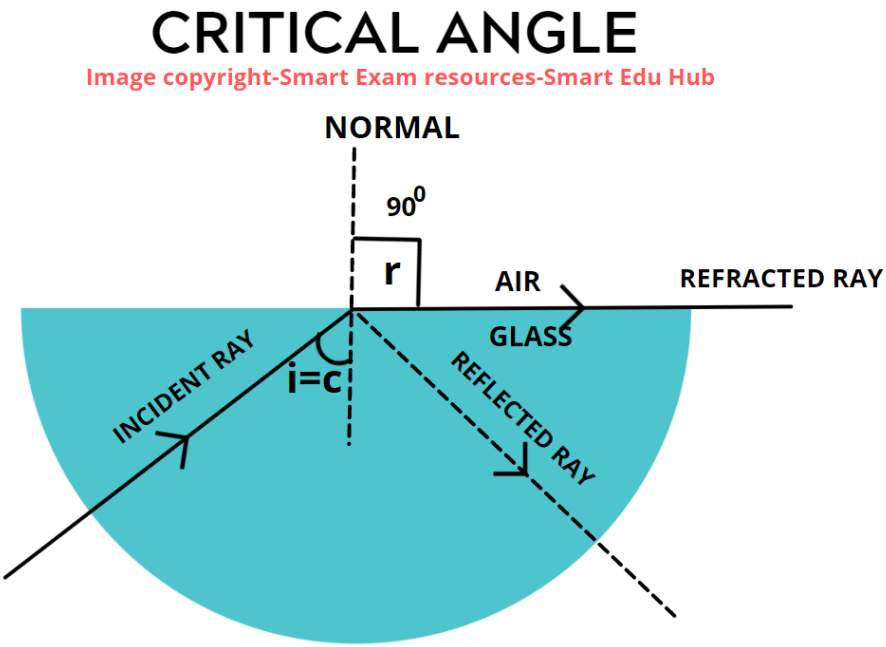


Fig.B

Critical angle is that angle of incidence for which the angle of refraction is 90 degrees

CRITICAL ANGLE AND TOTAL INTERNAL REFLECTION:

FIGURE C: If the angle of incidence is increased beyond the critical angle, then the refracted ray totally disappears and all the rays are totally internally reflected. This is termed as total internal reflection.

Refractive index is also defined as :

$\eta = \frac{1}{sinc}$ where c= critical angle

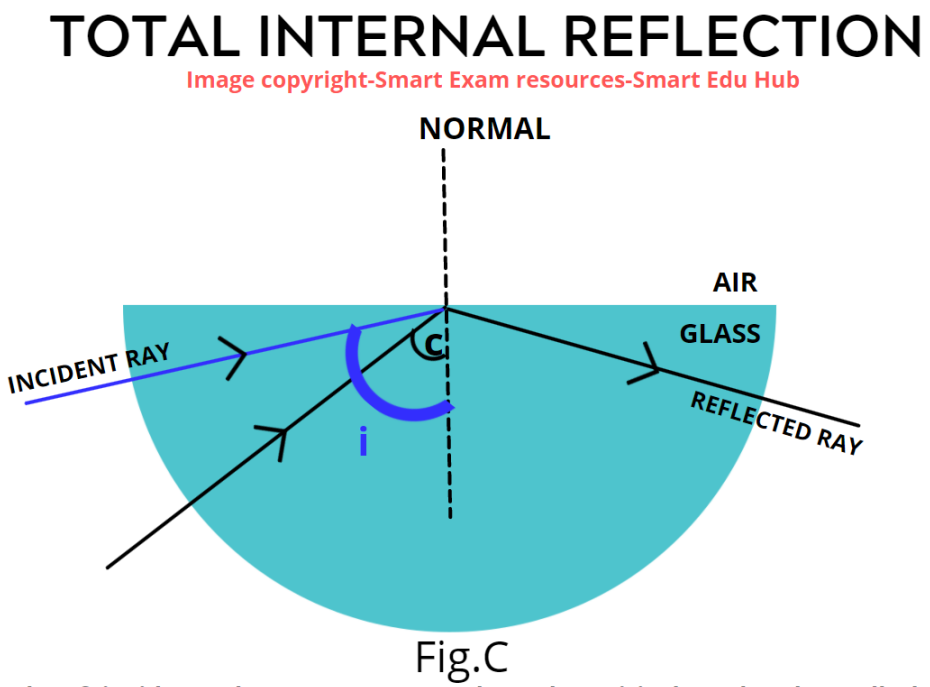


Fig.C

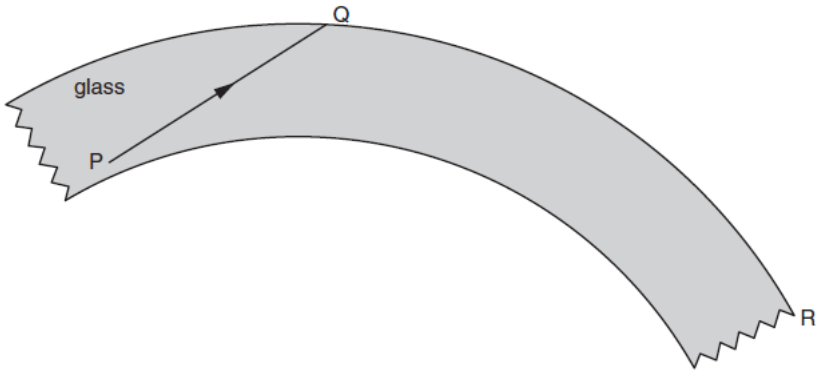
When the angle of incidence becomes greater than the critical angle, then all the rays are reflected internally and the refracted ray completely disappears. This is called as total internal reflection

OPTIC FIBRE:

For total internal reflection to happen in an optic fibre, the following conditions must be met:

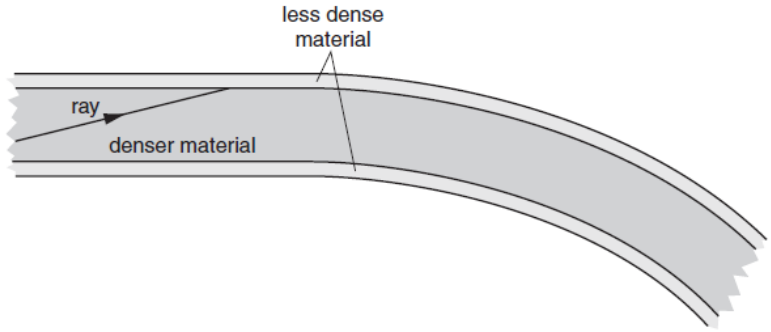
- The incident ray must be in the more dense medium.
- The angle of incidence must be more than the critical angle.
- No light should be refracted.
- The ray should be reflected with $\angle i = \angle r$

Diagram of total internal reflection:



Construction tips:

(b) reflection at Q only, no further reflections B2
(allow B1 only, if there is one further reflection at lower surface)
(give B0 for more than one further reflection)



When incident ray reaches the boundary of the two materials, total internal reflection occurs because angle of incidence is more than the critical angle.

APPLICATION OF TOTAL INTERNAL REFLECTION:

There are many uses of total internal reflection. Two of them are explained below:

1. Medical endoscope
2. Telecommunication optical fibre

1. Medical endoscope:

- Optic fibres are used to carry out internal examinations of the organs like the stomach.
- The cable that is used is made up of thousands of very thin optical fibres so that the cable becomes strong and does not break easily. Also using many optical fibres gives a greater resolution and a wider field of view.
- Light travels through the fibres and illuminates the internal organs through one bundle of fibres
- A tiny lens on the second bundle of fibres is used to form an image. This image that is formed returns up along another set of fibres.

2. Telecommunication fibre:

- Optical fibres are used in telecommunication because they can carry enormous amounts of information in light pulses trapped inside them. This information is carried at very high speed (approximately 2×10^8 m/s) along an optical fibre cable.
- Light or infra red radiations are sent as pulses. Optic fibre transmits these pulses. Total internal reflection prevents the escape of these impulses.

ADVANTAGES:

- Optical fibres can carry more information than an ordinary cable of the same thickness.
- The signals in optical fibres do not weaken as much over long distances as the signals in ordinary cables.

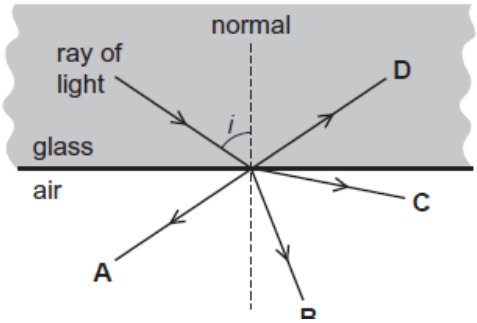
APPLICATION BASED QUESTIONS:

MCQ:

22 The diagram shows a ray of light incident on the edge of a piece of glass. The angle *i* is bigger than the critical angle.

Which arrow correctly shows the direction of the ray after it leaves the edge of the glass?

0625/11/M/J/10

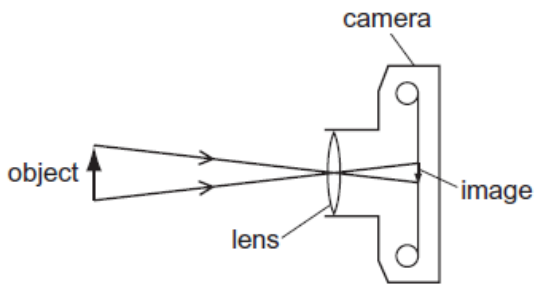


ANSWER:D

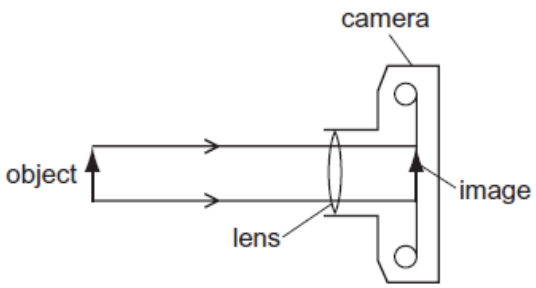
23 Which diagram correctly represents rays of light passing through a converging lens in a camera?

ANSWER:A

A

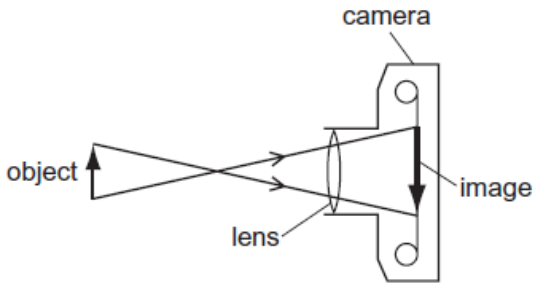


B

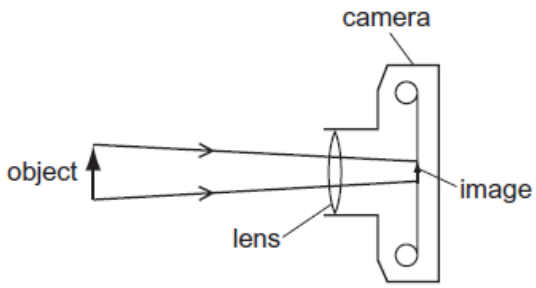


0625/11/M/J/13

C



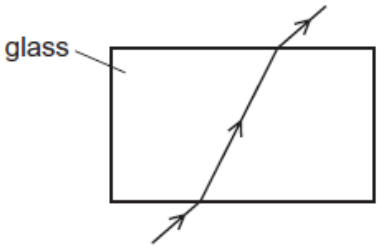
D



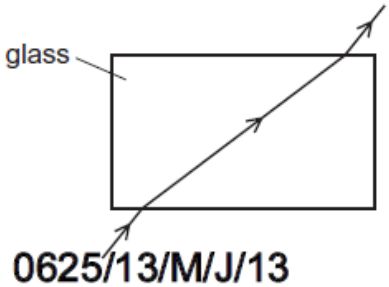
22 Which diagram shows how a ray of light could pass through a glass block in air?

ANSWER: A

A

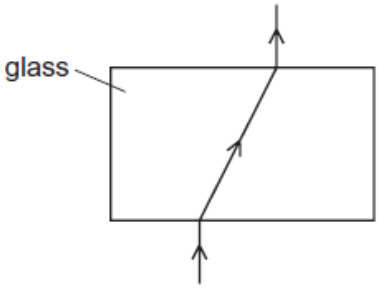


B

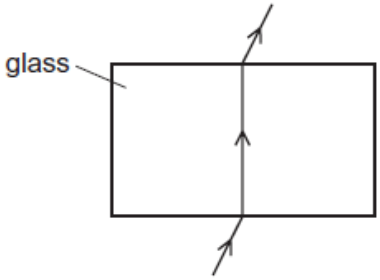


0625/13/M/J/13

C



D



APPLICATION QUATIONS-EXTENDED THEORY

9 Fig. 9.1 represents a ray of monochromatic light passing through a rectangular glass block.

O/N/11-P33

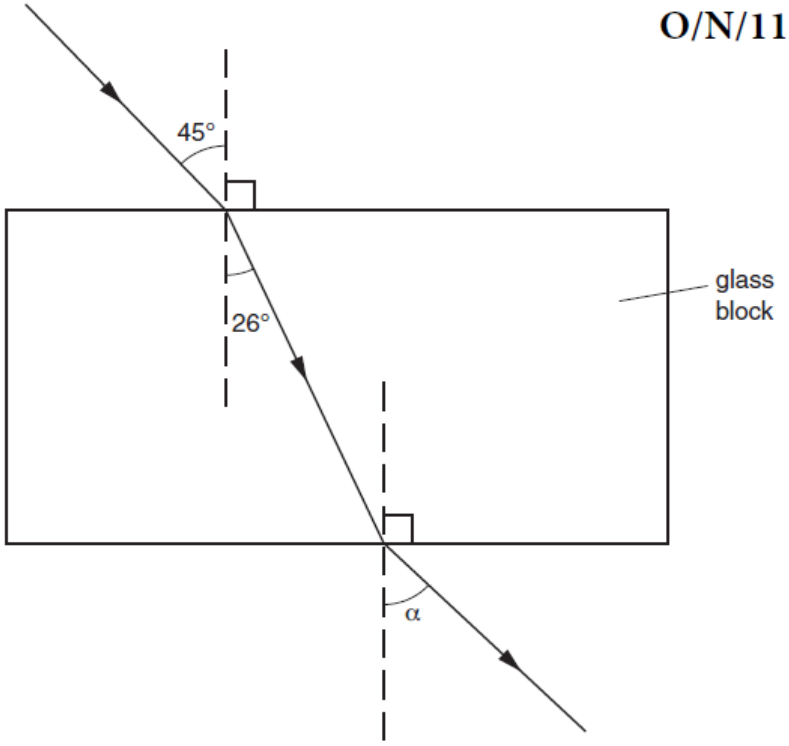


Fig. 9.1 (not to scale)

(a) What is meant by the term *monochromatic*?

.....

.....[1]

(b) Use the information on Fig. 9.1 to determine the refractive index of the glass.

refractive index = ...[2]

(c) The angle α on Fig. 9.1 is not drawn with the correct value.

State the correct value of angle α.

α = ...[1]

(d) After the ray has left the glass block, it passes into a block of ice, whose refractive index is 1.31.

How does the speed of light in ice compare with

(i) the speed of light in air, ...

(ii) the speed of light in glass. .....

[2]

MARKSCHEME:

(a) single frequency / wavelength IGNORE single colour / chromatic B1

(b) sin i/sin r OR sin45/sin26 IGNORE sin r/sin i C1

1.613 A1

(c) 45° B1

(d)

(e) i) less / slower / smaller B1

ii) more / faster / greater B1 [6]

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]

MARKSCHEME:

(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) [7]

7 A ray of light from a laser passes from air into a clear, semi-circular, plastic block. Fig. 7.1 shows the ray entering the block.

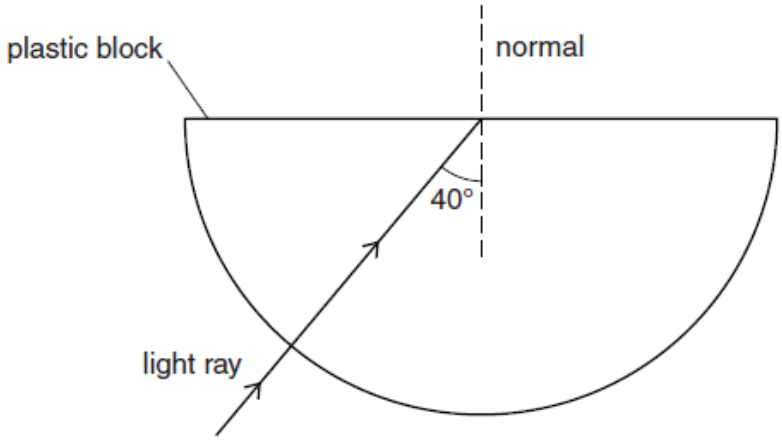


Fig. 7.1

The ray continues in the same direction and meets the middle of the opposite surface at an angle of 40° to the normal. The refractive index of the plastic is 1.5.

(a) The ray continues into the air.

Calculate the angle between the normal and the path taken by the light after it leaves the block.

angle = ... [3]

(b) The frequency of the light produced by this laser is 3.8×10^{14} Hz and its wavelength in the plastic block is 5.3×10^{-7} m (0.00053 mm).

Calculate

(i) the speed of light in this plastic,

speed = ... [2]

(ii) the speed of light in air.

speed = ... [2]

(c) Explain why the ray does not change direction as it enters the plastic block.

.....

.....

.....[2]

[Total: 9]

MARKSCHEME:

(a) n = sin i/sin r or n = sin r/sin i or (sin i =) 1.5 sin 40(°) i or (sin r =) 1.5 sin 40(°)

or 25° C1

0.9641 C1

75/74.6° to 2 or more sig. figs. A1 [3]

(b) (i) (v =) fλ or 3.8 × 1014 × 5.3 × 10-7 C1

2.01 × 108m/ s to 2 or more sig. figs. A1 [2]

(ii) (c =)nv or 1.5 × 2.0/2.01/2.014 × 108

(e.c.f. from 7(b)(i)) C1

3.02 × 108m/ s (accept 3 or 3.0 × 108m/ s only with working)

(e.c.f. from 7(b)(i)) A1 [2]

(c) wave(front) hits/enters the plastic at the same time or incident ray perpendicular

along normal/at 90° or i = 0° (condone it doesn't hit at an angle) B1

wave(front) all slows down at the same time or refracted ray perpendicular normal/at

90° or r = 0° by calculation B1 [2]

[Total: 9]

5 Light enters a glass fibre from air at an angle of incidence of 62°. The angle of refraction in the glass is 36°.

O/N/14-P33-Q5

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

Determine the speed of light in the glass fibre.

speed = ... [4]

(b) Describe how glass fibres are used in communications technology.

.....

.....

.....

.....[3]

[Total: 7]

MARKSCHEME:

(a) (n =) sin i/ sin r OR sin 62/ sin 36 C1

1.5(02) C1

(vg =) c / n OR 3.0×10^8/ 1.5 C1

2.0/ 2.00/ 1.997×10^8 m / s A1

(b) (infra-red/ light) encoded OR (sent as) pulses OR multiplexing OR many messages

OR signal OR information OR data OR internet B1

(optical fibre transmits) light/ infra-red (pulse) B1

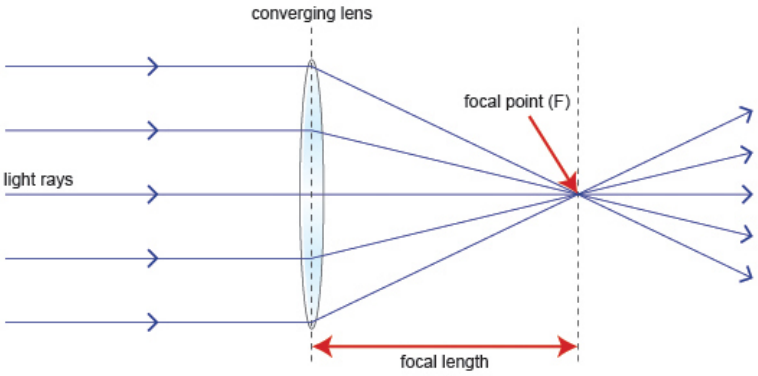
total internal reflection/TIR (prevents escape) B1

[Total: 7]

THIN CONVERGING LENS

ACTION OF A BEAM OF LIGHT ON A THIN CONVERGING LENS

Lens: A lens is transparent block that causes light to refract (changes the direction the light travels in).



A converging lens (or convex lens) is curved on both sides. This means the light rays coming out of it come together at a point – they converge.

Note: The fact that a double convex lens is thicker across its middle is an indicator that it will converge rays of light that travel parallel to its principal axis.

Key terms:

- **Focal point:** The point at which the light rays meet is called the focal point.
- **Focal length:** The distance between the centre of a lens and its principal focus is called as the focal length.

  The focal length is found by focusing a distant object on a piece of paper through the lens. The focal length is the distance between the centre of the lens and the image.
- Principal focus : The principal focus of a convex lens is the point on the principal axis where rays incident parallel to the principal axis will pass through, that point after getting refracted by the lens.
- **Principal axis:** The horizontal line passing through the optic centre of a lens is called as the principle axis.

RAY DIAGRAMS:

The position and the nature of the image formed by a lens depends upon the:

- **Focal length of the length**
- **The distance of the object to the lens**

==========

1. Draw a ray starting at the top of the object and passing through the centre of the lens.

2. Draw a ray starting from the top of the object, then passing through F and then parallel to the principal axis after refraction.

3. Draw a ray from the top of the object parallel to the principle axis and cutting through F behind the lens after getting refracted.

Note: It is enough to draw ray 1 and ray 2 or ray 1 and ray 3 for locating the position of the image.

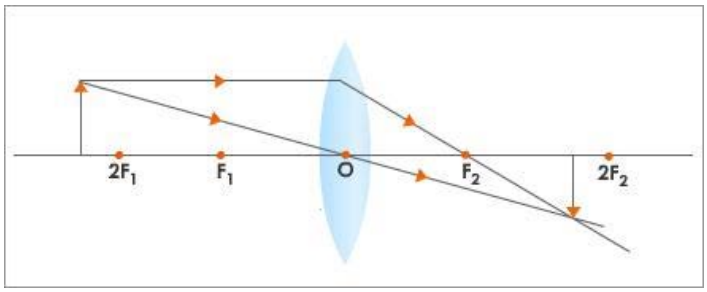
==========

Constructions

- **When the object is beyond 2F.**
- **When the object is between F and 2F.**
- **When the object is at 2F.**
- **When the object is between F and the lens.**

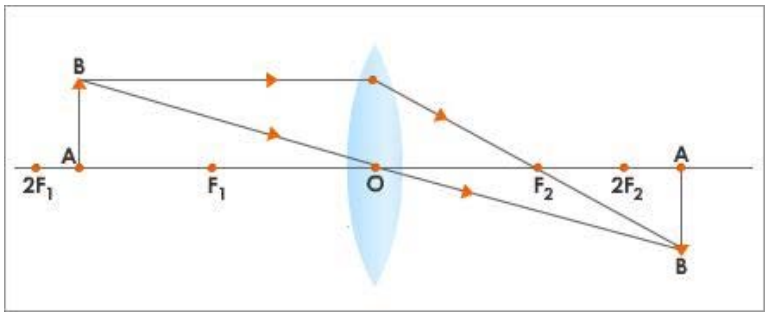
==========

When the object is beyond 2F:



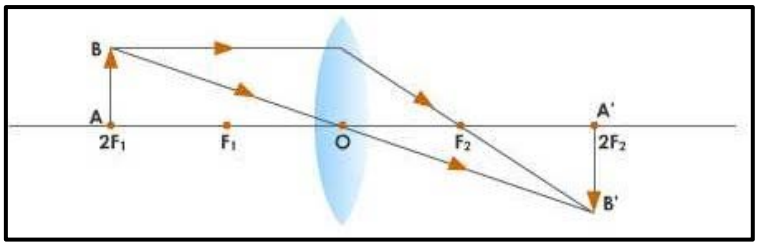
Object	Image
Beyond 2F	Between F and 2F
	Diminished image
	Real image, Inverted

When the object is between F and 2F:



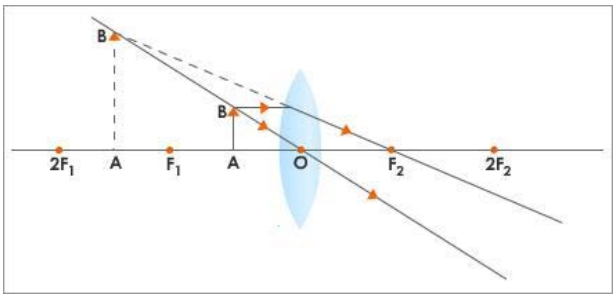
Object	Image
Between F and 2F	Beyond 2F
	Magnified image
	Real image, Inverted

When the object is at 2F



Object	Image
At 2F	At 2F
	Image size= Object size
	Real image, Inverted

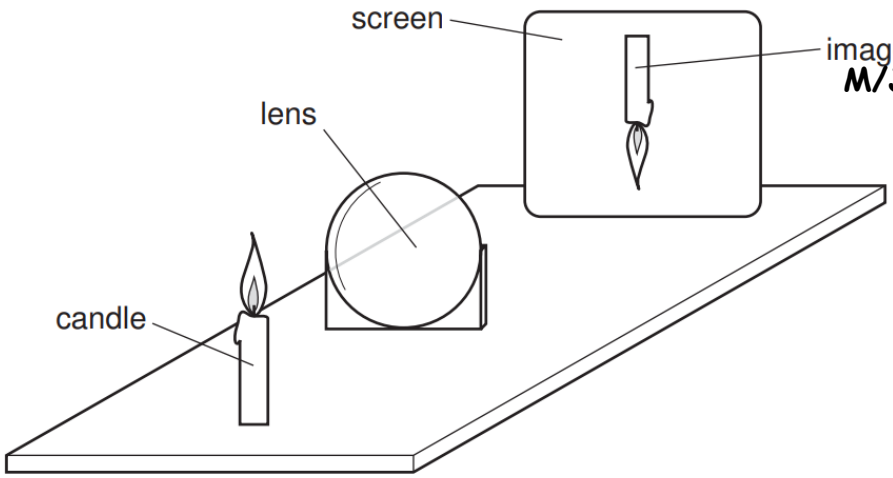
When the object is between F and the lens:



Object	Image
Between F and lens	Behind the object
	Magnified image
	Virtual image, Upright

APPLICATION BASE QUESTIONS-MCQ

1] A thin converging lens is used to produce, on a screen, a focused image of a candle.



M/J/11/11/-Q22

Various focused images are produced on the screen by moving the lens and the screen backwards and forwards.

Which statement is **always** correct?

A The image is at the principal focus (focal point) of the lens.

B The image is bigger than the object.

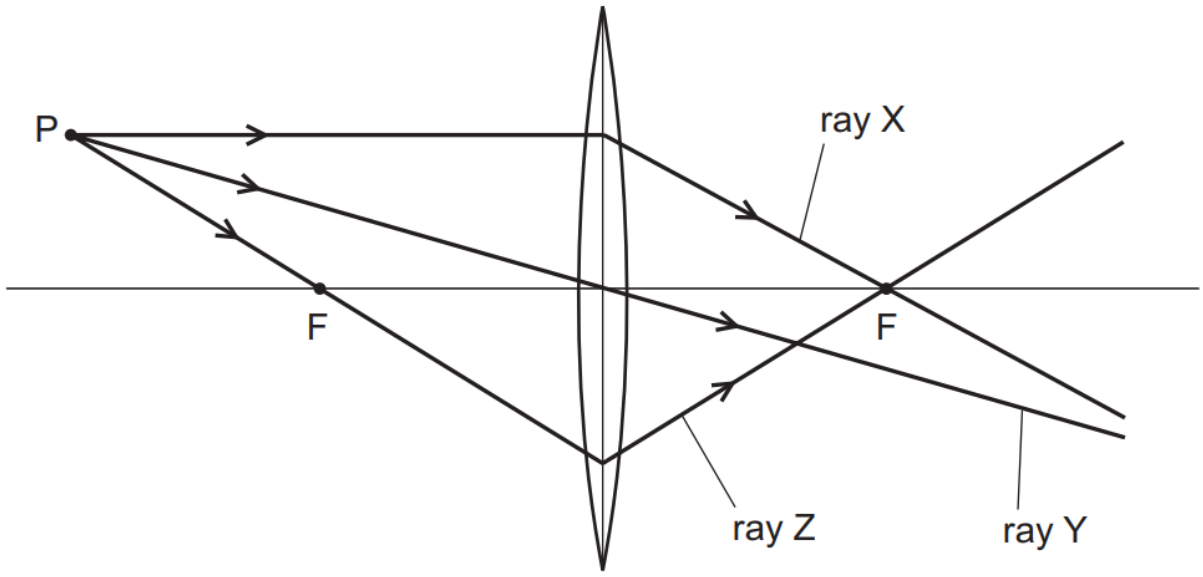
C The image is closer to the lens than the object is.

D The image is inverted.

M/J/12-13-Q21

2] A student draws three rays of light from point P through a converging lens.

Each point labelled F is a principal focus of the lens.



Which of the rays are drawn correctly?

A ray Y only

B ray Z only

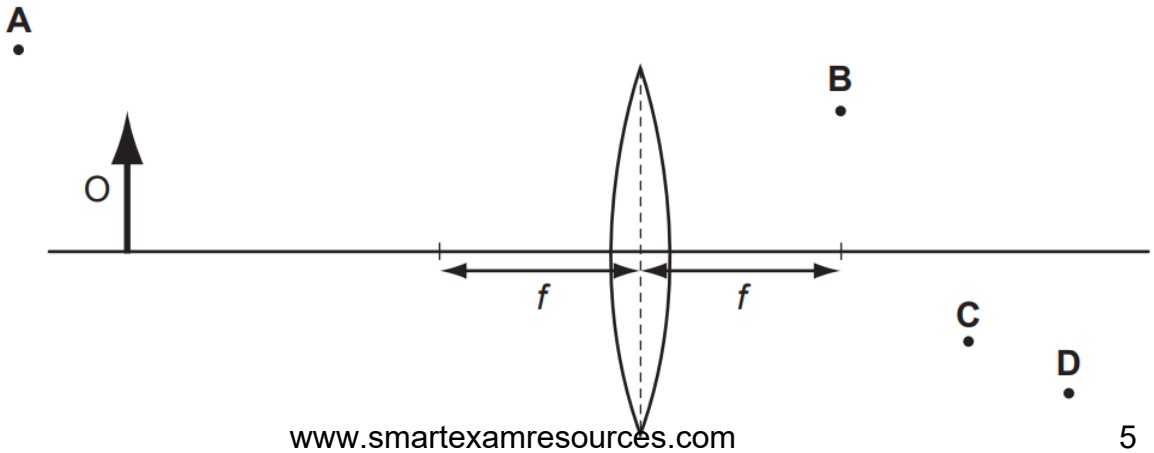
C ray X and ray Y

D ray X and ray Z

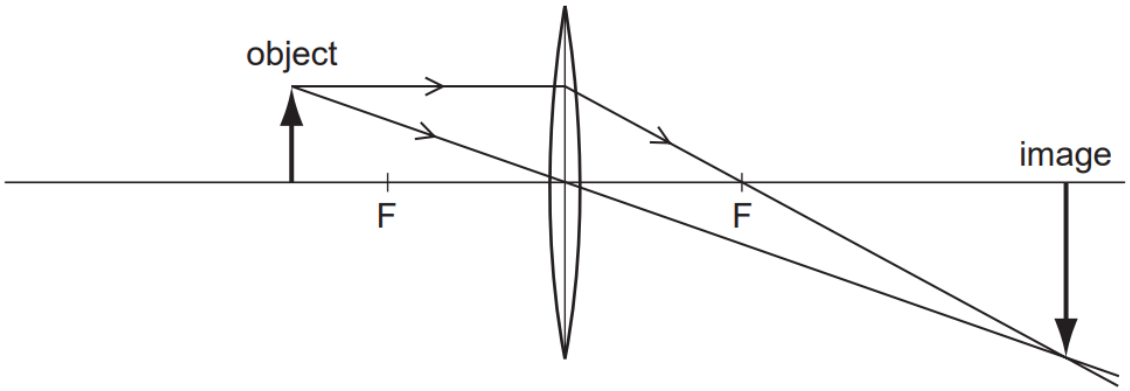
3] An object O is placed in front of a converging lens of focal length *f*.

At which point will the top of the image be seen?

O/N/09/11-Q22



4 A thin converging lens forms an image. **O/N/09/11-Q22**

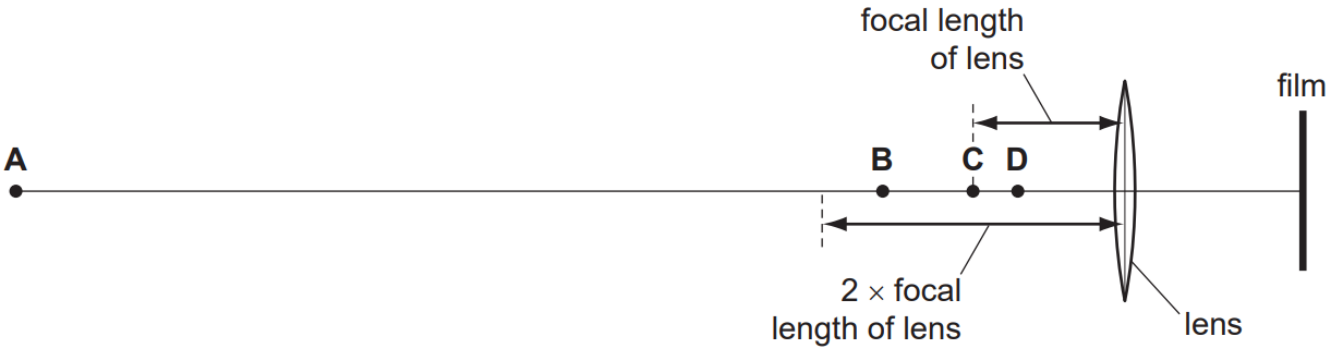


What is the nature of this image and can it be formed on a screen?

	nature of image	can be formed on a screen?
A	not real	no
B	not real	yes
C	real	no
D	real	yes

5] The converging lens in a camera is used to make an image on a film. **O/N/12-13-Q23**

At which labelled point could a large object be placed so that it makes a smaller image?



MARKSCHEME:

1-D
2-C
3-C
4-D
5-A

EXTENDED THEORY APPLICATION QUESTIONS:

1] 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

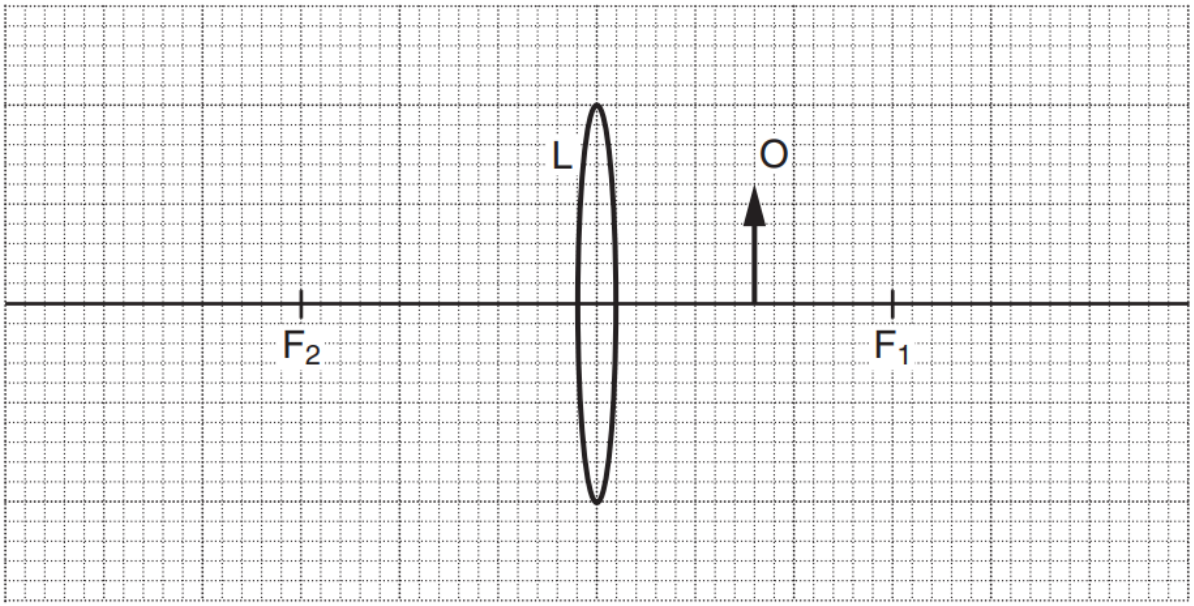


Fig. 6.1

(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]

MARKSCHEME:

(a) (for all rays, ignore any arrows, -1 for each incorrect extra ray) correct ray through F1 ± 1mm on axis)

)correct ray through F2 ± 1mm on axis) any 2 B1, B1)

ray through lens centre ± 1mm on axis)

image drawn between his intersection and axis B1

(b) virtual upright/erect magnified/enlarged further (from lens) any 3 B1 × 3

[6]

2] (a) What is meant by the focal length of a converging lens?

.....

.....

.....[1]

(b) An object is placed in front of a converging lens. A real image is formed, as shown in Fig. 7.1.

The converging lens is not shown.

(i) Explain what is meant by a real image.

.....[1]

(ii) Rays of light from point A on the object form point B on the image.

On Fig. 6.1, draw

1. a ray to find the position of the converging lens, showing the lens as a vertical straight line in this position,

2. a ray to find the position of a principal focus of the lens, marking this position F,

3. a third possible ray from A to B. [3]

(iii) The distance between the object and the lens is increased. State any changes which take place in

1. the distance of the image from the lens,

.....

2. the size of the image.

.....[2]

[Total: 7]

MARKSCHEME:

(a) distance from (principal) focus/focal point to (the centre of) the lens B1

(b) (i) image can be formed on a screen

OR is formed by rays of light meeting

OR is formed on the opposite side of the lens from the object B1

(ii) 1. straight line ray from point A to point B

AND lens at intersection of ray and axis. B1

2. ray from A parallel to axis, bent at lens to pass through B. F at intersection of ray and axis.

OR Ray from point A through nearer focus, labelled F, to lens, bent at lens, then parallel to axis, to point B B1

3. any third ray from A to B, bent at lens B1

(iii) (distance from image to lens is) reduced B1

(image is) smaller B1 [7]

DISPERSION

DISPERSION OF LIGHT BY A PRISM:

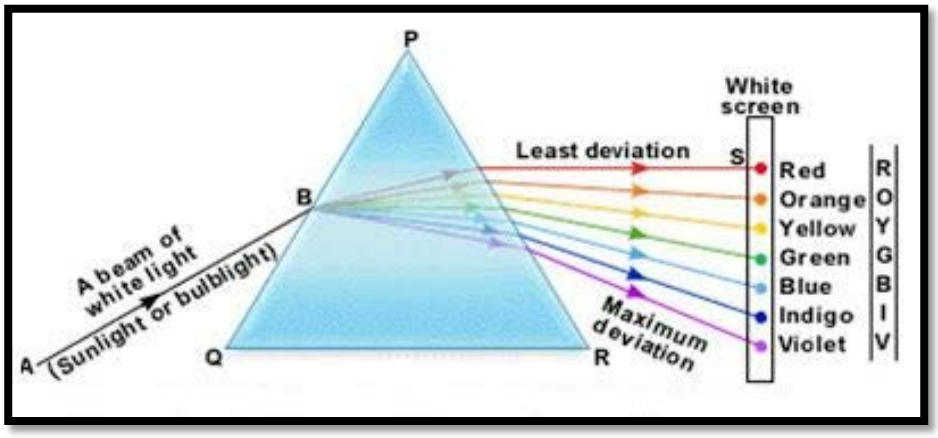
Dispersion: The separation of visible light into its different colors is known as dispersion.

Spectrum: A band of colours, as seen in a rainbow, produced by separation of the components of light by their different degrees of refraction according to wavelength.

Monochromatic light: Light of a single frequency is called as monochromatic light.

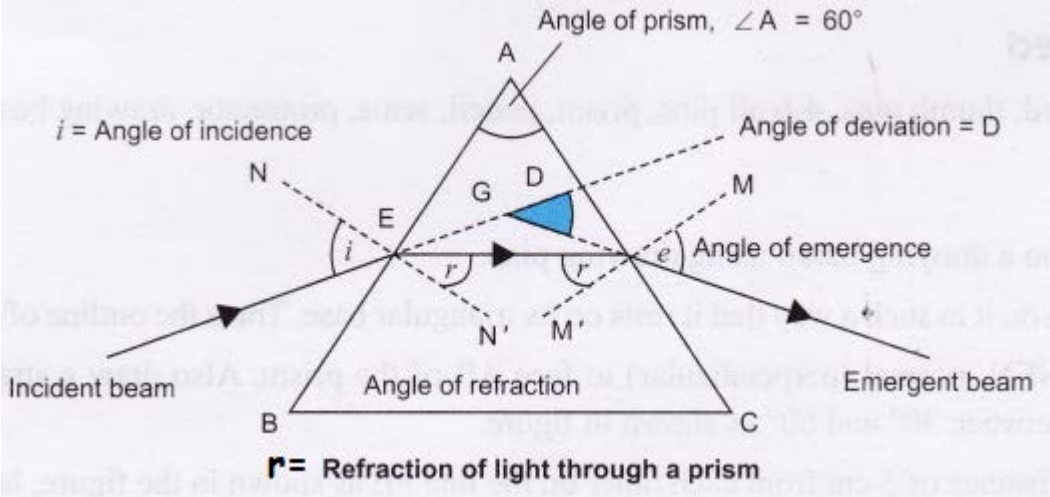
Explanation of dispersion:

- White light is a mixture of many different colours, each with a different frequency.



- White light can be split up into a spectrum of these colours using a prism, a triangular block of glass or Perspex.
- The different colours of light have a different frequency and a different wavelength.
- The different colours are refracted by different amounts.
- Red light has the longest wavelength and is refracted the least.
- Violet light has the shortest wavelength and is refracted most.

LABELLING THE ANGLE OF REFRACTIONS AND EMERGENCE IN A PRISM:



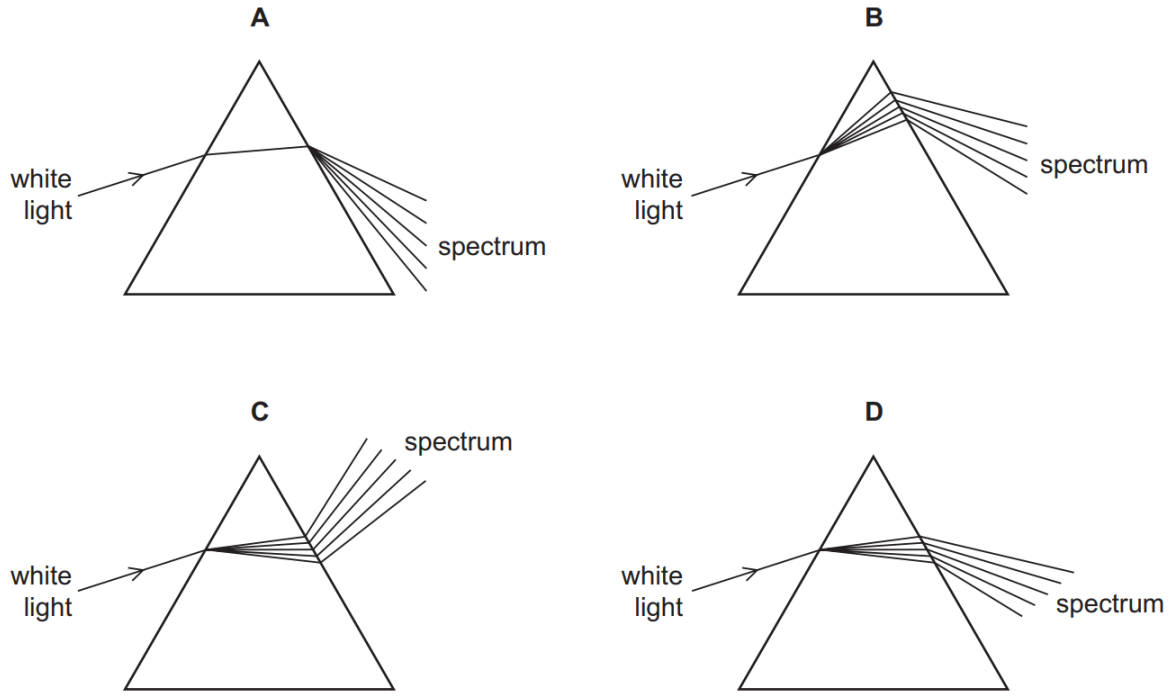
r= Refraction of light through a prism

APPLICATION BASED QUESTIONS:

MCQ:

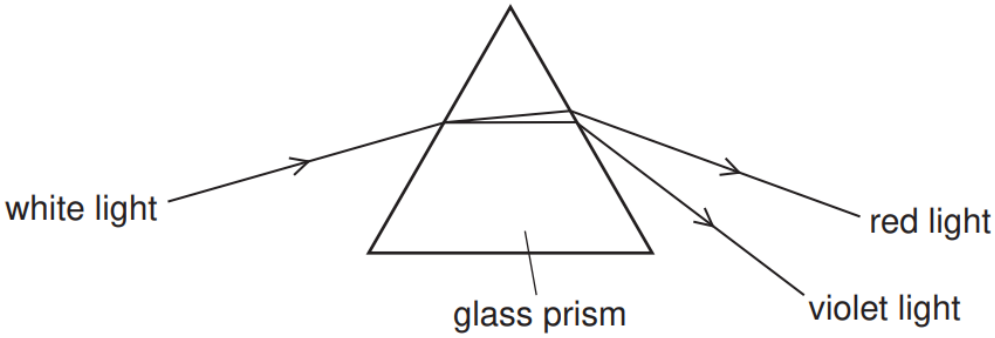
1] Which diagram shows what happens when a ray of white light passes through a prism?

ANSWER:D



2] The diagram shows the dispersion of white light by a glass prism.

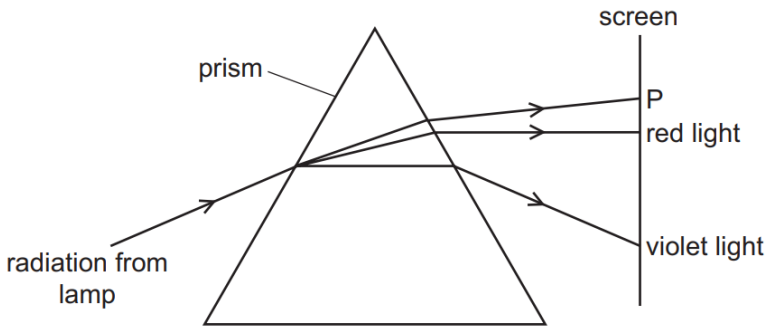
ANSWER:D



Why does dispersion occur when white light enters the glass?
A The frequency of red light decreases more than that of violet light.
B The frequency of violet light decreases more than that of red light.
C The speed of red light decreases more than that of violet light.
D The speed of violet light decreases more than that of red light.

3]The diagram shows radiation from a lamp passing through a prism.

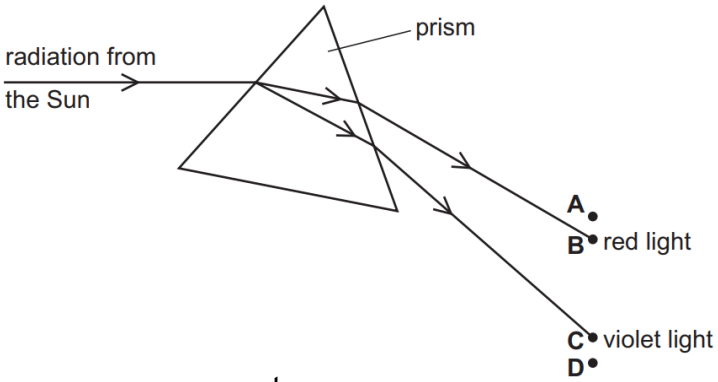
ANSWER:B



Which type of radiation is found at P?
A γ-rays
B infra-red
C ultraviolet
D X-rays

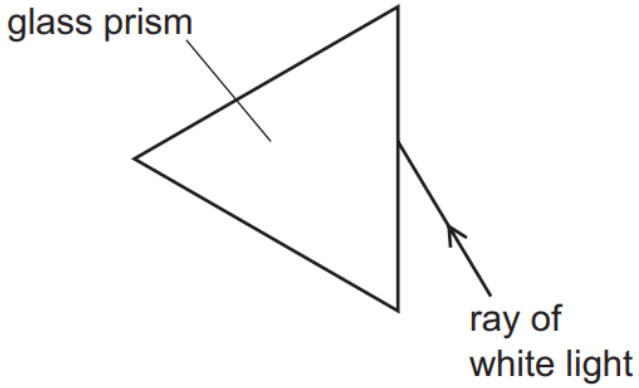
4] Radiation from the Sun is dispersed by a prism. The prism does not absorb any of the radiation.
Four identical thermometers are placed, one at each of the labelled positions.
In which position does the thermometer show the greatest rise in temperature?

ANSWER:A



5] The diagram shows a ray of white light incident on a triangular glass prism.

ANSWER:D



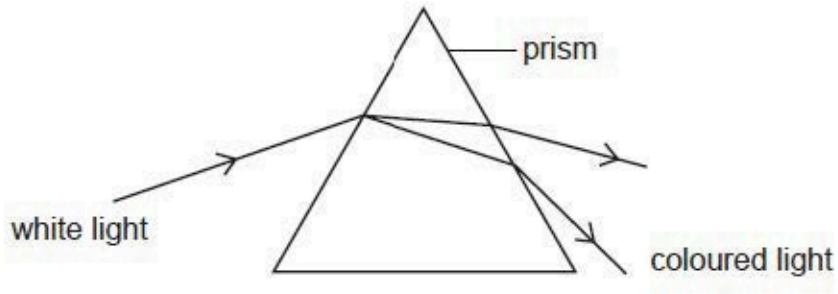
The ray enters the prism.

Which row correctly states if the light is refracted, and if the light is dispersed?

	refracted	dispersed
A	no	no
B	no	yes
C	yes	no
D	yes	yes

6] One of the effects of passing a ray of white light through a prism is to split the light into colours.

ANSWER:B



What is the name given to this effect?

A deviation

B dispersion

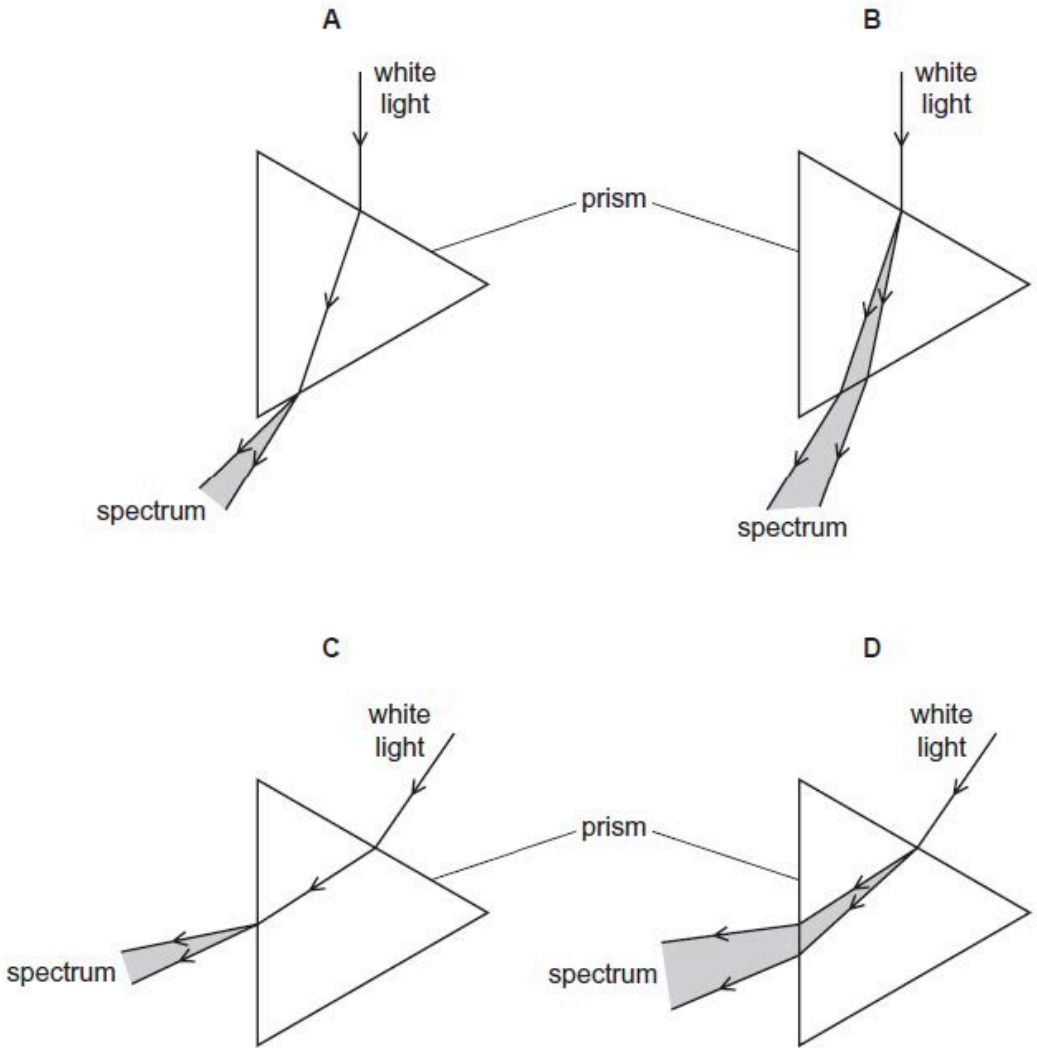
C reflection

D refraction

7] A teacher demonstrates the dispersion of white light using a triangular glass prism.

Which diagram shows how this dispersion happens?

ANSWER:B



EXTENDED THEORY:

1] Fig. 6.2 shows a ray of light incident on a glass prism.

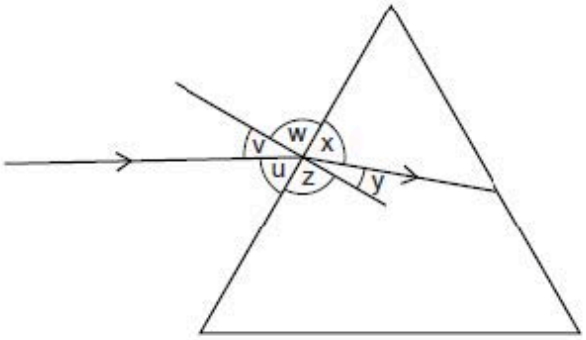


Fig. 6.2

Put **one tick only** in each line of the table to indicate which of the angles labelled in Fig. 6.2 are the angle of incidence and the angle of refraction.

	u	v	w	x	y	z
angle of incidence						
angle of refraction						

[2]

MARKSCHEME:

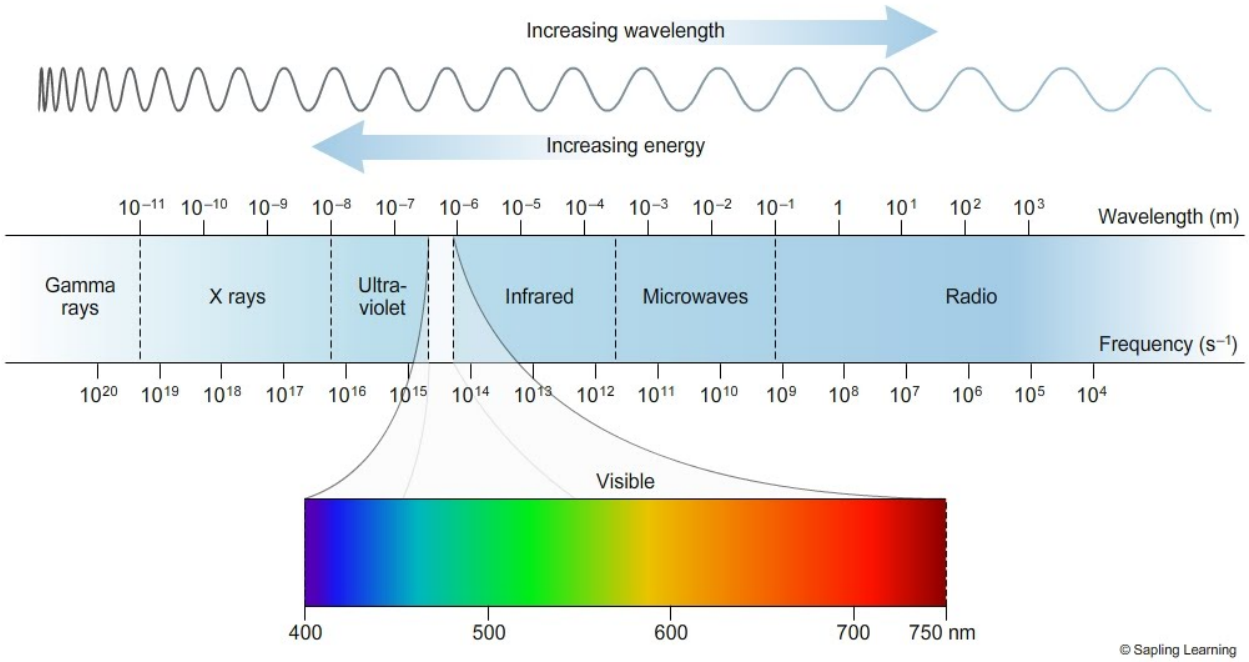
angle of incidence: any mark in v box only B1
angle of refraction: any mark in y box only B1

ELECTROMAGNETIC SPECTRUM

- Electromagnetic spectrum are electric and magnetic disturbances that transfer energy from one place to another.
- All electromagnetic waves travel with a speed of 3×10^8 m/s.
- Electromagnetic waves do not transfer matter.
- The energy they transfer depends upon the wavelength of the waves. That is why waves of different wavelengths have different effects.
-

Light is one of the family of radiations called the electromagnetic spectrum. Some types of electromagnetic radiation are used to transmit information such as computer data, telephone calls and TV signals.

ELECTROMAGNETIC SPECTRUM WAVELENGTH ,FREQUENCY AND USES



TYPICAL USES OD DIFFERENT REGIONS OF THE ELECTROMAGNETIC SPECTRUM

1.Radio waves: radio and television transmissions, astronomy, radio frequency identification (RFID
2.Microwave: satellite television, mobile phones (cell phones), microwave oven
3.Infrared: electric grills, short range communications such as remote controllers for televisions, intruder alarms, thermal imaging, optical fibre
4.Visible light: vision, photography, illumination
5. Ultraviolet: security marking, detecting fake bank notes, sterilising watter.
6.X-rays: medical scanning, security scanners
7.Gamma rays: sterilising food and medical equipment, detection of cancer and its treatment

HARMFUL EFFECTS OF EXCESSIVE USE OF THE ELECTROMAGNETIC SPECTRUM

1. Microwaves; internal heating of body cells
2. Infrared; skin burns
3. Ultraviolet; damage to surface cells and eyes, leading to skin cancer and eye conditions
4. X-rays and gamma rays; mutation or damage to cells in the body
5. Microwaves: Communication with artificial satellites is mainly by microwaves:
(a) some satellite phones use low orbit artificial satellites
(b) some satellite phones and direct broadcast satellite television use geostationary satellites

NOTE:
Many important systems of communications rely on electromagnetic radiation including:
(a) mobile phones (cell phones) and wireless internet use microwaves because microwaves can penetrate some walls and only require a short aerial for transmission and reception
(b) Bluetooth uses radio waves because radio waves pass through walls but the signal is weakened on doing so
(c) optical fibres (visible light or infrared) are used for cable television and high-speed broadband because glass is transparent to visible light and some infrared; visible light and short wavelength infrared can carry high rates of data

ANALOGUE AND DIGITAL SIGNALS:

- **Analogue signal is a continuous signal which represents physical measurements.**
- **Digital signals are discrete time signals generated by digital modulation.**
- A sound can be transmitted as a digital or analogue signal

BENEFITS OF DIGITAL SIGNALLING:

- Increased rate of transmission of data
- Increased range due to accurate signal regeneration

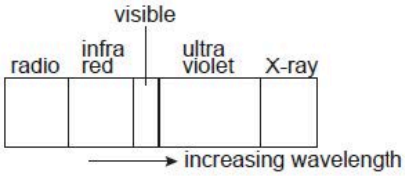
APPLICATION BASED QUESTIONS:

MCQ:

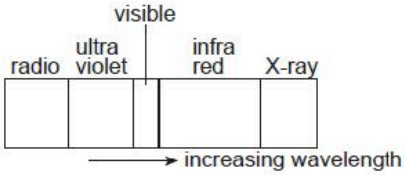
1] Which diagram shows the correct order of the waves in the electromagnetic spectrum?

ANSWER: C

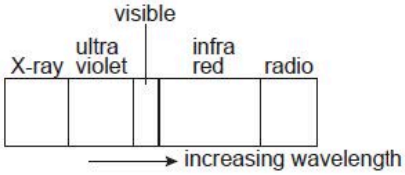
A



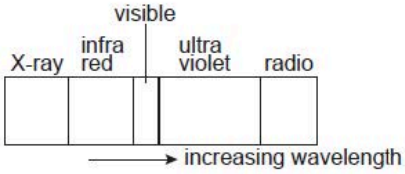
B



C



D



2] Which type of radiation lies between visible light and microwaves in the electromagnetic spectrum?

ANSWER: A

A infra-red

B radio waves

C ultra-violet

D X-rays

3] The table gives common uses for three types of electromagnetic wave.

Which row correctly identifies the waves?

ANSWER:B

	satellite television	terrestrial television (not satellite)	television remote controllers
A	infra-red waves	microwaves	radio waves
B	microwaves	radio waves	infra-red waves
C	radio waves	infra-red waves	microwaves
D	radio waves	microwaves	infra-red waves

4] Which type of electromagnetic wave is used in airport security scanners?

ANSWER:D

A infra-red

B microwaves

C radio waves

D X-rays

5] An electronic engineer makes devices which can receive television pictures from satellites.

Which type of electromagnetic radiation must these devices be able to receive?

ANSWER:B

A infra-red waves

B microwaves

C radio waves

D ultra-violet waves

6]

Which statement is correct about the speed of electromagnetic waves in a vacuum?

ANSWER:D

A Ultra-violet waves have the greatest speed.

B Visible light waves have the greatest speed.

C Infra-red waves have the greatest speed.

D All electromagnetic waves have the same speed.

7] Which group of electromagnetic radiations is arranged in order of increasing frequency?

A infra-red, visible light, ultraviolet **ANSWER: A**

B γ-rays, X-rays, infra-red

C ultra-violet, visible light, radio waves

D X-rays, radio waves, γ-rays

EXTENDED THEORY

1] **(b)** Fig. 7.1 shows part of the electromagnetic spectrum. **O/N/07-P3-Q7**

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]

MARKSCHEME:
(i) all 3 in correct positions B1
(ii) radio (waves) B1
(iii) 3×10^8 m/s B1

2] (a) State the type of electromagnetic radiation

(i) used in luggage security checks at airports,

.....

(ii) used by remote controls for TV sets.

.....[2]

(b) (i) The electromagnetic waves used in a microwave oven have a frequency of 2.45×10^9 Hz.

The speed of the waves is 3.00×10^8 m / s.

Calculate the wavelength of the waves.

wavelength = ... [2]

MARKSCHEME:

(a) (i) X-rays B1

(ii) Infra-red B1

(b) (i) $v = f\lambda$ in any form OR $v \div f$ OR $3.0 \times 10^8 \div (2.45 \times 10^9)$ C1

0.12m A1

3] **(a)** A police car siren emits sound waves that vary in pitch.

Tick **two** boxes that apply to the sound waves emitted by the siren.

- ☐ electromagnetic
- ☐ longitudinal
- ☐ transverse
- ☐ visible
- ☐ frequency 0.1–10 Hz
- ☐ frequency 100–10 000 Hz
- ☐ frequency 100 000–1 000 000 Hz

[2]

MARKSCHEME:

(a) longitudinal (2nd box) B1

frequency 100 – 10000Hz (6th box) B1

(note: –1 for e.e.o.o)

4] Fig. 7.1 shows the parts of the electromagnetic spectrum.

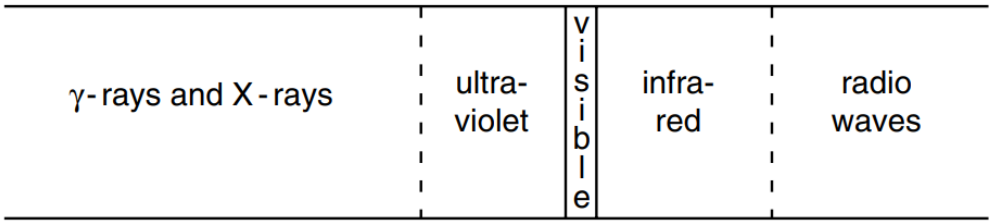


Fig. 7.1

(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 x 108m/s and a wavelength of 1.0 x 10^{-12}m.

Calculate the frequency of the γ-rays.

frequency = ... [2]

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

..... [1]

MARKSCHEME:

(i)x-rays or gamma rays B1

(ii) infra red or radio B1

5] (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]

MARKSCHEME:

(a) (i) sound B1

(ii) particle OR mechanical OR compression OR longitudinal OR matter wave B1

(iii) ultra violet/uv B1

6] A student draws a diagram to represent the electromagnetic spectrum.

Fig. 8.1 is the student's diagram.

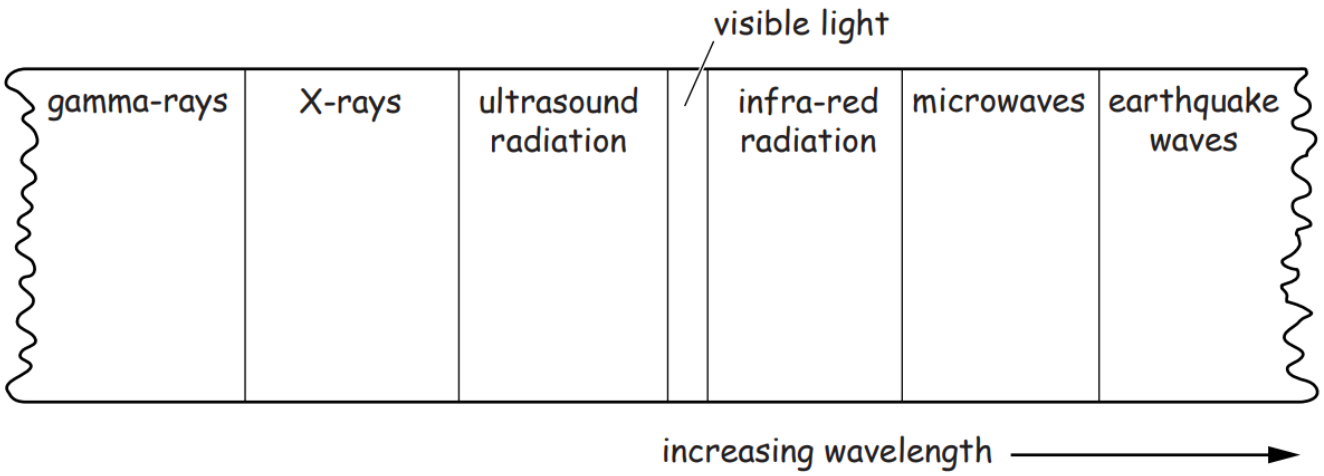


Fig. 8.1

The student has made two mistakes.

(a) On Fig. 8.1, cross out what is wrong and correct the diagram. [2]

(b) The speed of light in an optical fibre is 2.0 × 108 m / s.

(i) State the speed of light in a vacuum.

speed of light = ... [1]

MARKSCHEME:

(a) ultra-violet written above / below ultrasound B1

radio written above / below earthquake B1

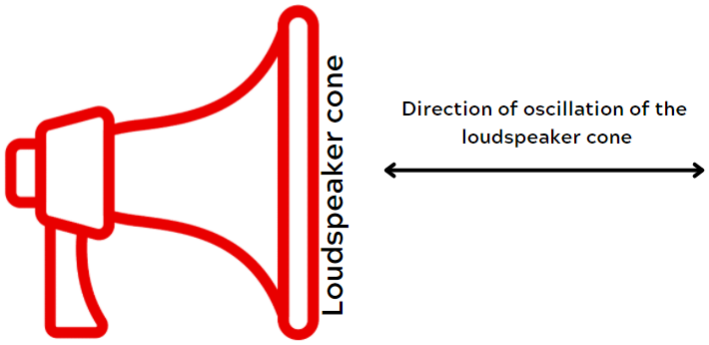
(b)(i) 3.0×10^8 m / s

SOUND

PRODUCTION OF SOUND BY VIBRATI NG OBJECTS

- A loudspeaker cone oscillates to produce sound waves

OSCILLATING LOUDSPEAKER CONE



When the loudspeaker cone vibrates, the cone moves forward (in the direction of travel of the waves). The cone thus pushes the particles together. This creates high pressure regions of air also called as compressions.
When the cone moves backwards(away from the direction of travel), it creates empty spaces in the air known as regions of rarefactions(regions of low pressure).As a result a series of compressions and rarefactions travel through the air. These are sound waves.

Speed of sound in air= 343m/s Speed of sound in water= 1450 to 1498m/s

Properties of sound waves:

- Sound waves are caused by vibrations.
- Sound waves are longitudinal waves.
- Sound waves require a material to travel.
- Sound waves can travel through solids, liquids and gases.

More about properties of sound waves:

Sound waves are caused by vibrations:

When the loudspeaker cone vibrates, the cone moves forward (in the direction of travel of the waves). The cone thus pushes the particles together. This creates high pressure regions of air also called as compressions.

When the cone moves backwards(away from the direction of travel), it creates empty spaces in the air known as regions of rarefactions(regions of low pressure).

As a result a series of compressions and rarefactions travel through the air. These are sound waves.

Sound waves are longitudinal waves:

Sound waves are longitudinal waves as the particles vibrate(oscillate) along the line of the waves(along the direction of the waves)

Sound waves need a medium to travel and cannot travel through vacuum:

A medium is required to pass on the oscillations.'

Sound can travel through solids, liquids and gases: it travels the furthest in gases and the fastest in solids

---

Note:

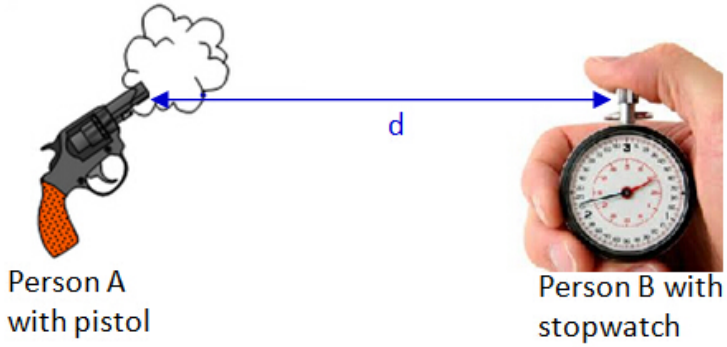
- Sound waves reach the observer after the light waves because the speed of light is much greater than the speed of sound.
- Speed of sound depends on the temperature of the air. Sound travels faster in warmer air than in cooler air.
- Speed of sound is different in different materials.
- Speed of sound does not depend upon the pressure of the air.
- **Ultrasound:**

Sound whose frequency is higher than the upper limit of the normal range of audible human frequency (20,000 hertz) is called ultrasound.

- **Infrasound: (NOT IN SYLLABUS)**

Sound at frequencies too low to be audible—about 20 hertz or lower—is called infrasound.)

Experiment to determine the speed of sound:



Apparatus needed: Source of sound(gun, stopwatch, meter tape) **Note the word" clock is rejected"**

Procedure.

A person A can fire a bullet in the air and produces a flash and the person B can start the stop watch when A presses the trigger and stop the stopwatch when the hears the bang.

Speed of sound $= \frac{Distance\ between\ the\ flash\ produced\ and\ the\ bang\ heard}{Time\ taken\ between\ the\ flash\ and\ the\ bang}$

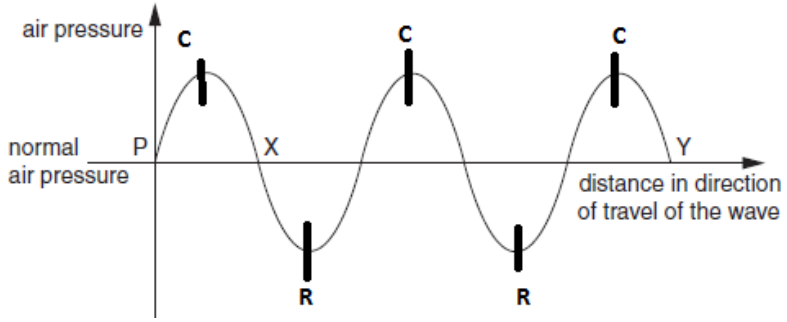
The accuracy of the experiment can be improved by:

- **Increasing the distance between the flash and the bang**
- **Repeating the experiment.**
- **Using a more accurate timer.**

Sound wave:

- **The sound wave consists of alternate regions of compressions and rarefactions.**
- **Compressions: Compressions are regions of above normal air pressure or high air pressure regions or regions where the particles are close together**
- **Rarefactions: Rarefactions are regions of below normal air pressure or low air pressure regions or regions where the particles are far apart.**

Diagram of sound waves:



Use of ultrasound:

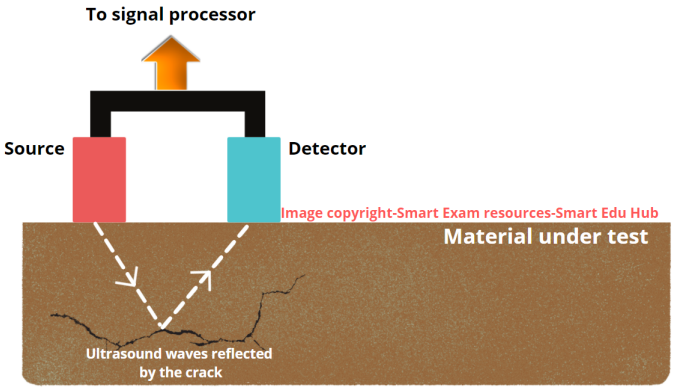
Medical:

3-D ultrasound scan of a human foetus

Computers are able to create detailed images by combining many ultrasound reflection readings. This is used in medicine for pre-natal scanning (checking unborn babies).

Industry:

Ultrasound can be used in industry for quality control procedures to check manufactured objects, such as railway tracks and oil pipelines, for damage or defects. The diagram shows how a piece of metal may be tested for cracks or other flaws using ultrasound.



Sonar is used on ships and submarines to detect fish or the sea bed. A pulse of ultrasound is sent out from the ship. It bounces off the seabed or shoal of fish and the echo is detected. The time taken for the wave to travel indicates the depth of the seabed or shoal of fish.

Speed of sound-Depends upon the material of the substance and the temperature of the substance

Material	Density(g/cm)	Speed(m/s)
Copper	8.90	6420
Steel	7.86	5940
Beryllium	1.93	12890
Aluminium	2.58	6420
Water	1.00	1496
Ethanol	0.79	1207
Air	0.00139	331.45
Helium	0.000178	965
Fat	0.95	1450
Muscle	1.07	1580
Skull bone	1.91	4080

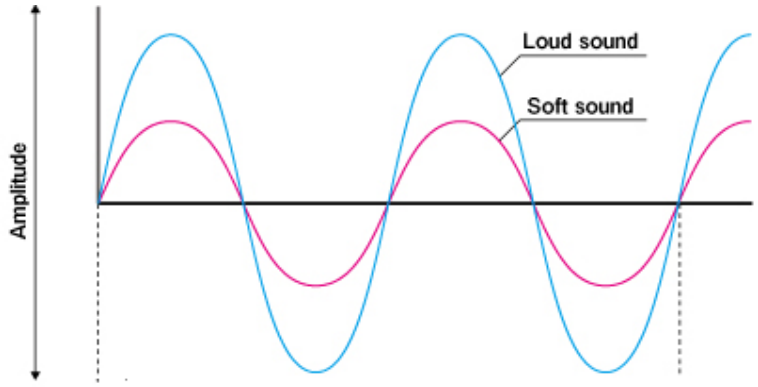
You are not expected to learn by heart these values. You need to have an idea of the relative speeds of sound in the different media.

Order of magnitude of the speed of sound:

Solids> $Liquids > Gases$

Loud and quiet sound and high and low pitched sound

- Loud sounds (High volume)are sound waves with bigger amplitude.
- Quiet sounds(Low volume sounds) are sound with smaller amplitude
- Loud sounds are high energy waves and quiet sounds are low energy waves



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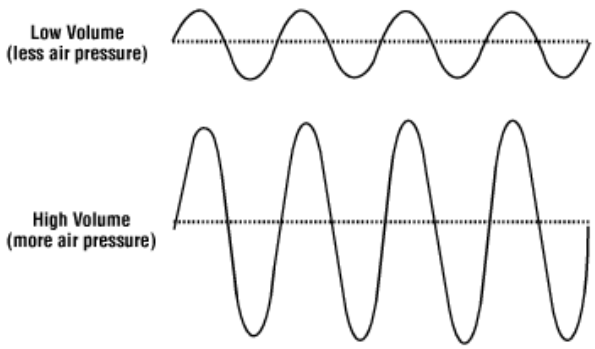
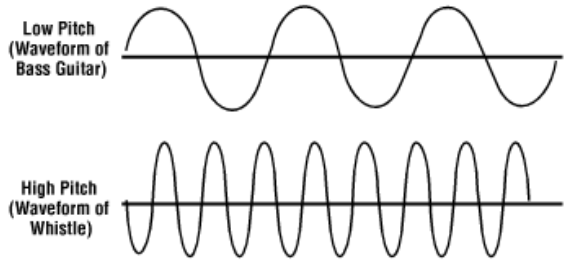


High pitch and low pitch sound:

- High pitch sound is a sound with high frequency and small wavelength
- Low pitch sound is a sound with low frequency and large wavelength



Echoes:

- Sound waves can reflect off surfaces. We hear sound reflections as echoes.
- Hard, smooth surfaces are particularly good at reflecting sound. This is why empty rooms produce lots of echoes.
- Soft, rough surfaces are good at absorbing sound. This is why rooms with carpets and curtains do not usually produce lots of echoes.

Reflection of sound produces an echo

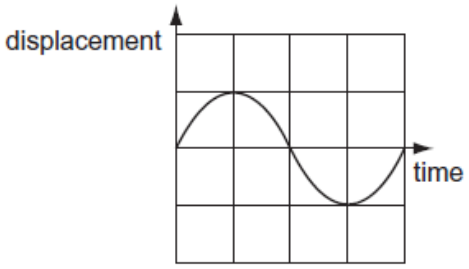
- An echo is a reflection of sound.
- Echoes can be heard in a large hall or a gallery which has with smooth walls.
- Sound waves are created which reflect off a smooth surface and reach you.
- The further you are from the reflecting surface, the longer the sound waves will take to reach the reflecting surface and then back to you, So there will be a longer delay between the original sound and the echo.

Unwanted echoes can be eliminated by:

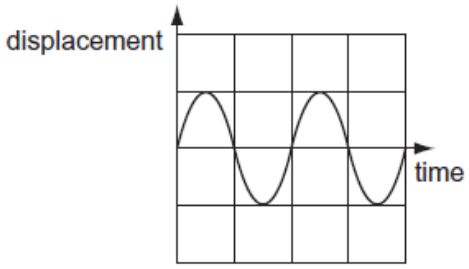
- Covering the walls in soft fabric . This will absorb sound waves instead of reflecting them. So no echoes will be heard.
- Make the surface of walls uneven. This will scatter the reflected sound. Hence echoes will not be formed.

Application based questions:

1] **24** The diagrams represent two sound waves. The scales in the two diagrams are the same.



sound wave 1



sound wave 2

Which statement describes the waves?

0625/11/M/J/13

A The waves have different loudness and different pitch.

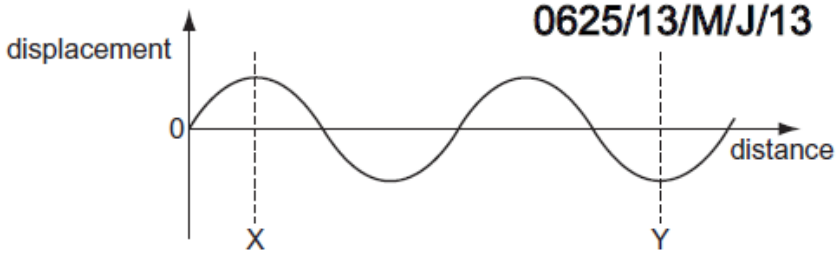
B The waves have different loudness but the same pitch.

C The waves have the same loudness and the same pitch.

D The waves have the same loudness but different pitch.

2] **21** The diagram represents a wave.

0625/13/M/J/13

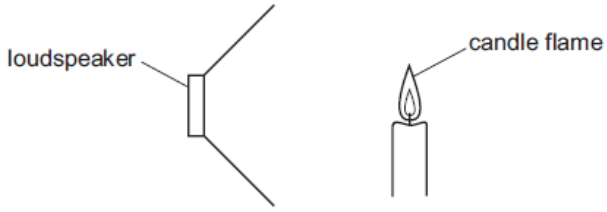


How many wavelengths are there between X and Y?

A $\frac{2}{3}$ **B** 1 **C** $1\frac{1}{2}$ **D** 3

3]

19 A lighted candle is placed in front of a loudspeaker that is making a loud, steady note. The candle flame vibrates because of the sound wave.



Which type of waves are sound waves and in which direction does the flame vibrate?

0625/13/M/J/14

	type of wave	direction of vibration
A	longitudinal	↕
B	transverse	↕
C	longitudinal	↔
D	transverse	↔

4]

18 A boy blows a whistle that has a frequency of 10 000 Hz. The boy's friend cannot hear the sound from the whistle. The friend has normal hearing.

0625/13/M/J/14

What could be a reason why he cannot hear the sound?

A The amplitude is too large.

B The amplitude is too small.

C The frequency is too high.

D The frequency is too low.

5] **23** A student wishes to measure the speed of sound in air. She plans to measure the time betwe making a sound and hearing the echo from a cliff.

0625/11/O/N/11

She will use the equation: speed = $\frac{\text{distance}}{\text{time}}$.

Which type of sound should she make and which distance should she use in her calculation?

	type of sound	distance to use
A	continuous sound	$\frac{\text{distance to cliff}}{2}$
B	continuous sound	distance to cliff × 2
C	short, sharp sound	$\frac{\text{distance to cliff}}{2}$
D	short, sharp sound	distance to cliff × 2

6] **25** A ship sends a pulse of sound vertically downwards to the sea bed. An echo is heard 0.4 seconds later.

0625/11/O/N/10

If the speed of sound in the water is 1200 m/s, how deep is the water below the ship?

A 240 m **B** 480 m **C** 1500 m **D** 3000 m

MARKSCHEME FOR MCQ'S:
1-D
2-C
3-C
4-B
5-D

APPLICATION BASED QUESTIONS-EXTENDED THEORY:

8. Figure 8.1 shows a loudspeaker cone oscillating to produce sound waves

O/N/11-p32

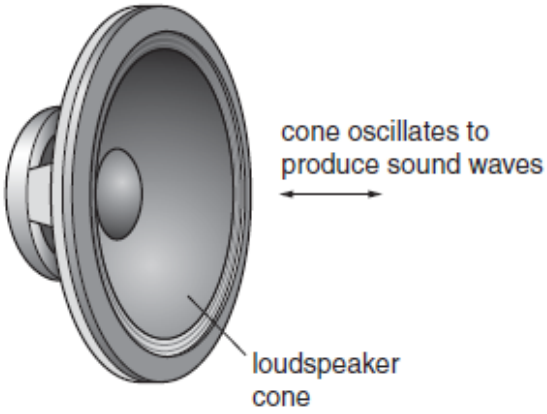


Fig. 8.1

(a) As the sound wave passes a point, it produces regions of higher and lower pressure. State the names of these regions.

higher pressure .....

lower pressure ..... [2]

(b) Describe how the movement of the loudspeaker cone produces these regions of different pressure.

higher pressure .....

.....

lower pressure .....

..... [2]

(c) State the effect on the loudness and pitch of the sound from the loudspeaker when

(i) the amplitude increases but the frequency of the sound stays the same,

loudness .....

pitch .....

(ii) the amplitude stays the same but the frequency increases.

loudness .....

pitch .....

[2]

MARKSCHEME:

(a) compression B1 rarefaction B1 [2]
(b) cone moves forward / in direction of travel of wave
OR cone pushes air particles closer o.w.t.t.e. B1
cone moves backwards / away from direction of travel of wave
OR cone causes empty spaces o.w.t.t.e. B1 [2]
(c) (i) loudness increases AND pitch same B1
(ii) loudness same AND pitch increases B1 [2]

6(a) Draw a straight line from each wave to the most appropriate speed on the right

O/N/13P32

wave	speed
	15 m/s (1.5×10 m/s)
	300 m/s (3×10^2 m/s)
light in air	1500 m/s (1.5×10^3 m/s)
sound in air	1 500 000 m/s (1.5×10^6 m/s)
sound in water	300 000 000 m/s (3×10^8 m/s)
	1 500 000 000 m/s (1.5×10^9 m/s)

[3

(b) Fig. 6.1 shows a railway-line testing-team checking a continuous rail of length 120 m The diagram is not to scale.

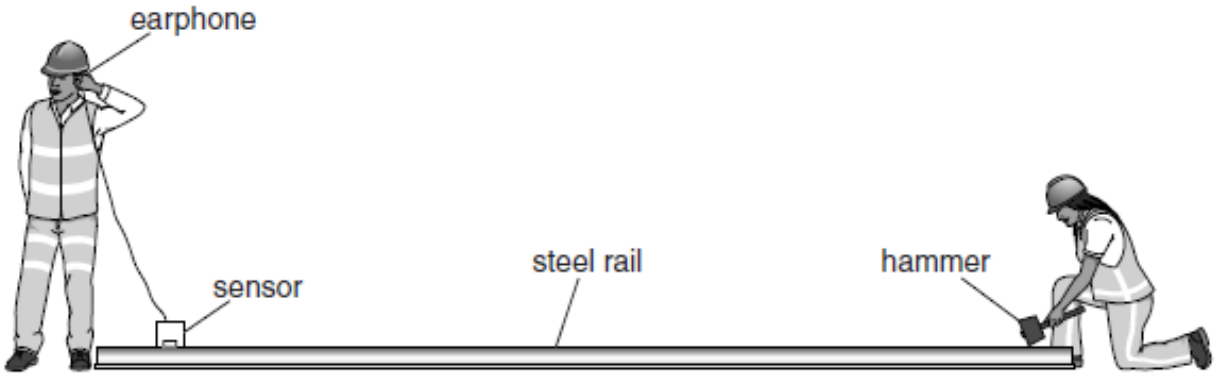


Fig. 6.1 (not to scale)

One tester strikes one end of the rail with a hammer. The other tester hears the sound transmitted through the air and transmitted through the rail. He hears the two sounds at two different times.

The speed of sound in steel is 5000 m/s.

Calculate the time difference, using your value from **(a)** for the speed of sound in air.

time difference = ...[4]

[Total: 7]

MARKSCHEME:

(a) light in air BOX 5 3 × 108m/ s

sound in air BOX 2 300m/ s B1

sound in water BOX 3 1500m/ s B1 [3]

(b) distance = speed × time in any form NOT speed = 2d/t

t_{air} = 120 ÷ value for speed of sound in air C1

t_{rail} (= 120/5000) = 0.024s C1

(time difference =) candidate's t_{air} – candidate's trail correctly evaluated

(expect 0.400 – 0.024 = 0.376s) A1 [4]

[Total: 7]

Observations of a distant thunderstorm are made.

(a) During a lightning flash, the average wavelength of the light emitted is 5×10^{-7} m. This light travels at 3×108 m/s.

Calculate the average frequency of this light.

frequency = ... [2]

(b) The interval between the lightning flash being seen and the thunder being heard is 3.6 s. The speed of sound in air is 340 m/s.

(i) Calculate the distance between the thunderstorm and the observer.

distance = ...

(ii) Explain why the speed of light is not taken into account in this calculation.

.....

.....[3]

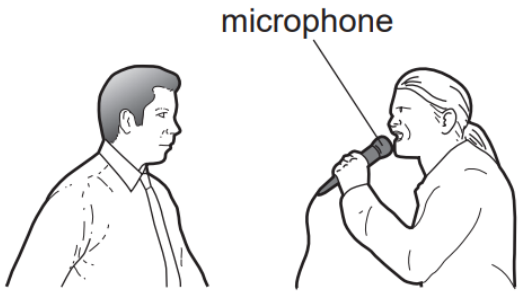
MARKSCHEME:

a	use of frequency = velocity/wavelength	C1	
	= 6×10^{14} Hz	A1	2
b(i)	340 x 3.6	C1	
	= 1224 m	A1	
(ii)	value so big time is negligible however expressed	B1	3

MCQ:

0625/11/O/N/09-Q9

1] The diagram shows a microphone being used in an interview.



Which energy change takes place in the microphone?

	input energy	output energy
A	chemical	electrical
B	electrical	chemical
C	electrical	sound
D	sound	electrical

2] **20** Which waves are longitudinal?

0625/11/M/J/10

A

light waves from a lamp

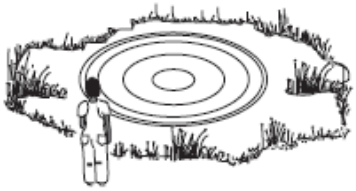
B

microwaves in an oven

C

sound waves from a trumpet

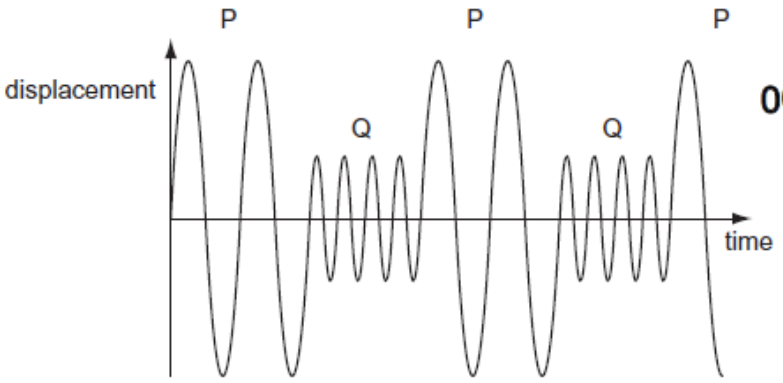
D



water waves on a pond

3]

25 A police car siren emits two different sounds P and Q. These are produced alternately. The diagram represents the sounds emitted.



0625/11/M/J/10

Which sound is the louder and which has the lower pitch?

	louder	lower pitch
A	P	P
B	P	Q
C	Q	P
D	Q	Q

4]

22 What is the approximate value of the highest frequency that can be heard by a young person?

A 20 Hz **B** 200 Hz **C** 2000 Hz **D** 20 000 Hz

5]

23 Sound travels by wave motion.

0625/11/M/J/11

Which property of waves causes echoes?

A diffraction

B dispersion

C reflection

D refraction

6]

25 A student claps once when standing 100 m away from a large wall.

The speed of sound in air is 330 m/s.

0625/11/M/J/13

How long after clapping does the student hear an echo?

A 0.30 s **B** 0.61 s **C** 1.7 s **D** 3.3 s

7]

26 In a test, a car horn is found to be too loud and the pitch of the note is too high.

What information does this give about the amplitude and the frequency of the sound wave produced?

	amplitude	frequency
A	too large	too large
B	too large	too small
C	too small	too large
D	too small	too small

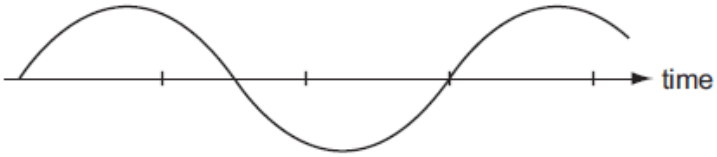
0625/11/O/N/12

8] **20** The diagrams represent the waves produced by four sources of sound. The scales are the same for all the diagrams.

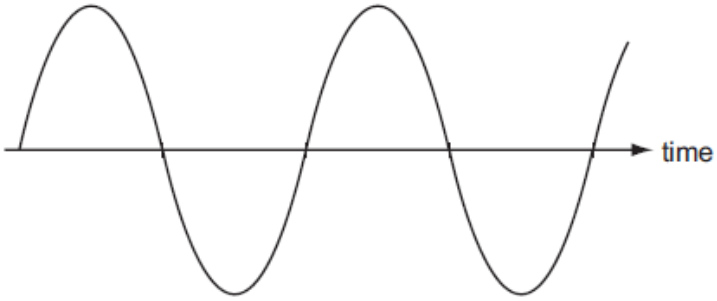
Which sound has the highest frequency?

0625/13/M/J/12

A

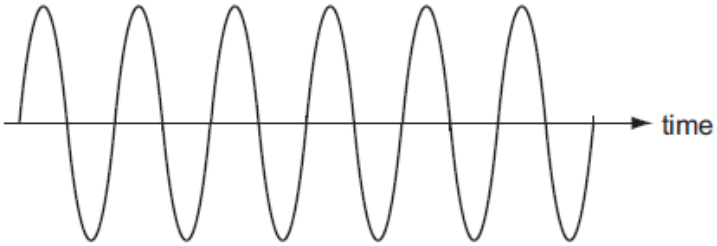


B



C

D



MARKSCHEME:
1-D
2-C
3-A
4-D
5-C
6-B
7-A
8-B