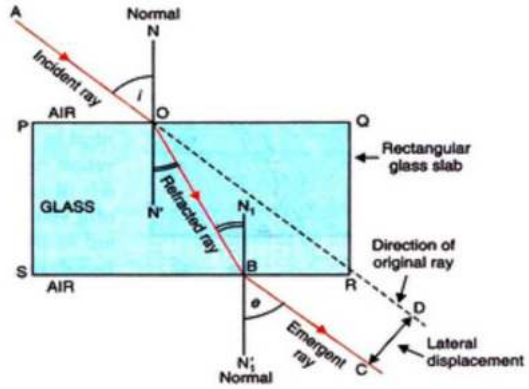
REFRACTION OF LIGHT

REFRACTION OF LIGHT THROUGH A PARALLEL SIDED TRANSPARENT BLOCK

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.



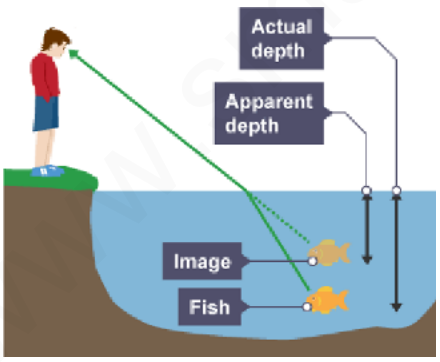
2. When a ray of light enters from a denser medium(say glass) to a rarer medium (for example air) the ray of light bends away from the normal. The speed of light increases.

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:

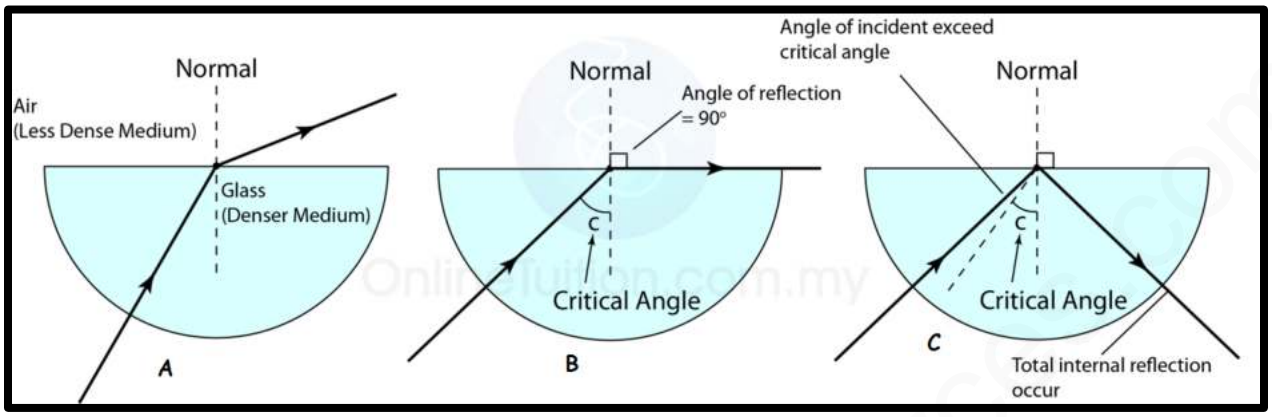


FIGURE A: When a ray travels from a denser medium to a rarer medium, the ray of light refracts away from the normal.

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.**

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 :

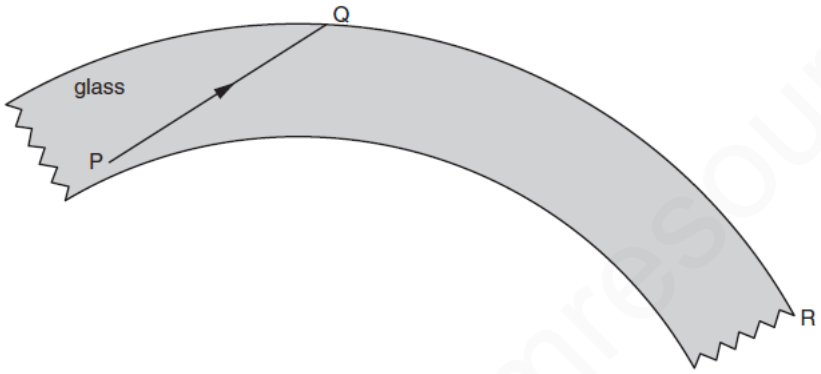
$\eta = \frac{1}{sinc}$ where c= critical angle

OPTIC FIBRE:

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

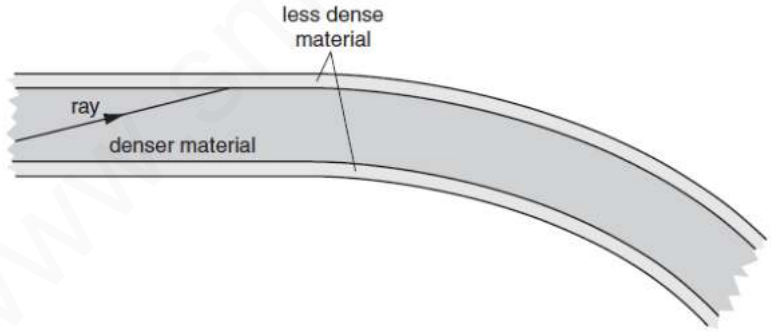
- The incident ray must be in the more dense medium.
- The angle of incidence must be more than the critical angle.
- No light should be refracted.
- The ray should be reflected with $\angle i = \angle r$

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.

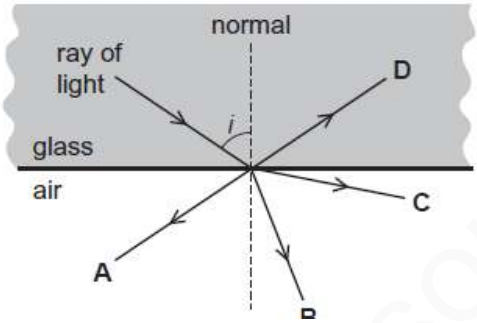
APPLICATION BASED QUESTIONS:

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.

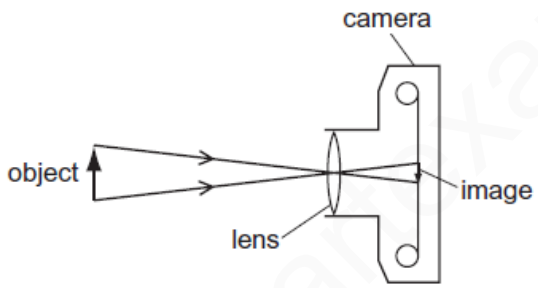
Which arrow correctly shows the direction of the ray after it leaves the edge of the glass?

0625/11/M/J/10

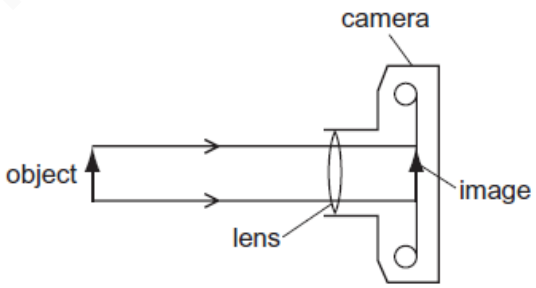


23 Which diagram correctly represents rays of light passing through a converging lens in a camera?

A

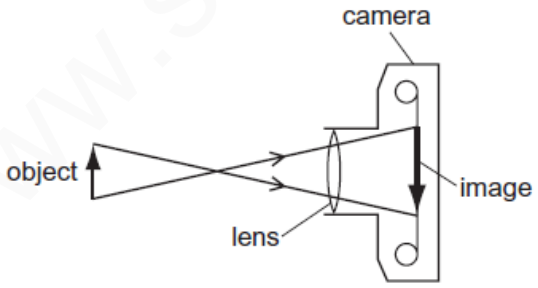


B

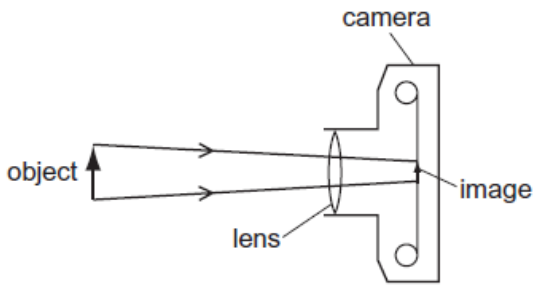


0625/11/M/J/13

C

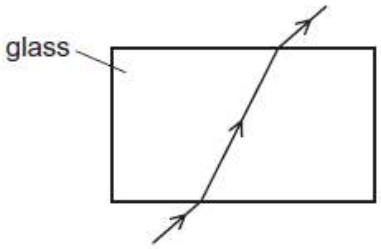


D

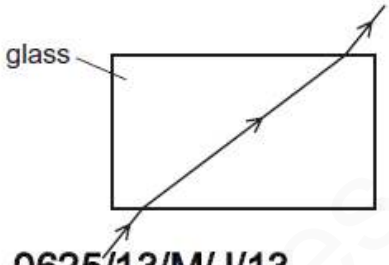


22 Which diagram shows how a ray of light could pass through a glass block in air?

A

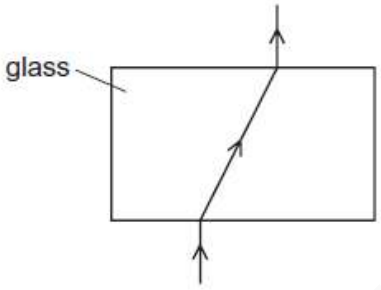


B

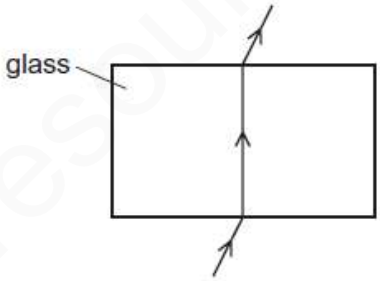


0625/13/M/J/13

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

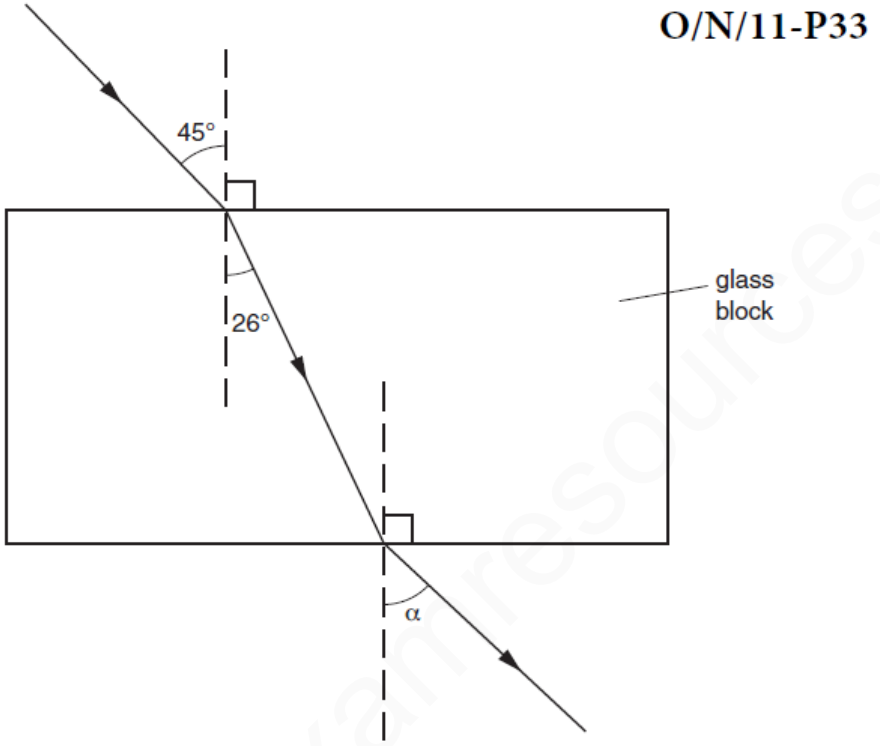


Fig. 9.1 (not to scale)

(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]

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°.

O/N/12-P31

(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]

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.

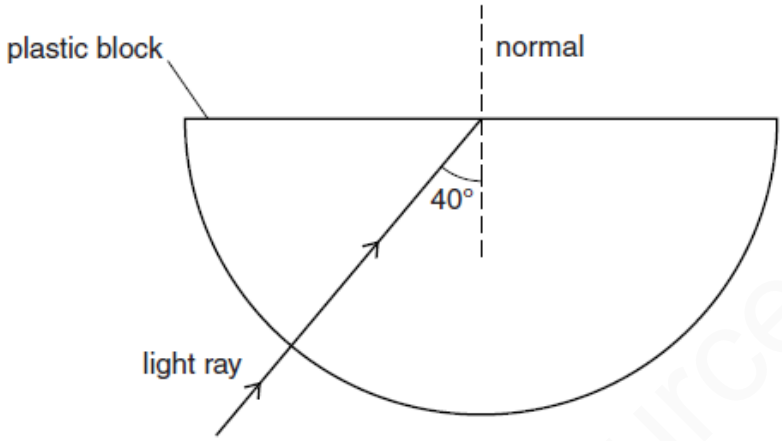


Fig. 7.1

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]

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]