Question based on Refraction and Refractive index. Glass Slab, Lateral Shift.

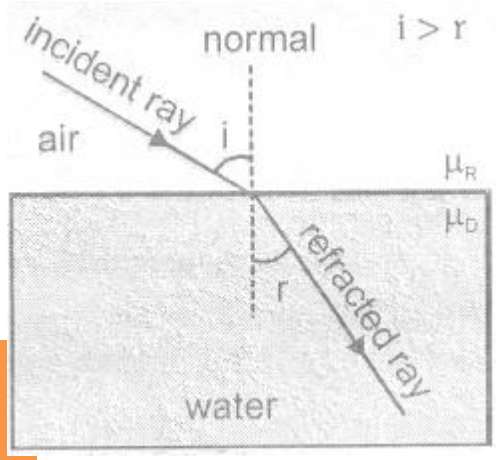
Q.What is refraction of light? What are the laws of refraction?

Ans: Deviation of ray of light from its original path when it travels from one transparent homogeneous medium to another transparent homogenous medium is called the refraction of light.

There are two laws of refraction :-

(I) incident ray, reflected ray and normal lie in the same plane.

(ii) The ratio of sine of angle of incidence and sine of angle of refraction is constant i.e. Sin i / Sin r = n. This is also called as Snell's law.



Q. Define Refractive Index:

Ans: It is the ratio of speed of light in vacuum to the speed of light in medium is called Refractive index.

Q. Give the ratio of velocities of two light waves travelling is vacuum and having wave lengths 4000A0 and 8000A0.

Ans: In Vacuum, light of all the wave lengths travel with the same velocity i.e. 3 X 108 m/sec.

Q.. For what angle of incidence, the lateral shift produced by parallel sided glass plate is zero?

Ans: For <i = 0.

Q. What are the factors on which the lateral shift depends?

Ans: Thickness of the refracting medium, angle of incidence and its refractive index.

Q. Refractive index of media A,B,C and D are

A	B	C	D
1.54	1.33	1.46	1.62

In which of the four media is the speed of light (i) Minimum (ii) Maximum.

Ans: (i) Speed of light is minimum in medium D (n = 1.62). (ii) Speed of light is maximum is medium B (n = 1.33).

Q. What is the value of Relative refractive index of air?

Ans: One.

Q. If speed of light in vacuum = 3 x 10^8 m/sec and Refractive index of water = 4/3, What is the speed of light in water?

Ans: Refractive index of water = Speed of light in vacuum / Speed of light in water;

4/3 = (3 x 108 m/sec)/ (Speed of light in water)

Speed of light in water = (3 x 10^8 m/sec) x ¾ = 9/4 x 10^8m/sec = 2.25 x 10^8 m/sec.

Q. For the same angle of incidence in media P, Q and R, the angles of refraction are 35^0, 25^0, 15^0 respectively. In which medium will the velocity of light be minimum?

Ans: According Snell's law n = Sin i / Sin = C / V

For given angle of incidence (i), V will be minimum, when angle of refraction <r is minimum

In given data it is for medium R.

Q. A coin in a glass beaker appears to rise as the beaker is slowly filled with water. Why?

Ans: It happens on account of refraction of light. A ray of light starting from the coin goes from water to air and bends away from normal. Therefore, bottom of the beaker on which the coin lies appears to be raised.

Q. When a ray of light passes through a parallel sided glass slab of transparent medium then show that angle of incidence is equals to angle of emergence.

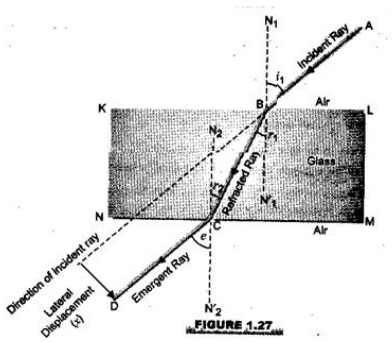


FIGURE 1.27

Applying Snell's Law at B,

Sin i_1 / Sin r_1 = n_g/n_a ----------(i)

Applying Snell's Law at C,

Sin r_2 / Sin $_e$ = $n_a/n_g \Rightarrow n_g/n_a$ = Sin $_e$ / Sin r_2 -------(ii)

From (i) & (ii)

Sin i_1 / Sin r_1 = Sin $_e$ / Sin r_2 ----------(iv)

Now, KL II MN and $N_1 \perp$ KL and $N_2 \perp$ MN

$\Rightarrow N_1$ II N_2 and BC is transversal,

$<r_2 = <r_1$

$\Rightarrow$ Sin r_2 = Sin r_1 ----------(v)

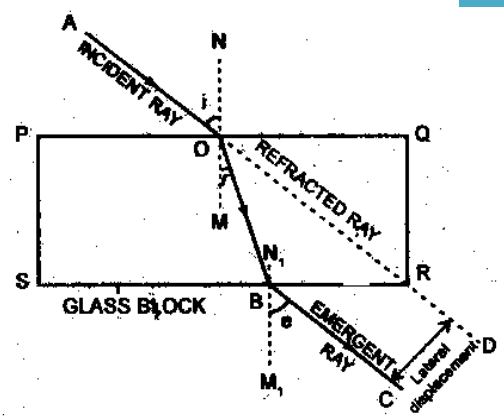
From (iv) & (v)

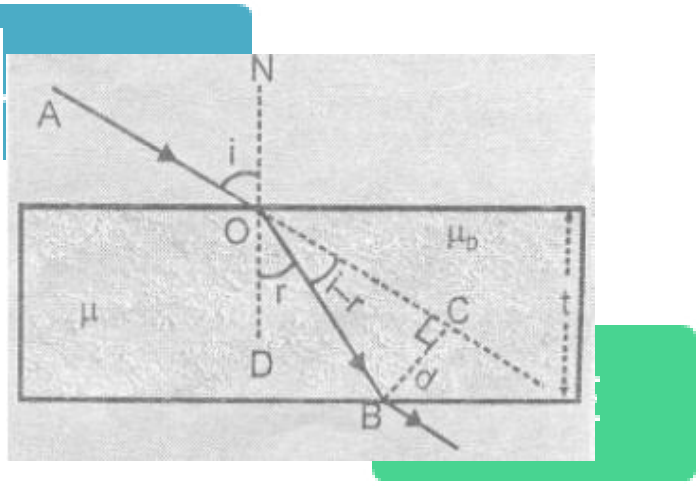
Sin i_1 = Sin $_e$

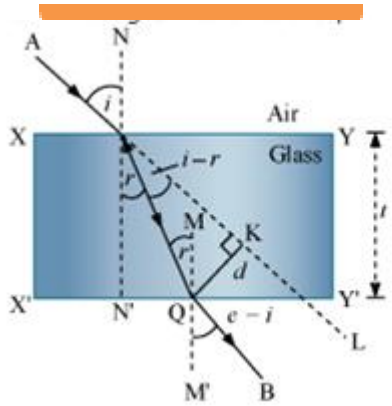
Angle of emergent at second boundary MN of glass slab is equal to angle of incidence at the first boundary KL of glass slab. Hence, CD II AB

Q. What is lateral shift? Explain with the help of a diagram.

Ans: When a ray of light travels through a glass slab from air, it bends towards the normal and when it comes out of the other side of the glass slab it bends away from the normal. It is found that the incident ray and the emergent ray are not along the same straight line, but the emergent ray seems to be displaced with respect to the incident ray. This shift in the emergent ray with respect to the incident ray is called lateral shift or lateral displacement. The incident and the emergent rays, however, remain parallel.







Lateral Shift

The perpendicular distance between incident and emergent ray is known as lateral shift. Lateral Shift d = BC and t = thickness of slab

In ΔBOC , sin(i - r) = BC/OB = d/OB ⇒ d = OB sin (i - r) ----------(i)

In Δ OBD , (cos r) =OD/OB = t/OB ⇒ OB = t/(Cos r) ----------(ii)

From (i) and (ii)

d = t sin (i - r) / (Cos r)

Q. An object under water appears to be at lesser depth than in reality. Explain why?

Ans: This is due to refraction of light. We know

Real depth / Apparent depth = n

Or Apparent depth = Real depth / n

Since n > 1, so apparent depth < real depth.

Q. When does Snell's law fail?

Ans: Snell's law fails when light is incident normally on surface of a refracting medium.

Q. Light of wavelength λ in air enters a medium of refractive index n. What will be its wavelength, velocity and frequency in the medium?

Answer: We know, n = c / v, where c = 3 x 10^8 ms-1

Therefore, v = c / n, which is the velocity of light in the medium.

Also c = vλ and v = vλ'

Therefore, c / v = λ / λ'

Or λ' = λ / (c / v) = λ / n , which is wavelength of light in the medium.

Frequency of light in air, v = c / λ

Frequency of light in medium, v' = v / λ' = (v / λ)n =(v / λ)(c / v) = c / λ.

Hence v' = v. So frequency of light in the medium is same as that in air.

Q. With respect to air the refractive index of ice and rock salt benzene are 1.31 and 1.54 respectively. Calculate the refractive index of rock salt with respect to ice.

Ans: We know that,

With respect to air the refractive index of ice and rock salt benzene

${}^{i}_{r}n = {}^{a}_{r}n / {}^{a}_{i}n$ = 1.54 / 1.31 = 1.17

Q. When light goes from one medium to another, the characteristics that remain unaffected is

(a) Speed (b) Direction (c) Wave length (d) Frequency

Ans: (d) Frequency

Q. Bending of a ray of light due to change in velocity with medium is called

a) Reflection b) Refraction c) Diffraction d) Dispersion

Ans: b) Refraction

Q. For no bending of a ray of light through a glass slab, angle of incidence must be

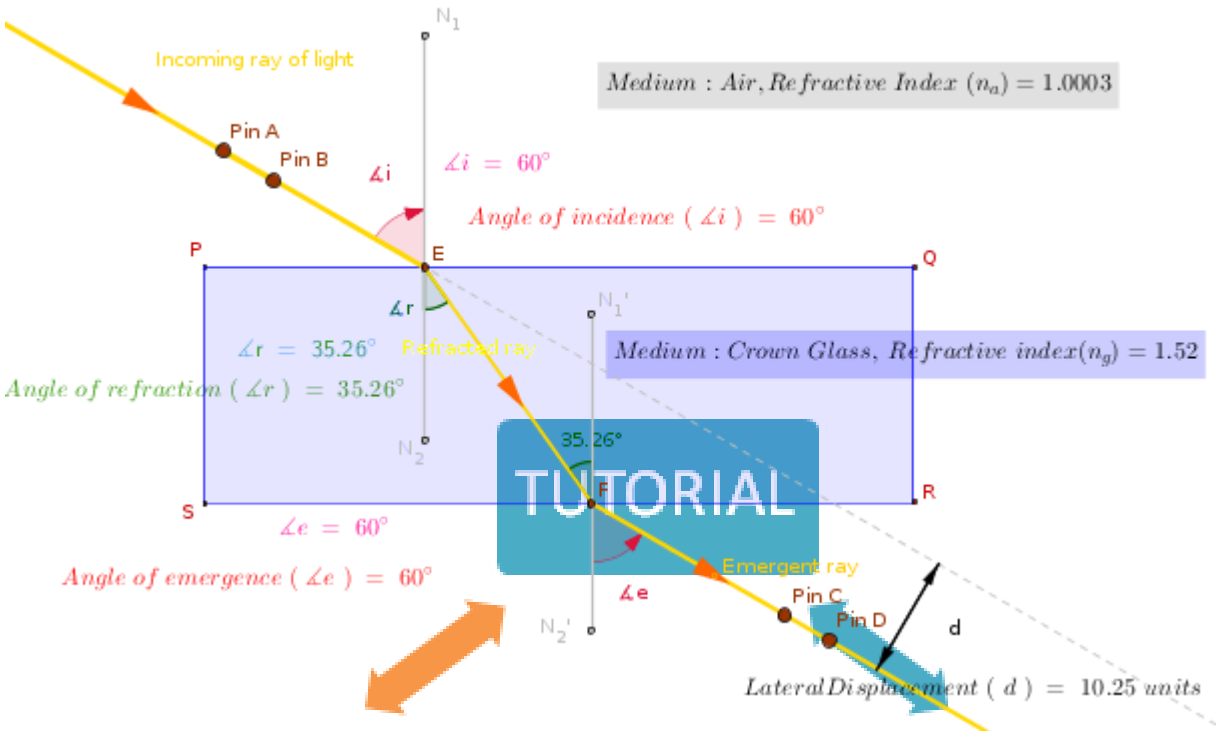
(a)0^0 (b) 30^0 (c) 60^0 (d) 90^0

Ans: (a) 0^0

Experiment:

Aim: To trace the path of a ray of light passing through a rectangular glass slab for different angles of incidence and to measure the angle of incidence, angle of refraction and angle of emergence and interpret the result.

Apparatus: A drawing board, rectangular glass slab, office pins, sheet of white paper, a protractor and sharply pointed pencil.



Conclusions :

The path of the incident ray, the refracted ray and the emergent ray when light passes through a rectangular glass slab is shown above .

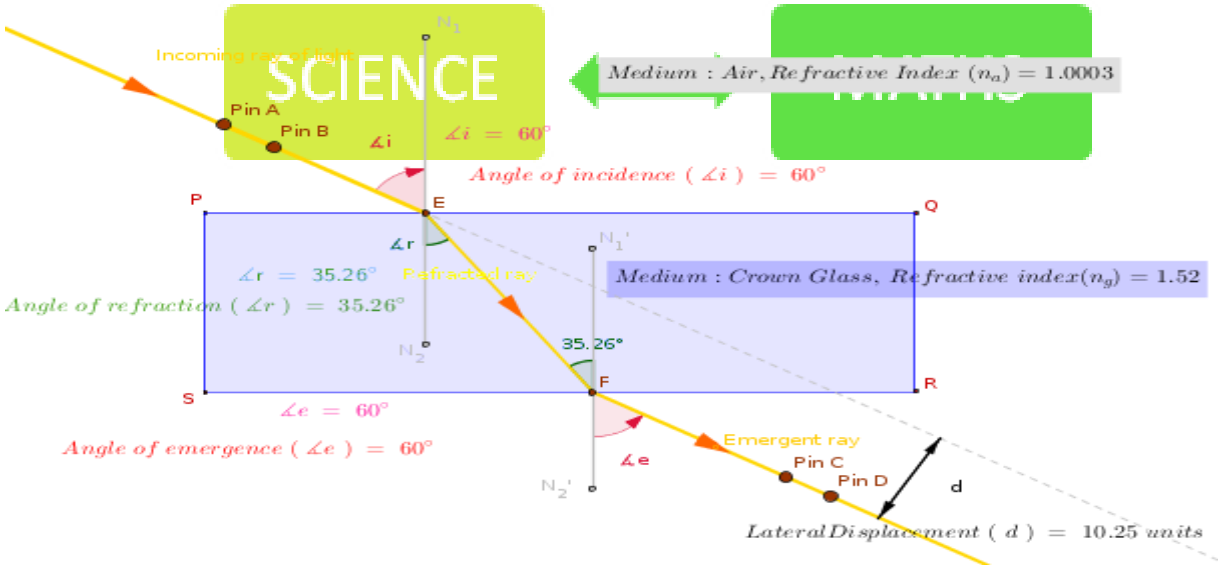
Within the experimental error,∠i = ∠e, this implies that the incident ray and the emergent ray are parallel to each other.

<u>Doing the Experiment</u>

Apparatus:

A drawing board, rectangular glass slab, office pins, sheet of white paper, a protractor and sharply pointed pencil.

About the experiment:



PQRS represents a glass slab. Consider that a ray of light enters the glass slab along AE. It means that light is travelling from a rarer medium (i.e., air) to glass which is denser medium. Thus the refracted ray bends towards the normal making r

At the other face of the slab, the ray EF while travelling through glass meets the surface SR of air which is a rarer medium . It emerges out along FD ,bending away from the normal.The ray FD is known as the emergent ray .

The angle which the emergent ray makes with the normal at the point of emergence is called the angle of emergence and is denoted by the letter E

Procedure :

Fix a sheet of white paper on a drawing board with drawing pins. Place the given glass slab nearly in the middle of the sheet.

Mark the boundary of the glass slab with a sharp pencil and label it as PQRS after removing the slab from its position.

On the line PQ mark a point E and draw a normal N_1EN_2 at it. Draw a line AE making angle AEN1 with the normal.The angle should neither too small nor too large (say about 40 degree).

Now place the glass slab again on its boundary PQRS and fix two pins A and B vertically about 10 cm apart on the line AE (say points A and B).

Look through the glass slab along the plane of the paper from the side SR and move your head until the images of the two pins A and B are seen clearly. Closing your one eye ,adjust the position of your head in such a way that the images of the pins A and B lie in the same straight line.

Fix two other pins C and D vertically in such a way that the images of the pins A and B and pins C and D, all these four, lie in the same straight line. Ensure that the feet of the pins (not their heads) lie in the same straight line.

Remove the slab and also the pins from the board and encircle the pin-pricks on the paper,with a sharp pencil.

Join the points D and C and produce the line DC towards the slab so that it meets the boundary line RS at the point F. Join the points e and F. Thus for the incident ray represented by line AE, the refracted ray and the emergant ray are represented by EF and FD respectively.

On the line RS draw a normal N_1 'FN_2 ' at point F. Now, with a protractor, measure angle AEN_1, angle FEN_2 and angle DFN_2 ' labelled as angle i, angle r and angle e respectively.

Now place the glass slab at some other position on the sheet of paper fixed on the board and repeat all the above steps again taking another angle of incidence.

Measure the angle of incidence i.e angle of refraction, angle of emergence, again.

Make a record of your observations in the observation table as shown below.

Observation Table :

S.No.	Angle of incidence $\angle i$ (Degree)	Angle of refraction $\angle r$ (Degree)	Angle of emergence $\angle e$ (Degree)	$\angle i - \angle e$ (Degree)
1.				
2.				
3.