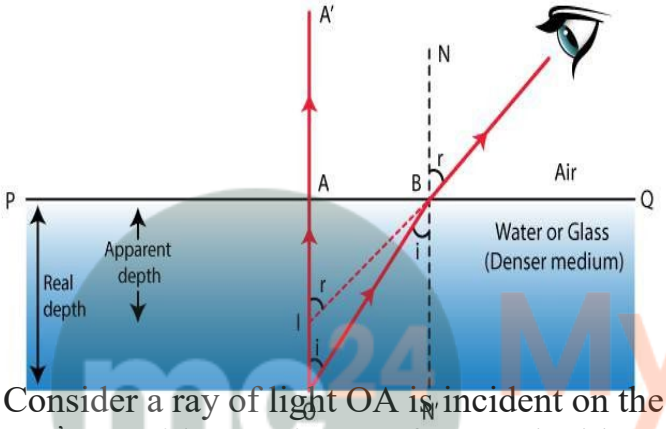
EXERCISE 4(C)

Solution:

The relation of refractive index μ with real and apparent depths is

μ = Real Depth / Apparent Depth

Solution:



Consider a ray of light OA is incident on the surface PQ normally. It passes straight along AA'. Consider another ray from O, incident at angle i along OB. This ray gets refracted and passes along BC. The ray BC appears to be coming from point I which is the virtual image of O, obtained on producing A'A and BC backwards. Hence, AI represents the apparent depth, which is less than the real depth.

Since, AO and BN' are parallel and OB is transversal line, so

∠AOB = ∠OBN[1] = i

Similarly, IA' and BN are parallel and IC is the transversal line, so

∠BIA' = ∠CBN = r

In right angle triangle BAO,

sin i = BA / OB and

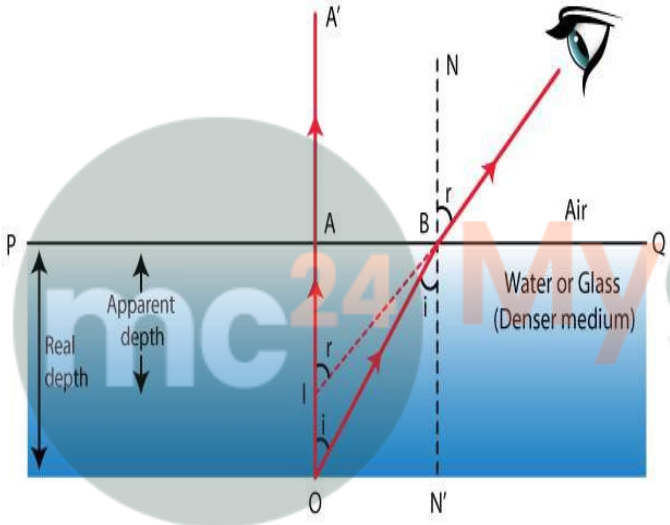
In right angle triangle IAB,

sin r = BA / IB

For refraction from medium to air, by Snell's law

$_m\mu_a$ = sin i / sin r = (BA / OB) / (BA / IB) = IB / OB
Hence, refractive index of medium with respect to air is,
$_a\mu_m = 1 / {}_m\mu_a$ = OB / IB
The object is viewed from a point vertically above the object O, since point B is very close to the point A.
∴ IB = OA
Hence $_a\mu_m$ = OA / IA = Real depth / Apparent depth

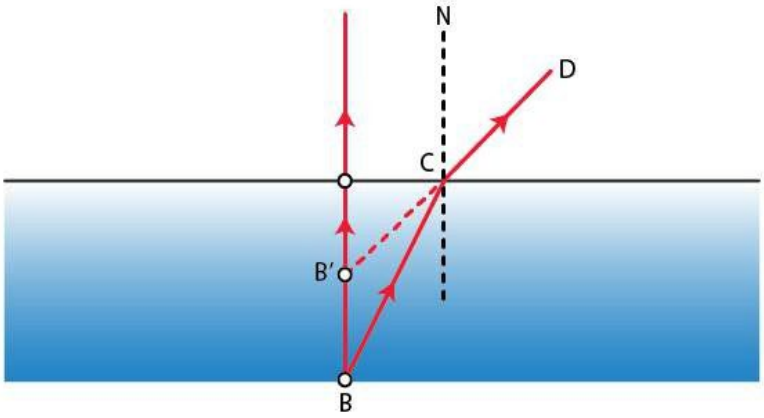
Solution:
(a) Due to the refraction of light from a denser medium to a rarer medium, the depth of the tank appears to be lesser than its real depth.
(b)



Question: 4
Water in a pond appears to be only three-quarters of its actual depth. (a) What property of light is responsible for this observation? Illustrate your answer with the help of a ray diagram. (b) How is the refractive index of water calculated from its real and apparent depths?
Solutions:
(a) Refraction of light is responsible for this observation

Due to refraction of light from denser medium to rarer medium, it is bent away from the normal.

(b)



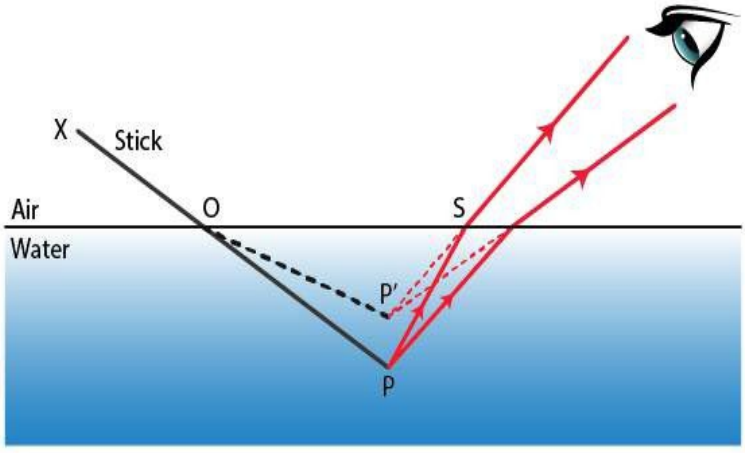
Let an object say B is at the bottom of a pond. Consider a ray of light BC from the object that moves from water to air. The ray moves away from the normal N along the path CD, after refraction from the water surface. The produce of CD appears from the point B'. The virtual image of the object B appears at B'.

Refractive index of water = Real depth / Apparent depth

Question: 5

Draw a ray diagram to show the appearance of a stick partially immersed in water. Explain your answer.

Solution:



The above figure shows that a stick appears bent or raised which is partially immersed in water in a glass container. This is due to the rays appears to come from P' which is the virtual image of the tip P of the stick. This is due to the refraction of light from denser

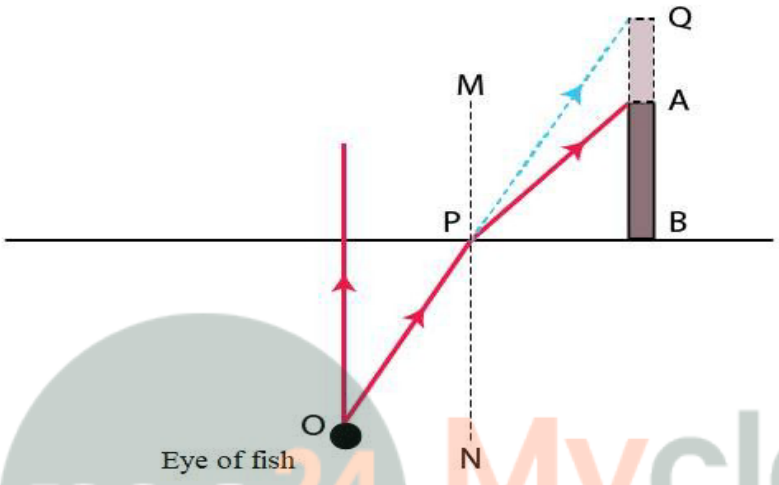
medium to rarer medium at the surface separating two media.

Question: 6

A fish is looking at a 1.0 m high plant at the edge of the pond. Will the plant appear shorter or taller than its actual height? Draw a ray diagram to support your answer.

Solution:

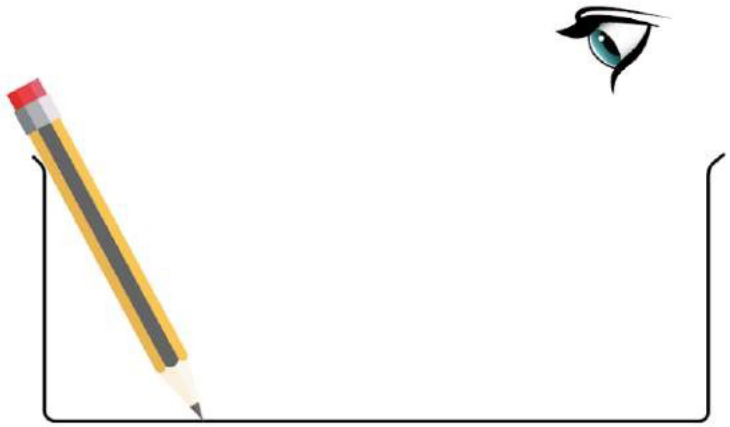
The plant appears to be taller than its actual height



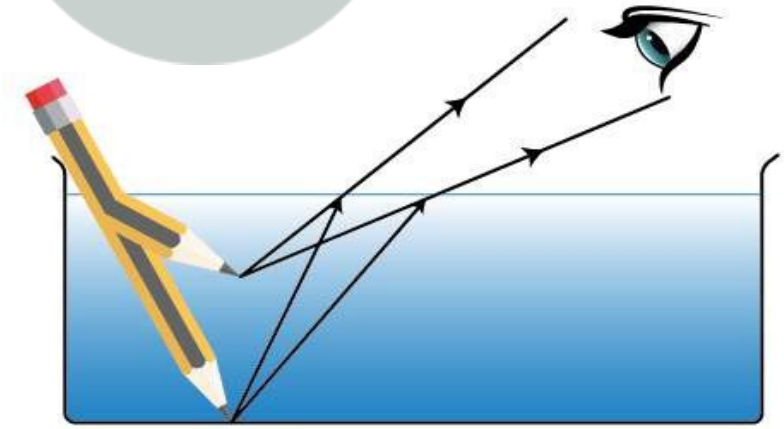
Let the fish is looking from the point O. Since air is a rarer medium in comparison of water, the ray will bend away from the normal MN when the ray OP emerges out from the water to air. But when we extend the ray OP it will meet at Q. Hence due to this the plant AB will look taller than its actual height.

Question: 7

A student puts his pencil into an empty trough and observes the pencil from the position as indicated in the Fig.



(i) What change will be observed in the appearance of the pencil when water is poured into the trough?
(ii) Name the phenomenon which accounts for the above started observation.
(iii) Complete the diagram showing how the student's eye sees the pencil through water.
Solution:
(a) When water is poured into the trough, part of the pencil which is immersed in water will look short and raised up.
(b) Refraction of light is responsible for the above observation
(c) The required diagram is shown below:



Question: 8
An object placed in one medium when seen from the other medium, appears to be vertically shifted. Name the factors on which the magnitude of shift depends and state how does it depend on them.

Solution:
The shift by which the object appears to be raised, depends on:
(i) The refractive index of the medium.
(ii) The thickness of the denser medium and
(iii) The colour or wavelength of incident light
With the increase in refractive index of the medium the shift increases. It also increases with the increase in thickness of the denser medium. But the shift decreases with the increase in the wavelength of light used.

MULTIPLE CHOICE TYPE
Question: 1
A small air bubble in a glass block when seen from above appears to be raised because of:
a. Refraction of light
b. Reflection of light
c. Reflection and refraction of light
d. None of the above
Solution:
A small air bubble in a glass block when seen from above appears to be raised because of refraction of light.

Question: 2
An object in a denser medium when viewed from a rarer medium appears to be raised. The shift is maximum for:
a. Red light
b. Violet light
c. Yellow light
d. Green light
Solution:
The shift is maximum for violet light.

NUMERICALS
Question: 1
A water pond appears to be 2.7 m deep. If the refractive index of water is 4/3, find the actual depth of the pond.
Solution:
Given,
Apparent depth = 2.7 m
Refractive index of water $\mu_w = 4 / 3$

Real depth = Apparent depth × μ_w
Real depth = 2.7 × 4 / 3
Real depth = 3.6 m

Question: 2
A coin is placed at the bottom of a beaker containing water (refractive index = 4/3) to a depth of 12 cm. By what height the coin appears to be raised when seen from vertically above?
Solution:

Given,
Refractive index of the water, $\mu_w = 4 / 3$
Real depth at which coin is placed = 12 cm
Shift in the image = ?
Shift = Real depth × (1 – 1 / μ)
Shift = 12 × (1 – 3 / 4)
Shift = 12 / 4
Shift = 3 cm or R = 3 cm

Question: 3
A postage stamp kept below a rectangular glass block or refractive index 1.5 when viewed from vertically above it, appears to be raised by 7.0 mm. Calculate the thickness of the glass block.
Solution:

Given,
Refractive index of the glass block, $\mu_g = 1.5$
Shift in the image = 7 mm or 0.7 cm
Thickness of glass block or real depth = ?
Shift = Real depth × (1 – 1 / μ)
0.7 = R × (1 – 1 / 1.5)
R = (0.7 × 1.5) / 0.5
R = 2.1 cm