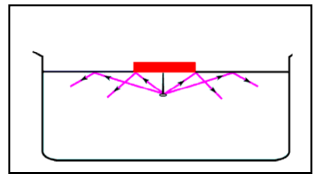
PROJECT WORK-

Take a thin thermocol sheet. Cut it in circular discs of different radii like 2cm, 3cm, 4cm, 4.5cm, 5cm etc and mark centers with sketch pen. Now take needles of length nearly 6cm. Pin a needle to each disc at its centre vertically. Take water in a large opaque tray and place the disc with 2cm radius in such a way that the needle is inside the water as shown in figure.



Now try to view the free end (head) of the needle from surface of the water.

- Are you able to see the head of the needle?
  Now do the same with other discs of different radii.
  Try to see the head of the needle, each time.

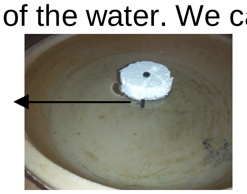
Note: the position of your eye and the position of the disc on water surface should not be changed while repeating the activity with other discs.

- At what maximum radius of disc, were you not able to see the free end of the needle?
- Why were you not able to view the head of the nail for certain radii of the discs?
- Does this activity help you to find the critical angle of the medium (water)?
- Draw a diagram to show the passage of light ray from the head of the nail in different situations.

Answer :

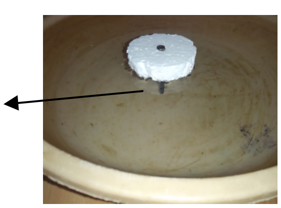
Take a thin thermocol sheet. Cut it in circular discs of different radii like 2cm, 3cm, 4cm, 4.5cm, 5cm etc and mark centers with sketch pen. Now take needles of length nearly 6cm. Pin a needle to each disc at its centre vertically.

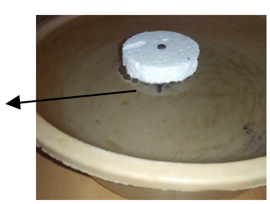
Take water in a large opaque tray and place the disc with 2cm radius in such a way that the needle is inside the water . Now try to view the free end (head) of the needle from surface of the water. We can easily observe the free end of the needle.

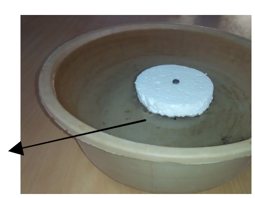


In the same way take the disc with 3cm radius in such a way that the needle is inside the water . Now try to view the free end (head) of the needle from surface of the water. We can easily observe the free end of the needle.

Now repeat this experiment by taking thermocol discs with radii 4cm, 4.5cm, 5cm, 6cm, etc., and observe the free end of needle in each case. Free end of needle can be visible in each case.







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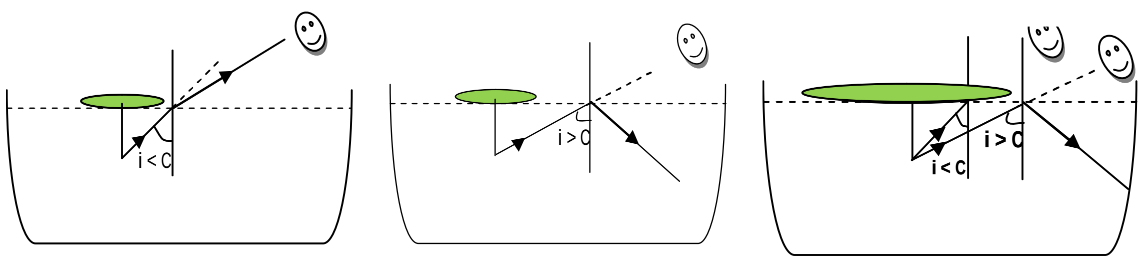
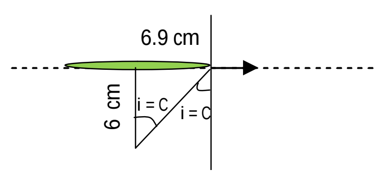
In the case of 6.5 cm., also we are able to see the tiny edge of free end of needle by careful observation.

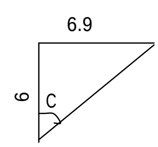
Now in the same manner take water in the same opaque tray and put 7cm., 7.5 cm., thermocol discs with needles. In these cases we are unable to see the free end of the needle.

- The free end of needle visible when we take the thermocol discs with radii less than 7cm.,
- The free end of needle not visible when we take the thermocol discs with radii like 7cm., 7.5 cm.,and Accurately when the radius of the disc is greater than 6.9 cm.
- **<u>Reason</u>**: When angle of incidence is greater than the critical angle, total internal reflection occurs. If the angle of incidence is less than the critical angle, we can see the free end of the needle. But as the radius of the disc increases, it should come across in the path of incident ray. That's why we are unable to see the free end.



- We can find the critical angle of the medium (Water) by this experiment. To calculate critical angle, we have to use trigonometric ratios in the right angled triangle.





$$\text{Tan } C = \frac{\text{Opposite side}}{\text{Adjacent side}} = \frac{6.9}{6} = 1.15$$

➔ Tan C = Tan 48.99^o It means the critical angle value is 48.99^o (approximately 49^o)

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Now Check whether the result is correct or wrong.

The light ray travels from denser medium (Water) to rarer medium (Air).

Here $n_1 = n_{water} = 1.33$ Angle of incidence $i = C$

$n_2 = n_{air} = 1.0003$ Angle of refraction $r = 90^o$

According to Snell's law $n_1 \text{ Sin } i = n_2 \text{ Sin } r$

$\Rightarrow \frac{Sin\, i}{Sin\, r} = \frac{n_2}{n_1}$

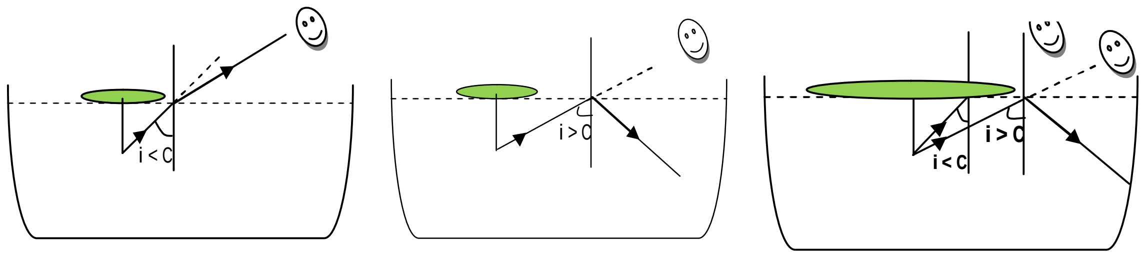
$\Rightarrow \frac{Sin\, C}{Sin\, 90} = \frac{1.0003}{1.33}$

$\Rightarrow \frac{Sin\, C}{1} = 0.7521$

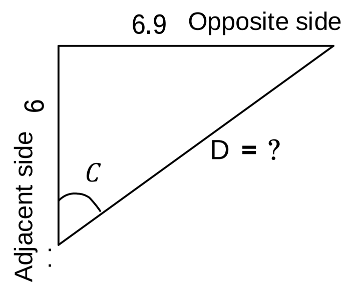
$\Rightarrow Sin\, C = \text{Sin } 48.77^o$

$\Rightarrow C = 48.77^o$ (approximately 49^o)

- The diagrams to show the passage of light ray from the head of the nail in different situations are shown below.



Note : Critical angle can be measured in another way.



Diagonal (D) $= \sqrt{6.9^2 + 6^2}$

$= \sqrt{47.61 + 36}$

$= \sqrt{83.61}$

$= 9.1439$

$$\text{Sin } C = \frac{\text{Opposite side}}{\text{Diagonal}} = \frac{6.9}{9.1439} = 0.7546$$

$\Rightarrow$ Sin C = Sin 48.99^o It means the critical angle value is 48.99^o (approximately 49^o)

For another needle having length "h" ,

The maximum radius of the disc is 1.14 x h

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