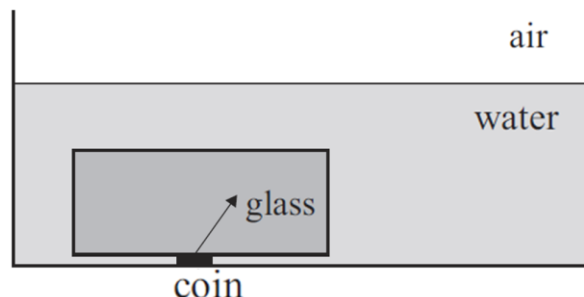


WAVES: REFRACTION QUESTIONS

REFRACTION (2010;3)

Jane puts a glass block on top of a coin in a trough. She then pours water over this. The diagram below shows the situation.



The arrow represents a ray of light travelling from the coin through the glass.

The refractive index of glass is 1.55

The refractive index of water is 1.33

The refractive index of air is 1.00

- Complete the diagram to show what happens to the ray of light as it enters the water and then travels into the air.
- Use calculations to determine whether the ray of light will enter the air when the angle of incidence of the ray of light at the glass-water interface is 48.7° .
 - Explain your answer to (i).

REFRACTION (2009;2)

When Bianca is sailing her boat out of the harbour, she notices that the apparent depth of the water is different from the real depth. The two arrows indicate two rays of light travelling from the bottom of the harbour towards the surface of the water.



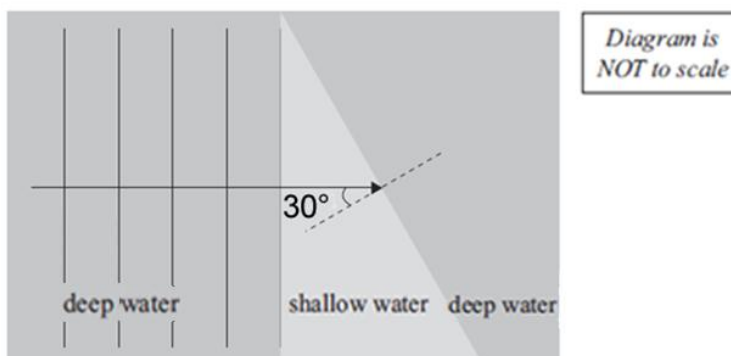
- Complete the diagram above to show where the bottom of the harbour appears to be. Use your diagram to explain why Bianca observes that the harbour depth appears to be different from what it really is.
- State what happens to the frequency and speed of the light as it leaves the water.
- One light ray is incident on the water/air interface as shown.



The refractive index of water is 1.33. The refractive index of air is 1.00. Calculate the angle of refraction. Give your answer to the correct number of significant figures.

WAVES (2009;3)

Bianca notices that there is a shallow triangular reef near her boat. There is deep water all around the reef. The water waves travel at a speed of 1.6 ms^{-1} in deep water, and 1.2 ms^{-1} in shallow water. The waves have a wavelength of 45 cm in deep water.



- Show that the wavelength of the waves in shallow water is 34 cm.
- Calculate the time it takes for one complete wave to move onto the reef.
- On the diagram, show what happens to the waves as they travel through the shallow water and then into deep water. Make sure you make it clear (use labels if necessary) what has changed and what has stayed the same.
- The wavelength changes as the waves go from shallow water to deep water. The waves have a wavelength of 0.45 m in deep water. The waves have a wavelength of 0.34 m in shallow water. Refer to the diagram and calculate the angle of refraction when the waves go from shallow water to deep water.

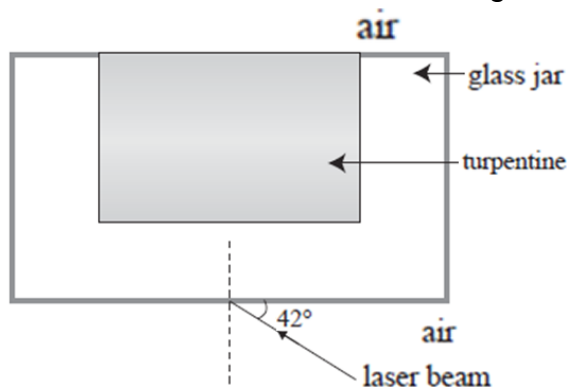
WAVES (2008;1)

Petra and Callum notice that the wavelength changes as the waves approach the beach through shallower water.

- Explain how the wavelength of the wave changes as it passes into the shallow region.
- The waves travel at 4.0 ms^{-1} , and the crests are 5.0 m apart. Calculate the time taken for one wave to pass a point.

REFRACTION (2008;5)

Jane shone a laser beam through turpentine, which was in a glass jar. The refractive index of turpentine is 1.472. The refractive index of glass is 1.67.



- Calculate the angle of refraction of the laser beam in the turpentine, when the laser beam passes from the glass into the turpentine. Give your answer to the correct number of significant figures. (Note: It has been assumed that you remember that the refractive index of air = 1.00)

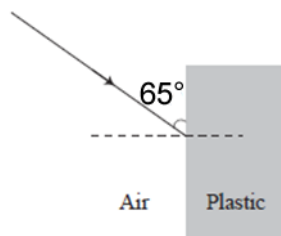
THE OPTICIAN (2007;1)

Pita is visiting the medical centre to get a new pair of glasses. He finds out that lenses can be made of either plastic or glass.

Plastic has a refractive index of 1.60. Glass has a refractive index of 1.50.

- (a) State the meaning of the term "refractive index".

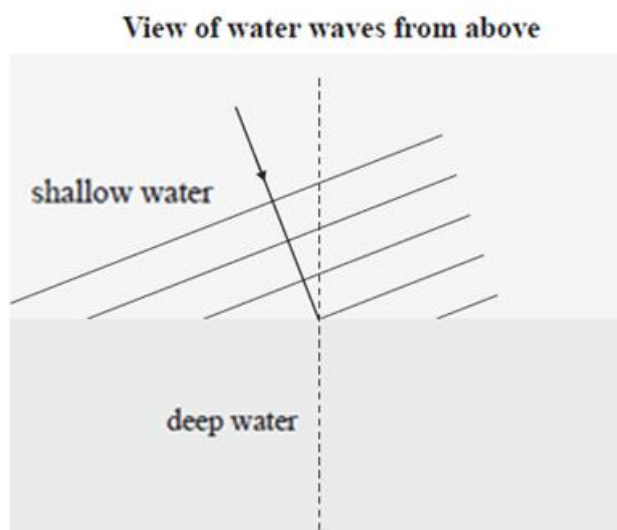
A ray of light enters the plastic lens as shown.



- (b) Calculate the size of the angle of incidence.
(c) Calculate the size of the angle of refraction.

At the Harbour (2007;2)

Further out to sea, Maria sees water waves travelling through shallow water above a reef and then into deep water, as shown in the diagram below (The water waves travel more slowly in shallow water).



- (a) On the diagram, draw the wavefronts in the deep water, and an arrow showing the direction the refracted waves are travelling.
(b) Use the information provided below to calculate the angle of refraction in deep water.

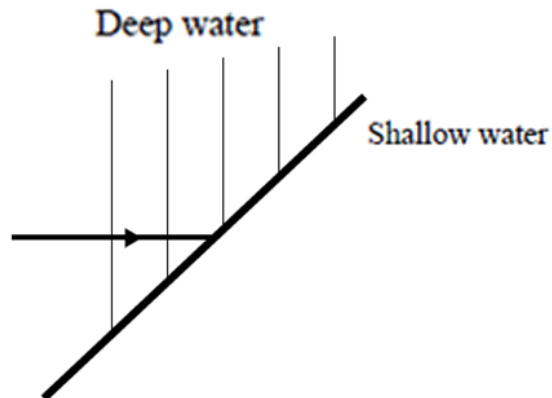
Speed of waves in shallow water = 0.25 ms^{-1}

Speed of waves in deep water = 0.35 ms^{-1}

Angle of incidence in shallow water = 35°

Waves (2006;1)

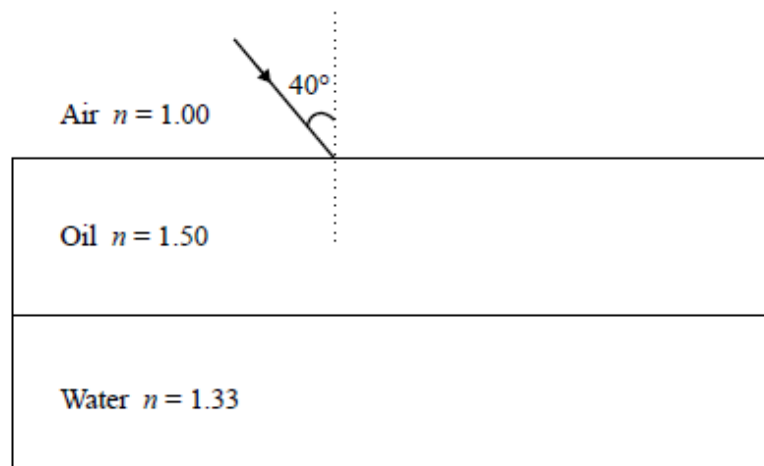
Roy and Sally spent time on a beach watching the incoming waves. The diagram below shows wavefronts as they approach shallow water. The waves travel slower in shallow water.



- On the diagram, draw an arrow showing the wave direction and the refracted wavefronts in the shallow region.
- Clearly explain why the waves behave as you have drawn them in the diagram above.
- State what happens to the frequency and wavelength of the waves as they pass from deep to shallow water.

Light (2006;2)

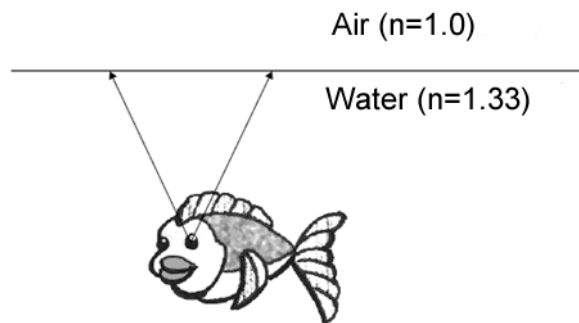
Roy and Sally noticed a puddle of water with oil floating on top. The diagram below shows a ray of light travelling from air as it meets the air-oil interface.



- Complete the path of the ray of light in the diagram to show what happens to the ray as it enters the oil, and then the water.
- The ray of light meets the air-oil interface at an angle of incidence of 40° . Calculate the angle of refraction when the ray goes into the water.

Roy and Sally visited a pet shop to buy a fish in a tank.

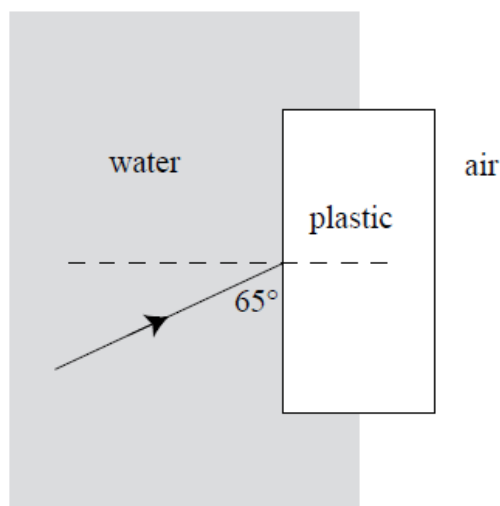
- (c) On the diagram draw appropriate rays to locate the image of the fish if Roy was looking at it from above.



QUESTION TWO (2005;2)

Robbie and Amy decide to practise their underwater swimming. They are both wearing swimming goggles.

- (a) The diagram shows a ray of light entering the transparent plastic goggles. Continue the ray showing how it bends as it enters the plastic, and then as it enters the air. (The plastic is optically denser than water.)

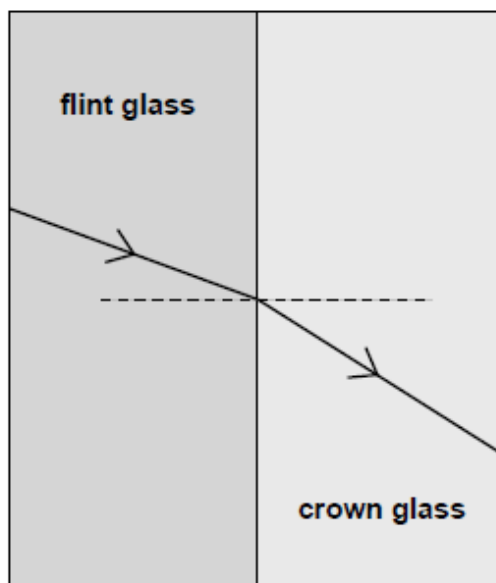


- (b) The ray of light deviates (or changes direction) through an angle of 4.0° as it enters the plastic. The refractive index of plastic is 1.5. Calculate the refractive index of the water.
- (c) State the meaning of the term "absolute refractive index".

REFRACTION (2004;3)

Lee is a keen astronomer. He discovers that good telescope lenses are often made of two types of glass of different refractive index cemented together.

The diagram shows the path of a ray of light as it travels through two such pieces of glass.



(a) Clearly mark the angle of incidence for the ray from flint glass to crown glass in the diagram.

Use the information below to answer the questions (b), (c) and (d).

| | |
|-----------------------------------|---------------------------------------|
| Refractive index of crown glass | = 1.52 |
| Refractive index of flint glass | = 1.66 |
| Speed of light in crown glass | = $1.974 \times 10^8 \text{ ms}^{-1}$ |
| Angle of incidence in flint glass | = 19.8° |

(b) Show that the angle of refraction in the crown glass is 21.7° .

(c) Calculate the speed of light in flint glass.