



7 Refraction, reflection, and total internal reflection

Warning: Wear eye protection. Never look directly into the beam of a laser. Stand out of the plane of the laser beam and behind the laser to avoid direct line of sight with the laser beam. Make sure that students do the same.

Aim: To demonstrate the principle of reflection, refraction at the air-water interface, and total internal reflection at the water-air interface.

Equipment:

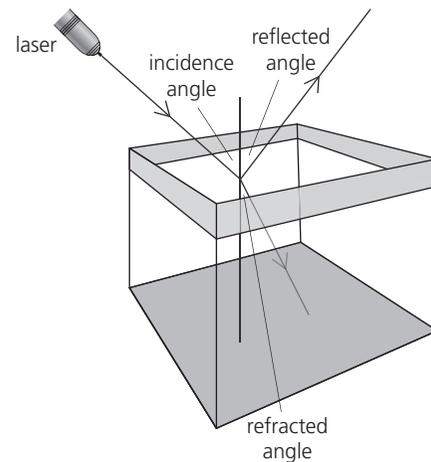
- Small rectangular fish aquarium
- Laser
- One flat mirror, 5cm × 4cm, with a string glued to one end
- Smoke machine or chalk dust
- Colouring to add to the water

Demonstration 1: reflection

- Fill the tank with coloured water.
- Arrange the laser such that the laser beam is incident at 45° to the air-water interface.
- You should see the reflected beam of light at the air-water interface when smoke or chalk dust is present in the air above the water.

Explanation

At a smooth surface, such as a mirror, and at an interface between transparent media such as air and water, light can be reflected. The angle of reflection, as measured with respect to the surface normal, is equal to the angle of incidence.



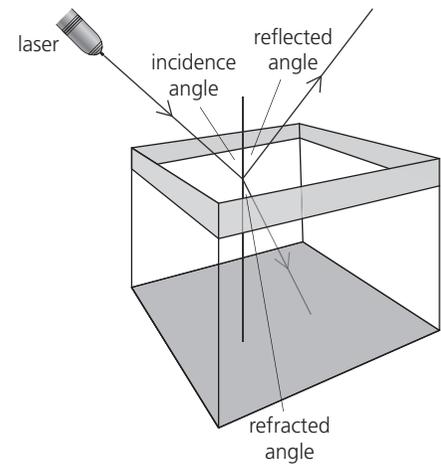


Demonstration 2: refraction

- Fill the tank with coloured water.
- Arrange the laser such that the laser beam is incident at 45° to the air-water interface.
- Illuminate the path of the laser beam using a smoke machine or chalk dust.
- Note the change of direction of the incident beam of light from the laser in air and the beam in the water; the refracted beam.

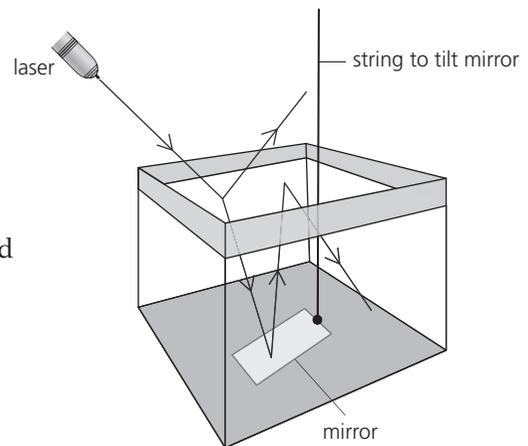
Explanation

The speed of light in a transparent medium depends on the optical density through which the light travels. If the beam of light is not at perpendicular incidence when it enters a new medium then the change in medium results in a change of angle of the beam of light.



Demonstration 3: total internal reflection

- Fill the tank with water.
- Place the second mirror at the bottom of the tank.
- Place the supported mirror at 45° above the tank.
- Arrange the laser such that it enters the water hitting the mirror at the bottom of the water.
- Using the string attached to the mirror, slowly raise one end of the mirror to change the angle of incidence of the laser beam on the mirror.
- Increase the angle until the reflected beam hits the surface of the water and no refraction is seen. Beyond this angle the water-air interface becomes mirror like and totally reflects the incident beam.



Explanation

On going from a more optically dense medium, such as water, to a less optically dense medium, such as air, the beam of light cannot be refracted into the less optically dense medium if the incident angle is greater than a certain value, the critical angle. Therefore the beam can only be reflected, hence total internal reflection.