

# Introduction to Physical Science

Optics: Reflection & Refraction  
Presented by Robert Wagner

## Light as a Ray

- Light travels in straight lines - rays
- We do not see the wave nature of light when light interacts with everyday objects
- Geometric optics - describes how light changes direction when it interacts with matter

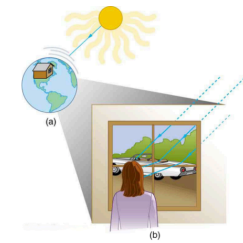


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## Law of Reflection

- We measure angles from the perpendicular to the surface at the point where light strikes
- Rough surface - rays are reflected in all directions - diffused
- Smooth surface - Light is reflected at specific angles
- Law of Reflection: The angle of reflection equals the angle of incidence

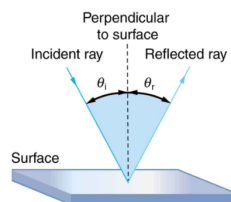


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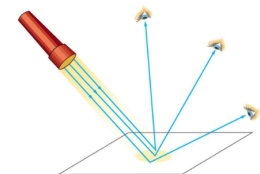


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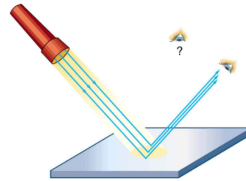


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## Law of Refraction

- Refraction: The changing of the direction of a light ray when it passes through variations in matter
- Can see multiple images of objects
  - Light waves change direction when passing through different materials
  - Light changes speed ( $c$  = speed of light in a vacuum)

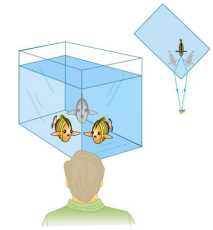


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## The Speed of Light

- How to measure the speed of light?
- Early attempts - knew light moved extremely fast
- Roemer - Measured speed of light using Jupiter's moons (25% error)
- Michelson - Measured using rotating mirrors and stationary mirror 35 km away (0.04% error)
- Speed of light ( $c$ ) =  $2.99792458 \times 10^8$  m/s

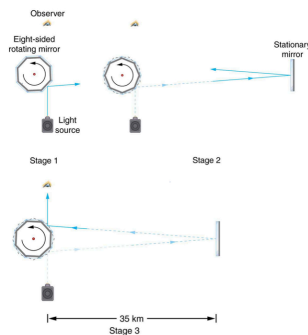


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## Index of Refraction

- The speed of light through material will be less than the speed of light in a vacuum
- Index of refraction:  $n$ , where
- The larger the index of refraction, the more light slows down in that material
- Air:  $n = 1.000293$
- Diamond:  $n = 2.419$

## Example

$$n_{\text{zircon}} = 1.923 \text{ (Table 25.1)}$$

- Calculate the speed of light in zircon, a material used in jewelry to imitate diamond.

$$n = \frac{c}{v}; v = \frac{c}{n}$$

$$v = \frac{3.00 \times 10^8 \text{ m/s}}{1.923} = 1.56 \times 10^8 \text{ m/s}$$

- Draw a sketch (if applicable)
- Identify known values
- Identify equation
- Enter values in the equation and solve

## Law of Refraction

- Light rays will change direction when they pass from one medium to another
- It moves closer to the perpendicular when it slows down
- It moves away from the perpendicular when it speeds up
- Snell's Law:

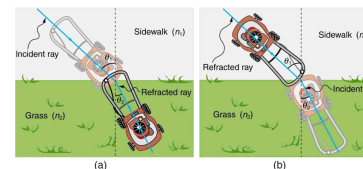


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## Total Internal Reflection

- At a boundary, some light is reflected and some refracted
- The critical angle is the angle such that the angle of refraction is equal to 90 degrees
  - For greater angles, all of the light is reflected - total internal reflection

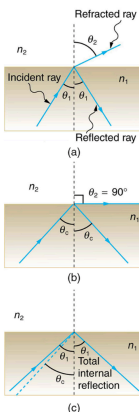


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## Summary

- We can use geometric optics to describe what happens to light rays
- Law of reflection: Angle of reflection equals angle of incidence
- Law of refraction: Snell's law
- Total internal reflection occurs when the angle of the ray is greater than the critical angle