

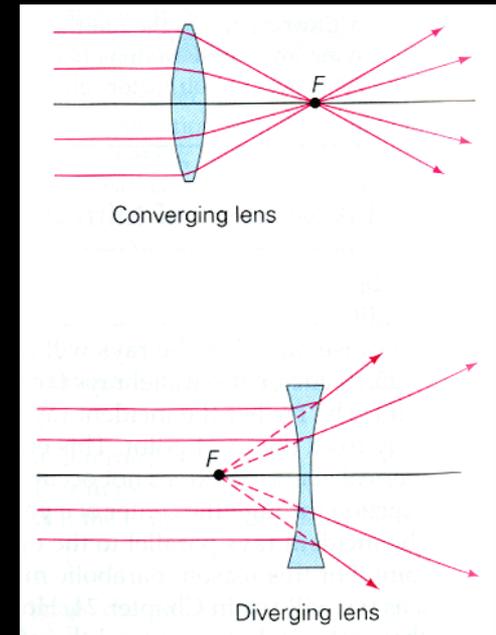
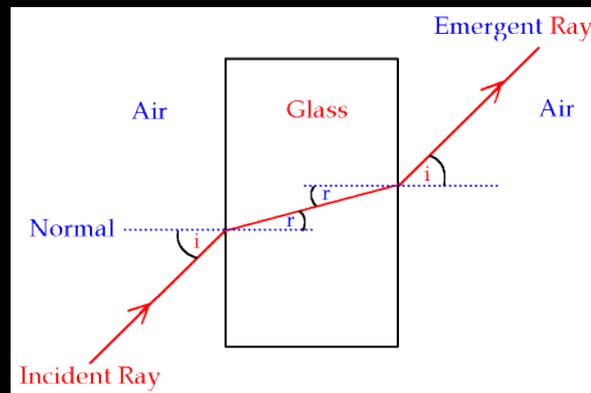
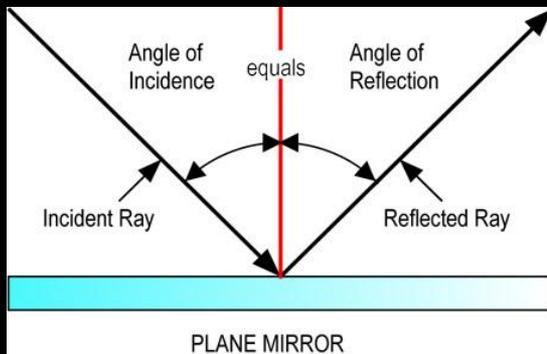
Pre-AP Physics

Unit 10: Light and Optics

Part 2 – Optics Principles

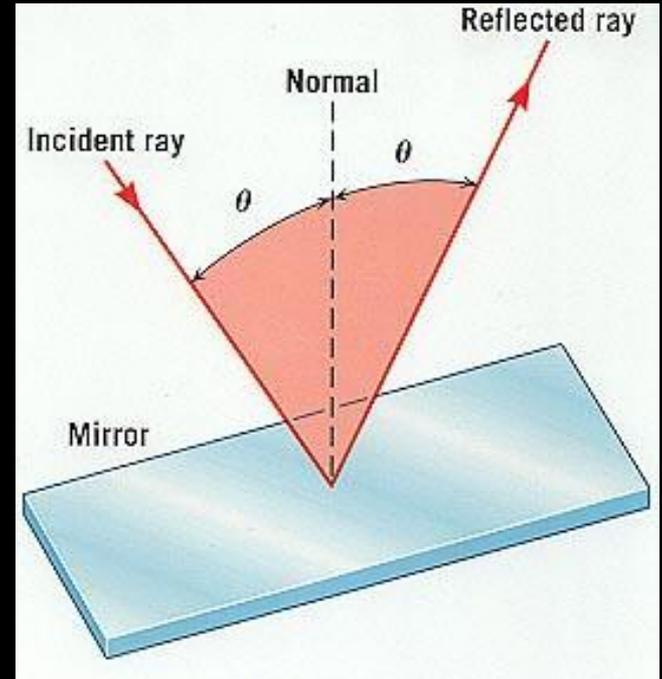
Optics

- The study of the reflection and refraction of light.
- Mirrors and Lenses



The Law of Reflection

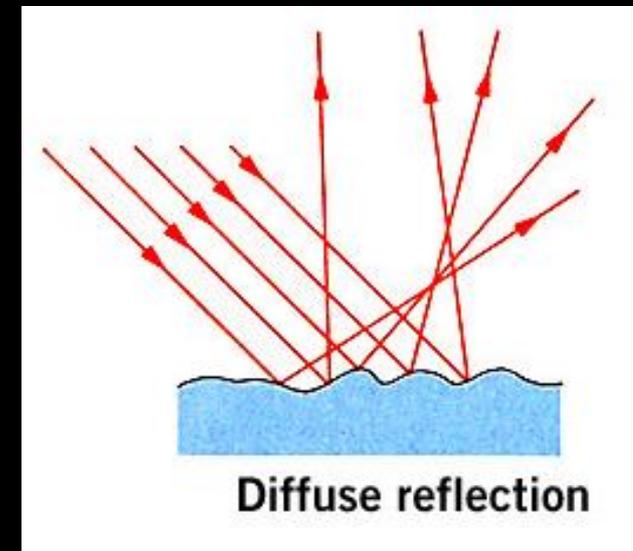
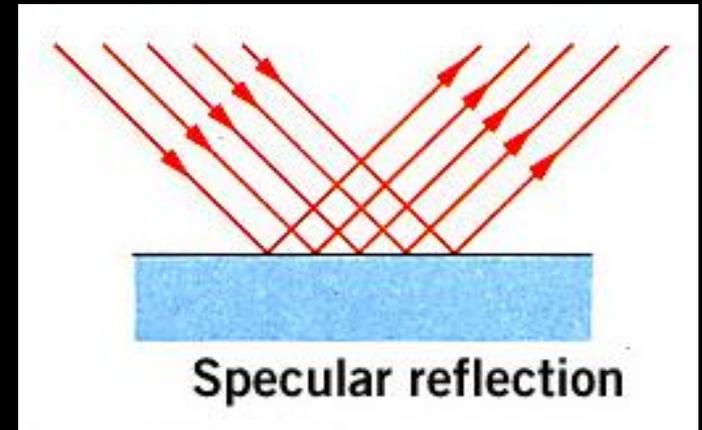
- The angle of the incident ray is equal to the angle of the reflected ray.
- Angle of incidence = angle of reflection
- Both angles are measured from the normal.



“Normal” – Line perpendicular to the surface.

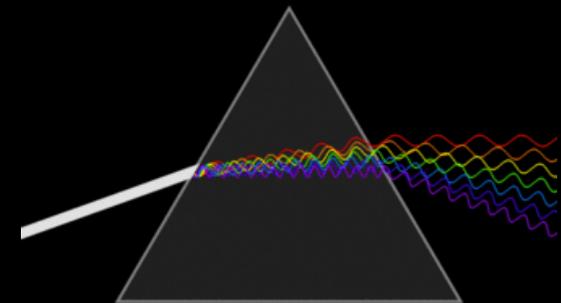
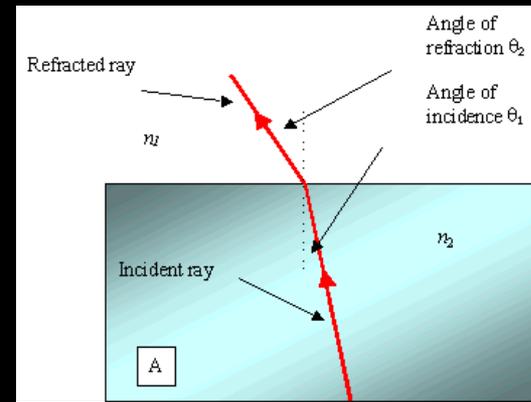
Reflection

- Specular Reflection
 - Reflection from a smooth flat surface, such as a mirror.
 - Reflected rays are all in the same direction.
- Diffuse Reflection
 - Reflection from a rough surface.
 - Reflected rays are in different directions.



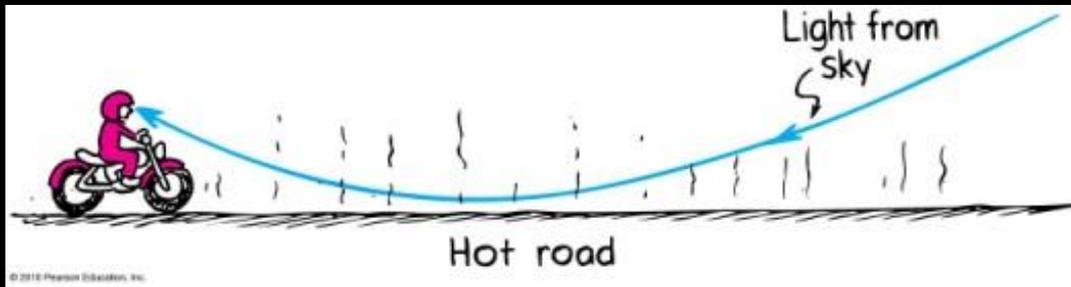
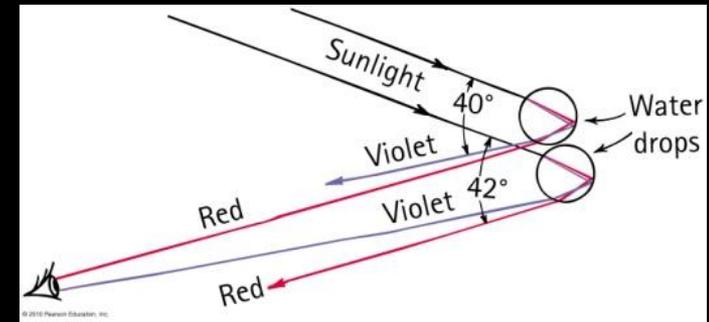
Refraction

- The bending of light as it passes from one medium to another.
- This happens because the light ray changes speed.
- Dispersion – different wavelengths of light bend by different amounts.
 - Example: Prisms split light into different colors.



Other examples of Refraction

- Rainbows
 - Water droplets act like tiny prisms, dispersing the light into different colors.
- Mirages
 - Light bends as it encounters the air over a hot surface.



Index of Refraction

- Describes how light will propagate through a medium.
- The ratio of the speed of light in a vacuum to the speed of light in the medium.

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

- Equation

n : index of refraction (no units)

c : speed of light in a vacuum = 3.00×10^8 m/s

v : speed of light in the medium

| Material | Speed of Light | Index of Refraction (n) |
|----------|------------------------|-------------------------|
| Air | 3.00×10^8 m/s | 1.00 |
| Water | 2.26×10^8 m/s | 1.33 |
| Glass | 1.97×10^8 m/s | 1.52 |
| Diamond | 1.24×10^8 m/s | 2.42 |

Example 1

The index of refraction of light in amber is 1.55. What is the speed of light through amber?

Snell's Law of Refraction

- Relates the index of refraction of two materials to the angles of incidence and refraction as a ray of light moves from one medium to the other.

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

- Equation

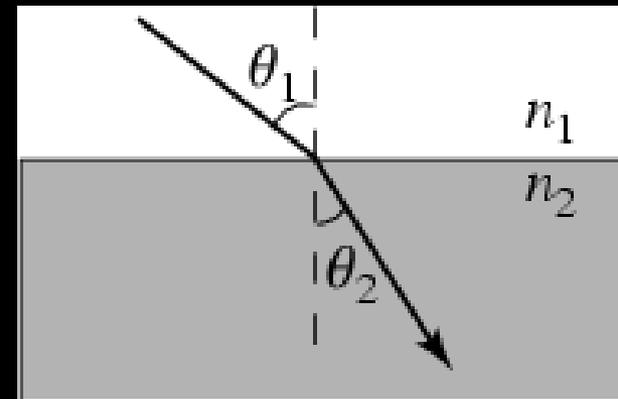
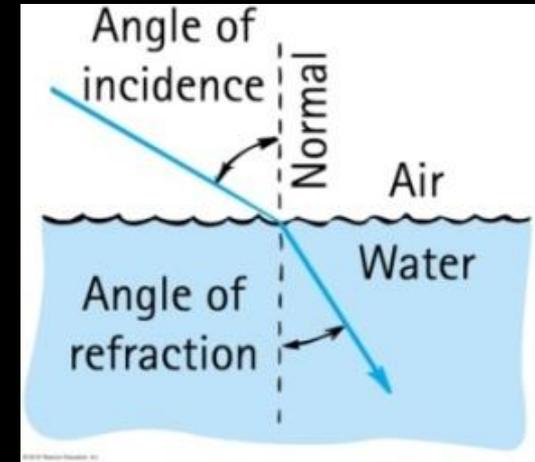
n_1 : index of refraction of the first material

θ_1 : angle of incidence from the normal (in degrees)

n_2 : index of refraction of the second material

θ_2 : angle of refraction from the normal (in degrees)

- Light will bend toward the normal when entering a higher IOR from a lower IOR and light will bend away from the normal when entering a lower IOR from a higher IOR.



Example 2

A ray of light travels from glass ($n = 1.52$) at an incident angle of 28° into an unknown clear liquid. The light refracts at an angle of 19° as it enters the liquid. What is the index of refraction of the liquid?

Example 3

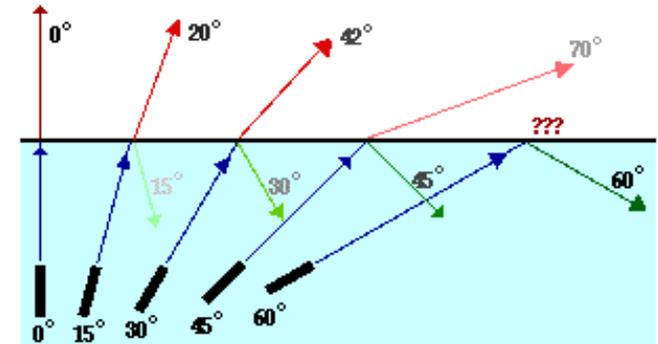
Jeffrey shines a laser beam from air ($n = 1.00$) into water (1.33) at an angle of 59° from the normal. At what angle will the laser beam be refracted?

Total Internal Reflection

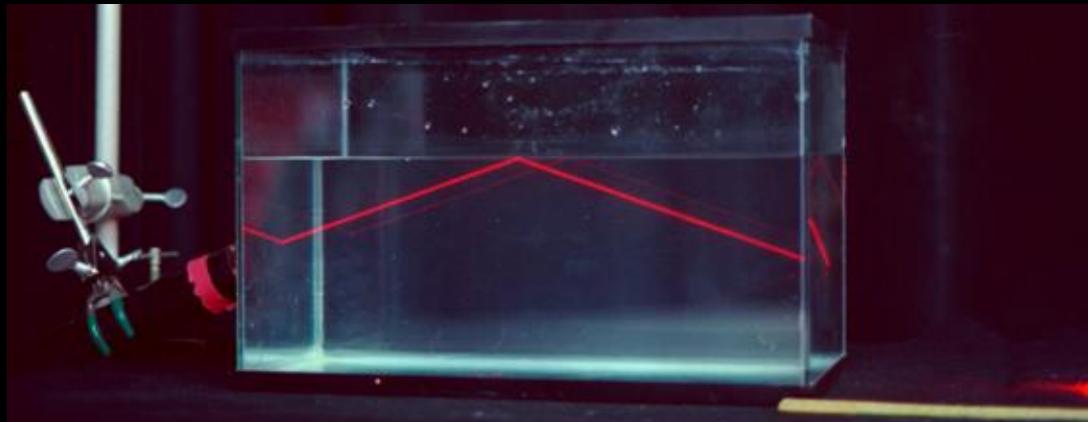


- A special case of refraction.
- As light approaches the barrier between two media, part of it leaves and is refracted while the other part is reflected internally. This is called partial internal reflection.
- Total internal reflection occurs when the angle of refraction is $>90^\circ$, so all of the light is reflected back into the medium.
- TIR only occurs when going from a higher refractive index to a lower one.

As the angle of incidence increases from 0 to greater angles ...



...the refracted ray becomes dimmer (there is less refraction)
...the reflected ray becomes brighter (there is more reflection)
...the angle of refraction approaches 90 degrees until finally a refracted ray can no longer be seen.



Total Internal Reflection

- Diamonds “sparkle” because of the way they are cut. Jewelers cut the angles so that as much light as possible is internally reflect back out of the diamond instead of passing through.
- Fiber optic cables make use of total internal reflection to transmit pulses of light down a wire to transfer information.

