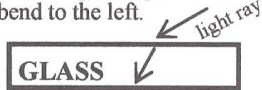


# Optics – The Study of Light

## Refraction

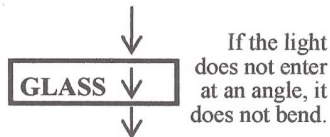
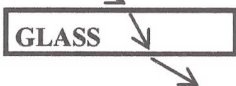
Light *refracts* when passing between two substances *at an angle*.

Light slows down in glass. Here the left side slows down first causing the light to bend to the left.



Light speeds up in air. Here the left side speeds up first causing the light to bend to the right.

The right side hits first and slows down: bends to the right.



If the light does not enter at an angle, it does not bend.

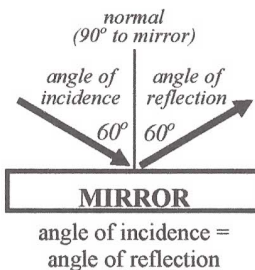
## Reflection

Light reflects at shiny boundaries we call mirrors.

**Normal** – an imaginary line 90° (perpendicular to a surface).

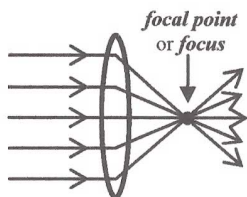
**Angle of Incidence** – the angle between the incoming ray and the normal.

**Angle of Reflection** – the angle between the outgoing ray and the normal.



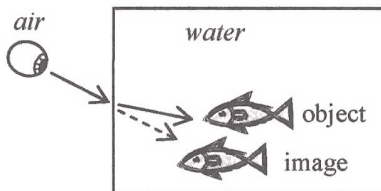
## Focus

Every lens or mirror has a place where all of the parallel rays will meet. This is known as the **focal point** or **focus**.



## Straight Lines

Mirrors and lenses can make things look bigger or smaller because our eyes always think that light comes from straight lines, even if they have been refracted or reflected.



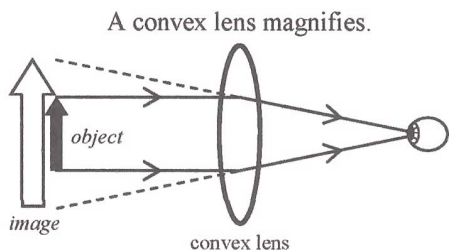
## Object vs. Image

The **object** is what you are looking at: the actual thing.

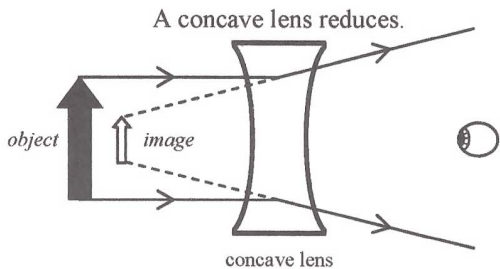
The **image** is what you think you see: the object enlarged, reduced, or moved.

## Lenses

Lenses work by refraction, by the light bending when moving between two substances.



A convex lens is **convergent**—the light rays come together.



A concave lens is **divergent**—the light rays spread apart.

*Lenses and mirrors work opposite of each other. If a concave lens reduces, then a concave mirror magnifies.*

### Concave or Convex

Concave looks like the sides have caved in.

*concave*

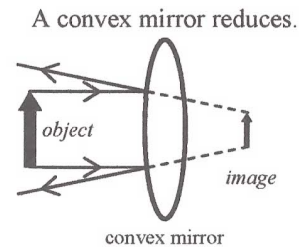
Convex—the middle is bigger than the ends.

*convex*

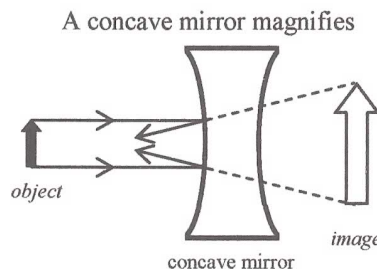
## Mirrors

Mirrors work by reflection, by the bounding of light off of a shiny surface. **Images in mirrors always look twice as far away as the object.**

*Ex. An image looks 20 m away in a mirror. How far away is the object?*  
**Answer: Half the distance: 10 meters.**



A convex mirror is **divergent**.



A concave mirror is **convergent**.

## Optical Systems



Microscopes and telescopes are **optical systems** that use combinations of lenses and/or mirrors to magnify light. Combining optical devices allows us to see very distant or very small objects.