LIGHT SPECTRUM

Module A

Unit 2

OBJECTIVES

- Introduction to the theory of light
- Review the light spectrum
- Understand the concept of refraction
- Learn the characteristics of concave lenses
- Learn the characteristics of convex lenses

THEORY OF LIGHT

What is light?

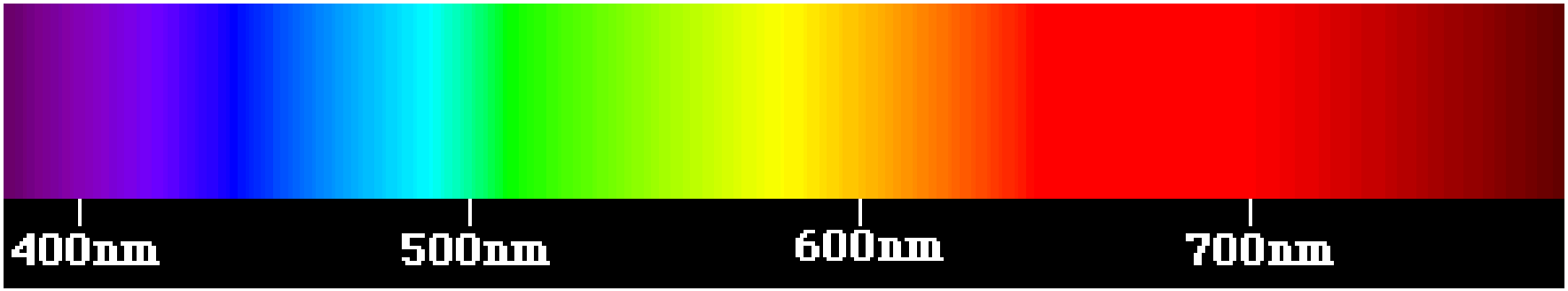
- Energy that the eye responds to.
- Travels in lines.
- Consists of waves
- Wavelength: the distance from the top of one wave to the top of the next.

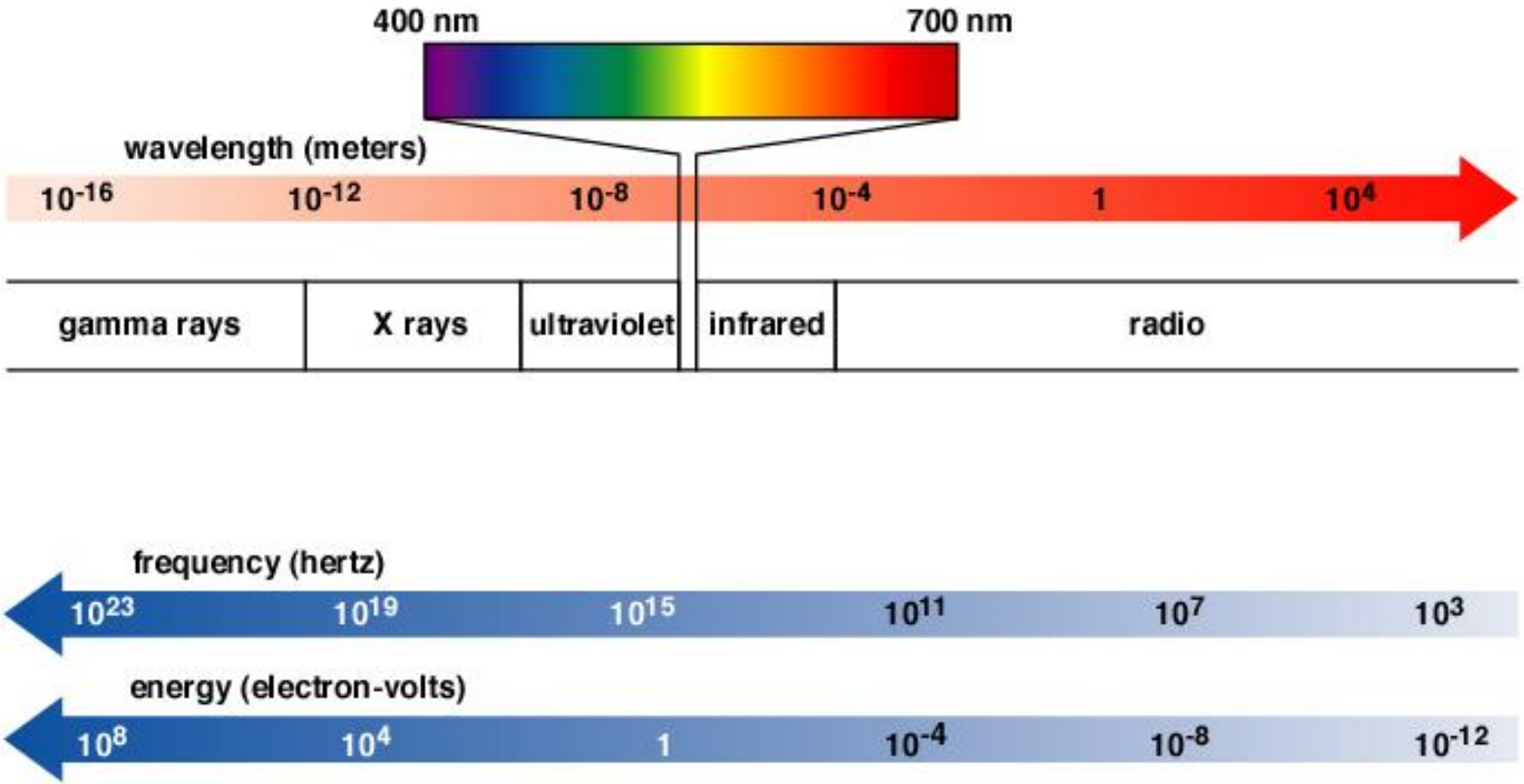
Speed of light

- Light travels at 186,355miles per second in a vacuum, slightly slower in air
- We measure light as moving 186,000 mps through air.

The Visible Spectrum

A range of light waves extending in wavelength from about 400 to 700 nanometers.





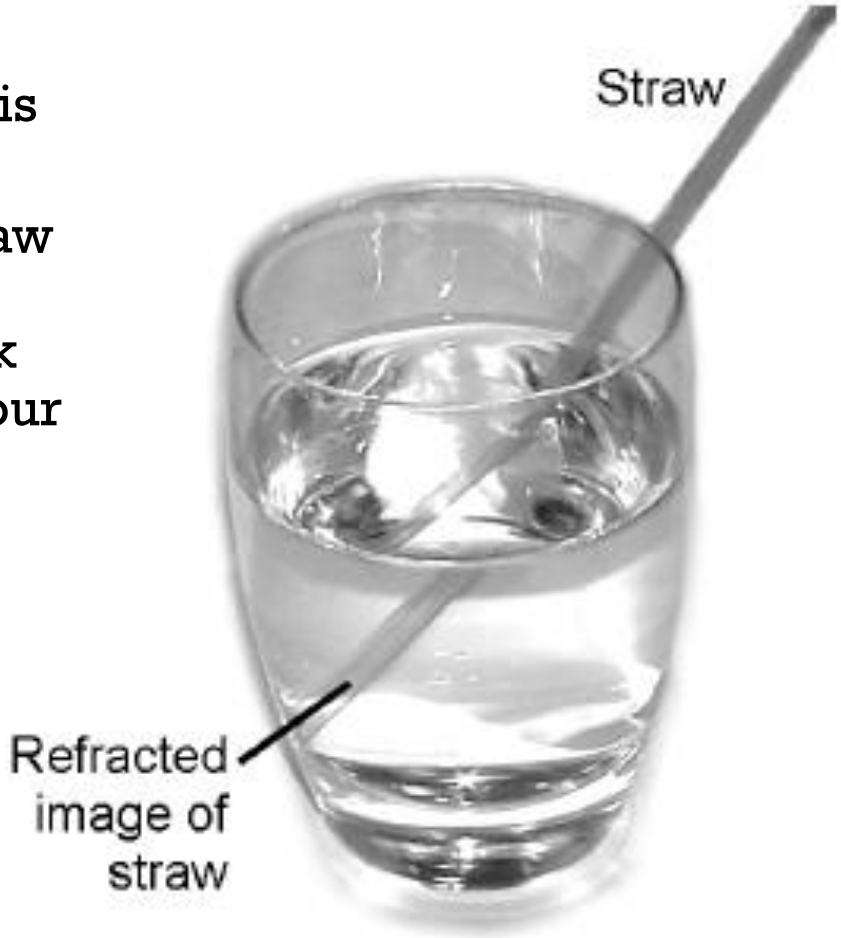
FACTOR	...or in full ...	or in words	SI PREFIX	SI SYMBOL
1,0E+24	1 000 000 000 000 000 000 000 000	septillion	yotta-	Y
1,0E+21	1 000 000 000 000 000 000 000	sextillion	zetta-	Z
1,0E+18	1 000 000 000 000 000 000	quintillion	exa-	E
1,0E+15	1 000 000 000 000 000	quadrillion	peta-	P
1,0E+12	1 000 000 000 000	trillion	tera-	T
1,0E+9	1 000 000 000	billion	giga-	G
1,0E+6	1 000 000	million	mega-	M
1,0E+3	1 000	thousand	kilo-	k
1,0E+2	100	hundred	hecto-	h
1,0E+1	10	ten	deca-	da
1,0E-1	0,1	tenth	deci-	d
1,0E-2	0,01	hundredth	centi-	c
1,0E-3	0,001	thousandth	milli-	m
1,0E-6	0,000 001	millionth	micro-	µ
1,0E-9	0,000 000 001	billionth	nano-	n
1,0E-12	0,000 000 000 001	trillionth	pico-	p
1,0E-15	0,000 000 000 000 001	quadrillionth	femto-	f
1,0E-18	0,000 000 000 000 000 001	quintillionth	atto-	a
1,0E-21	0,000 000 000 000 000 000 001	sextillionth	zepto-	z
1,0E-24	0,000 000 000 000 000 000 000 001	septillionth	yocto-	y

OPTICS

- The overall study of how light behaves is called optics.
- A lens is an optical device that is used to bend light in a specific way.
- A converging lens bends light so that the light rays come together to a point.
- A diverging lens bends light so it spreads light apart instead of coming together.

REFRACTION

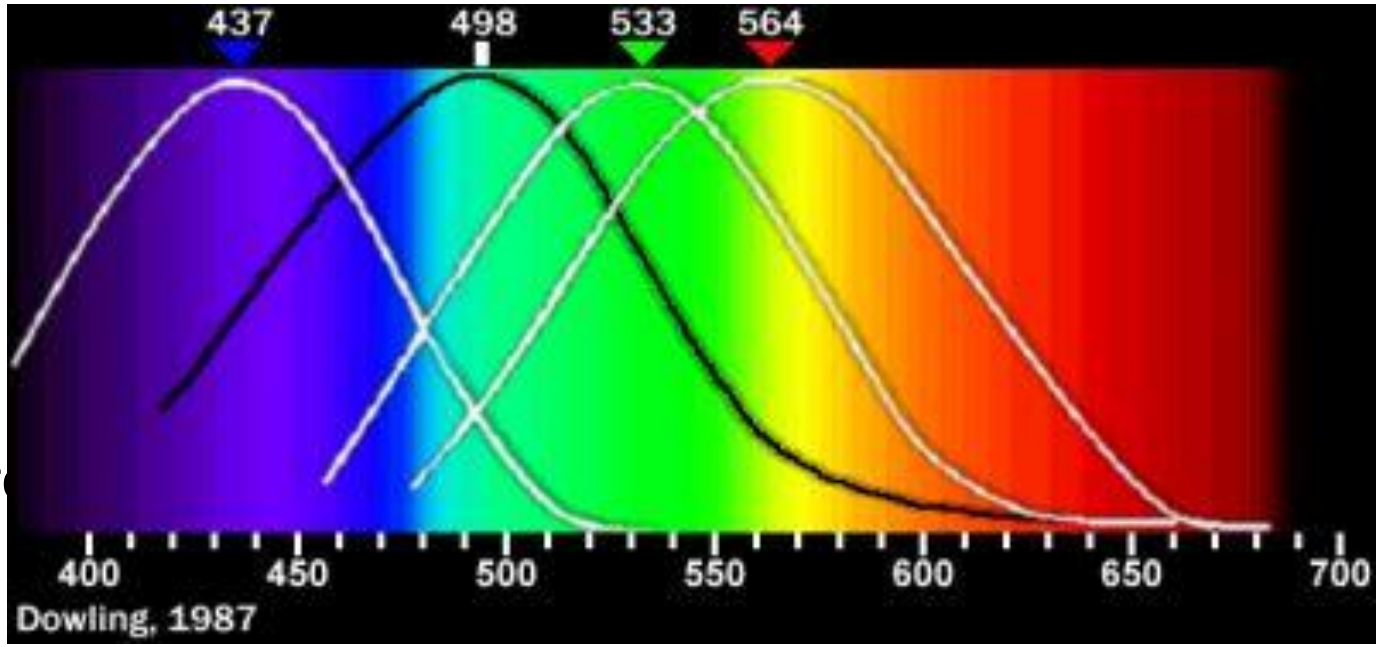
- Light rays may bend as they cross a boundary from one material to another, like from air to water.
- This bending of light rays is known as refraction.
- The light rays from the straw are refracted (bent) when they cross from water back into air before reaching your eyes.




FABER-CASTELL

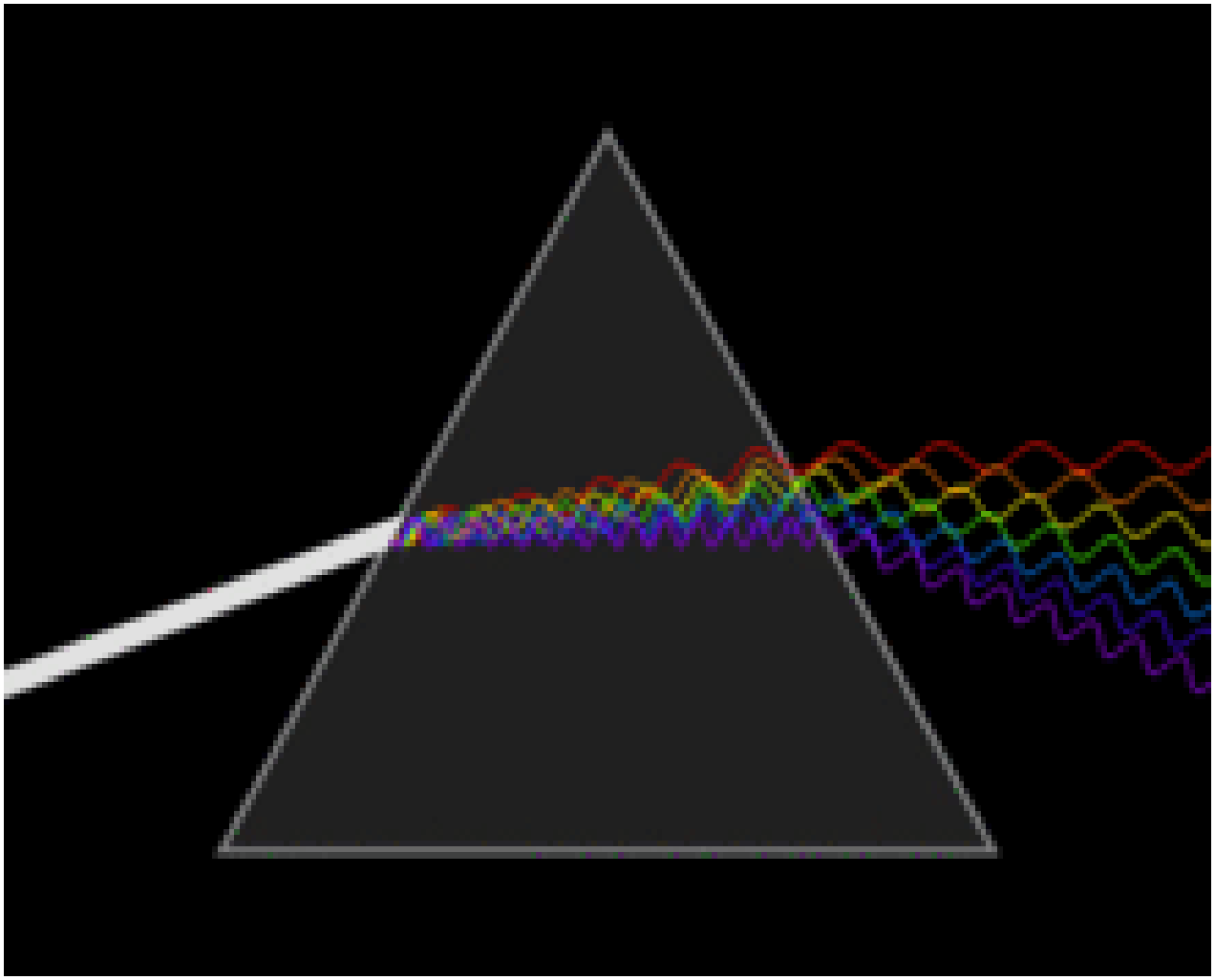
BICONVEX LENS

- Rods - brightness receptors
- Cones - color receptors
  - Three Types: Red, Green, Blue



- Cones are mor
- Rods are more

PRISM

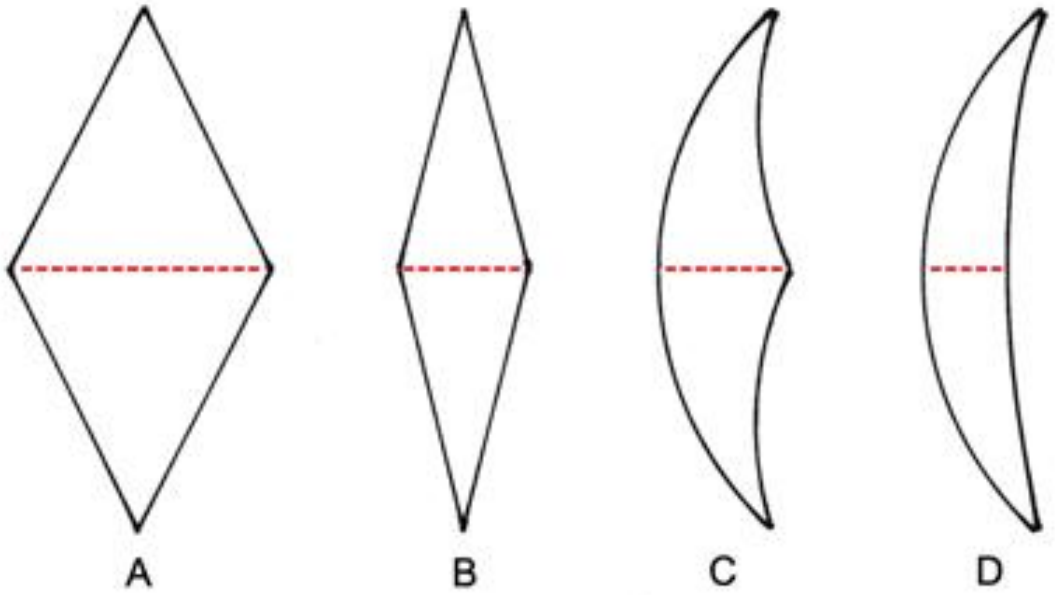


PRISM

WHAT IS PRISM

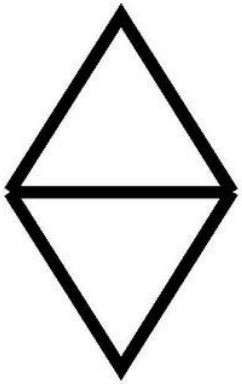
- A prism is a triangular piece of glass, which allows light to spread out into a band of six colors

PRISM

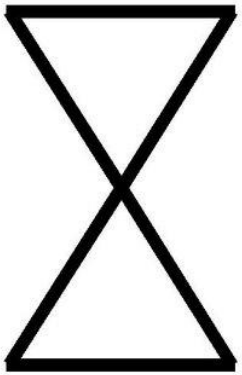


PRISM AS A LENS

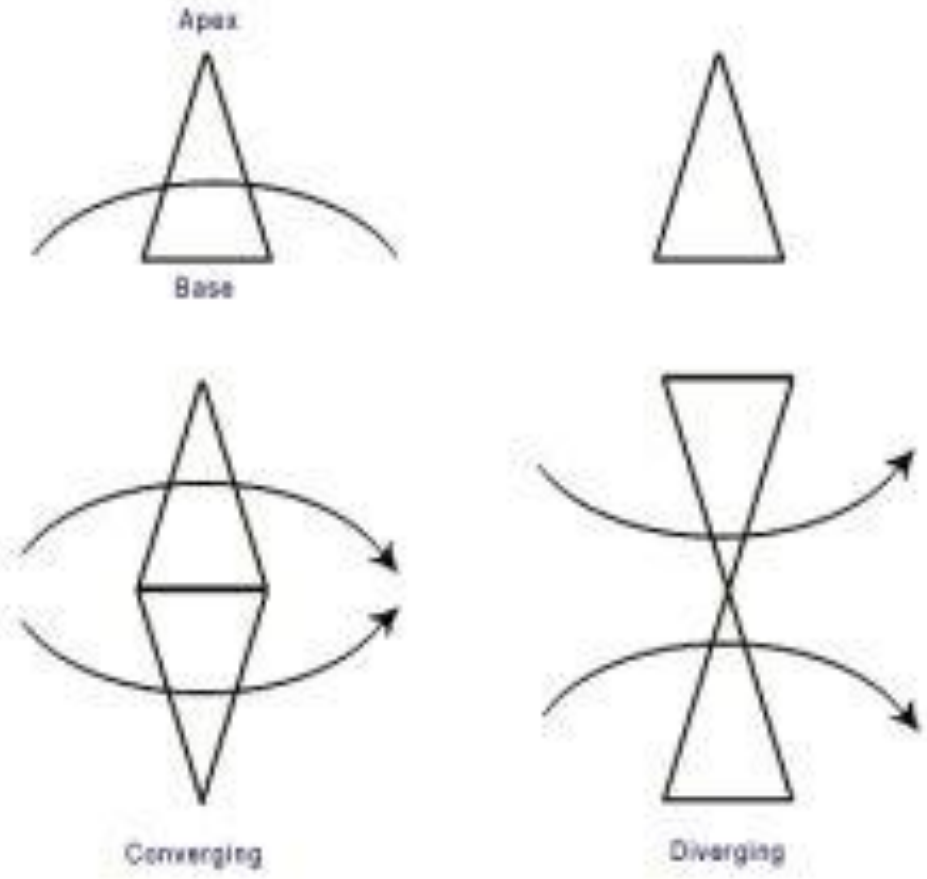
+ LENS



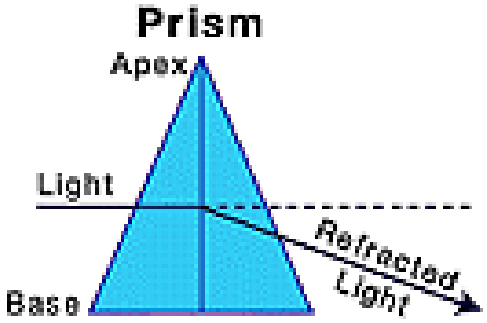
- LENS

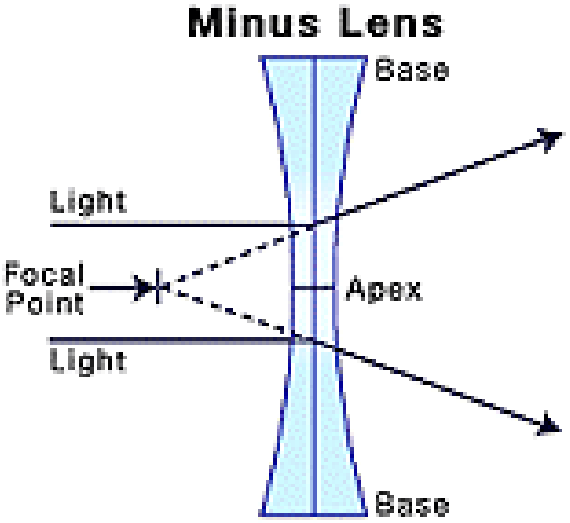


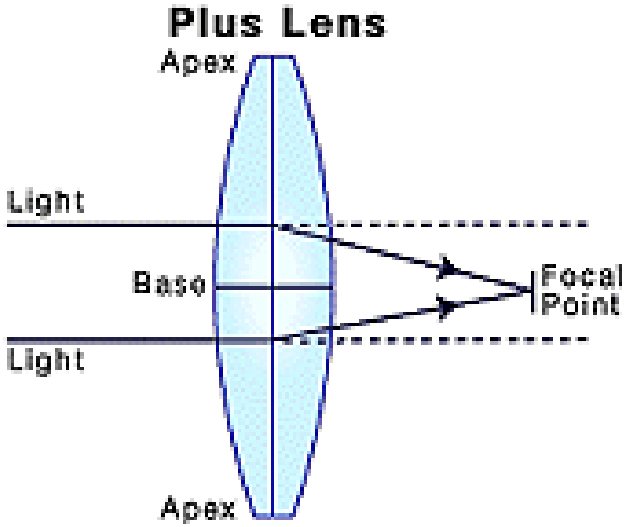
PRISM AS A LENS



PRISM AS A LENS

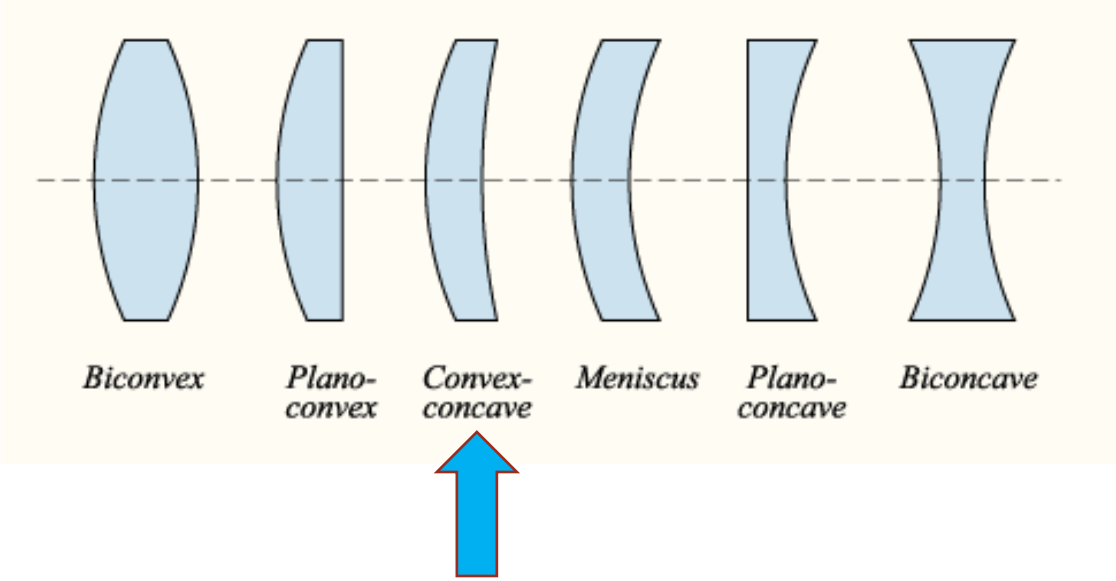




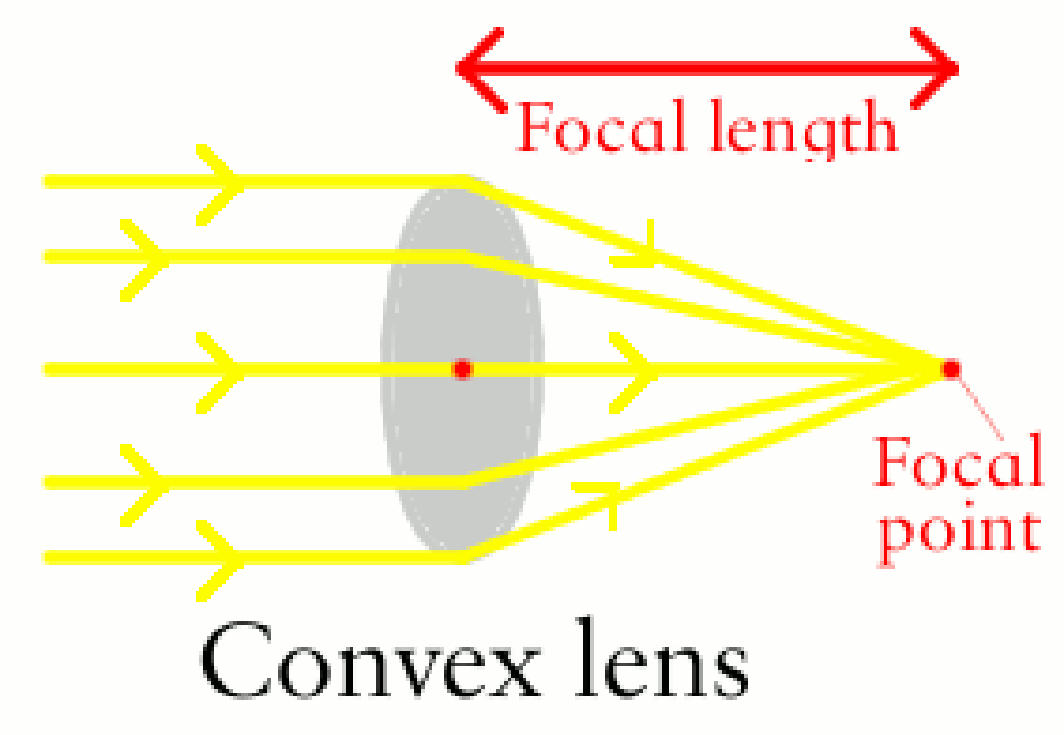


LENSES

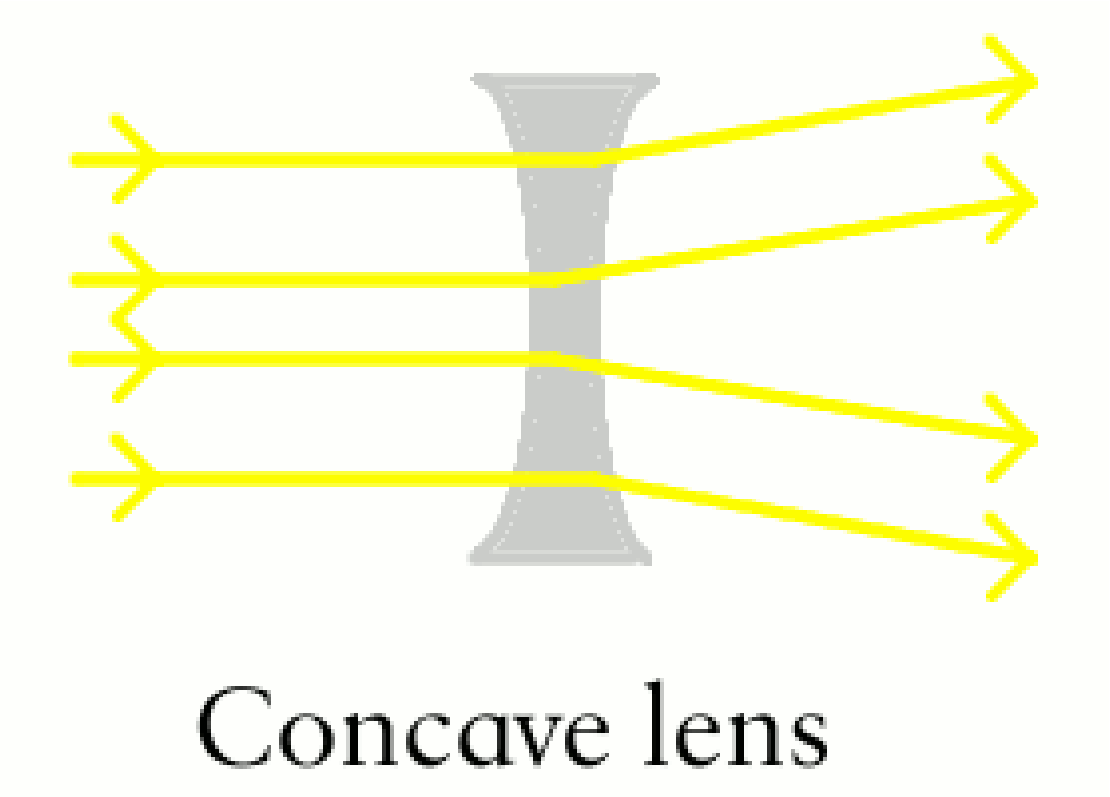
- Most lenses are spherical, meaning they are created from a portion of a sphere.
- The line joining the centers of the spheres which make up the lens surfaces is called the axis of the lens.



CONVEX LENSES



CONCAVE LENSES



HOW LENSES CORRECT

- A spherical minus lens redirects the light rays entering the eye so they fall onto the retina.
- The minus lens pushes the rays further back in the eye so they strike further back onto the retina.

Concave Lenses Correct Myopia

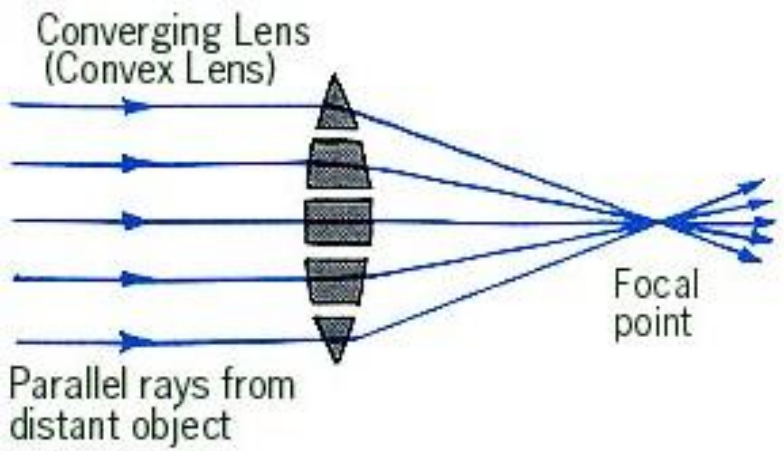
- A spherical plus lens redirects the light rays entering the eye so they fall onto the retina.
- The plus lens pulls the rays back towards the front of the eye so they strike earlier onto the retina.

Convex Lenses Correct Hyperopia

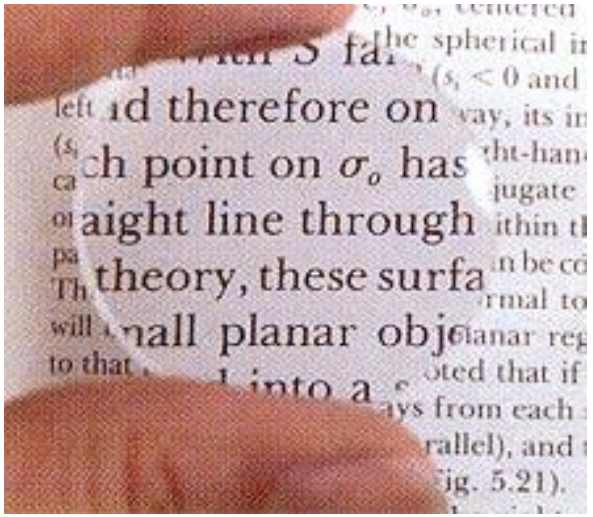
CONVEX LENSES

Thicker in the center than edges.

- Lens that converges (brings together) light rays.
- Forms real images and virtual images depending on position of the object

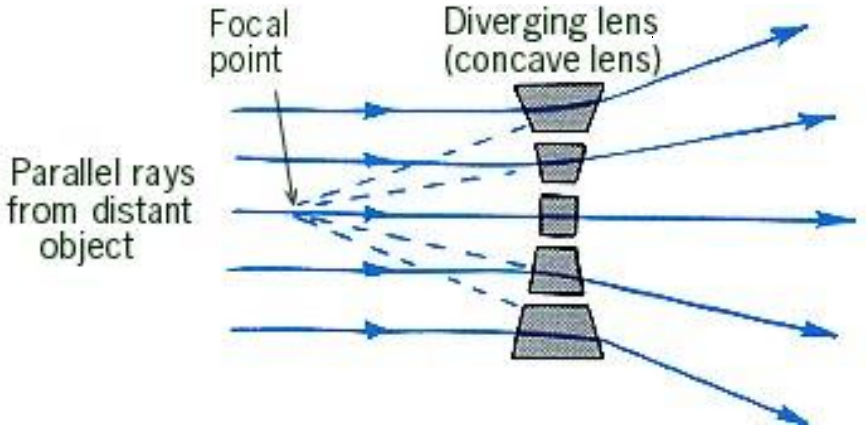


The Magnifier



CONCAVE LENSES

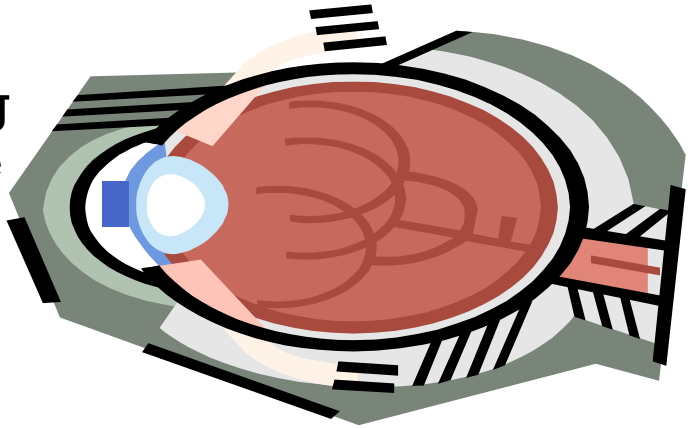
- Lenses that are thicker at the edges and thinner in the center.
  - Diverges light rays
  - All images are erect and reduced.



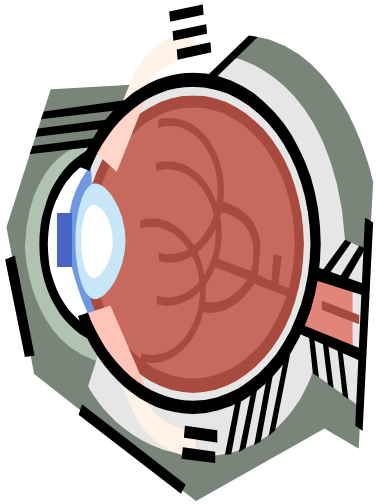
The De-Magnifier

HOW YOU SEE

- Near Sighted Eyeball is too long and image focuses in front of the retina
  - Near Sightedness – Concave lenses expand focal length



- Far Sighted Eyeball is too short so image is focused behind the retina.
  - Far Sightedness – Convex lens shortens the focal length.



HOW CURVED LENSES REFRACT LIGHT

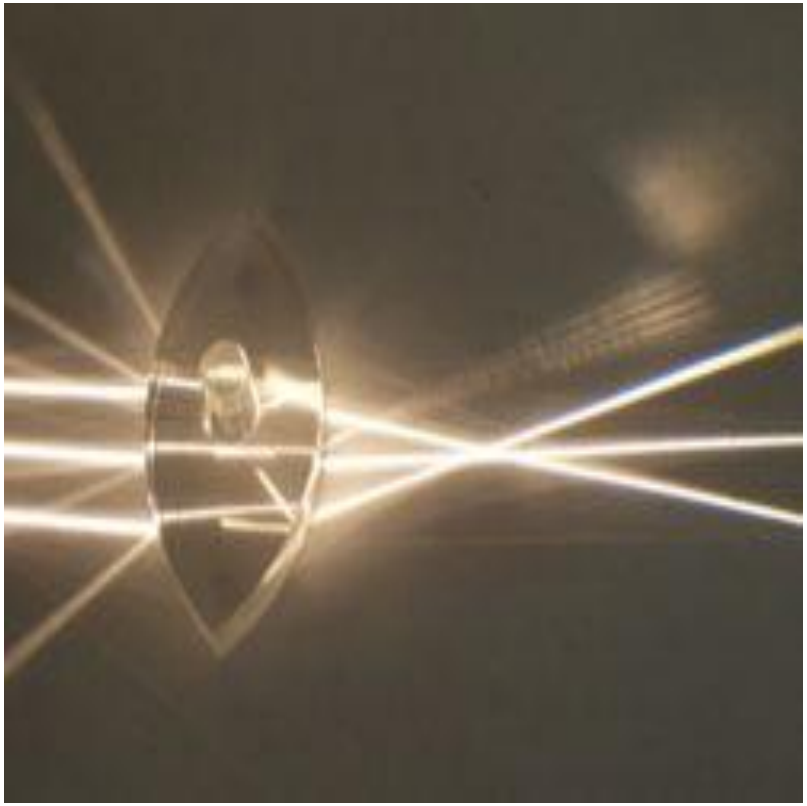
- Light enters as multiple rays.
- Lens surfaces are curved, not straight.
- With a CURVED refracting surface, multiple rays will all be either directed toward or away from a specific point in space.
- As diverging rays move farther from the source, the more parallel they become.
- At an infinite distance from the object, the light rays become parallel.
- SOD: Figure 12-17, 18, 19, 20

CURVED LENSES

- The main feature of curved lenses is their ability to bend rays of light.
- With a curved refracting surface, multiple rays will all be either directed toward or away from a specific point in space.
- The shorter the radius of curvature, the more light is bent when striking the surface and consequently the closer to the lens the focal point will be.

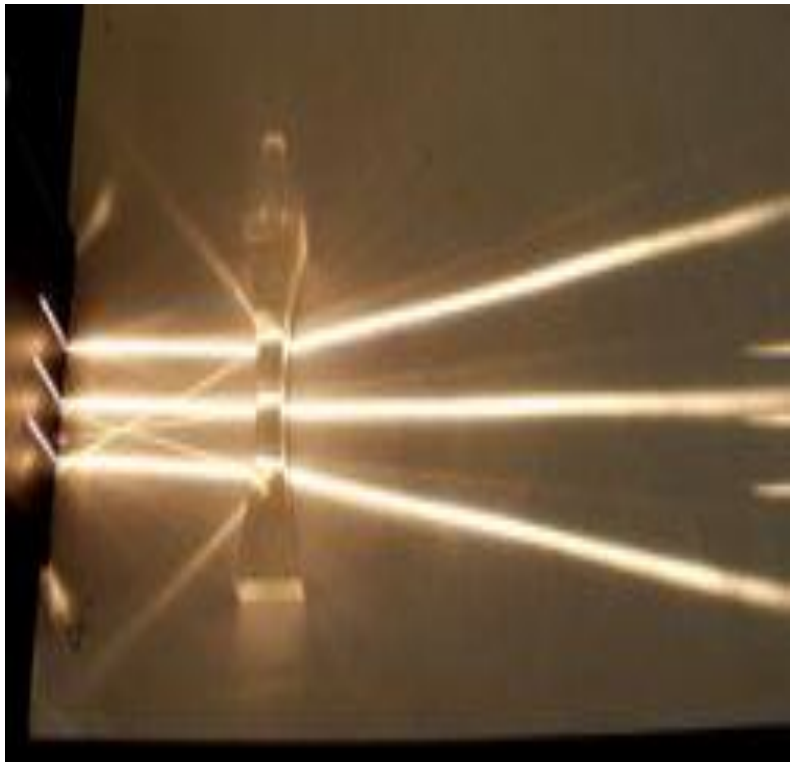
FOCUSING LIGHT

- The type of lens that causes parallel rays of light to converge is known as a positive or plus lens.
- Light from an object brought to focus by a lens will form an image of that object.
- This is known as a real image



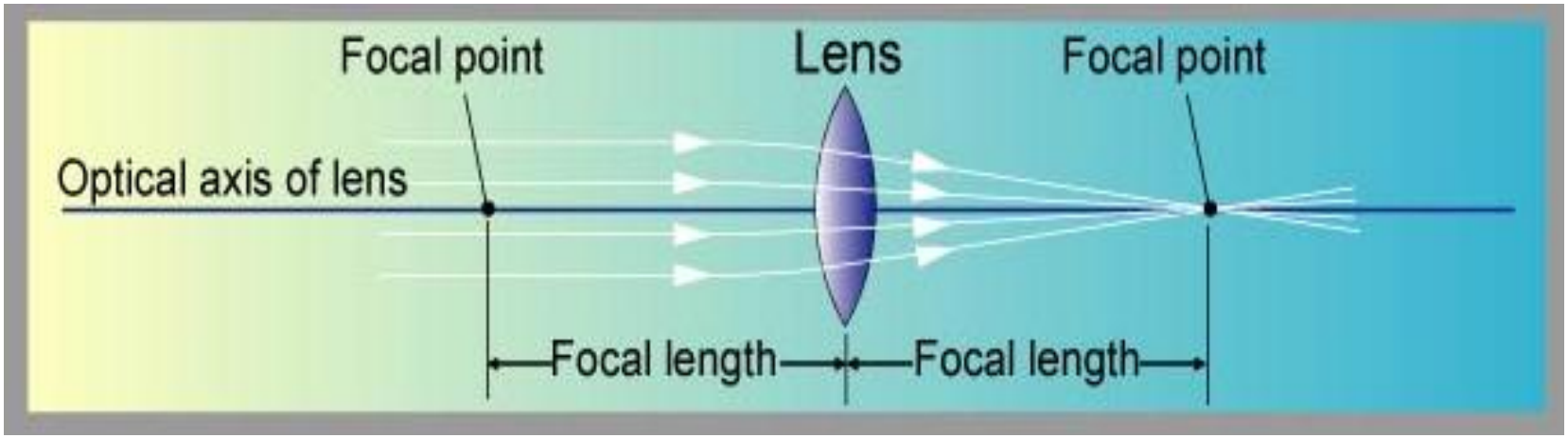
FOCUSING LIGHT

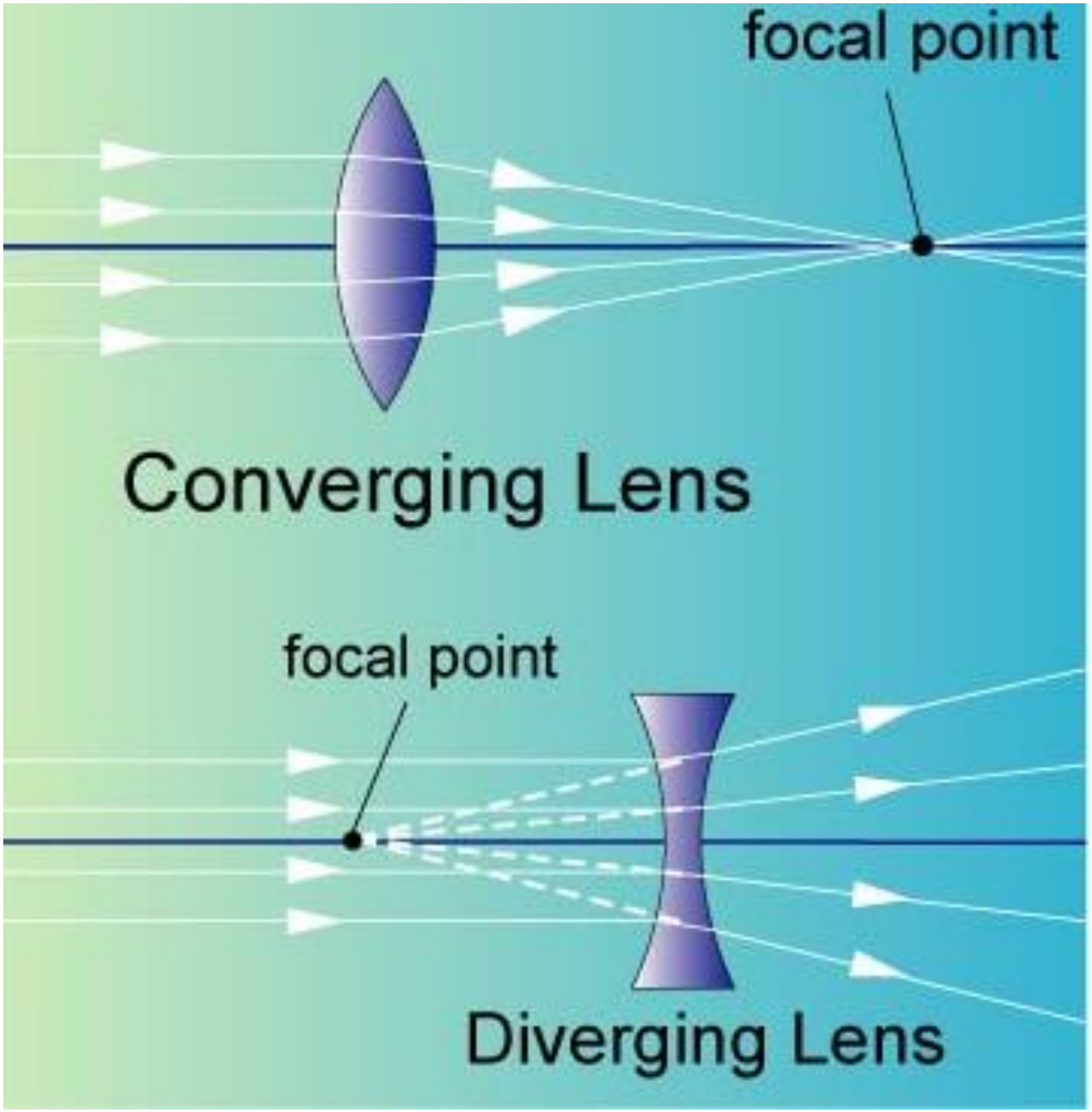
- When parallel rays enter a lens that has a negative focal length (which means it also holds a negative power) rays leaving the lens diverge.
- A lens whose focal point is to the left of the lens will have a negative focal power.
- The rays of light therefore are separating as they move out of the lens. The focal point therefore is virtual.



MIRRORS, LENSES, AND IMAGES

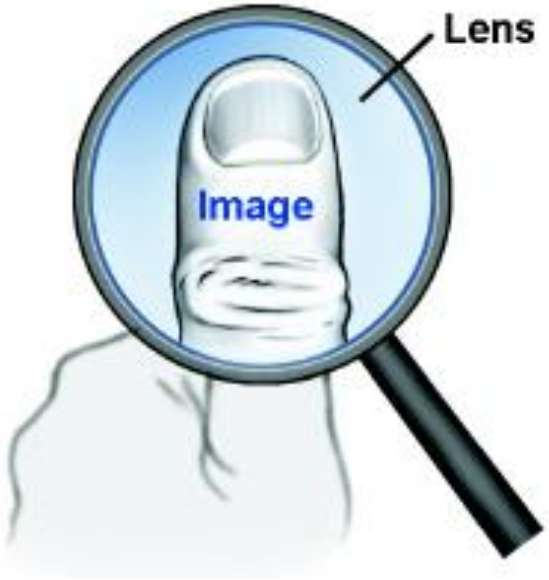
- Light rays that enter a converging lens parallel to its axis bend to meet at a point called the focal point.
- The distance from the center of the lens to the focal point is called the focal length.
- The optical axis usually goes through the center of the lens.

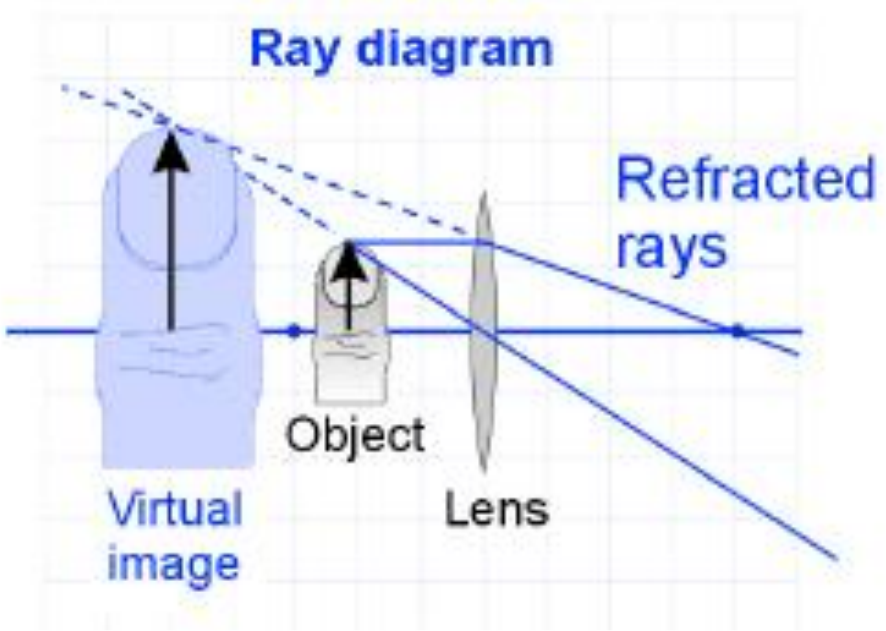



focal point
Converging Lens
focal point
Diverging Lens

THE IMAGE FORMED BY A LENS

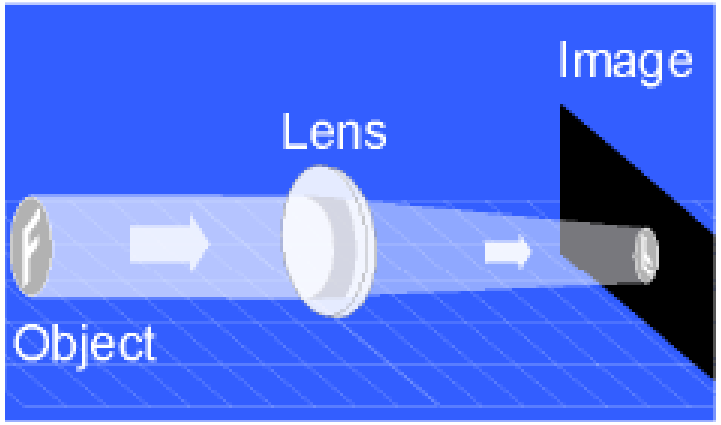
- A lens can form a virtual image just as a mirror does.
- Rays from the same point on an object are bent by the lens so that they appear to come from a much larger object.

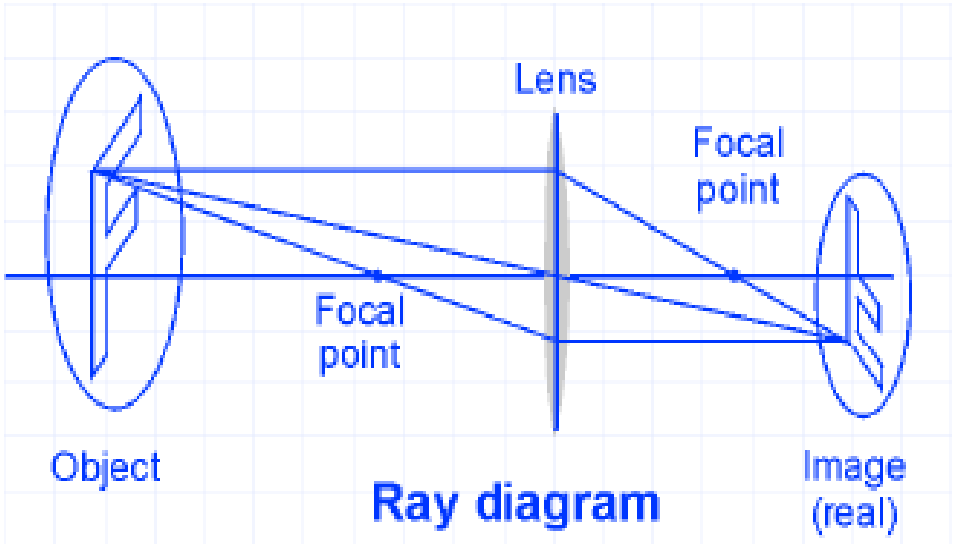




THE IMAGE FORMED BY A LENS

- A converging lens can also form a real image.
- In a real image, light rays from the object actually come back together.



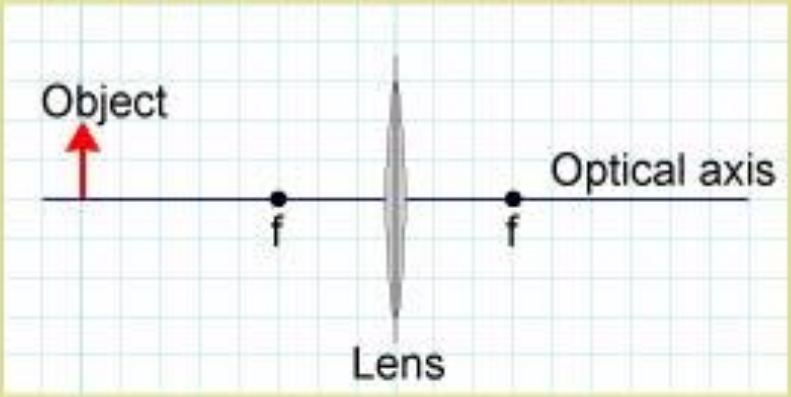


DRAWING RAY DIAGRAMS

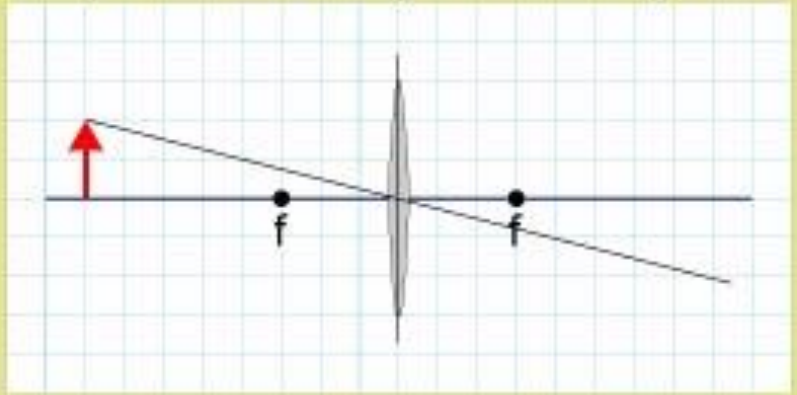
- A ray diagram is the best way to understand what type of image is formed by a lens, and whether the image is magnified or inverted.
- These three rays follow the rules for how light rays are bent by the lens:
  1. A light ray passing through the center of the lens is not deflected at all (A).
  2. A light ray parallel to the axis passes through the far focal point (B).
  3. A light ray passing through the near focal point emerges parallel to the axis (C).

Drawing a Ray Diagram

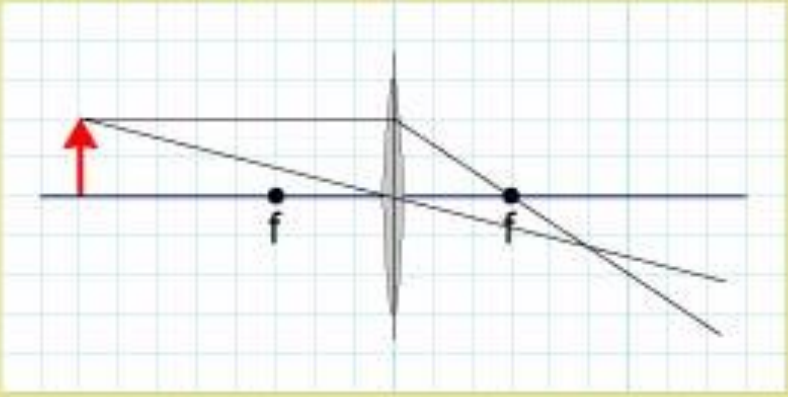
Setting up



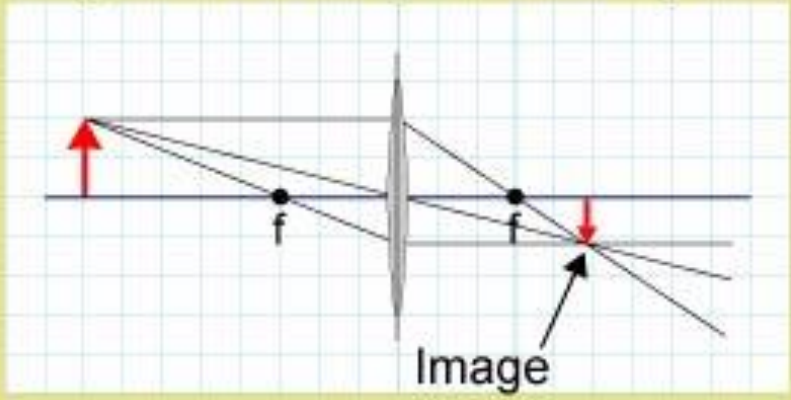
Step 1 Drawing the first ray



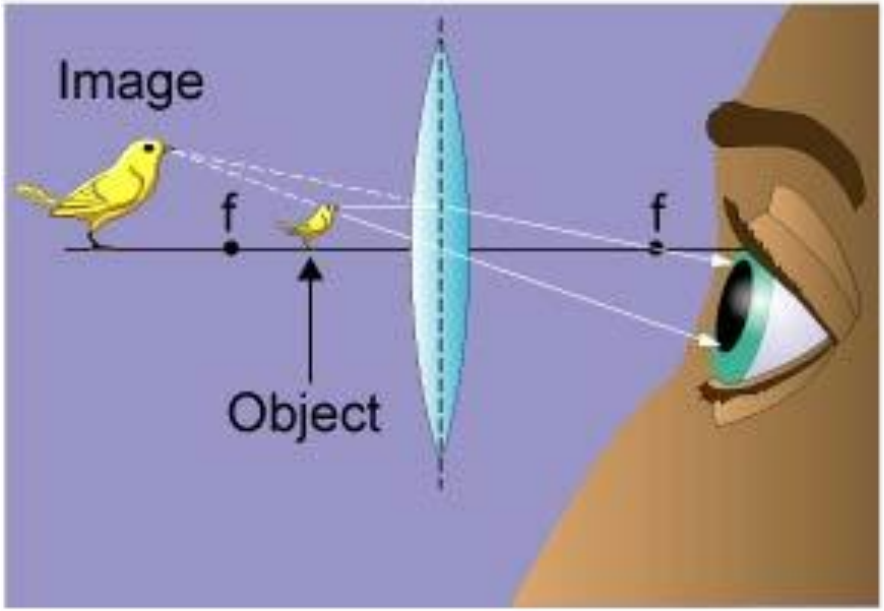
Step 2 Drawing the second ray

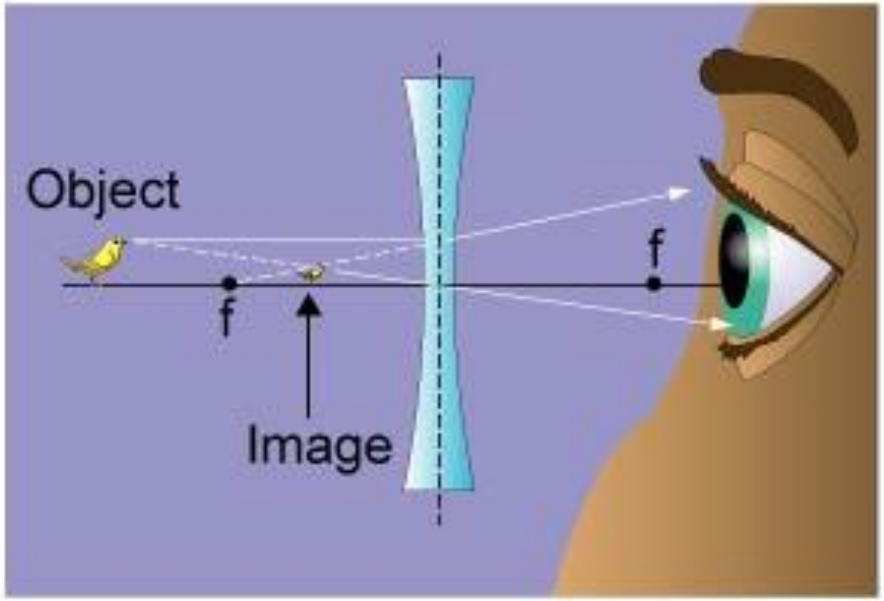


Step 3 Drawing the third ray



Images





Lens	Position of object	Image
Converging	Beyond the focal length	Real
Converging	Inside the focal length	Virtual and larger
Diverging	Anywhere	Virtual and smaller than object

DIOPTERS & FOCAL LENGTH

- Diopters are a unit of measure.
- Technically a diopter is a way of expressing where the rays of light that are passing through a lens (two prisms) will fall.
- Formula for the value of a diopter is:
- D = 1/f
  - Where D is diopter
  - f is the focal length of a lens in meters.
- The formula can be used for the focal length:
  - f = 1/D
- Example: A lens that will focus the rays of light passing through it at a distance of 2 meters from the lens will have the diopter power of 0.50.
  - D = 1/2
  - so D = 0.50
  - f = 1/0.50 so f = 2

FOCAL LENGTH

- The **focal length** is a measure of how strongly the lens converges (focuses) or diverges (defocuses) light.
- It is the distance over which initially parallel rays are brought to a focus.
- A system with a shorter focal length has greater optical power than one with a long focal length (it bends the rays more strongly, bringing them to a focus in a shorter distance)

FOCAL LENGTH

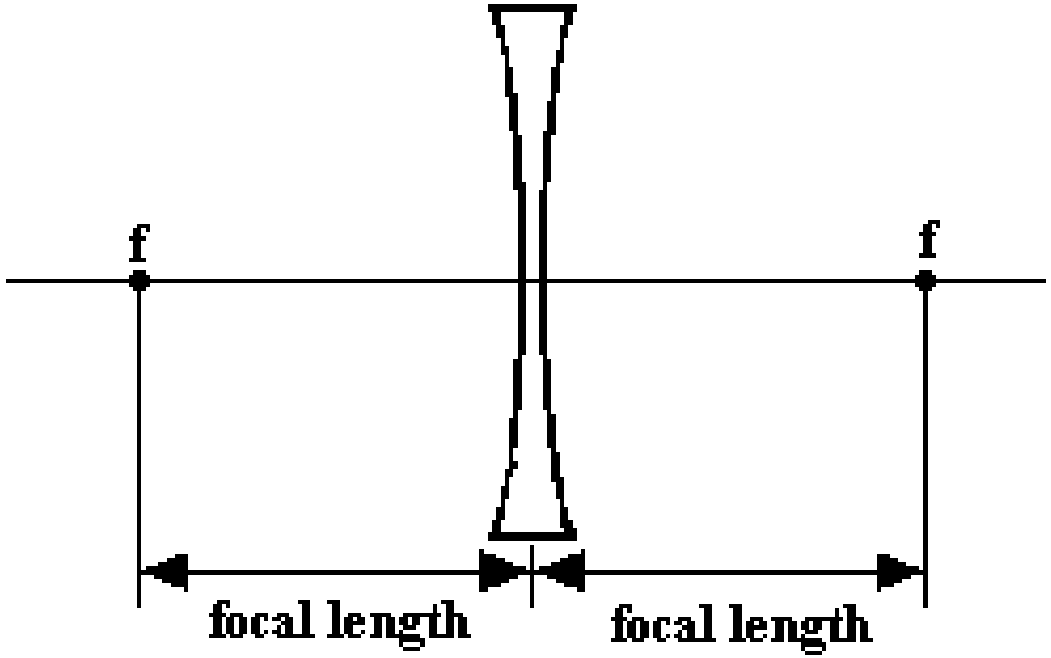
- How powerful a lens is.
- The focal length of a lens is the distance from the center of the lens to the point at which it focuses light rays.
- The smaller the focal length, the more powerful the lens.
- Focal lengths are written either in ordinary units of length (cm, mm, or in) or in diopters.
- The diopter measurement of a lens is the reciprocal of the focal length in meters (one divided by the focal length), so 1 diopter = 1 m, 2 diopters = 0.5 m, 3 diopters = 0.33 meters etc.
- Eyeglass prescriptions show the strength of the corrective lenses in diopters.

FOCAL POINT

- When the rays of light meet at a certain point, this point is known as the focal point.
- Rays traveling toward one specific point are converging.
- Rays traveling away from a specific point are diverging.
- Units of focal power are measured in Diopters.

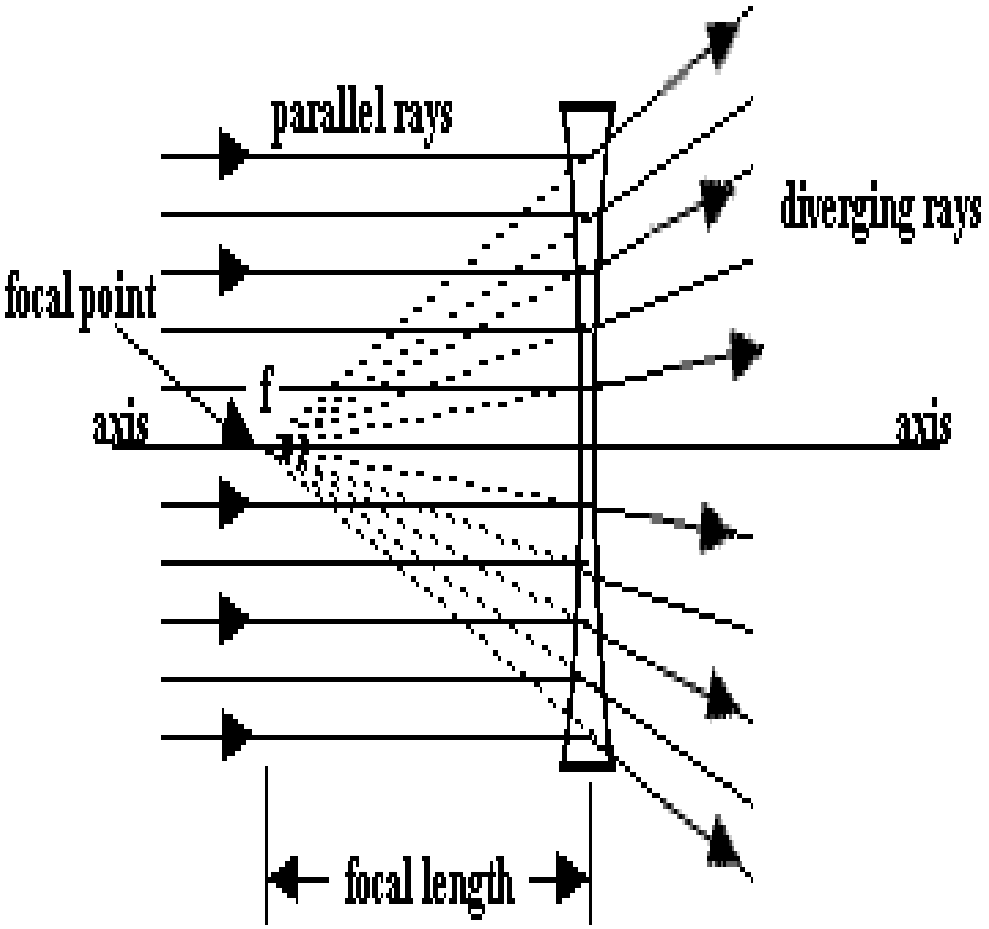
VIRTUAL FOCAL POINT

- The focal point of a concave lens is called "virtual" which means that it only appears to have the effect of a focal point.

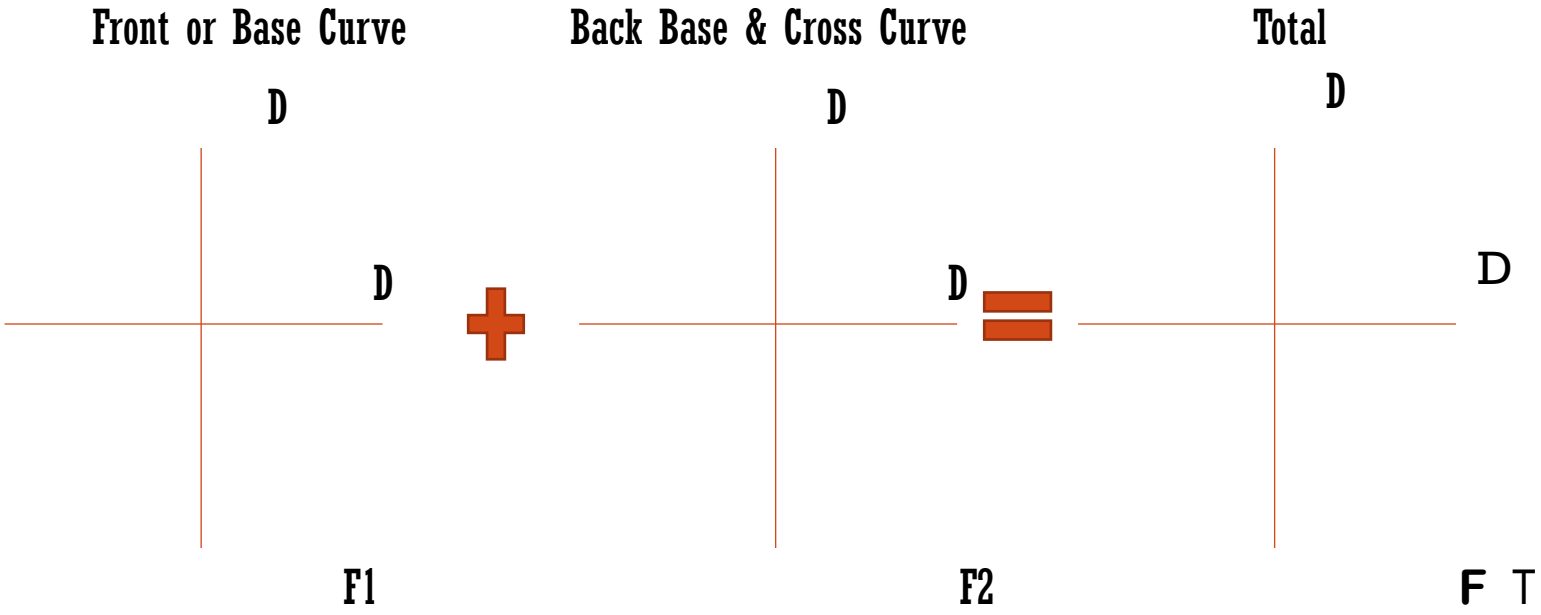


FOCAL LENGTH

- A lens must be considered in terms of its focal length.
- The distance from the center of the lens to the focal point is known as the focal length.
- The power of a lens is equal to the reciprocal of its focal distance measured in meters.
- Expressed in Diopters
- Formula:
- D=1 / F
- D=Power of lens in diopters
- F= Focal length in meters



POWER CROSS


Front or Base Curve
D
D
F1
Back Base & Cross Curve
D
D
F2
Total
D
D
F T