UNIT 26 LIGHT ENERGY

Light is also called electromagnetic radiation because it is related to electricity and magnetism. When light travels through space, it travels at 300,000 meters per second or 186,000 miles per second. Light to travel from the Sun to the Earth.

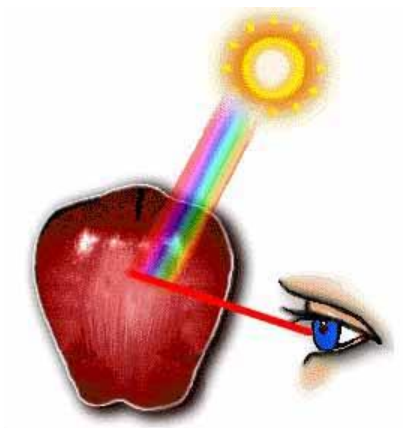
MIRROR

A mirror is an object with at least one reflective surface. It is actually of glass with a silvery or metallic backing. It can be set into a frame or attached to a handle. The surface of the mirror is capable of reflecting light to form an image of an object placed in front of it. It is important to remember: a mirror is opaque, and reflects.

REFLECTION, REFRACTION & ABSORPTION

The color of objects that we see, is a result of the way objects interact with light. When light strikes an object, it can be reflected, refracted or absorbed.

Absorption - When light hits the object, it stops at the object. It does not bounce back. So the objects appear dark or opaque. Example: wood



Reflection (on a smooth surface) When light hits the object, it bounces off the surface of a material at an angle equal to the incoming light. Example: glass, mirror. The amount of light reflected is highly dependent on the texture of its surface.

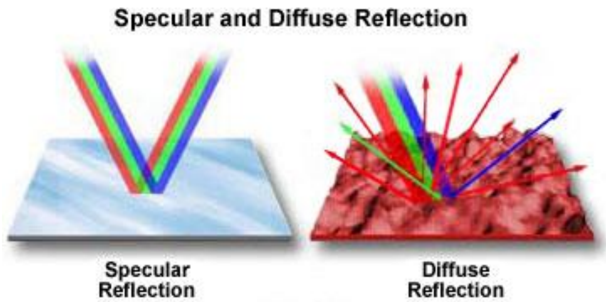
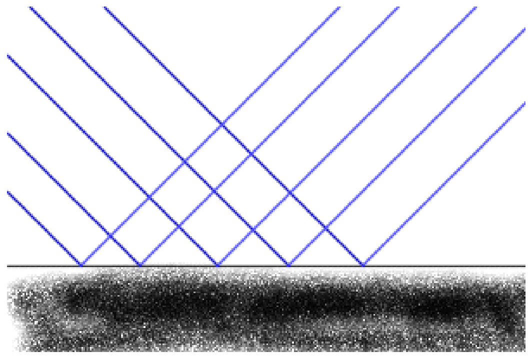
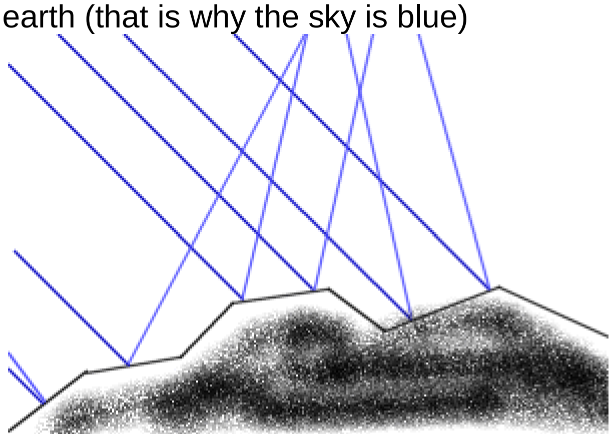


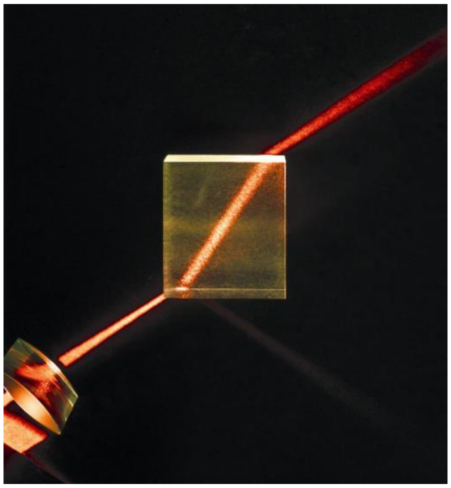
Figure 2

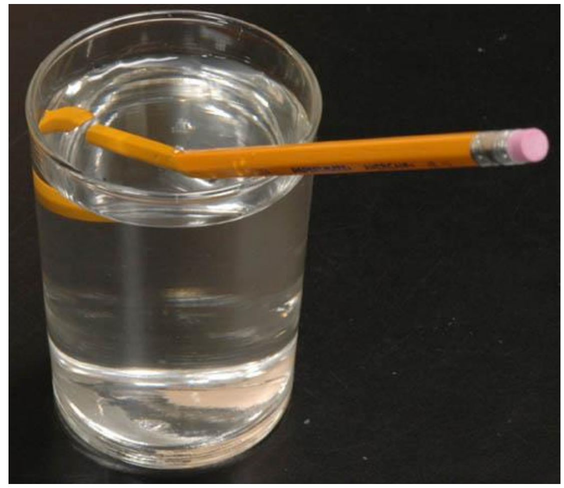


Reflection (on a rough surface) Light waves bounce off the object at many different angles because the surface is uneven. Reflection on a rough surface is also called ***scatter.*** Example: the earth (that is why the sky is blue)



Refraction When light hits the object, it goes through the object and bends at an angle. Example- diamond, water





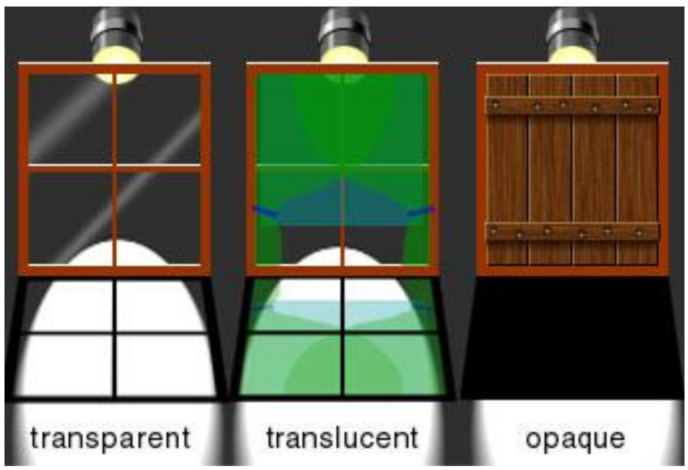
TRANSPARENT, TRANSLUCENT & OPAQUE

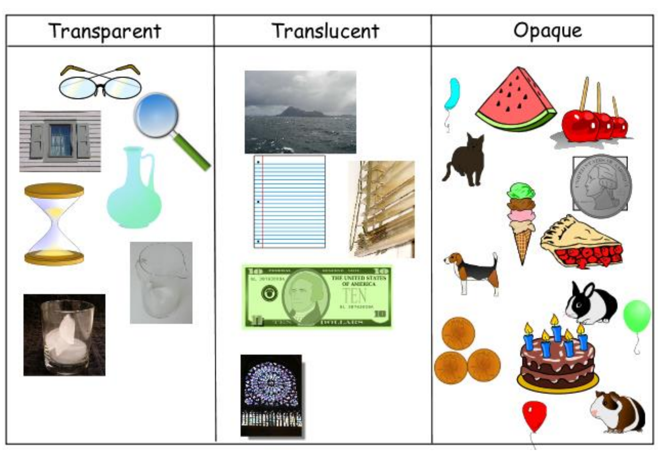
These terms compare how much light, objects will allow to pas through them.

Transparent: A transparent object is one that allows all of the light to pas through it. Example: glass, some kinds of plastic food wrap.

Translucent: A translucent Object is a material that allows only some of the light rays to pass through it. Example: cloth, paper.

Opaque: An opaque object is one that allows no light to pass through it. Example a wooden dresser, mirror. The reason is because opaque objects are denser in molecules, so they do not let light go through. Transparent & translucent materials are less dense in molecules.





SHADOW

It is a dark image that is cast on the ground or some surface. It is caused by a body intercepting light. It is an area that is not illuminated or is only partially illuminated because of the interception of light by an opaque object between the area and the sources of light.

PRISM

It is a transparent body, often of glass. It usually has triangular ends. It is used to separate white light passed through it, into the colors of the spectrum.

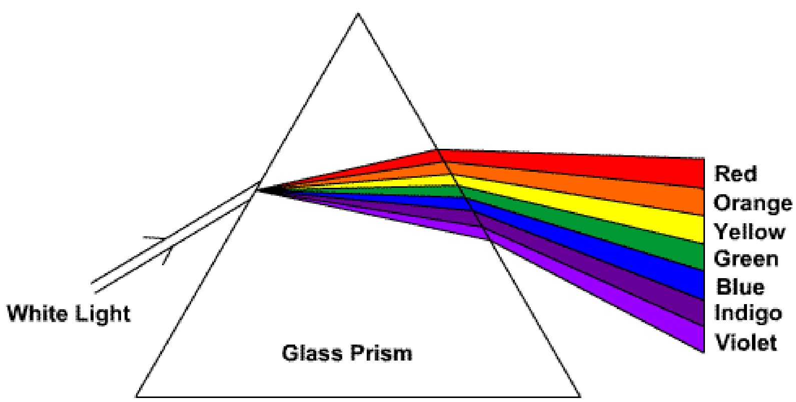
How a prism works: As light enters through one side of the prism at an angle, the glass slows it down so the light bends it hits the other face and that is when dispersion happens and the white light splits into the spectrum of 7 colors.

DISPERSION

Visible light is actually made up of different colors. The splitting up of light into these different colors is called dispersion. Each color bends by a different amount when it goes through glass. (refraction).

SPECTRUM / COLOR SPECTRUM OF LIGHT:

The color spectrum is the distribution of colors produced when light is dispersed by a prism. The colors that appear in the color spectrum are VIBGYOR- Violet, Indigo, Blue, Green, Yellow, Orange, Red.



WAVES IN THE ELECTROMAGNETIC SPECTRUM

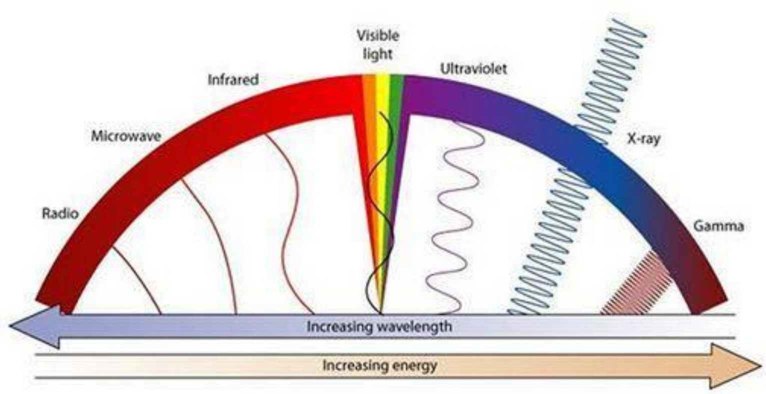
Electromagnetic waves are transverse waves that transfer radiation or energy. These waves are created by electrically charged particles that move. There are different types of electromagnetic waves or radiation. Scientists use the electromagnetic spectrum to classify the different type of waves. This is similar to the periodic table where elements are classified according to their structure. Every time we feel the sun's rays, hear a song on the radio, get an x-ray, use the microwave, an electromagnetic energy and waves that exist in the world.

Waves and Wavelength: Electromagnetic energy and waves are created by vibration. This vibration produces waves that carry energy. These energies travel and produce a characteristic signature wave with a unique length, energy and frequency that scientists can measure and identify. This is called the wavelength. Electromagnetic waves are organized in the electromagnetic spectrum according to their wavelength from longest to shortest.

FREQUENCY

One way to measure the energy of an electromagnetic wave is to measure its frequency. Frequency is the number of waves that a vibration creates in a certain period of time, like counting how frequently cars pass through a traffic signal. In general, the higher the frequency, the higher the number of waves created, the greater is the energy of the radiation.

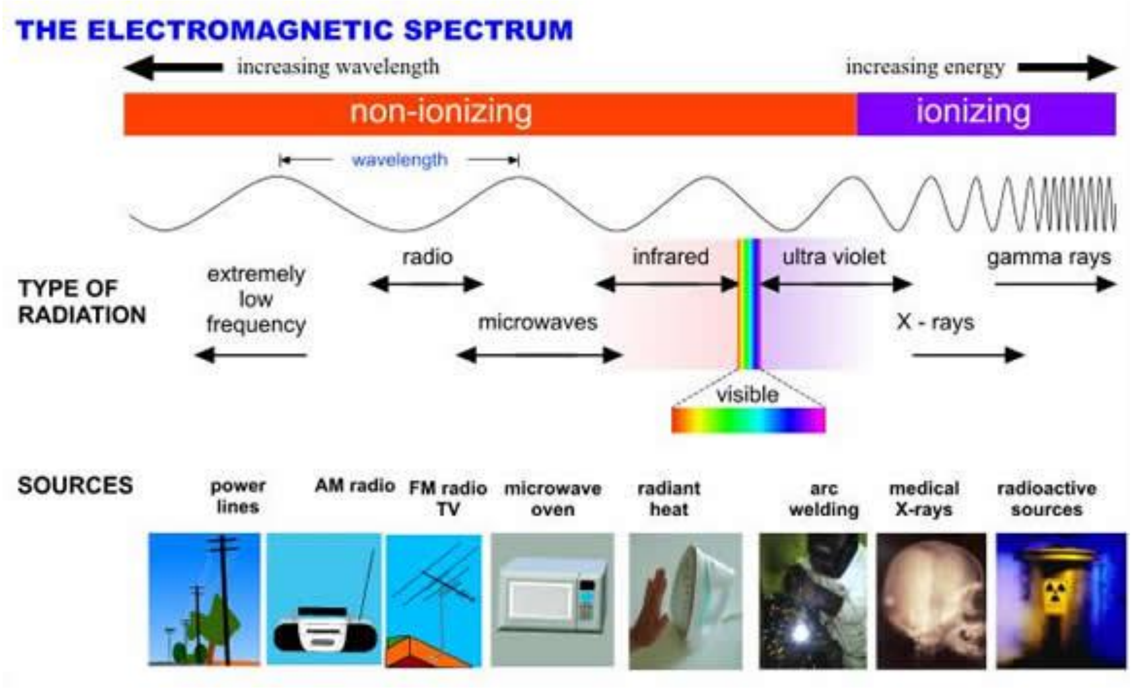
Wavelength and frequency are inversely related. The greater the length of the wave, the lower the frequency. Also the greater the frequency, the shorter the wave, and the higher is the energy.



Raaghav's mother is visiting Uncle Xavier's Gardening Club

TYPES OF WAVES

1. **RADIOWAVES** – They are used mostly for communication like radio and TV. The regions of radio waves are assigned for use (to ships, planes, military, police, TV & radio stations, satellite and space personnel) so that there is no communication overload and interference. The waves have long wavelengths. Radio waves transmit signals over long distances by bouncing radio waves off a layer of the Earth's atmosphere the ionosphere.
2. **MICROWAVES** – Microwaves can go through fog and rain and are ideal for cell phone signals. These waves are also used in radar tracking and radio navigation. Microwaves are primarily produced by man made communication technology.
3. **INFRARED WAVES** – Infrared radiation is emitted from warm bodies and absorbed by cool bodies. For example, the Sun's infrared radiation is responsible for warming the Earth and we feel this as heat. Infrared waves can be used in practical ways, like photographing a house to see areas that are leaking and losing heat.
4. **VISIBLE WAVES** – These make up the smallest part of the electromagnetic spectrum and are the part our eyes can see (which are the colors of VIBGYOR and their hues). It would be harmful if our eyes and bodies took in all the other waves of the electromagnetic spectrum.
5. **ULTRAVIOLET RAYS** – UV rays are emitted naturally from hot bodies like stars and the Sun. we cannot see it but our skin is sensitive to it and too much exposure can cause sunburns, cause skin cancer or eye cataracts. Before ultra violet rays reach the Earth, most of them are absorbed by gases in the atmosphere like ozone, which makes them less harmful.
6. **X-RAYS** – X-rays originate in space in the stars. Exploding stars like supernovas, black holes, the sun, pulsars all emit x-rays. X-rays can also be created by a machine to view parts of your body.
7. **GAMMA RAYS** – These have the shortest wavelength and the highest frequency of electromagnetic waves. They are created by some of the most hostile and violent events in nature, like collisions between stars. Gamma rays can pass through all matter. Because of their high energy, they are very dangerous to living cells. Doctors use gamma rays in radiotherapy treatments to kill cancer cell but they are monitored carefully.
8. **COSMIC RAYS** – They are at the top of the electromagnetic spectrum's energy scale. They are given off by the Sun, supernovas, pulsars (dense stars that rotate quickly). Too much exposure can cause cell damage & gene mutations.



PHOTON

A photon is a discrete packet of energy associated with electromagnetic radiation. Light is made up of billions of tiny particles called photons. These photons travel in waves. Most of the light on Earth comes from the Sun. The Sun shoots out billions of photons every second in all directions and the photons pointed to Earth come here. Photons are tiny little particles of light that are too small to see individually. They have no mass. They travel at speed of light. If a photon moves in short wavelengths like x-rays or ultraviolet light, then it has more energy.

HOW IS LIGHT BOTH A WAVE AND A PARTICLE

There has been an age old debate about light "Is light a wave or a stream of particles". One point of view says light is wave-like in nature, producing energy that travels through space similar to ripples spreading over a still pond after a rock is dropped in it. The other point of view is that light is made of a steady stream of particles, much like tiny droplets of water sprayed from a garden hose.

The fact is that light exhibits behavior that are characteristic of both waves and particles. This is called the wave-particle duality of light.

www.ed.ted.com/lessons/is-light-a-particle-or-a-wave-colm-kelleher

WAVELIKE BEHAVIOR OF LIGHT: Light exhibits behaviors that are similar to waves and that would be hard to explain with just a particle-view.

1. **Reflection**: light reflects in the same way as wave does.
2. **Refraction**: light, like a wave, refracts when it passes from one medium to another.
3. **Diffraction**: diffraction is the change in the direction of waves as they pass through an opening or around an obstacle in their path. When light encounters an obstacle, a shadow tends to be formed. However, the edges of the shadow tend to be fuzzy, due to the diffraction of light. This shows wave-like property and waves diffract.
4. **Interference**: wave interference is a phenomenon that occurs when two waves meet while traveling along the same medium. Light shows interference like waves.
5. **Doppler effect**: light exhibits the Doppler Effect, just like waves do.

PARTICLE-LIKE BEHAVIOR OF LIGHT:

1. It was found that light could remove electrons from atoms to give them a positive charge. This indicates that light is made of particles, and does not travel in waves. (Photoelectric effect)
2. Albert Einstein said that light might have particle characteristics and developed the quantum theory. This stated that the electrons in atoms in a metal can absorb a certain amount of light, and thus have the energy to escape. His famous equation E = mc squared where E is the energy of a particle, m is mass, and c is the speed of light.

LASER

Laser is an acronym for Light Amplification By Stimulated Emission of Radiation. Many things use lasers – CD and DVD players, the barcode readers in stores, and doctors use lasers for eye surgery, metal worker use lasers to cut & weld metal.

Lasers are special form of light. Laser light does not exist in nature. It is created by human technology. Ordinary light like sunlight has many different wavelengths of light. The light from a laser contains only one wavelength or one color. Scientists refer to this as "**monochromatic**" meaning one color.

Secondly, in a laser all the wavelengths are in phase, all the high points and low points are lined up. Scientists refer to this as "**coherent**".

Third, while the light waves from ordinary sources like flashlights or light bulbs is spread out in all directions, laser light waves travel in the same direction, exactly parallel to one another. This means that laser light beams are very narrow and can be concentrated on one tiny spot. Scientists refer to this as "**collimation**".

Because laser light is **monochromatic, coherent and collimated**, all of its energy is focused and it can produce a small point of intense power. It makes it possible to control laser light very precisely and do useful things. Lasers can be used instead of scalpels to perform delicate surgeries. Laser light is more powerful than ordinary light because all its rays have the same wavelength, move together, can be focused in a narrow beam with great precision.

CONVEX AND CONCAVE LENSES

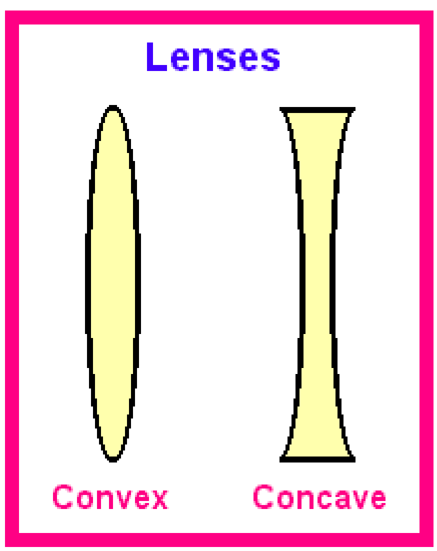
A lens is usually formed from a piece of shaped glass. It has a curved surface. Lenses can be either convex or concave. Convex lenses are thicker in the middle while concave lenses are thicker at the edges. When light travel through the lenses, refraction occurs and the light bends. A convex lens converges the light while a concave lens diverges the light.

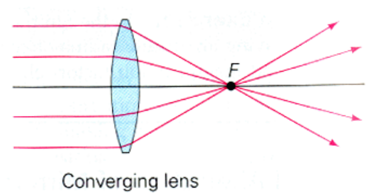
Lenses are used for eye glasses to help in converging or diverging an image correctly on the eye for proper sight. A camera also uses lenses.

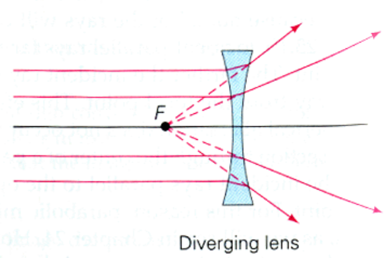
Convex lens are thicker in the middle. These lenses magnify images and make them look larger, like a magnifying glass lens. Since these lenses magnify, they are used for reading glasses and to correct long sightedness (hypermetropia).

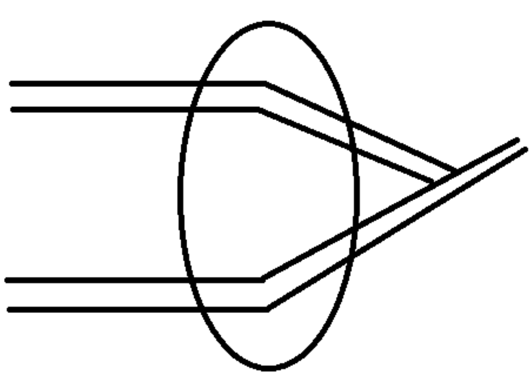
Concave lenses are thin in the middle. They make an image look smaller. This has the advantage of providing a sharper, clearer image. These lenses shrink things and correct short sightedness (myopia). Many high quality cameras, telescopes, and binoculars, use concave lenses.

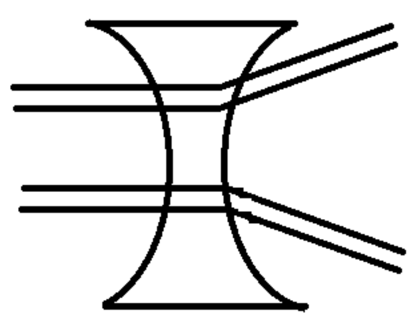
Convex lens: converging, thicker in middle, corrects hypermetropia/ long-sightedness
Concave lens: diverging, thicker at ends, corrects myopia/ short sightedness.







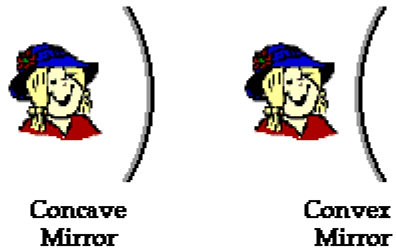




CONVEX AND CONCAVE MIRRORS

A convex mirror is a curved mirror in which the reflective surface bulges towards the source of light. The image formed cannot be projected since the image is inside the mirror. The most common use of a convex mirror is the rear view mirror on a car. They are also found on ATM machines for security, in stores and supermarkets for surveillance. They are used for sunglasses.

A concave mirror or a converging mirror has a reflecting surface that bulges inward or away from the source of light. They reflect light inward to a focal point and use to focus light. Concave mirrors are used by dentists to see enlarged image of tooth. Concave mirrors are used as make up or as shaving mirrors, to see an enlarged view of the face. Concave mirrors are used by doctors (ENT specialists) to focus light into ears and throat. Concave mirrors are used in reflector type telescopes


Concave Mirror
Convex Mirror

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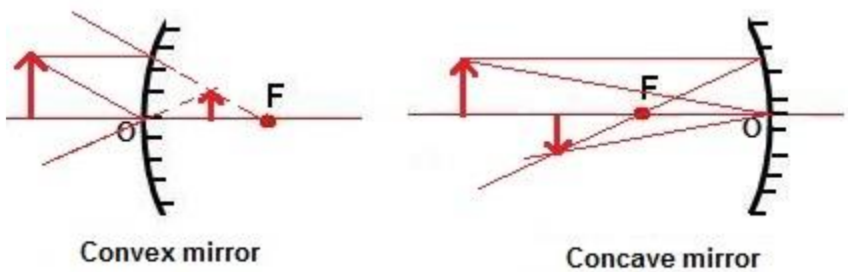
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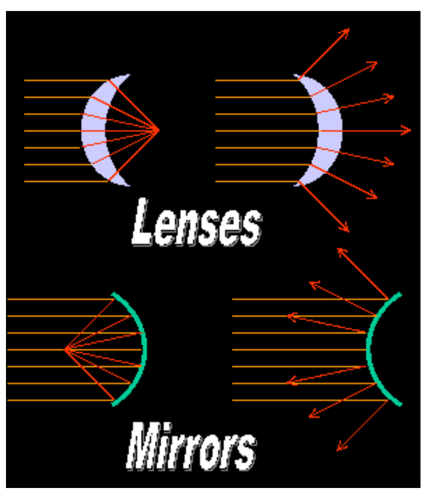

Lenses
Mirrors

OPTICS

Real and Virtual Image – An image which can be obtained on a screen is a real image. For example – images on a cinema screen. An image which cannot be obtained on a screen is a virtual image. For example – an image of our face in a plane mirror.

CONVEX AND CONCAVE MIRRORS

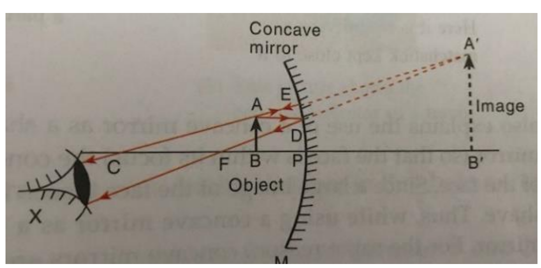
A concave mirror is a speherical mirror that reflects light from the bent in surface. A convex mirror reflects from the bulging out surface.

FORMATION OF IMAGES BY A CONCAVE MIRROR

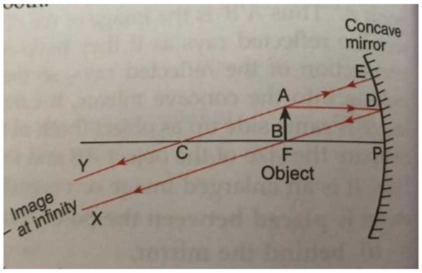
Summary of the Images Formed by a Concave Mirror

Position of object	*Position of image*	*Size of image*	*Nature of image*
1. Within focus (between pole *P* and focus *F*)	Behind the mirror	Enlarged	Virtual and erect
2. At focus (*F*)	At infinity	Highly enlarged	Real and inverted
3. Between *F* and *C*	Beyond *C*	Enlarged	Real and inverted
4. At *C*	At *C*	Equal to object	Real and inverted
5. Beyond *C*	Between *F* and *C*	Diminished	Real and inverted
6. At infinity	At focus (*F*)	Highly diminished	Real and inverted

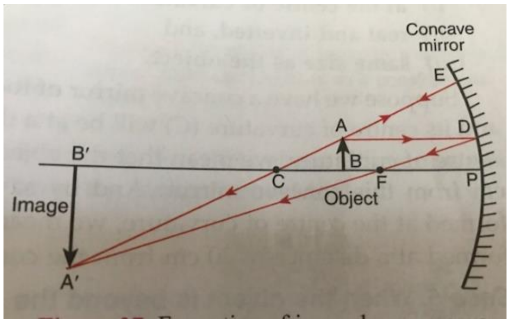
1. **When the object is between the pole and focus** – The image formed is behind the mirror, virtual and erect, and magnified (larger than the object). A concave mirror can be used to magnify objects – like a dentist's mirror or a make up mirror.



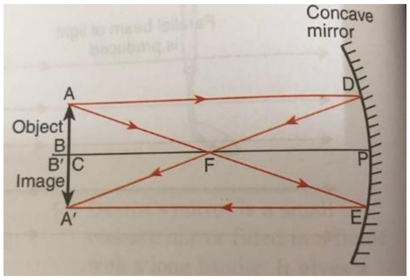
2. **When the object is at the focus** – The image formed is at infinity, real and inverted, and highly magnified. This is commonly used in reflectors for torches, car head lights and search lights.



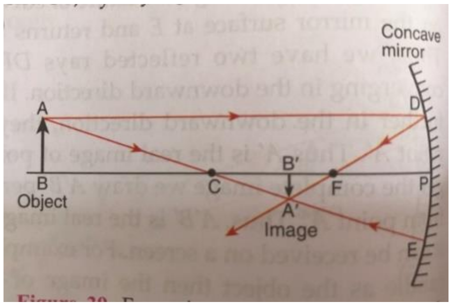
3. When the object is between the focus and center of curvature – The image if formed beyond the CC (center of curvature), real and inverted, magnified.



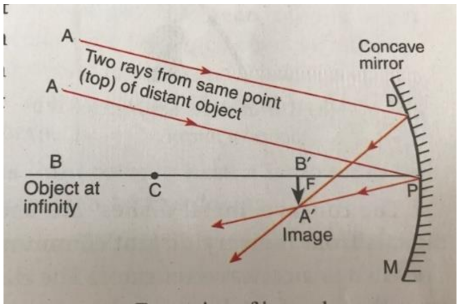
4. When the object is placed at the CC – The image is formed at the CC, real and inverted, same size as the object.



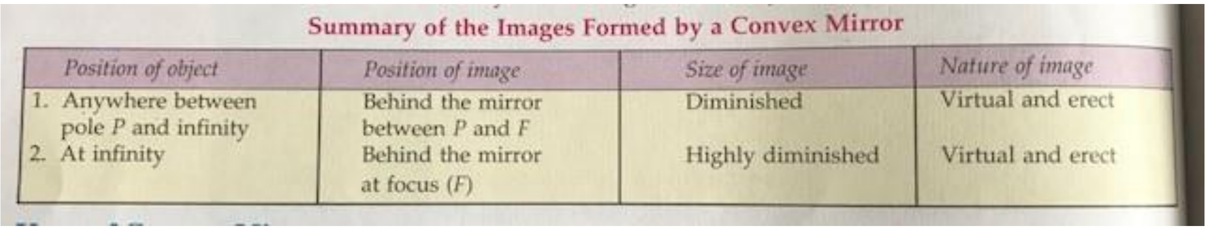
5. When the object is beyond the CC – The image is formed between the focus and CC, real and inverted, dimished



6. When the object is at infinity – The image is formed at the focus, real and inverted, highly diminished.



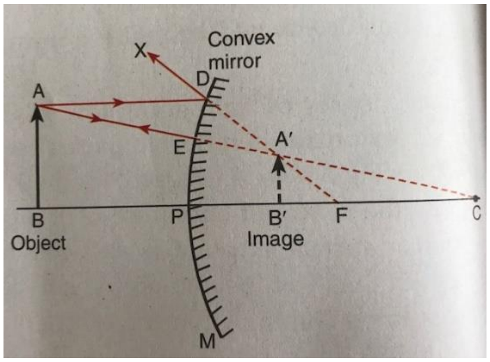
<u>**FORMATION OF IMAGES BY A CONVEX MIRROR**</u>



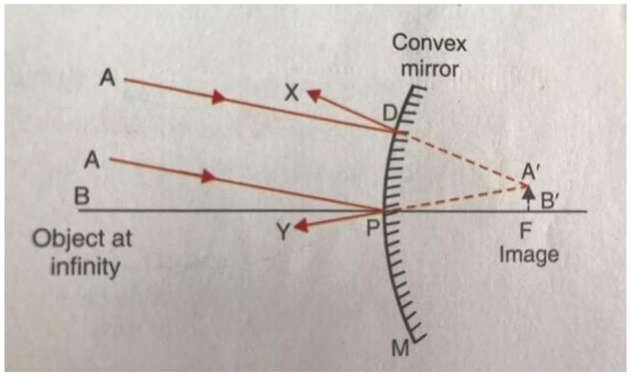
Summary of the Images Formed by a Convex Mirror

Position of object	Position of image	Size of image	Nature of image
1. Anywhere between pole *P* and infinity	Behind the mirror between *P* and *F*	Diminished	Virtual and erect
2. At infinity	Behind the mirror at focus (*F*)	Highly diminished	Virtual and erect

1. When the object is between pole and infinity – The image is behind the mirror between the pole and focus, virtual and erect, diminished.



2. When the object is at infinity – The image formed is behind the mirror at focus, virtual and erect, highly diminished.



MIRROR FORMULA AND SIGN CONVENTIONS

It gives the relationship between focal length (f), image distance (v) and object distance (u).

$$1/f = 1/v + 1/u$$

M = h2/h1 where m is magnification, h2 is image height and h1 is object height

M = - v/u where m is magnification, v is image distance and u is object distance.

According to sign convention –

1. The focal length of a concave mirror is positive.
2. The focal length of a convex mirror is negative.
3. The object distance (u) is positive because it is on the left side of mirror.
4. If the image is formed to the left of mirror then v is negative and if image is formed to the right of mirror then v is positive. In a convex mirror, the image is always formed on the right hand side so v for a convex mirror is always positive.
5.If image is real (lhs), v is positive and if image is virtual (rhs), v is negative.
6. h1 (object height) is always positive but h2 (image height) can be positive or negative. If the image is formed above the principal axis,h2 is positive and if it is formed below the principal axis,h2 is negative. Since all virtual images are erect and above the principal axis, the height of all virtual and erect images is positive. On the other hand, all real images are inverted so h2 for all real and inverted images is negative.

Magnification

1. If m is positive, then image is virtual and erect. If m is negative then image is real and inverted.
2. If m > 1, then image is larger than object. If m = 1, then image is same size as object. If m < 1, then image is smaller than object.
3. A concave mirror can form virtual or real images, so m can be positive or negative. Also, a concave mirror can form images which are smaller, equal to, or larger than the object, so m can be <1, = 1, or >1.
4. A convex mirror only forms virtual images so m is always positive. Also, a convex mirror forms images that are always smaller than the object so m <1.
5. A plane mirror forms images of same size as object so m = 1.

To summarize

Concave mirror – f positive

Convex mirror – f negative

Object distance u – always positive
Image distance v positive – image is real (and erect)
Image distance v negative – image is virtual (and inverted)

M positive – image is upright/erect (and real)
M negative – image is inverted (and virtual)

LENSES

Refraction is the bending or change in direction of light when it passes from one medium to another.

Optical Denser and Optically Rarer Medium – A medium in which the speed of light is more is optically rarer. For example, air is optically rarer comared to glass and water. A medium in which the speed of light is less is optically denser.

- When light goes from a rarer medium to a denser medium, it bends towards the normal. (RDT)
- When light goes from a denser to a rarer medium, it bends towards the normal. (DRA)

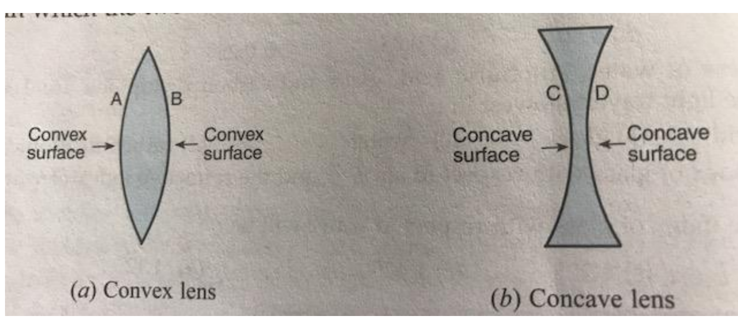
REFRACTIVE INDEX AND SNELL'S LAW

Accordingly to Snell's Law, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant called the refractive index. The refractive index is an indication of the light-bending ability of the medium. A medium that has higher refractive index, is optically denser, and has more light bending ability.

Refractive Index = Sine i/Sine r

Refractive index = Speed of light in vacuum or air / Speed of light in medium

Convex and Concave Lens – A convex lens is thicker in the center. It is a converging lens. A concave lens is thinner in the center. It is a diverging lens.

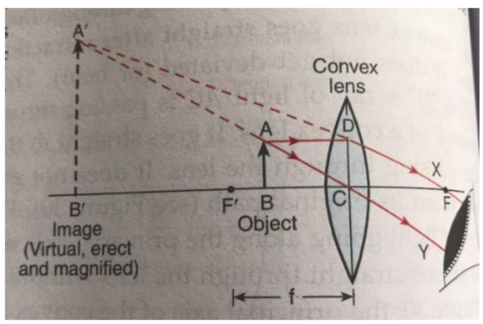


FORMATION OF IMAGES BY A CONVEX LENS

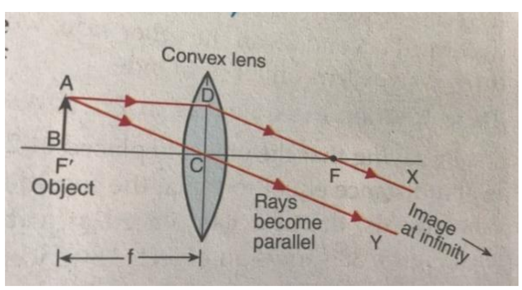
Summary of the Images Formed by a Convex Lens

Position of object	*Position of image*	*Size of image*	*Nature of image*
1. Between *f* and lens	On the same side as object	Enlarged	Virtual and erect
2. At *f* (at focus)	At infinity	Highly enlarged	Real and inverted
3. Between *f* and 2*f*	Beyond 2*f*	Enlarged	Real and inverted
4. At 2*f*	At 2*f*	Same size as object	Real and inverted
5. Beyond 2*f*	Between *f* and 2*f*	Diminished	Real and inverted
6. At infinity	At *f* (at focus)	Highly diminished	Real and inverted

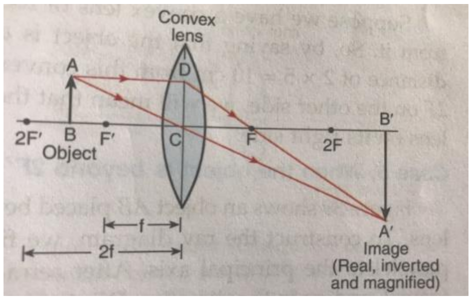
1. When object is between optical center and focus – The image is formed behind the object on the left hand side of the lens, virtual and erect, magnified. This is used for a magnifying glass. The smaller the focal length, the greater the magnifying power.



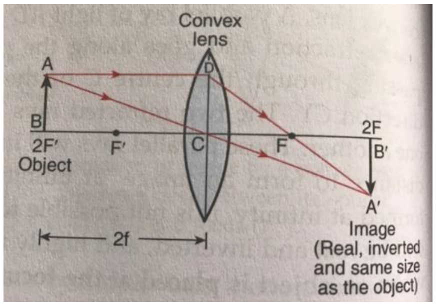
2. When an object is at focus – The image is formed at infinity, real and inverted, highly enlarged



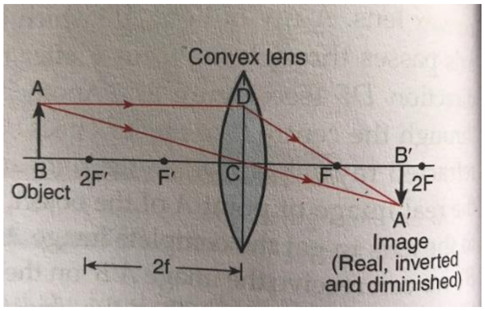
3. When the object is between F and 2F – The image is formed beyond 2F, real and inverted, magnified



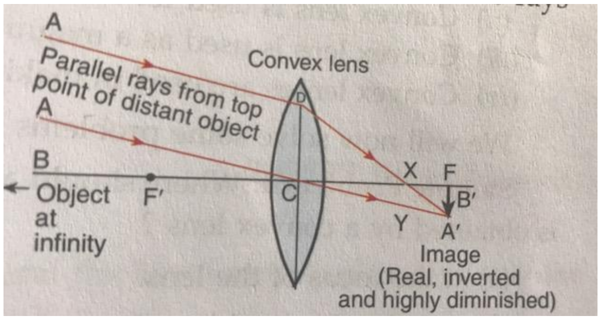
4. When object is at 2F – the image is formed at a distance of 2F on the other side of the lens, real and inverted, same size as the object



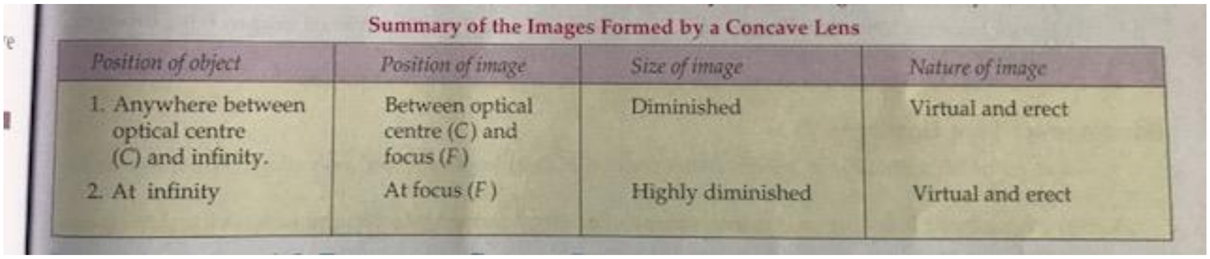
5. When object is beyond 2F – The image is formed between F and 2F on the right side of the lens, real and inverted, smaller



6. When object is at infinity – The image is formed at focus, real and inverted, highly diminished.



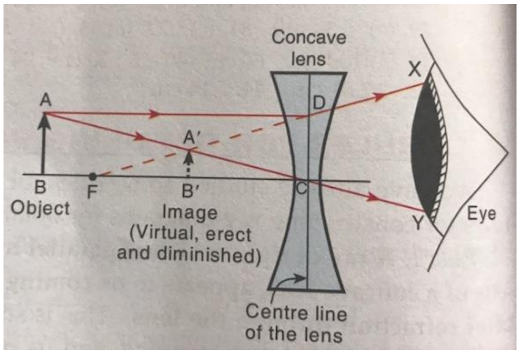
IMAGES FORMED BY A CONCAVE LENS



Summary of the Images Formed by a Concave Lens

Position of object	Position of image	Size of image	Nature of image
1. Anywhere between optical centre (C) and infinity.	Between optical centre (C) and focus (F)	Diminished	Virtual and erect
2. At infinity	At focus (F)	Highly diminished	Virtual and erect

1. When object is anywhere between optical center and infinity – The image formed is between optical center and focus, virtual and erect, diminished (smaller than object)



2. When object is at infinity – The image is formed at focus, virtual and erect, highly diminished

LENS FORMULA AND SIGN CONVENTIONS

Lens Formula – It gives the relation between image distance (v),object distance (u) and focal length (f)

1/f = 1/v – 1/u

Sign Conventions

1. The focal length of a convex lens is positive while the focal length of a concave lens is negative
2. Distances measured from optical center to left hand side are negative while from optical center to right hand side are positive.
3. Object distance (u) is negative.

Magnification

M = height of image (h2) / height of object (h1) **m = h2/h1**

M = image distance (v) / object distance (u) **m = v/u**

1. If m is positive, image is virtual and erect. If m is negative, image is real and inverted.
2. Since a convex lens can form virtual and real images, m can be positive or negative. Since a concave lens only forms virtual images, m is always positive.
3. A convex lens can form images that are smaller, larger, and same size, so m can be 1, <1, or >1. A concave lens forms images that are always smaller so m <1 always.

To summarize

Convex lens (converging) – f positive
Concave lens (diverging) – f negative

Object distance u – always positive
Image distance v positive – image is real (and erect)
Image distance v negative – image is virtual (and inverted)

M positive – image is upright/erect (and real)
M negative – image is inverted (and virtual)

MIRROR FORMULA AND SIGN CONVENTIONS

It gives the relationship between focal length (f), image distance (v) and object distance (u).

$$1/f = 1/v + 1/u$$

M = h2/h1 where m is magnification, h2 is image height and h1 is object height

M = - v/u where m is magnification, v is image distance and u is object distance.

According to sign convention –

1. The focal length of a concave mirror is positive.
2. The focal length of a convex mirror is negative.
3. The object distance (u) is positive because it is on the left side of mirror.
4. If the image is formed to the left of mirror then v is negative and if image is formed to the right of mirror then v is positive. In a convex mirror, the image is always formed on the right hand side so v for a convex mirror is always positive.
5. 5.If image is real (lhs), v is positive and if image is virtual (rhs), v is negative.
6. h1 (object height) is always positive but h2 (image height) can be positive or negative. If the image is formed above the principal axis,h2 is positive and if it is formed below the principal axis,h2 is negative. Since all virtual images are erect and above the principal axis, the height of all virtual and erect images is positive. On the other hand, all real images are inverted so h2 for all real and inverted images is negative.

Magnification

1. If m is positive, then image is virtual and erect. If m is negative then image is real and inverted.
2. If m > 1, then image is larger than object. If m = 1, then image is same size as object. If m < 1, then image is smaller than object.
3. A concave mirror can form virtual or real images, so m can be positive or negative. Also, a concave mirror can form images which are smaller, equal to, or larger than the object, so m can be <1, = 1, or >1.
4. A convex mirror only forms virtual images so m is always positive. Also, a convex mirror forms images that are always smaller than the object so m <1.
5. A plane mirror forms images of same size as object so m = 1.

To summarize

Concave mirror – f positive
Convex mirror – f negative

Object distance u – always positive
Image distance v positive – image is real (and erect)
Image distance v negative – image is virtual (and inverted)

M positive – image is upright/erect (and real)
M negative – image is inverted (and virtual)

PRIMARY COLORS

These are colors that cannot be created through the mixing of other colors. The 3 primary colors are red, yellow and blue.

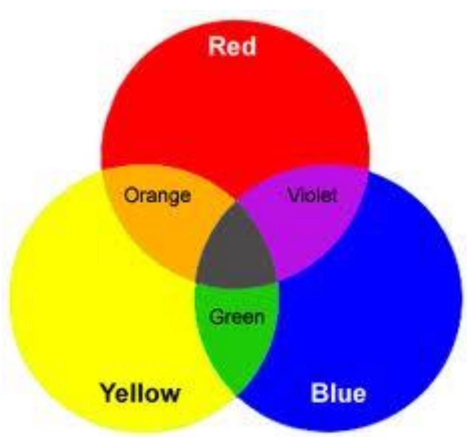
SECONDARY COLORS

Primary colors can be mixed together to produce secondary colors.

yellow + blue = green

blue + red = purple

red + yellow = orange



COMPLEMENTARY COLORS

An important rule of the color wheel is that colors opposite to each other on the color wheel, usually work well together in a color scheme. These are known as complementary colors.

LIGHT SPECTRUM

The visible spectrum or light spectrum is the portion of the electromagnetic spectrum that is visible to the human eye. A human eye will respond to wavelengths from about 390 – 750 nanometers.

PRISM SPECTRUM

A prism has a base and sides like a pyramid, it is polished and transparent. It refracts light and a prism can be used to break light up into its constituent spectral colors. Light changes speed as it moves from one medium to another (from air to the glass of the prism). This change in speed causes the light to bend and enter the new medium at a different angle. In a prism, the light of different colors is refracted differently and leaves the prism at different angles creating an effect similar to a rainbow. This can be used to separate a beam of white light into its spectrum of colors VIBGYOR.

RED SHIFT

Doppler Effect: Imagine you are out on a walk and a screeching ambulance races past you. As it approaches, the higher is the pitch of its siren. As it passes, the pitch of the siren becomes lower as the ambulance recedes into the distance. This change in sound as something approaches and recedes is called the Doppler Effect.

As the ambulance moves closer to you, the wavelength of the sound waves is shortening and the frequency (and pitch) of the waves is increasing. As the ambulance moves away, the opposite happens; the wavelength is increasing and the frequency is decreasing.

Blue Shift: Light also moves in waves. The same process that we have observed with sound also happens with light. When an object is emitting light and moving towards you, the wavelength decreases and the frequency increases; in other words it gets squished. This wavelength corresponds to the blue end of the visual color spectrum. The object is said to have **blueshifted.**

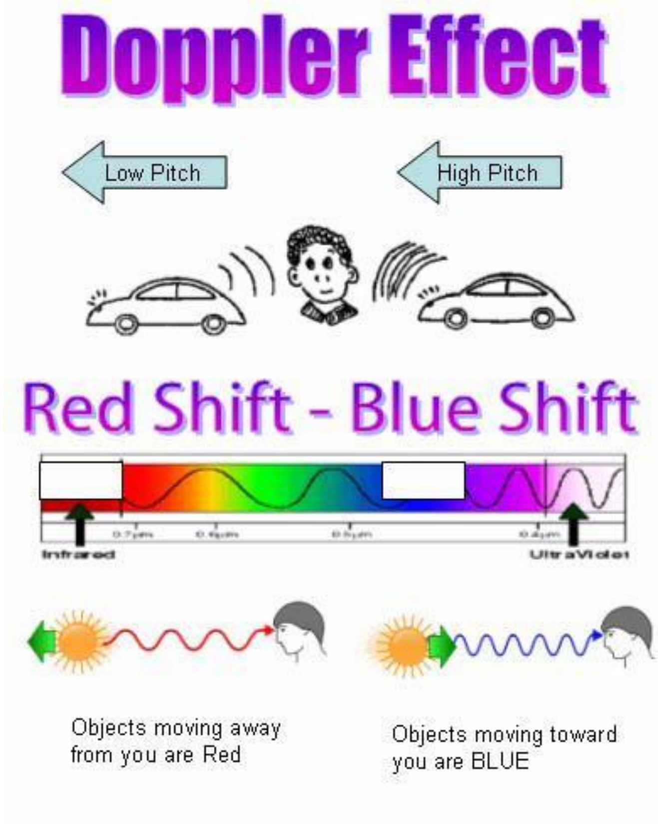
Red Shift: In reverse, when the object is moving away, the wavelength of light that it is emitting increases, the frequency decreases; it gets stretched out. This corresponds to the red end of the color spectrum and the object has **redshifted.** A redshift is a shift in the frequency of a photon toward lower energy, or longer wavelength.

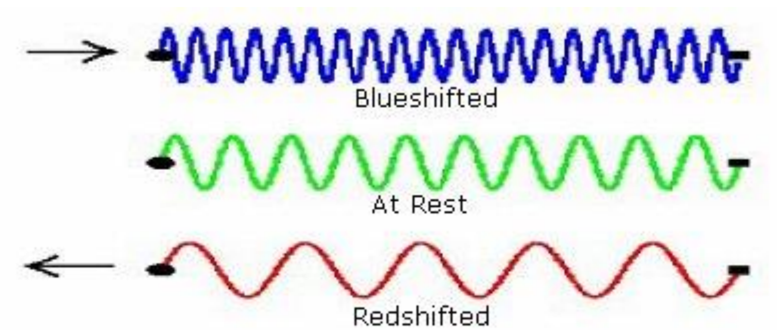
Types of Red Shifts: Different types of redshifts have different causes.

Doppler Red Shift: This results from the relative speed (motion) between the "photon emitting" object, and the observer. If the source of energy is moving away from you, then the wavelength is stretched out. This is called the red shift.

Cosmological Red Shift: This is the red shift caused by the expansion of space. The wavelength of light increases as it travels the expanding universe, from the point of its emission, to the point of its detection. Edwin Hubble used the concept of redshift and blueshift to calculate the distances between galaxies. Through this he found that galaxies were moving away from each other, that the Universe was not static, it was actually expanding. The newfound knowledge led to the Big Bang Theory.

Gravitational Red Shift: This is the shift in the frequency of a photon to lower energy and lower wavelength, as it climbs out of a gravitational field.


Doppler Effect
Low Pitch
High Pitch
Red Shift - Blue Shift
Infrared
UltraViolet
Objects moving away from you are Red
Objects moving toward you are BLUE


Blueshifted
At Rest
Redshifted