Physics:

Energy can be transferred as both a particle and a wave

- What are the properties and behaviors of light?
- How do you sense light?
- What are the effects of electromagnetic energy behaving like both a particle and a wave?

Student Objectives

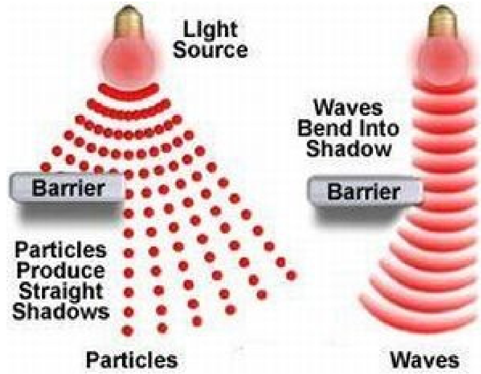
Statement	Beginning	Approaching	Meeting	Succeeding	Exceeding
I can describe light as a wave (wavelength, amplitude, frequency)					
I describe how transparent, translucent, and opaque objects affect light rays					
I can describe types and uses of electromagnetic radiation					
I can explain the Law of Reflection					
I can explain the refraction of light					
I can represent how lenses and mirrors affect rays of light					
I can identify the parts of an eye					
I can describe the functions of the parts eye					

Summary of Key Points

- Properties of Light
  - Acts like both a wave and a particle
  - Waves have amplitude, wavelength, and frequency.
- Electromagnetic Radiation
  - The Electromagnetic Spectrum consists of Radio, microwave, infrared, visible light, UV, X-rays, and gamma rays
  - Effects of the electromagnetic radiation include: cancer treatment (positive), sunburns (negative), etc.
  - Different colours of light have different wavelengths.
- Behaviours of Light
  - Effects of transparent, translucent, and opaque objects
  - Mirrors reflect light according to the law of reflection
  - Refraction: Light rays bend when they pass between two different materials
- Ways of Sensing
  - Human Vision: Light is detected by the eye using the cornea-lens-retina system.

- Vision deficiencies include near-sightedness, far-sightedness, astigmatism, and deficiencies in distinguishing between different colours.

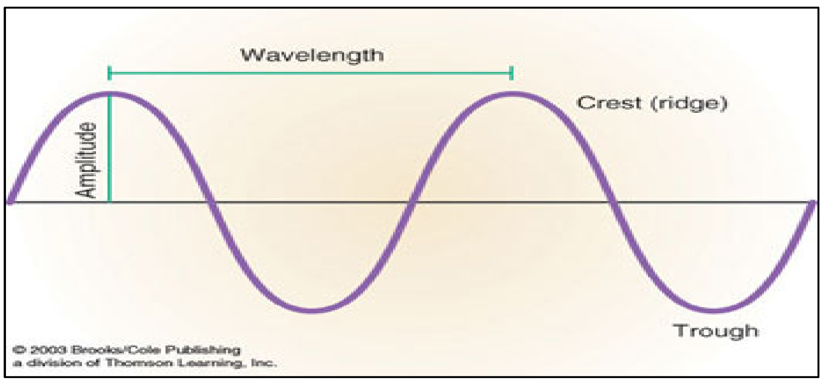
Properties of Light (Wave and Particle)



Light has a dual nature

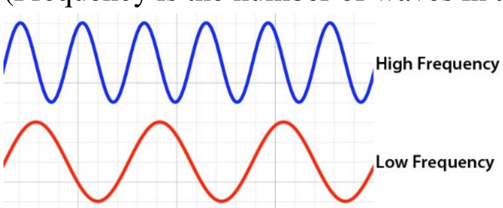
- Sometimes it behaves like a particle (called a photon), which explains how light travels in straight lines
- Sometimes it behaves like a wave, which explains how light bends (or diffracts) around an object
- Scientists accept the evidence that supports this dual nature of light

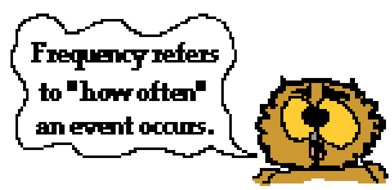
1. Light as a **WAVE**



- The greater the amplitude the greater the Energy
  - A bright light will have a large amplitude and a dim light will not
  - Wavelength and Frequency have an inverse relationship (This means as one increases the other decreases)

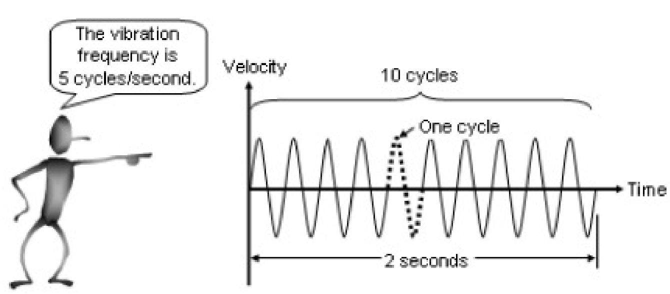
- **Frequency** (f): the number of cycles that pass the observer in a given time. (Frequency is the number of waves in a given period of time)





Frequency (Hz) = $\frac{\text{number of waves}}{\text{Seconds}}$

Hertz is the unit of frequency, and just means how many cycles per second



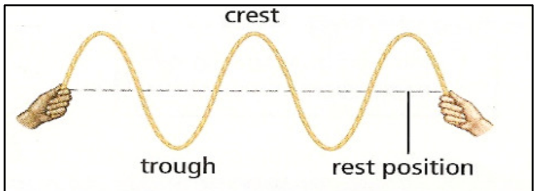
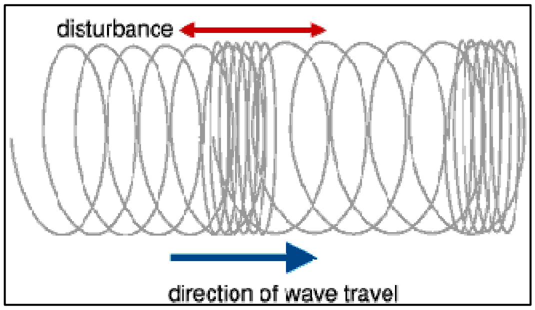


Figure 4.7 A transverse wave travels horizontally along the rope, and the rope moves up and down.

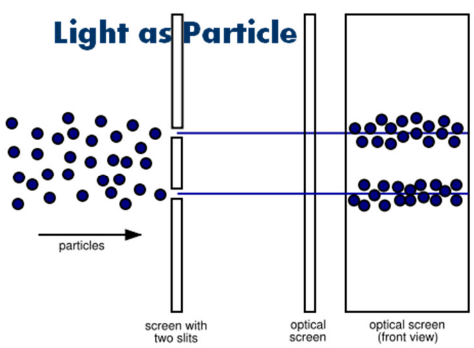
Transverse waves: matter in the medium moves up and down perpendicular to the direction that the wave travels.



Compression waves: matter in the medium moves back and forth along the same that the wave travels. (Example: Sound waves)

- Water waves and seismic waves (earthquake) waves are a combination of transverse and compression waves.
- Seismic waves can travel through Earth and along Earth's surface. Objects on the Earth's absorb some of that energy causing them to move and shake.
- Not all waves need a medium to travel. Visible light and radio waves can travel through space were there is no material.

2. <u>Light as a **PARTICLE**</u>



Light is thought to consist of tiny bits of energy that behave like particles called photons

Particles explain how light travels in straight lines or reflects off of mirrors

How can a Slinky simulate wave action?

Materials:

1. Slinky
2. Students

Procedure:

1. Get a Slinky from the teacher
2. In pairs stretch out the Slinky
3. Simulate wave motion by having 1 partner start a wave

1. Look for the crest. How can you make it bigger?

____

2. Look for the trough. How can you make it deeper?

____

3. How can you make the wavelength shorter?

____

4. How can you make the wavelength longer?

____

5. How can you increase the frequency?

____

6. How can you decrease the frequency?

____

7. What is the difference between a compression and transverse wave?

____

8. How can you make a transverse wave?

____

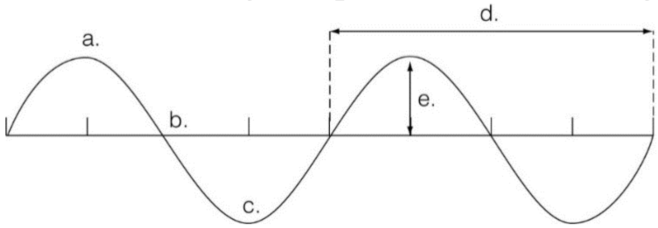
9. How can you make a compression wave?

____

10. Estimate the frequency in Hertz of the waves you produce. ________

Quick Check: Waves

1. **In the diagram below, fill in the labels on the right side of the picture. Choose words from this list: trough, amplitude, crest, wavelength, rest position.**



a. ____________________
b. ____________________
c. ____________________
d. ____________________
e. ____________________

2. **How many wavelengths are shown in the above diagram?**
   ____

3. **The number of cycles per second is the _______________, which is measured in _______________ (Hz).**

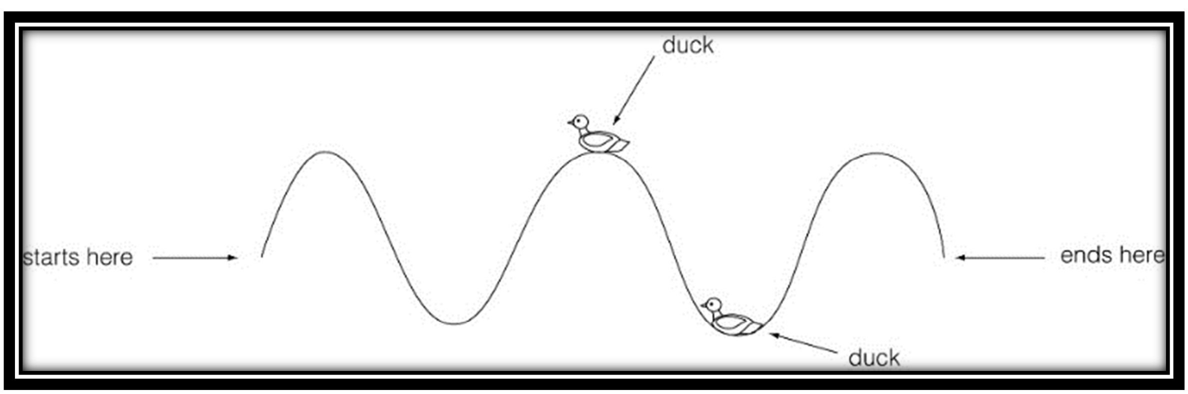
4. **Calculate the frequency of a wave that goes up and down 8 times in 4 seconds.**
   ____

5. **A hummingbird flaps its wings 120 times in 3 seconds.**
   ____

6. **A DVD spins 35 times in 7 seconds.**
   ____

7. **In the diagram below, how many wavelengths apart are the two ducks?**
   ____

8. **In the diagram below, how many wavelengths are shown?**
   ____



9. What are two ways to increase the energy carried by a wave? (give a "stranger test" answer)

10. a) Draw a wave with a wavelength of 8 cm and an amplitude of 1 cm. Label the crest, the trough, the amplitude and the wavelength.

b) Draw a diagram to illustrate a wave with a high frequency, a short wavelength and a large amplitude.

c) Draw a diagram to illustrate a wave with a low frequency, a long wavelength and a small amplitude.

11. Calculating the frequency. (refer to your notes for help – show your work)

Recall: **Frequency (Hz) = cycles/seconds**

a) A buzzer vibrates 900 times in 5 seconds. What is its frequency?

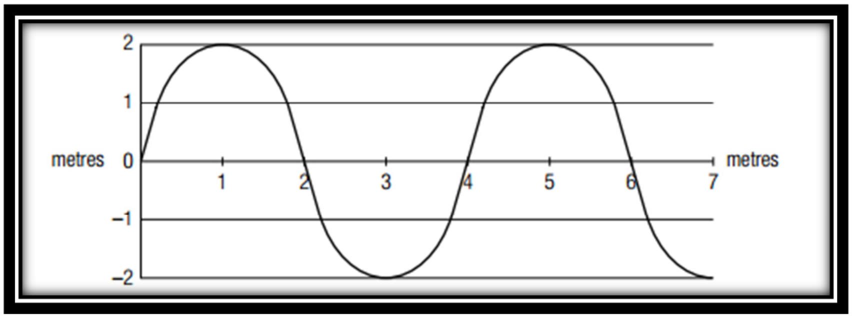
b) A ball bounces on the floor 10 times in 50 seconds. What is its frequency?

c) A pendulum swings 180 times in 2 minutes. What is its frequency?

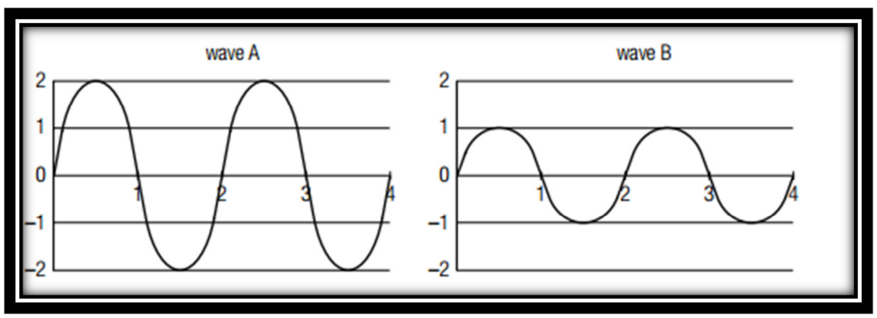
d) A speedboat zips by on a lake and sends a series of waves towards a dock. The frequency of the waves is 5 Hz. How many wave crests will pass by the dock in 8 seconds.

Characteristics of Waves:

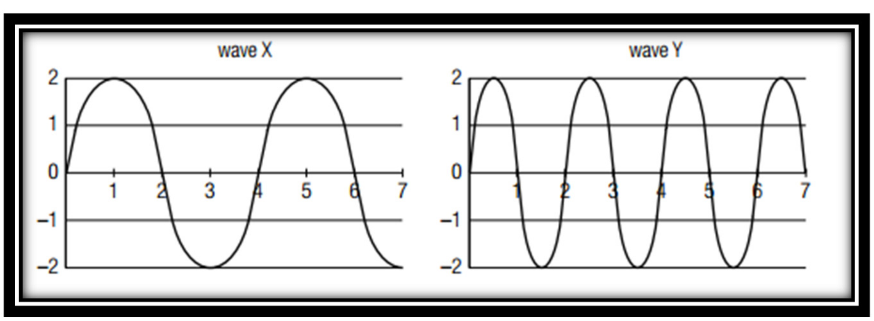
12. **How long is the wavelength of the wave below? __________**
13. **How large is the amplitude of the wave? __________**



14. **Which wave below has the smaller amplitude, A or B?**
15. **Which wave carries more energy, A or B?**

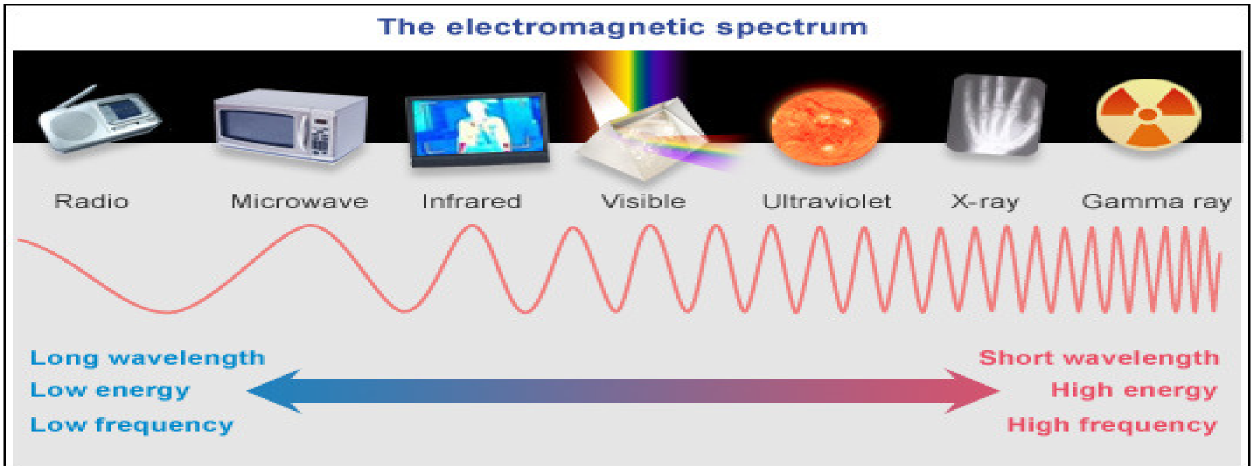


16. **What is the same for the waves X and Y below: amplitude, wavelength, or frequency?**
17. **Which wave has a greater frequency, X or Y?**
18. **Which wave has a longer wavelength, X or Y?**

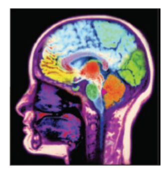


Electromagnetic Radiation
Light is classified as electromagnetic radiation.

Electromagnetic Radiation is the transmission of energy in the form of waves that extend from the longest radio waves to the shortest gamma rays.



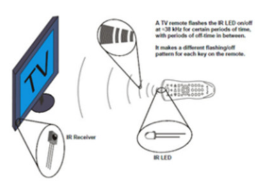
The radiation behind radios, visible light and nuclear blasts is all exactly the same thing, just with different amounts of energy.



Radio waves: longest wavelength and lowest energy and frequency
- Radio waves are as long as soccer fields
- MRI technology uses radio waves to see inside our body.

Microwaves (Type of Radio Wave)
- Microwaves are used in: cooking food, and telecommunications.
- Radar uses short wavelength microwaves (Radar is used in: tracking the motion of objects, weather forecasting, and taking images of the Earth's surface).

Infrared Waves
- Infrared radiation is also referred to as heat.
- Infrared waves are used in: remote controls, infrared cameras, and CD-ROM readers.



***Visible Light**
- The portion of the electromagnetic spectrum our eyes can see

Ultraviolet Waves

- This radiation possesses much more energy than visible light.
- UV waves striking your skin allow your body to make Vitamin D.
- Overexposure to UV can cause sunburns and possible skin cancer.

X rays

- X rays are commonly used to photograph teeth and bones.
- X rays are also used to detect small cracks in metals and also to photograph the inside of machines.

Gamma Rays (Gamma rays are smaller than an atom)

- Gamma rays result from nuclear reactions.
- Gamma rays can be used in radiation therapy to kill cancer cells.

Fill in the Table using the info/chart above

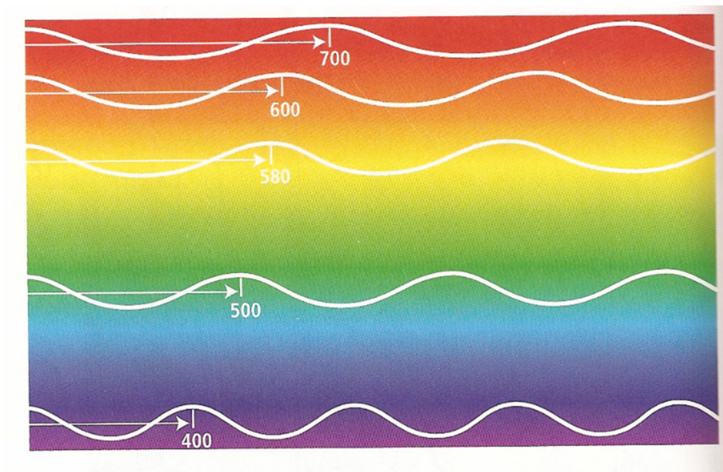
Type of Wave	Wavelength **(W)** Frequency **(F)** Energy **(E)**	**List two uses**
Radio (include television,	Long W Low F Low E	-help see in our bodies (Magnetic Resonance Imaging (MRI) -television broadcasting
Microwaves		
Infrared		
Ultraviolet		
X Rays		
Gamma Rays		

Visible Light

Remember:
Visible Light is a wave that you can see.

It includes all the colours of the rainbow.
The seven colours are Red, Orange, Yellow, Green, Blue, Indigo, and Violet (ROY G BIV).

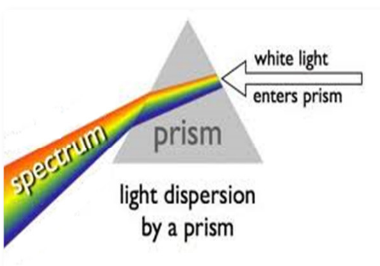
R
O
Y
G
B
I
V



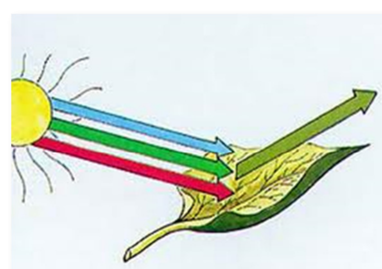
Terms we will get to later:

Refraction (Bent): is the bending or the changing direction of the light wave as it passes from one material to another. (Example: air into water)

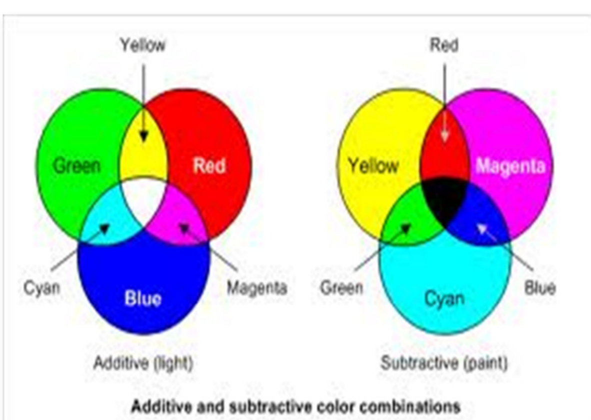
Reflection (Bounces off): occurs when a light waves strikes an object and bounces off.



- If sunlight/white light is **refracted** (bent) by a prism, the different wavelengths bend by different amounts causing us to see different colors.



- When sunlight/whitelight strikes coloured clothing, some colours are **reflected** while others are absorbed. Only the reflected colours can be seen. **Green** Leaf reflect **Green**



- Only three colours are needed to produce all the colours of the rainbow. These are called the primary colours. They are red, blue and green

Quick Check

1. **Question: Why does a bright yellow shirt appear black in a dark room?**
   ____
   ____

Bill Nye - Light and Color

2. **What happens when a bright light goes through a prism?**
   ____

3. **What are the colours of the rainbow?**
   ____

4. **What happens when you mix the colours red and blue?**
   ____

5. **In order to see a rainbow, the angle between the sunlight and you has to be __________ degrees.**

6. **Why are things black?**
   ____

7. **A red shirt will absorb all colours except** ___________________________________

8. **What colors would a white shirt reflect?**
   ____

9. **Black colours absorb all colours and convert them into** _______________________

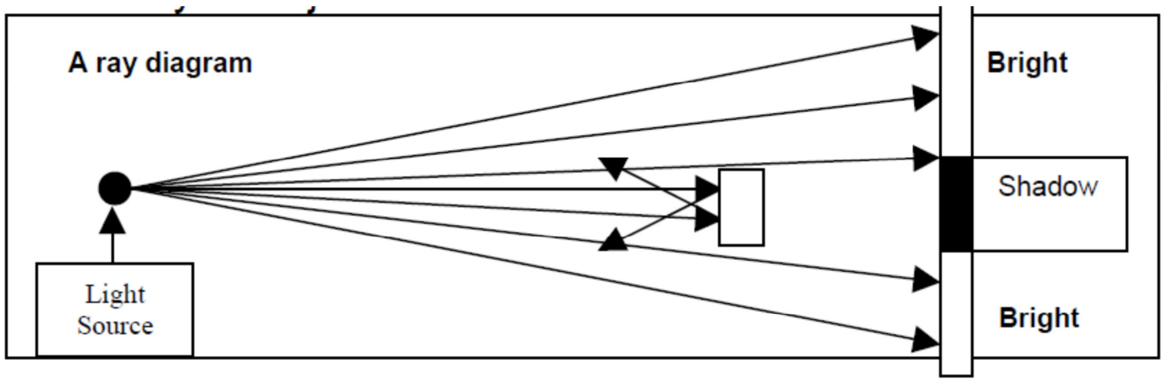
10. **What are the 'science' primary colours?**
    ____

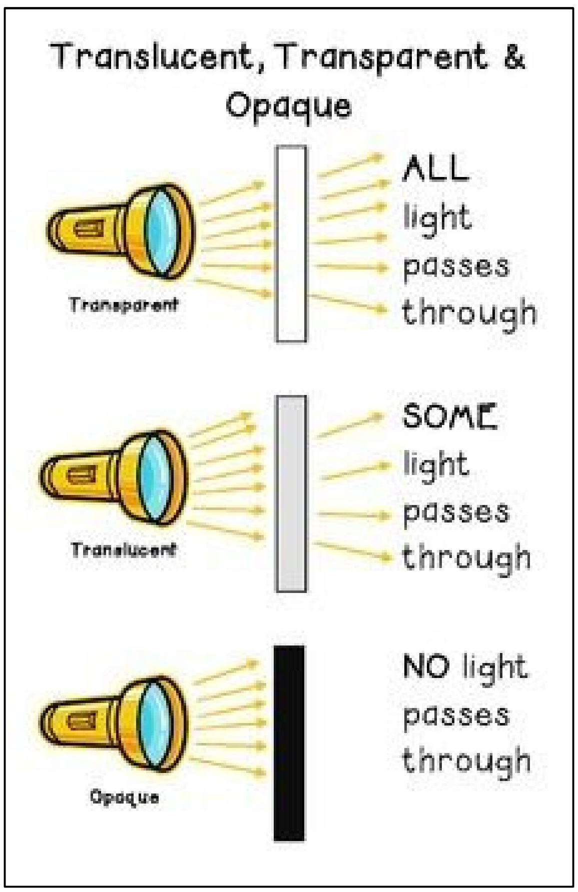
11. **Why is the sky blue?**
    ____

12. **Why is water blue?**
    ____
    ____

The Ray Model of Light: 'Light travels in straight lines'

Because of this principle, the ray model of light can help to explain certain properties light. A ray is a straight line that represents the path of a beam of light. The ray model helps to explain how shadows can be formed, when the ray of light is blocked by an object.





The type of surface will determine how the light will continue.

- If the surface is **transparent**, the light continues in a straight path through the object

- If the surface is **translucent**, the light will be diverted (refracted) after it passes through

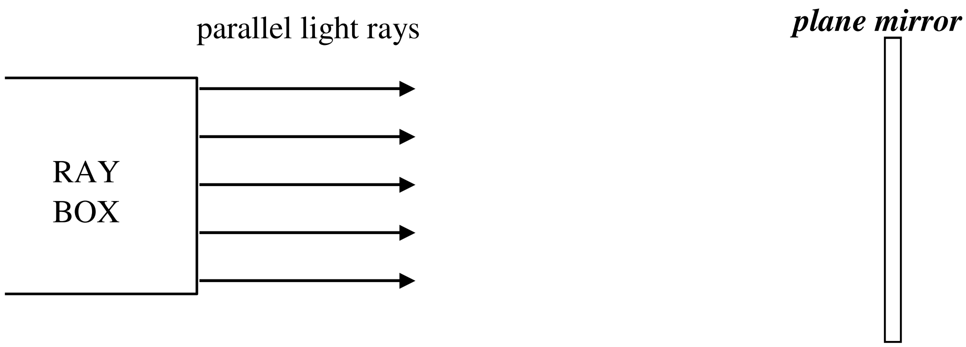
- If the surface is **opaque**, the light will be blocked and not allowed through the object

Reflection and Mirrors

Reflection is the process in which light strikes a surface and bounces back off that surface.

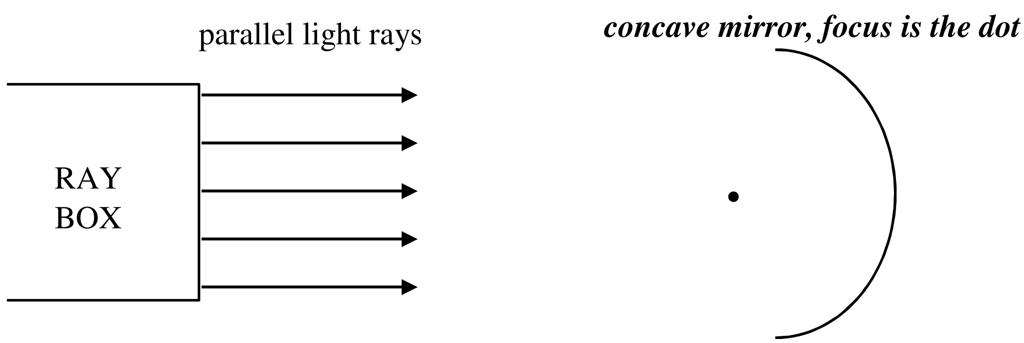
- *For each of the three types of mirrors, set up the Ray Box and see what happens. Using a ruler, draw the* ***reflected rays****:*

1. Plane Mirror: Flat and smooth



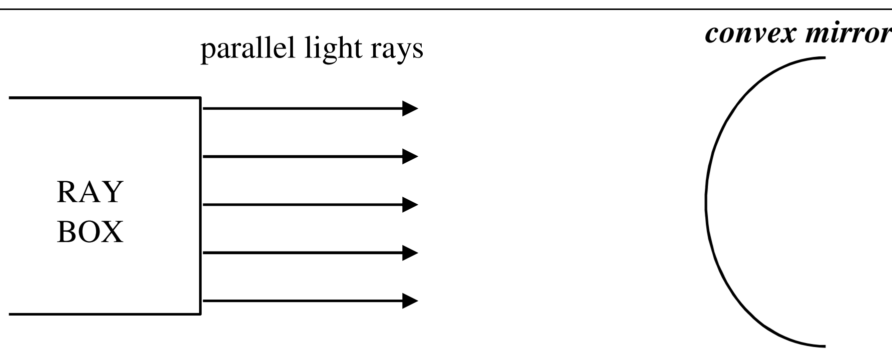
Do light rays: *diverge* *converge* *bounce straight back*

2. Concave Mirror: Folds Inwards



Do light rays: *diverge* *converge* *bounce straight back*

3. Convex Mirror: Folds Outwards

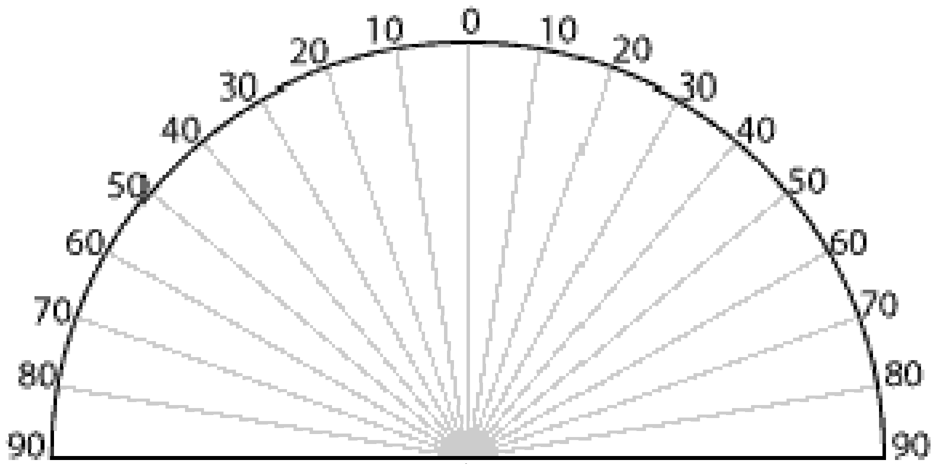


Do light rays: *diverge* *converge* *bounce straight back*

LAW OF REFLECTION:
How does light bounce of a plane mirror when it comes in from an angle?:

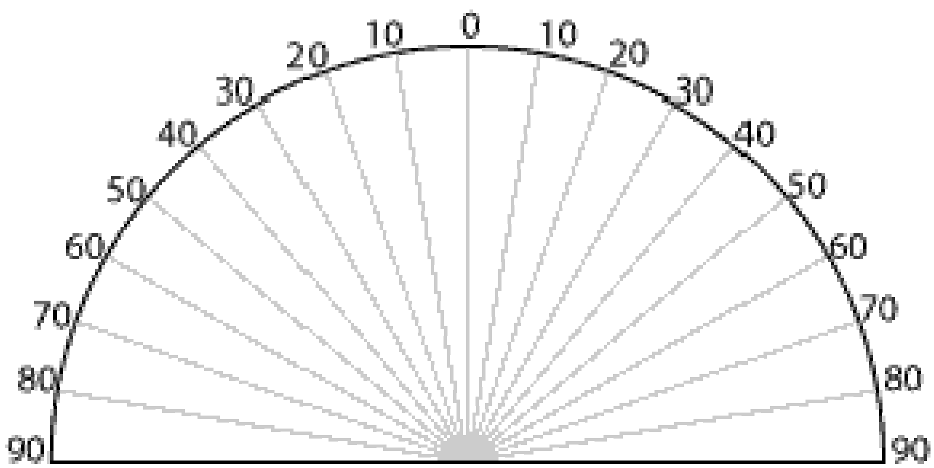
Incident Ray: Incoming Ray
Reflected Ray: Outgoing Ray
Normal: Dotted Line perpendicular (90°) to object being used for reflection

- Draw **the incident ray, reflected ray**, and **normal** using a Ray Box when the incident ray is 30°. Label the angle of incidence and reflection



Place Mirror Here

- Draw the incident ray, reflected ray, and normal using a Ray Box when the incident ray is 80°. Label the angle of incidence and reflection



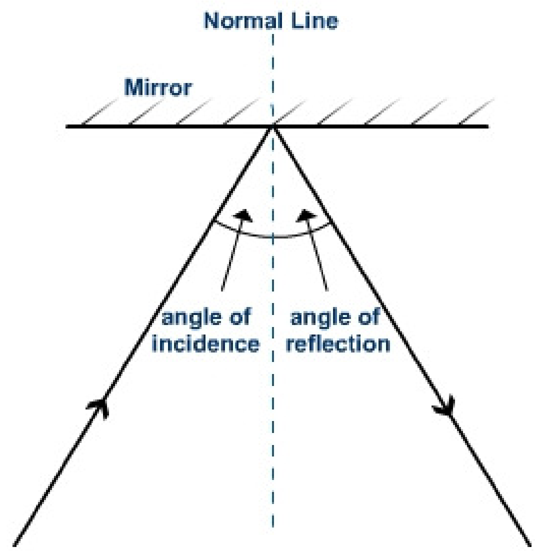
Place Mirror Here

The Law of Reflection states:
___
___
___

<u>LAW OF REFLECTION:</u>
States that:

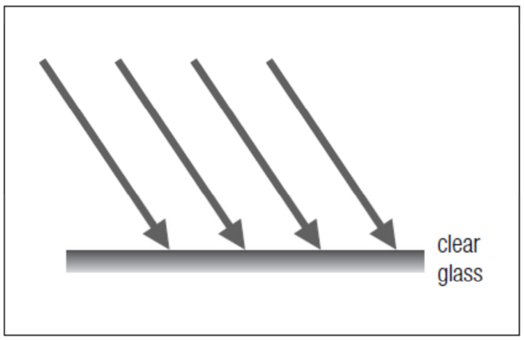
- the **incident** ray (incoming),
- the **reflected** ray,
- and the **norma**l to the surface of the mirror all lie in the same plane.

Furthermore, the angle of **reflection** is equal to the angle of **incidence**.

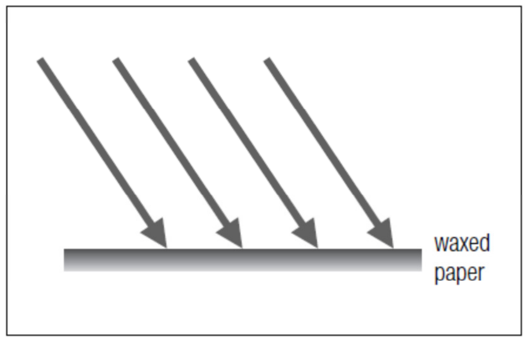


Complete the diagrams below.

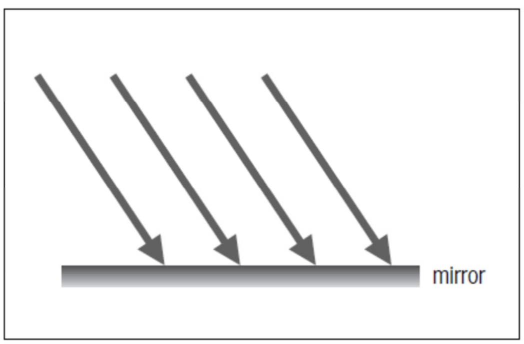
1. Draw the light rays that result when light rays strike a transparent surface.



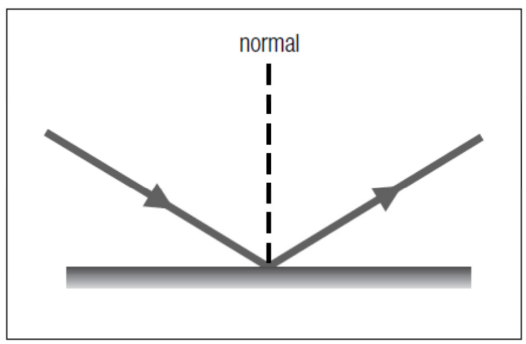
2. Draw the light rays that result when light rays strike a translucent surface.



3. Draw the light rays that result when light rays strike an opaque surface.



4. Label the angle of incidence and the angle of reflection.



TEACHER – REFLECTION BULLSEYE ACTIVITY

Overview

This is the culminating activity, requiring students to use their knowledge of the law of reflection. An emphasis should be placed on making accurate measurements and predictions of angles, and in following the rules of the challenge.

Students Will Learn…

How to use the law of reflection to design an "obstacle course" for a laser using multiple mirrors to direct the laser beam to a specific target.

- Challenge includes designing the setup WHILE THE LASER IS TURNED OFF. They should NOT turn the laser on at any point before they have called the instructor over to inspect the setup.

What You Need

For each group of 2-3 students:

- 3 mirrors (3"x3"), mounted in plastic holders
- 1 laser
- 3 paper or plastic protractors
- String
- Roll of masking tape
- Copy of paper target
- 1 yardstick or ruler
- Copy of "STUDENT HANDOUT: Hit the Target" (put Scorecard on the back side)

HINT: The Y bullseye design target requires that students take the planar nature of the law of reflection into account. It is more difficult than the vertical stripes target.

REFLECTION BULLSEYE

Objective

Now that you have had practice measuring and using the law of reflection, you can apply what you've learned to hit a target with a laser by strategically placing mirrors.

The word "LASER" stands for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. A laser is an optical light source that emits a concentrated beam of photons. Lasers are usually monochromatic – the light that shoots out is usually one wavelength and color, and is in a narrow beam. By contrast, light from a regular incandescent light bulb covers the entire spectrum as well as scatters all over the room. (Which is good, because could you light up a room with a narrow beam of light?).

Your Challenge

- Round 1- Hit the target using one mirror
- Round 2- Hit the target using two mirrors
- Round 3- Hit the target using three mirrors

Materials

(Note: you do not have to use all provided materials)

- 3 mirrors (3"x3"), mounted in plastic holders
- 1 laser
- 3 protractors
- String
- 1 roll of masking tape
- 1 target
- 1 yardstick or ruler

Rules

1. **Most importantly**: the laser must be turned off while you are moving the mirrors.
2. The target must be placed 4 feet away from the laser and not in its direct path.
3. Mirrors must be 1-4 feet away from each other and the laser.
4. Call your instructor over when you are ready to test your setup.
5. Turn on your laser and record your score. You will have three tries to hit the target. After each attempt the laser will be turned off so you can make adjustments. Record your score after each attempt.

Questions for each group to ponder:

- How will you keep track of the laser's path?
- How will you make sure the path you mark is straight?
- Will you decide on the mirror positions first or decide on the path of the laser first?
- How will you use the protractors to predict the path of your reflections?
- Are there other methods of checking that your setup will work?
- How will you manage your time to get in 3 accurate attempts for each round?

Reflection Bullseye Scorecard

You get three attempts to hit the target in each round. If you get a 100, move on to the next Round. Record your scores in the table below.

Round 1 : One mirror

Attempt	Score
1	
2	
3	

Round 1 Best Score : _______

Round 2 : Two mirrors

Attempt	Score
1	
2	
3	

Round 2 Best Score : _______

Round 3 : Three mirrors

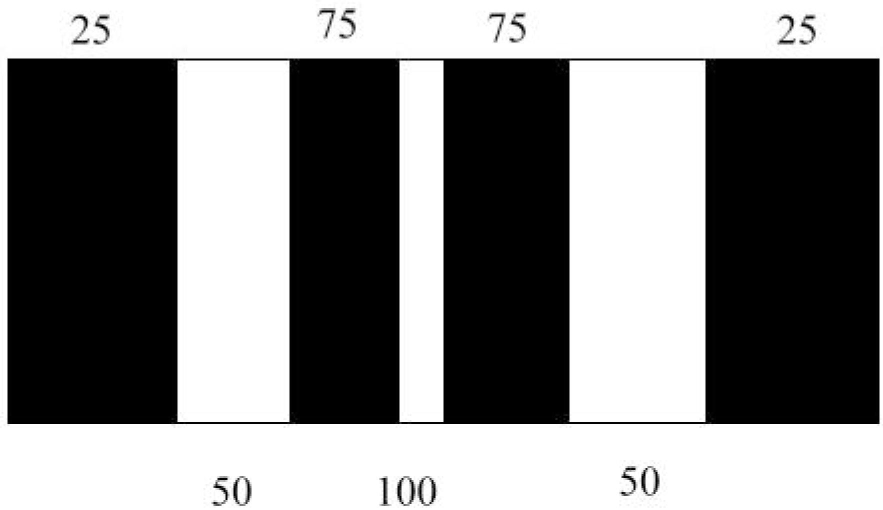
Attempt	Score
1	
2	
3	

Round 3 Best Score : _______

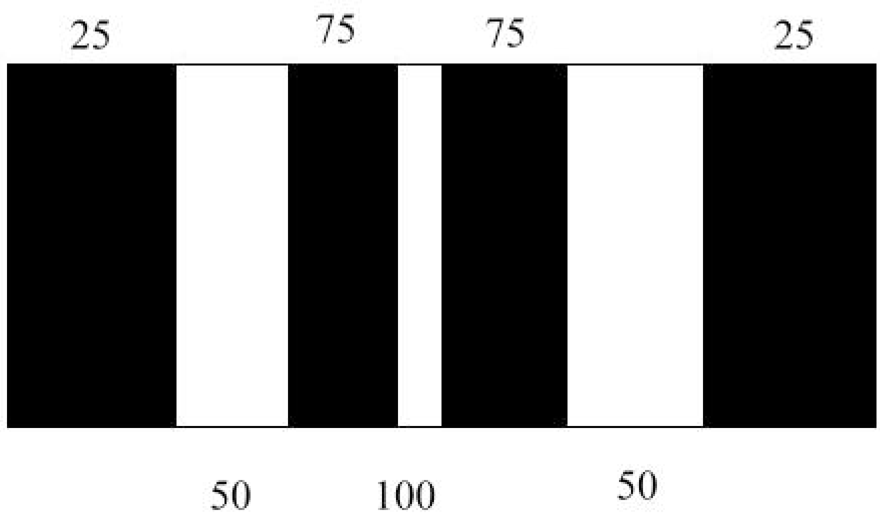
Grand Total of Best Scores:

____

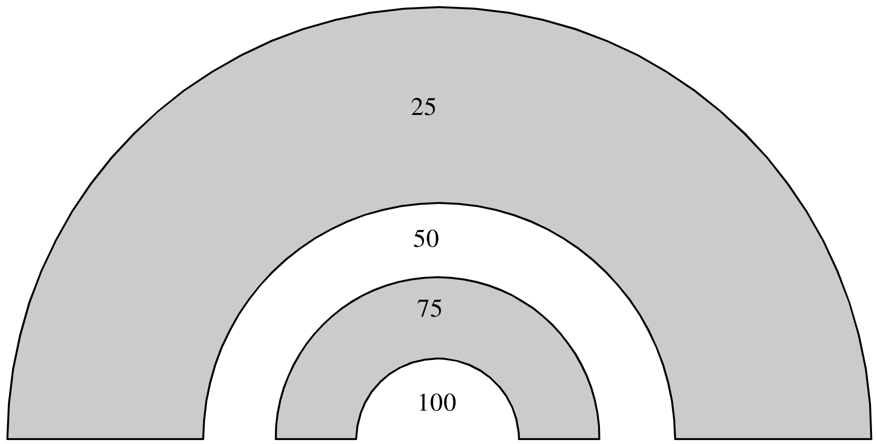
Targets for the *Hit the Target* Activity



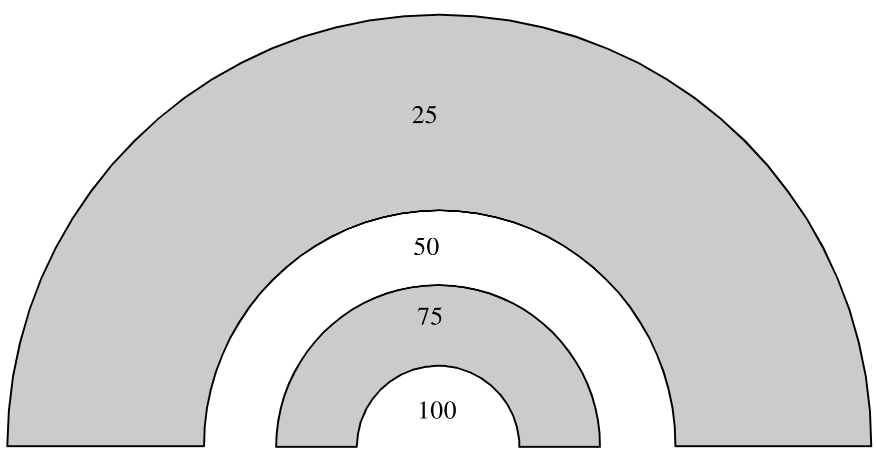
-- Cut along this line. --



-- Cut along this line. --



-- Cut along this line. --



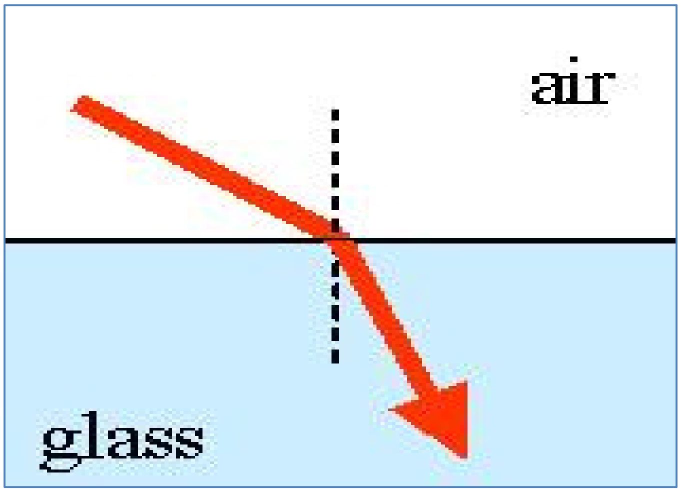
-- Cut along this line. --

Refraction and Lenses

Refraction occurs because light bends as it passes from one *medium* (material) to another of different density because its speed is different.

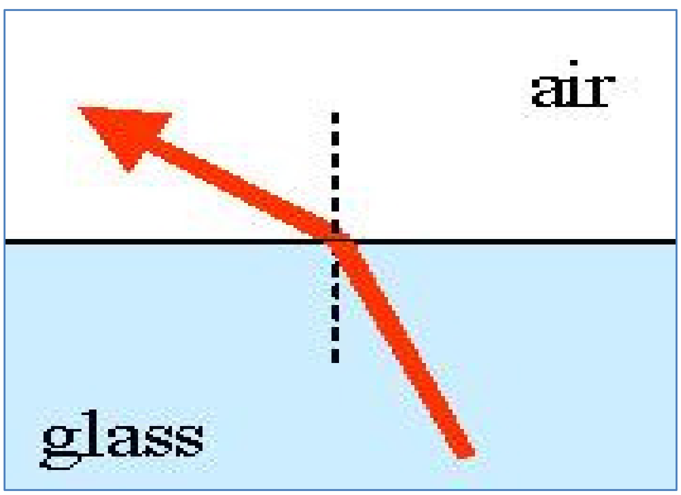
Incident Ray: Incoming Ray
Refracted Ray: Outgoing Ray
Normal: Dotted Line perpendicular (90°) to objects light changes medium

Label/Draw the **incident ray, refracted ray, normal, angle of incidence and angle of refraction**



The light starts in the air and hits the glass in the bottom half of the picture. As it enters the glass, **it bends towards** the normal--when light slows down (enters glass) it bends TOWARDS normal

Label/Draw the **incident ray, refracted ray, normal, angle of incidence and angle of refraction**

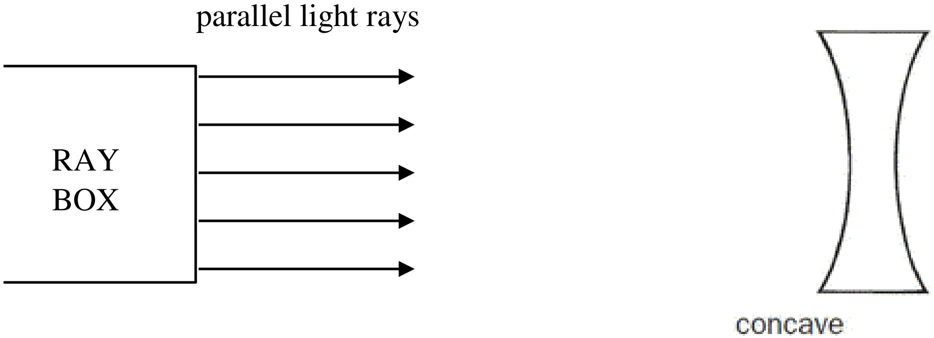


When light travels from glass into air, the exact opposite thing happens: It will **bend away from the normal**-- when light speeds up (enters air) it bends AWAY from the normal

- *For concave and conves lenses, set up the Ray Box and see what happens. Using a ruler, draw the **refracted rays**:*

Concave Lens

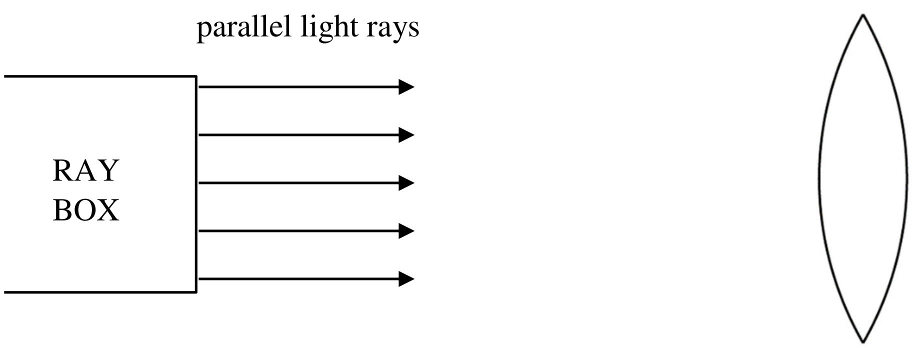
parallel light rays



Do light rays: *diverge* *converge* *go straight through*

Convex Lens

parallel light rays



Do light rays: *diverge* *converge* *go straight through*

Compare what happens with REFLECTED RAYS when they strike Concave and Convex Mirrors with REFRACTED RAYS when they strike Concave and Convex Lenses.

____

____

____

____

Concave Lenses Uses

Glasses/Contacts

- Opticians use concave lenses to correct nearsightedness -- also called myopia. A nearsighted eyeball is too long, and the image of a far-away object falls short of the retina. Concave lenses in glasses correct this shortfall by spreading out the light before it reaches the eye, thereby enabling the person using them to see distant objects more clearly.

Flashlights

- Concave lenses are used on flashlights to magnify the light produced by the bulb. The light falls on the concave side of the lens, and the rays diverge on the other side, thereby increasing the apparent radius of the light source and providing a wider beam.

Peepholes

- Door viewers, or peepholes, are small security devices that provide a panoramic view of objects and environments outside doors or walls.

Convex Lenses Uses

Binoculars*/Telescopes*/Microscopes/Magnifying Glass

- Binoculars and telescopes employ convex lenses to magnify objects and make them appear closer

Glasses/Contacts

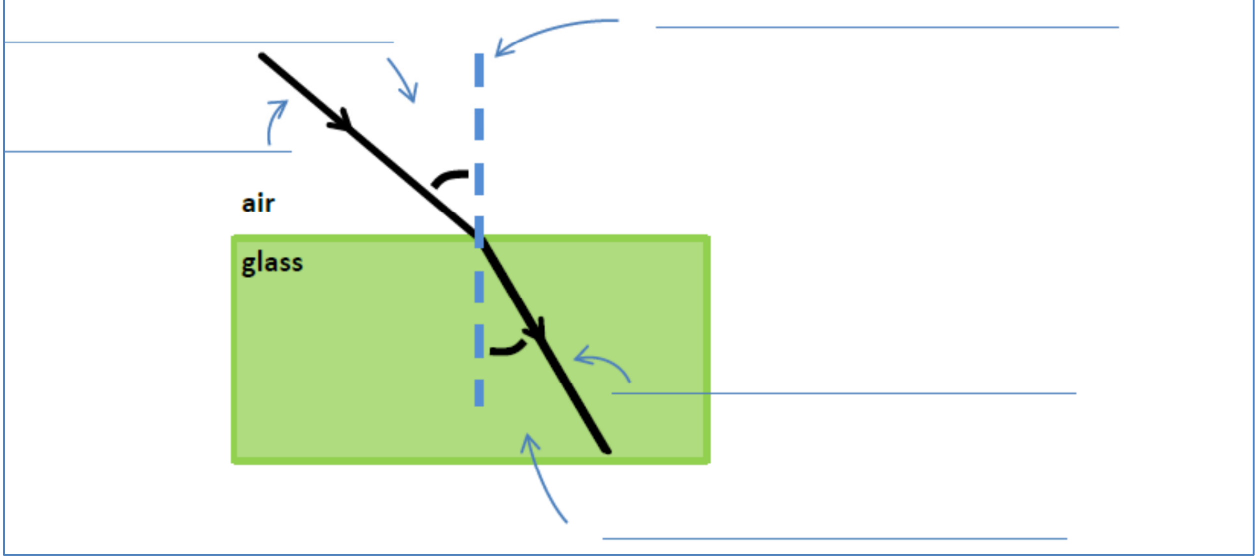
- Opticians use convex lenses to correct farsightedness.

Cameras

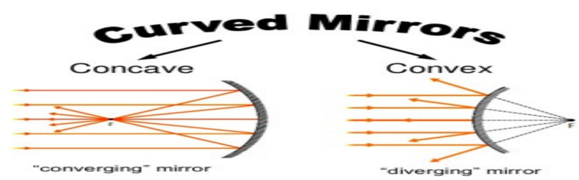
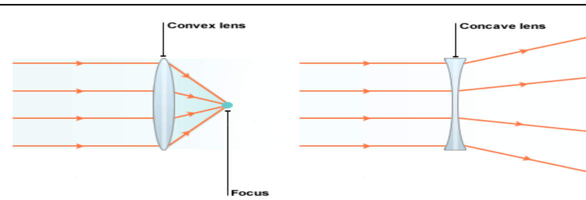
- Camera manufacturers use combinations of concave and convex lenses to improve the quality of photographs. The primary lens of a camera is convex.

*Also contain Concave lenses to make image appear clearer.

Label the following diagram.



List 3 <u>uses</u> each for Concave/Convex Mirror and Lenses

<u>Mirrors</u>	
Concave Mirror	**Convex Len**
• • •	• • •
<u>Lenses</u>	
Concave Lens	**Convex Lens**
• • •	• • •

Human Vision

Summary: What happens to light that enters the eye?

1. First, light rays are refracted by the ***cornea***. The cornea does most of the focussing of the light rays.

2. Next, the refracted rays enter the eye through the ***pupil***. The ***iris*** changes the size of the pupil. The pupil gets larger to let more light in if light levels are dim. The pupil gets smaller to let less light in if light levels are bright.

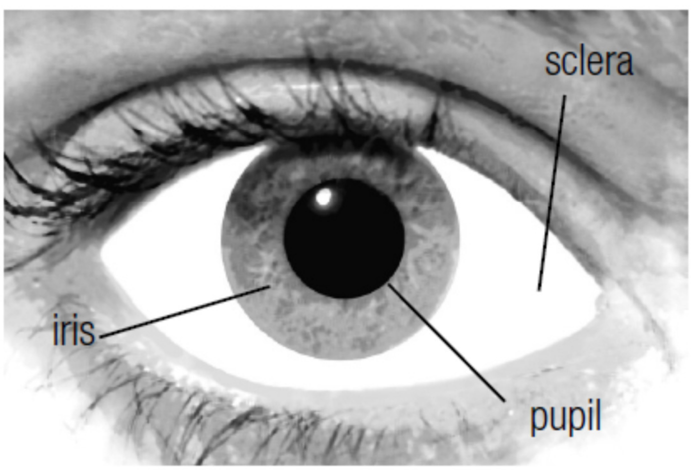
3. Then the light rays pass through the ***lens***. They converge on the ***retina***. The lens gets thicker to help focus light rays from objects that are closer to you. The lens gets thinner to help focus light rays from objects that are farther away.

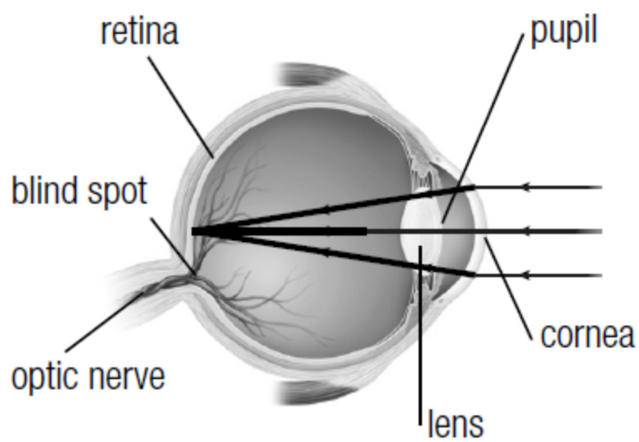
4. The image formed on the retina is upside down. Cells in the retina change the image into electrical signals.

5. The electrical signals are sent to the brain along the ***optic nerve***. As the brain interprets the signals, it changes the image so that it is upright

.

***Read pages 202-205 in the SCIENCE 8 TEXTBOOK* . Complete the following assignment.**





Provide the definitions

Pupil:

____

____

Iris:

____

____

Cornea:

____

____

Sclera:

____

____

What is the function of the iris? Explain.

The chambers in front and behind the lens appear empty – is this true? Explain.

What part(s) of the eye focus the light rays as they enter the eye? Explain.

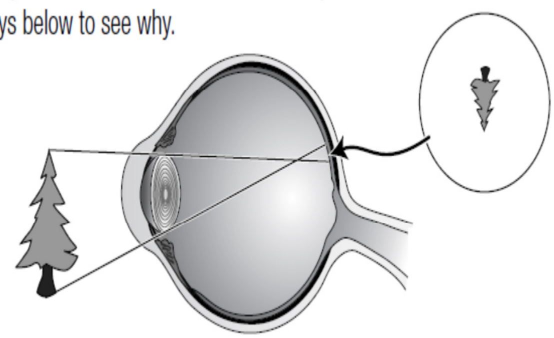
How does your eye adjust so it can focus on both near and far objects? Explain.

Provide the definitions

a) **Retina:**

b) **Optic Nerve:**

The image of an object that is formed on the retina is upside down. Follow the light rays below to see why.



Where is the "blind spot" located in the eye? Explain.

To locate your blind spot, hold this page at arm's length. Cover your right eye with your hand. Stare at the **X** while you move the book slowly toward yourself. The dot should disappear and then reappear as its image moves onto your blind spot and then off again.

● **X**