SNC 2DI - 10.2 Properties of Light and Reflection

Light travels in straight lines, this is referred to as _____... this means that light does not bend...

_____

Reflection :

Light travels in a straight line as long as it is moving through the _____

A medium is a substance in which waves can travel through,
***examples air, water, lead

A ray is a straight line with an arrowhead that shows the direction in which light is traveling

Application: **Shadows**

*Why is a shadow greater when the object is closer to the light source than farther away?

-It has to do with how much of the ray is blocked and emphasises the concept that light travels in straight lines and is not capable of bending or curving around an object.

Fermat's Principle: light follows the path that will take the least amount of time, ie therefore it follows the shortest path

Laws of Reflection:

The Laws of Reflection are:

Images in Plane Mirrors

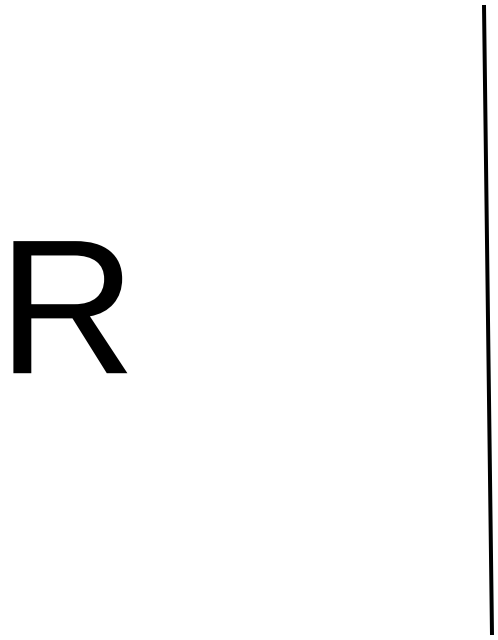


Image Characteristics (LOST)

*__Location__: relative location of image compared to object

*__Orientation:__ is the image erect (upright) or inverted (upside down)

*__Size__: is the image larger, smaller or the same size as the object

*__Type__: real or virtual

*A real image can be seen on a screen

*A virtual image cannot be seen on a screen – light rays never cross to produce an image

*** Show how the eye perceives the letter R in the mirror in the above diagram***

SNC 2DI Images in Concave Mirrors

Concave mirror, is a mirror with a reflecting surface that curves inward

*Remember the **angle of** _____ **always equals** _____

*Visualize the concave mirror as having many flat mirrors, that jaggedly put together represent a curve, these small flat mirrors represent the surface of the mirror where the 'normal" is drawn from

*If you draw the normals for all the small flat mirrors, all the normals come together at one point, this point is called the **centre of curvature**... see below...

*The normal that touches the centre of the mirror is called the _____

*The point where the principle axis cuts the centre of the mirror is called the _____

KEY points when drawing rays for concave mirrors

Parallel rays with the principle axis will always reflect through the same point, this point is called the focal point

AND

Any ray that travels through the focal point will always reflect parallel to the principle axis

The distance between the focal point and the vertex is called the _____

NOTE: The bottom of an object is always placed on the principle axis, therefore only need to draw rays from the top of the object to determine the LOST principles of the image

Finder Rays are used to form the image, **they must originate from the same point on the object**

1. Parallel to the principle axis and reflects through the focal point

2. To the vertex and reflects at the same angle the incident ray went in but on the other side of the principle axis

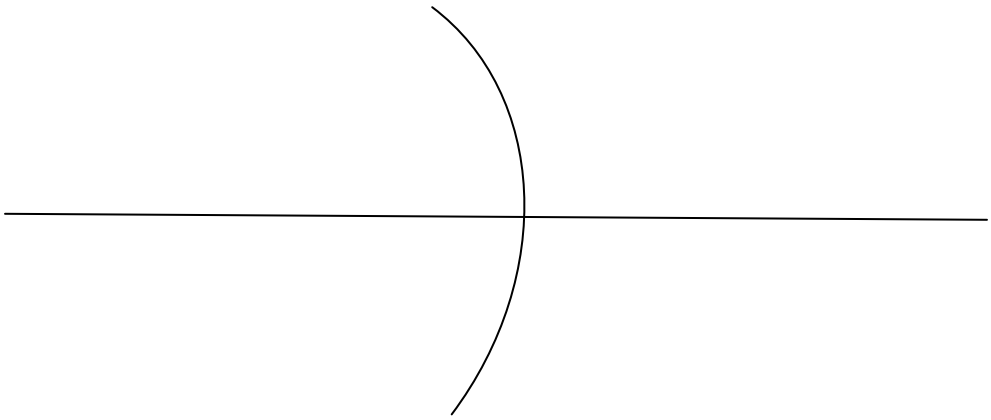
3. Through the focal point and reflect parallel to the principle axis

NOTE: Where the reflected rays cross is where the image forms

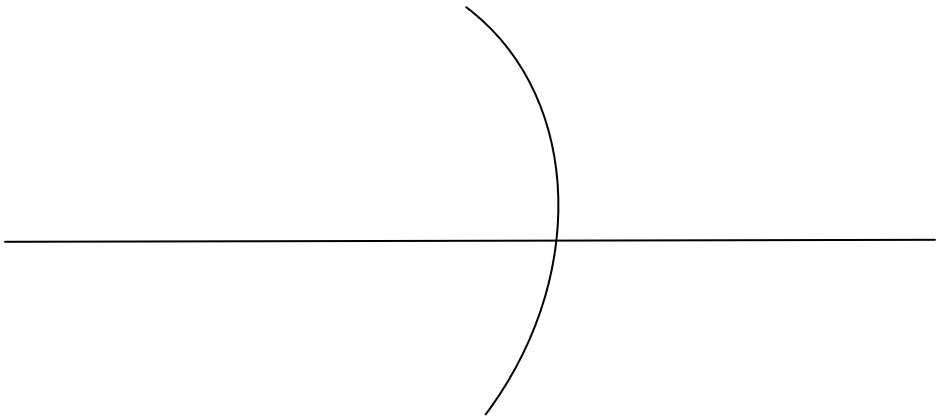
ONLY reflected rays can be extended

Using the finder rays determine the LOST principles for the situations below.

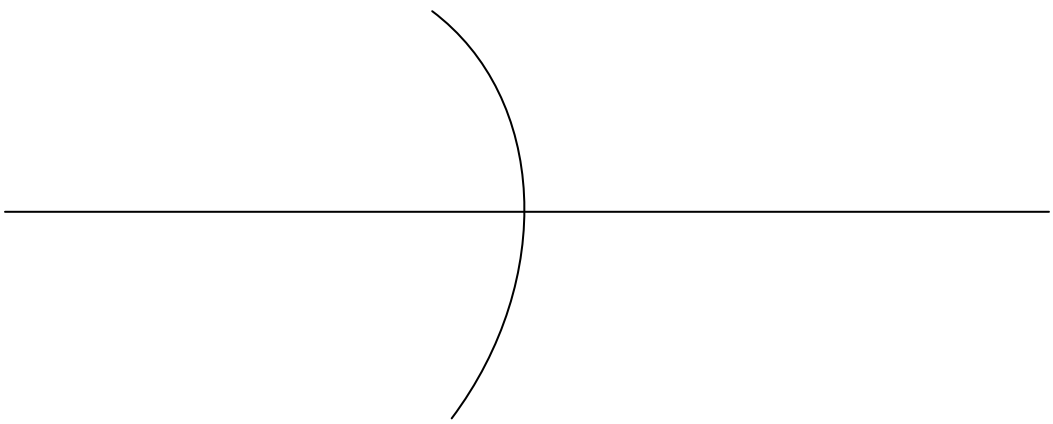
Situation 1 Object between the focal point and the mirror



Situation 2 Object between focal point and centre of curvature

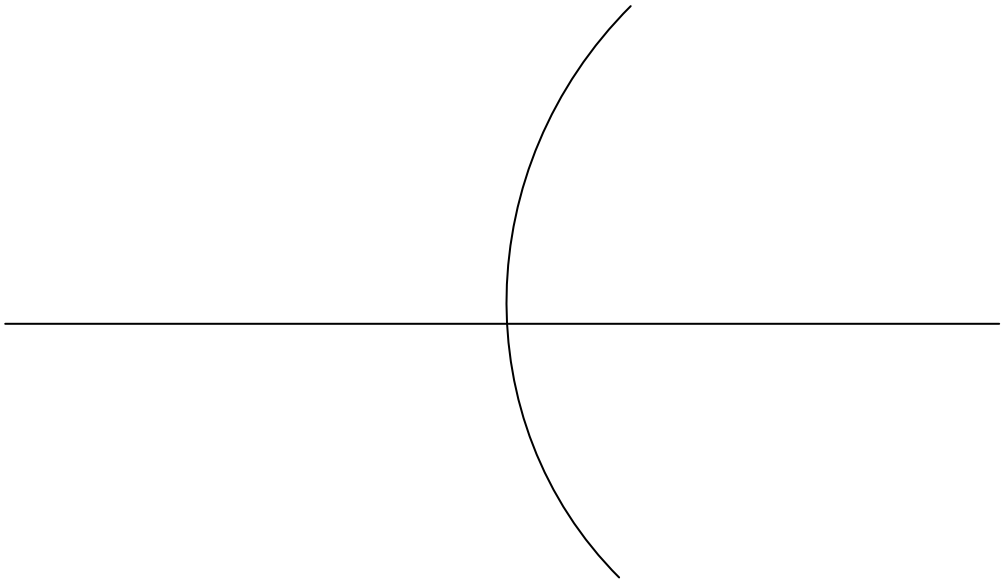


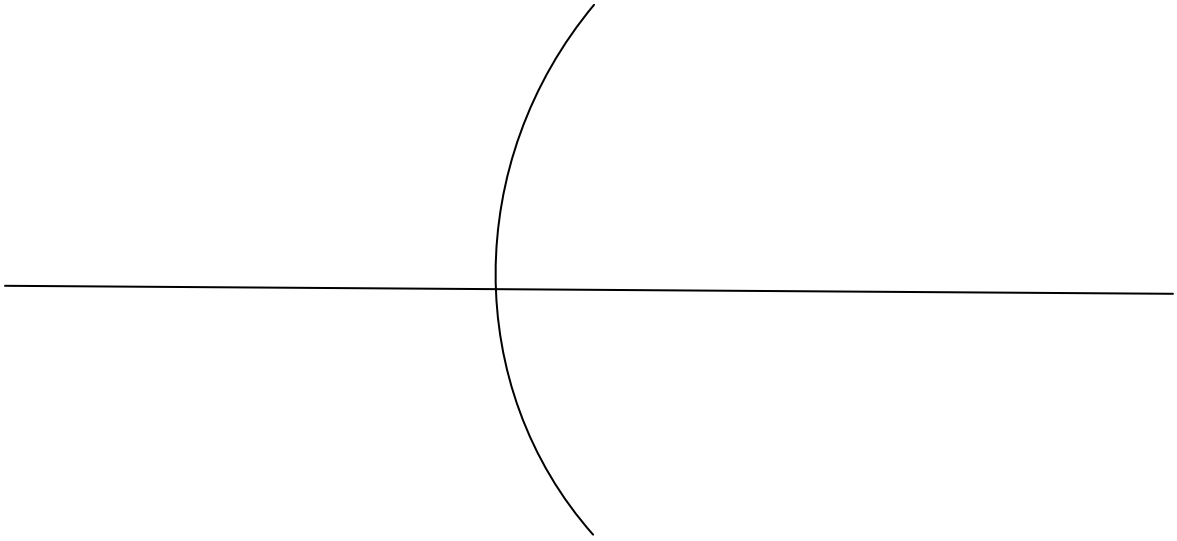
Situation 3 Object beyond Centre of Curvature

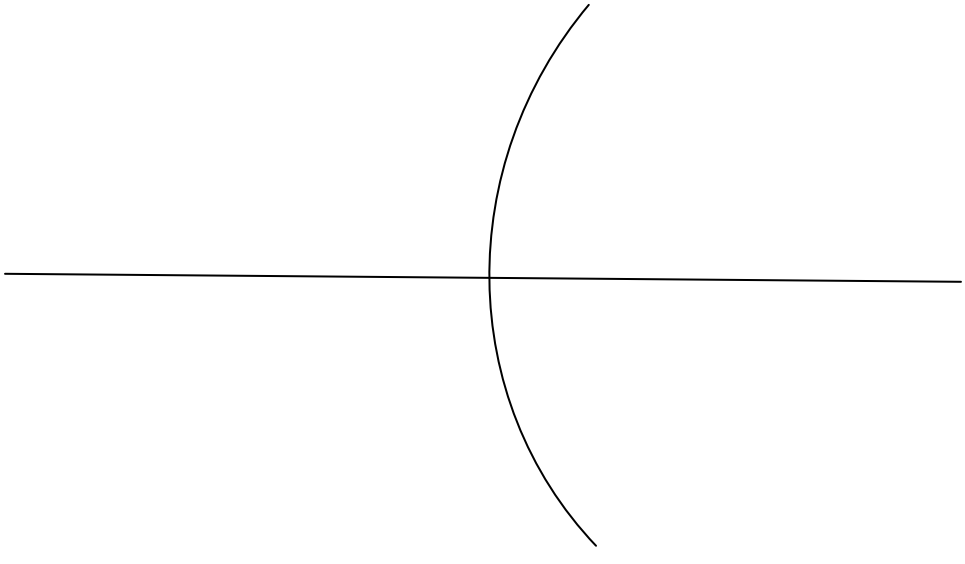


Convex Mirrors....

-Convex mirrors are also known as _____ because....







Calculations...

*There are two equations that can be used to predict the characteristics of images

Mirror Equation:

Magnification Equation:

Sample Questions:

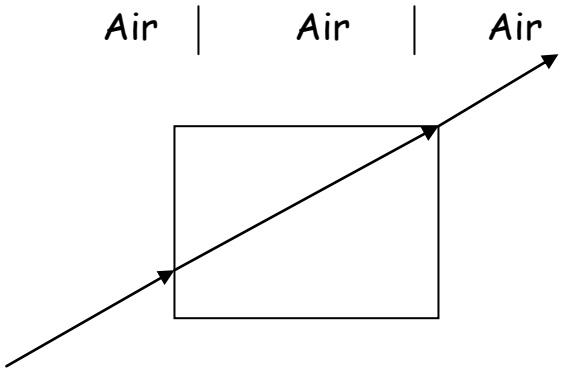
1. A concave mirror has a focal length of 15cm. The height of the object is 4.0cm and is placed 35cm in front of a concave mirror. Determine the images distance and height.

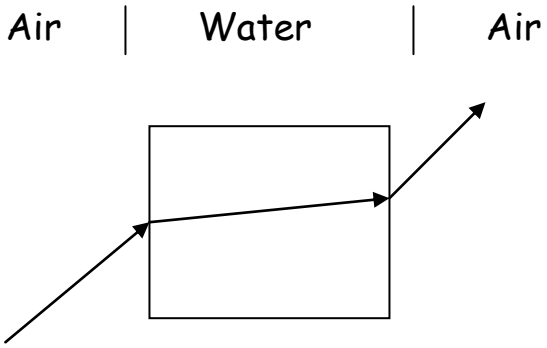
2. Determine the focal point for a mirror in which the distance from the object to the mirror is 30 cm and the distance from the image to the mirror is 45 cm.

SNC 2DI

Refraction

We have discussed how light travels in a straight line as long as it stays in the same medium. But what happens when light moves into a new medium?

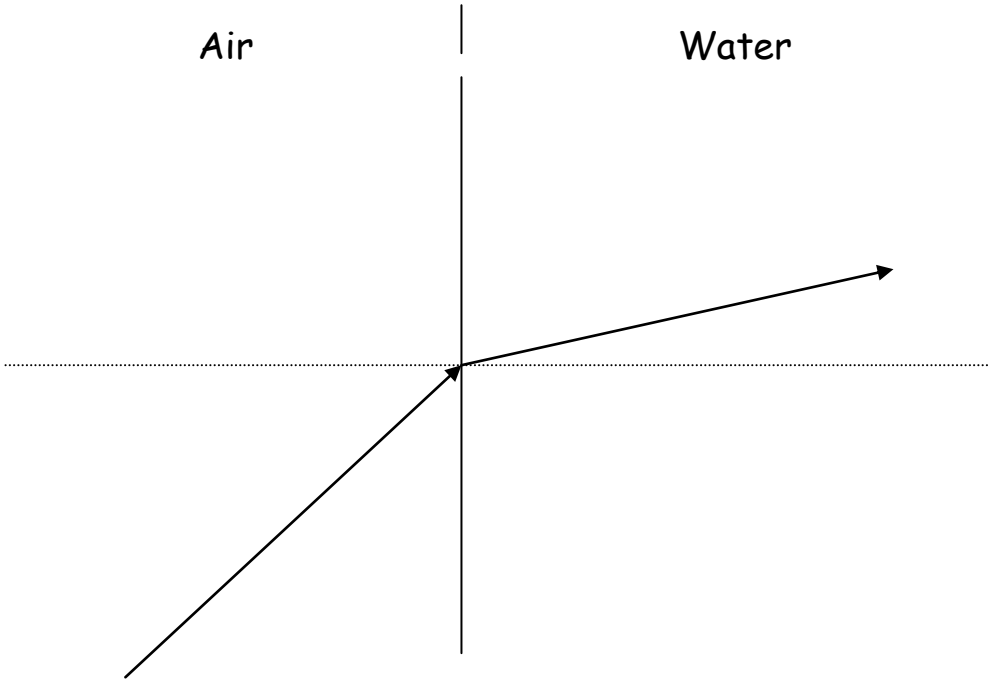




When light crosses a _____ into a new medium it bends changing the ray's direction. When a light ray _____ it is called _____.

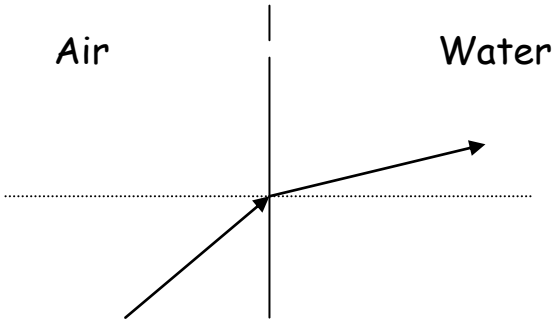
Light refracts because when travelling through a more _____ medium it slows down. Optical density is a measurement of how much light is slowed down by a medium. Light travels the fastest in a vacuum like in space. The speed of light in a vacuum is _____. In all other mediums it is slower.

First let's review some terminology:

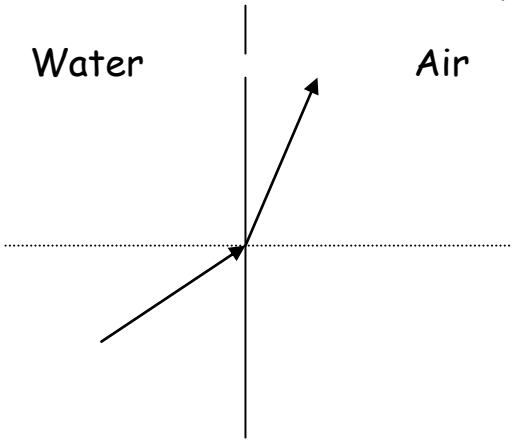


Rules of Refraction

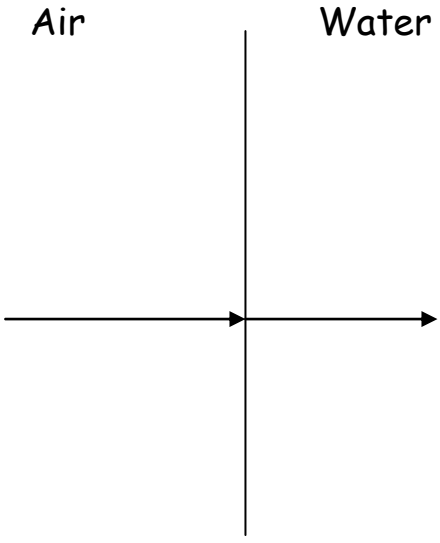
1. When light travels from a less _____ dense medium to a more optically dense medium the refracted ray bends _____ the normal.



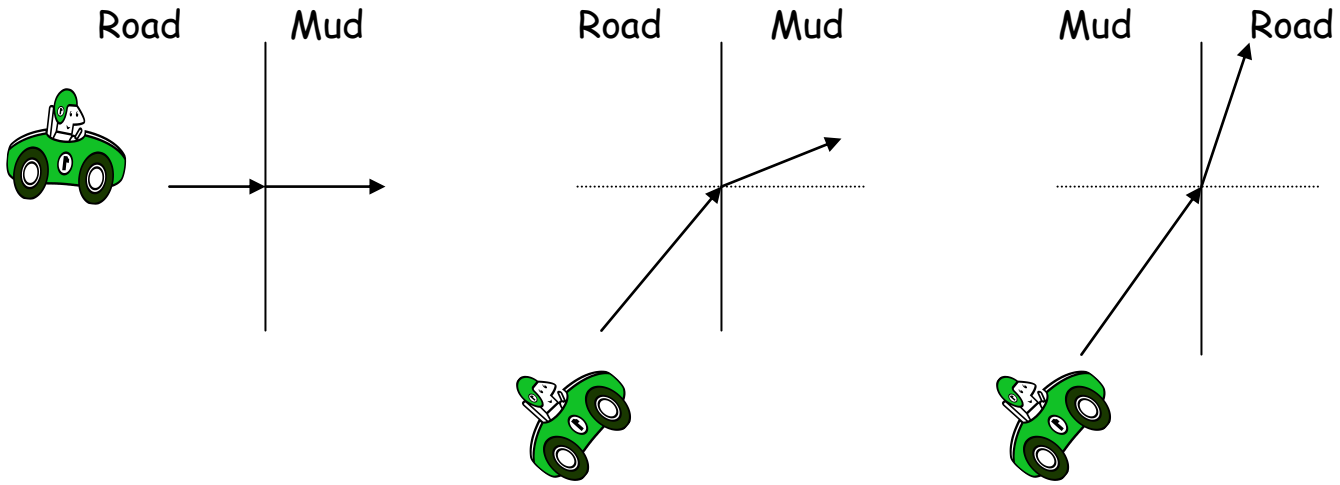
2. When light travels from a more optically dense medium to a less optically dense medium the _____ bends away from the _____.



3. When the angle of incidence is 0, no _____ occurs.



Light refracts because of its _____ properties but refracting light can be thought of like a car.



Think of your car as a beam of light. When it comes to a barrier with mud if there is ___ angle it will _____ affect the direction of the car.

If you approach mud on an angle, the tires contacting the mud will _____ while the tires on the road will keep going the same speed. This will turn the car into the mud. The opposite will be true for leaving the mud.

Index of refraction

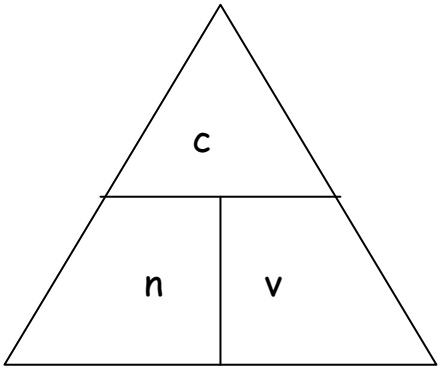
The index of refraction:

$$n = c/v$$

n =

c =

v =

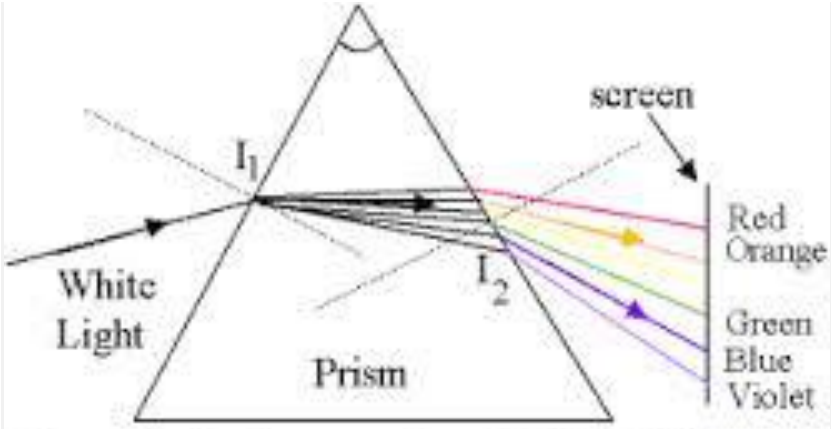


Let's do a practice problem together.

You are told that the index of refraction for glass is 1.5. What is the speed of light in glass? (use the G.R.A.S.P. method)

Application: White Light and Prisms:

Q – How do prisms form little rainbows?



Dispersion is the separation of light into its constituent colors.

11.2 Partial Refraction and Total Internal Reflection

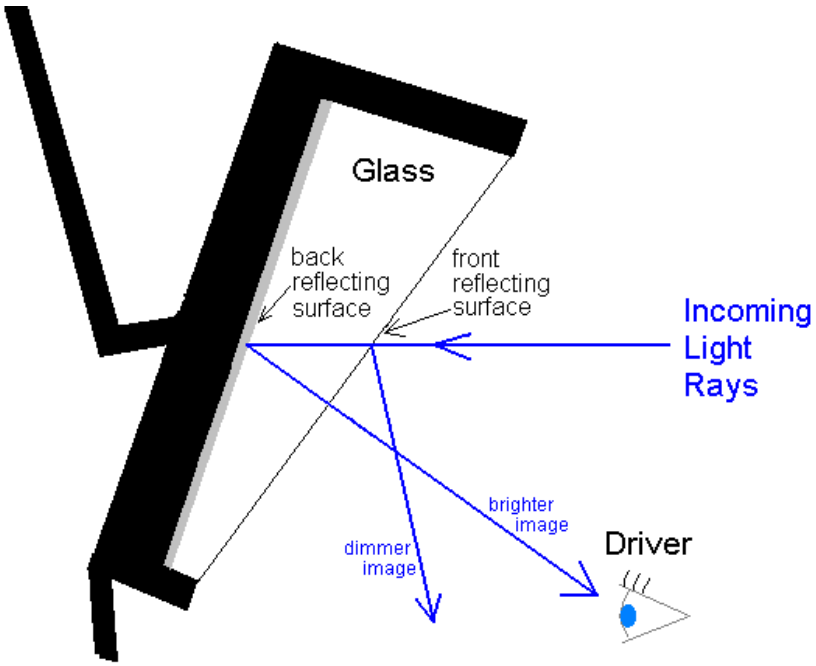
*When an incident ray strikes a surface, some rays reflect forming a mirror image and some rays refract, ie penetrate through the surface… this is called partial reflection and partial refraction

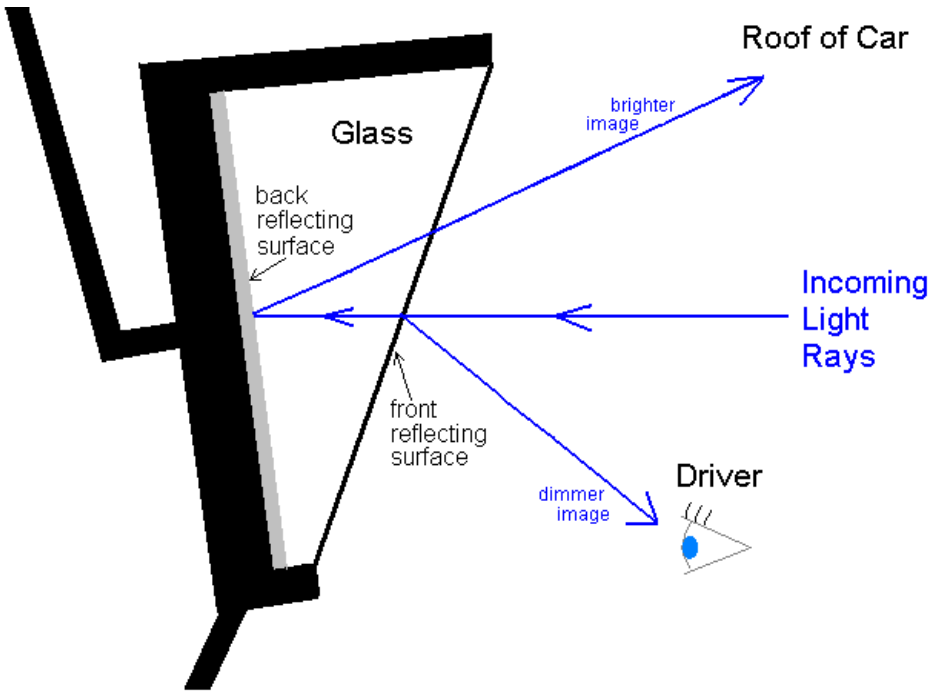
*As the angle of incidence increases, more light is reflected than refracted

Examples: *sunset – lots of rays are reflected that is why the surface of a lake or pond sparkles at that time of day

*Mid day – there would be more refraction than reflection, cause the sun is directly overhead

Rear view Mirrors

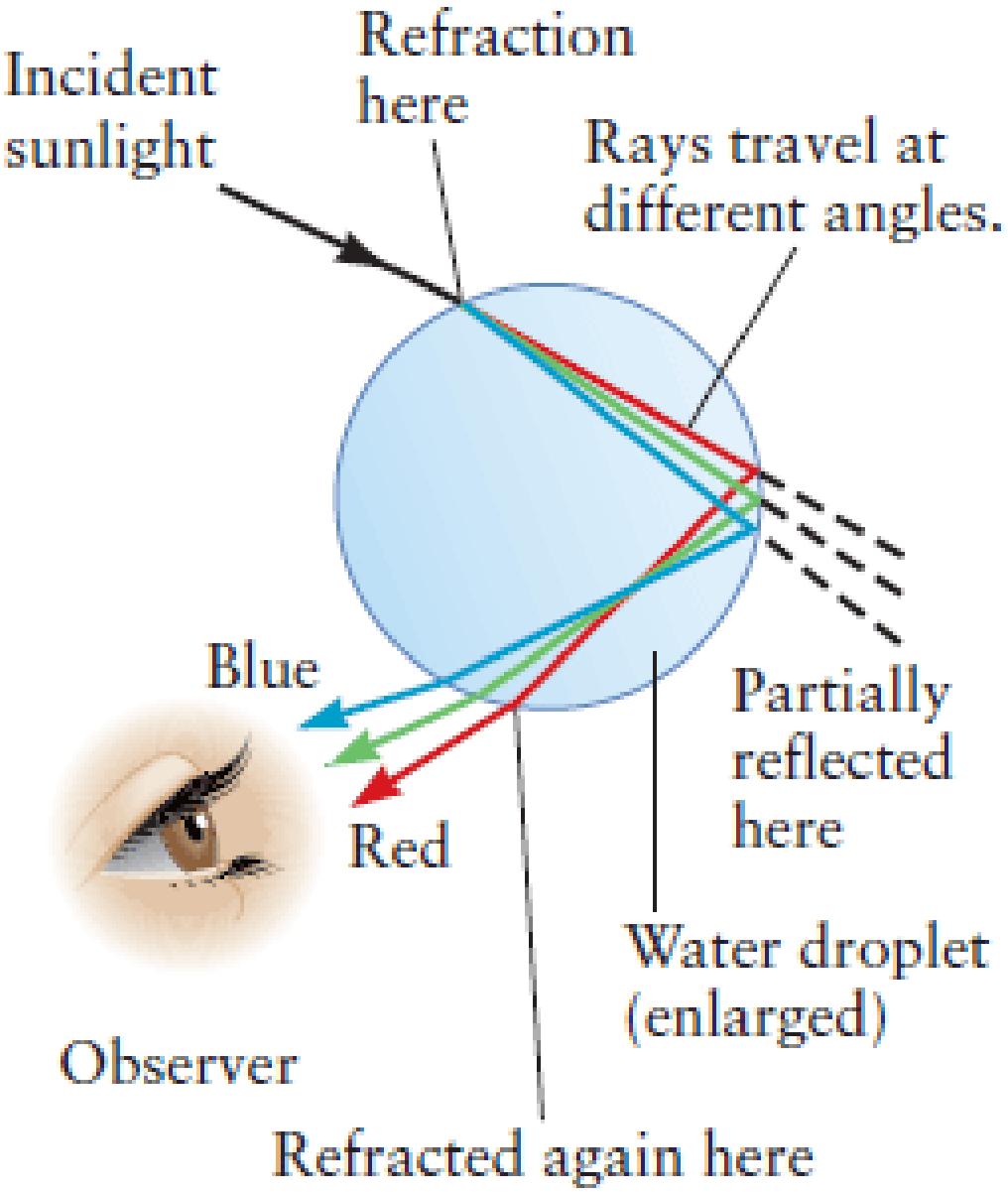




How Rainbows Form …

The next thing you need to know is that the amount of refraction also depends on the wavelength the light wave entering into it. Visible light ranges from about 400 nanometers to 700 nanometers – the longest wavelength of visible light appear red to us, while the shortest are the blues and violets.

So now that our white light, which contains all of the colors, has entered the water droplet, the different wavelengths of light refracted at different slightly different angles causing them to separate. The light waves then hit another side of the water droplet, and are reflected off of the surface back into water droplet. It finally hits the inside surface of the droplet for a third time and leaves. As it leaves, it is again refracted and the wavelengths are further separated.



Critical Angle:

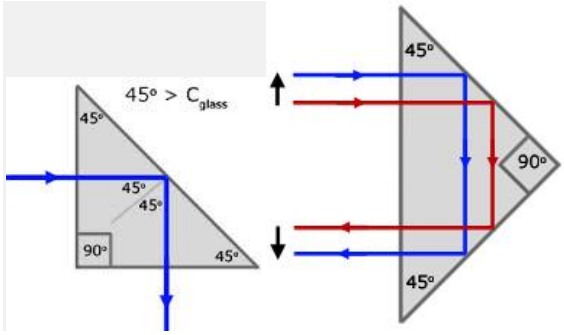
water
air

Critical Angle – the angle of incidence that produces an angle of refraction of 90 degrees

Total Internal Reflection: when the angle of incidence is greater than the critical angle, all the light is reflected within the medium and is not refracted

Applications:

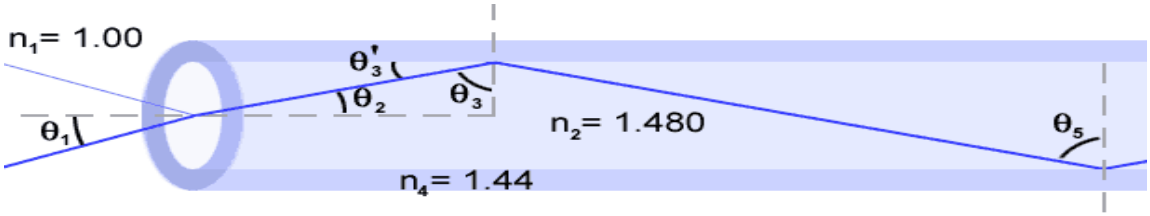
*__Glass Prisms__: the critical angle for glass and air is 42 degrees, therefore shining a light at 45 degrees will cause all the light to be internally reflected



***Retroreflectors** – bike reflectors

*light comes in and is reflected back
*Reflectors ONLY work when light is shined on them

*__Optical Fibres__ aka Fibre Optics: (Total Internal Reflection)
-can carry hundreds of phone conversations, cable and tv signals and data
-used in medicine and lab procedures

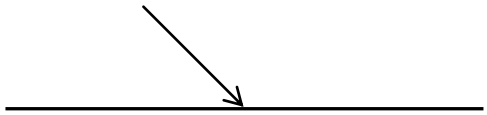


Snells Law…

Review - Draw the estimated refracted rays for the following diagrams …

Diagram A

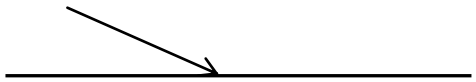
n = 1.00



n = 2.42

Diagram B

n = 1.33



n = 1.00

*From the lab of Refraction Light we completed we know that

$$\frac{\sin i}{\sin R} = n$$

Since there is a relationship of sin of the incident ray and sin of the Refracted ray the above equation can be developed further into… **Snells's Law**

$$\mathbf{n_1 \sin O_1 = n_2 \sin O_2}$$

Therefore we can use this equation to determine the angle of incidence OR angle of refraction OR the critical angles. Let's practice with the questions below.

Ex. Light travels from crown glass into air. The angle of refraction in air is 60 degrees. What is the angle of incidence in glass?

Note: Critical angle occurs when the angle of refraction is 90 degrees, therefore determine the following;
*Determine the critical angle for when light travels from crown glass into air.

Refraction Practice Questions:

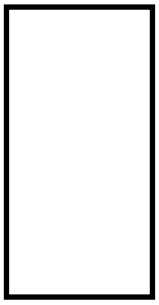
1. What is the index of refraction of a solid in which the speed of light is 1.943×10^8 m/s.
2. Determine the speed of light in a diamond.
3. What is the speed of light in glycerine?
4. Determine the time taken for light to travel a distance of 3500 km along the core of an optical fibre.
5. Determine the change in the speed of light as it passes from ice into water, n for ice is 1.31.
6. What is the index of refraction of a material if the angle of incidence in air is 50 degrees and the angle of refraction in the material is 40 degrees? What is the substance?
7. If the index of refraction for diamond is 2.42, what will be the angle of refraction in diamond for an angle of incidence, in water of 60 degrees?
8. A ray of light passes from water into carbon disulfide (n=1.63) with an angle of incidence of 30 degrees. What is the angle of refraction in the carbon disulfide?
9. A diver shines her flashlight upward from beneath the water at an angle of 30 degrees to the vertical. At what angle to the vertical does the beam of light emerge from the water?
10. What is the critical angle in flint glass when light passes from flint glass into air?

SNC 2DI Lenses

Lenses are defined as

Converging Lenses **Diverging Lenses**

NOTE: A glass block that has 2 flat sides, will cause rays of light to be _____, but does not cause rays of light to diverge or converge, there a glass block is ____ a lens.



Aberrations:

***Spherical Aberration**
-applies to mirrors
-occurs when there are irregularities in an image prisms
in a curved mirror that result when reflected rays from the outer parts of the mirror do not go through the focal point

***Chromatic Aberration**
-applies to lenses
-the edge of a lens is similar in shape to

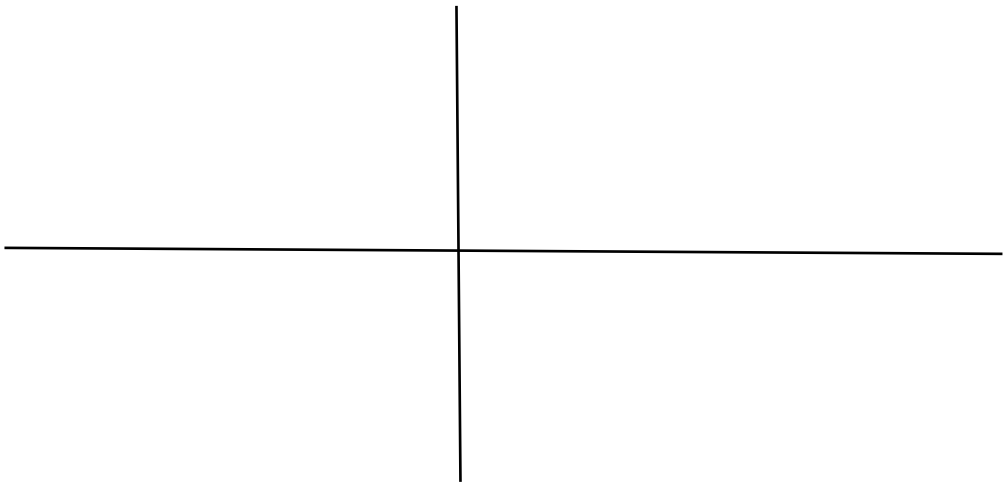
therefore, chromatic aberration occurs when light strikes the edge of the lens and light is dispersed into its individual colours

Lenses Terminology
*Principle Axis:

*Axis of Symmetry

Ray Diagrams for Converging and Diverging Lenses

Principle Rays for **Converging Lenses:**



Principle Rays for **Diverging Lenses:**