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Honors Physical Science Additional Notes

Light Reflection and Refraction

**Reflection:**

When the re-emitted light is returned into the medium from which it came, it is said to have been \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, this process is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. This paper is white because it re-emits light of \_\_\_\_\_\_\_\_\_ the \_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. However, the ink is black because no light is reflected; in fact all the visible light frequencies are being \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ by the ink.

What frequencies of light are being reflected by your neighbor’s shirt?

What color is your neighbor’s shirt?

***Fermat’s principle of least time***says, out of all possible paths light might take to get from one point to another, it takes the one that requires the shortest time.

See the figure below to work out how to do this when light must be reflected off a mirror to get from point A to point B. (C is the point where the ray of light would intersect with the mirror, and B’ is the image of B you would see in the mirror.)

The figure above illustrates that the *angle of incidence equals the angle of reflection.* This is known as the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The figure below illustrates ***the law of reflection.***

Instead of measuring the angles of incidence and reflection from the plane of the mirror, they are measured from an imaginary line that lies perpendicular to the plane of the mirror called the *normal.*

**Plane Mirrors- a flat mirror**

If you placed a candle in front of a plane mirror, an infinite number of rays of light will be sent out radially in all directions from the candle. When some of these rays encounter the mirror, they are reflected at angles equal to the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Because these rays are diverging from the candle light they will also diverge from the mirror. However, they also seem to be coming from a particular point from behind the mirror, and thus we see this point as the reflection of the candle. The actual name for this is the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. This image appears to be the same \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ behind the mirror as the candle is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the mirror. In a plane mirror this image will also appear to be the same \_\_\_\_\_\_\_\_\_\_\_\_\_\_ as the candle.

See the figure below.

**Curved Mirrors**

When the mirror is curved, the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of an object and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are no longer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Although the law of reflection still holds, because the mirror is curved we must assume that the curve is actually a succession of flat mirrors, each placed at a slightly different \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Therefore allowing each ray of light to have an angle of incidence equal to the angles of reflection. Due to the mirror’s curved shape, where the mirror is convex (curves outward) the image appears smaller and closer, and where the mirror is concave (curves inward) the image appears bigger and farther away.

When light is re-emitted on a very smooth surface like a mirror, the reflection is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or specular reflection. Here incident rays remain parallel on the reflection. However, on a rough or irregular surface the incident rays do not reflect parallel. In fact they reflect in different directions creating an appearance that is less shiny and polished. This form of reflection is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (or diffuse) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Refraction:**

Light travels at \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in a vacuum. However, the speed at which light will travel is somewhat governed by the medium/material it is in. The more \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the medium becomes, the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ light will travel. As light changes speeds as it moves from one medium to another it \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. This bending is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. This is commonly observed when light bends as it goes from traveling through air into a glass of water. Despite this bending of light by refraction, the past of least time is still observed.

Imagine light going through a thick pane of glass. If the light hits the glass perpendicularly, it will continue traveling in a straight line. However, this is not the case when the light approaches the glass from an angle. (See the figure below)

The light will be forced to slow down. When light is forced to slow don it will bend towards the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. This change in angle will allow the light to travel a shorter distance through the glass, following the path of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. As the light emerges through the other side of the glass it will speed up and bend away from the normal resulting in a path that runs parallel to its original path. The more you move the source of light away from perpendicular, the more pronounced the angle of refraction would become.

**The Index of Refraction**

The index of refraction is a ratio that determines the difference in speed between light traveling in a vacuum and another medium. It is represented by the letter *n*, and can be calculated by dividing the speed of light in a vacuum by the speed of light in another medium. The index has no units. The index for light in a vacuum will always be one and in other mediums result in a number greater than one.

**Dispersion**

When light enters a transparent medium, it will slow down to a value less than  *c* (the speed of light in a vacuum). As white light enters a prism , light of a high frequency will travel slower than low frequency light. As a result of this, ultraviolet and blue light will refract differently than infrared and red light. Due to light refracting by different amounts in transparent prisms they bend at different amounts, as the light emerges through the other side a spectrum of colors is exhibited. This separation of light into their colors is called dispersion. By this same process in millions of raindrops during a shower, you are able to see a rainbow.

**Internal Reflection**

If you shine light from below the surface of water, some will emerge at a refracted angle and some will be reflected back below the surface of the water. As the source of light moves further from the perpendicular, less light emerges as more is being reflected. Eventually, the source of light will reach an angle at which no more light emerges, as all the light is reflected below the surface of the water. This reflection is called *internal reflection* and the angle at which no light is emerging and all light starts to be reflected below the surface is called the *critical angle*. When all the light is being reflected below the surface of the water we call this *total internal reflection.* This principle is used to determine the purity of gemstones, through identifying the critical angle, and also in the use of fiber optic cables.

**Lenses**

Lenses that cause light to converge are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ lenses. They are thicker in the middle than they are on the ends. Lenses that cause light to diverge are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ lenses