A branch of physics that studies electromagnetic radiation (for example, light and infrared radiation), its interactions with matter, and instruments used to gather information due to these interactions. Optics includes the study of sight.

Optics is the science of light. You rely on optics every day. Your digital camera, wireless mouse, and even your Blu-ray disc of your favorite movie are all technologies enabled by the science of optics. More specifically, optics is a branch of physics describing how light behaves and interacts with matter. OK, that sounds like something your 5th period teacher rambles on about, - right?

Think of it this way…The power and special properties of light can be used to explore the universe, monitor the environment, and even solve crimes. By utilizing their knowledge of how light behaves under different conditions, scientists and engineers create cool technologies that make your world better.

When a ray of light strikes a plane mirror, the light ray reflects off the mirror. Reflection involves a change in direction of the light ray. The convention used to express the direction of a light ray is to indicate the angle which the light ray makes with a normal line drawn to the surface of the mirror. The angle of incidence is the angle between this normal line and the incident ray; the angle of reflection is the angle between this normal line and the reflected ray. According to the law of reflection, the angle of incidence equals the angle of reflection.

The bottom line is: without light, there would be no sight. The visual ability of humans and other animals is the result of the complex interaction of light, eyes and brain. We are able to see because light from an object can move through space and reach our eyes. Once light reaches our eyes, signals are sent to our brain, and our brain deciphers the information in order to detect the appearance, location and movement of the objects we are sighting at. The whole process, as complex as it is, would not be possible if it were not for the presence of light. Without light, there would be no sight.

If you were to turn off the room lights for a moment and then cover all the windows with black construction paper to prevent any entry of light into the room, then you would notice that nothing in the room would be visible. There would be objects present that were capable of being seen. There would be eyes present that would be capable of detecting light from those objects. There would be a brain present that would be capable of deciphering the information sent to it. But there would be no light! The room and everything in it would look black. The appearance of black is merely a sign of the absence of light. When a room full of objects (or a table, a shirt or a sky) looks black, then the objects are not generating nor reflecting light to your eyes. And without light, there would be no sight.

The objects that we see can be placed into one of two categories: luminous objects and illuminated objects. Luminous objects are objects that generate their own light. Illuminated objects are objects that are capable of reflecting light to our eyes. The sun is an example of a luminous object, while the moon is an illuminated object. During the day, the sun generates sufficient light to illuminate objects on Earth. The blue skies, the white clouds, the green grass, the colored leaves of fall, the neighbor's house, and the car approaching the intersection are all seen as a result of light from the sun (the luminous object) reflecting off the illuminated objects and traveling to our eyes. Without the light from the luminous objects, these illuminated objects would not be seen. During the evening when the Earth has rotated to a position where the light from the sun can no longer reach our part of the Earth (due to its inability to bend around the spherical shape of the Earth), objects on Earth appear black (or at least so dark that we could say they are nearly black). In the absence of a porch light or a street light, the neighbor's house can no longer be seen; the grass is no longer green, but rather black; the leaves on the trees are dark; and were it not for the headlights of the car, it would not be seen approaching the intersection. Without luminous objects generating light that propagates through space to illuminate non-luminous objects, those non-luminous objects cannot bee seen. Without light, there would be no sight.

A common Physics demonstration involves the directing of a laser beam across the room. With the room lights off, the laser is turned on and its beam is directed towards a plane mirror. The presence of the light beam cannot be detected as it travels towards the mirror. Furthermore, the light beam cannot be detected after reflecting off the mirror and traveling through the air towards a wall in the room. The only locations where the presence of the light beam can be detected are at the location where the light beam strikes the mirror and at the location where the light beam strikes a wall. At these two locations, a portion of the light in the beam is reflecting off the objects (the mirror and the wall) and traveling towards the students' eyes. And since the detection of objects is dependent upon light traveling from that object to the eye, these are the only two locations where one can detect the light beam. But in between the laser and the mirror, the light beam cannot be detected. There is nothing present in the region between the laser and the mirror that is capable of reflecting the light of the beam to students' eyes.

But then the phenomenal occurred (as it often does in a Physics class). A mister is used to spray water into the air in the region where the light beam is moving. Small suspended droplets of water are capable of reflecting light from the beam to your eye. It is only due to the presence of the suspended water droplets that the light path from the laser to the mirror could be detected. When light from the laser (a luminous object) strikes the suspended water droplets (the illuminated object), the light is reflected to students' eyes. The path of the light beam can now be seen. With light, there can be sight. But without light, there would be no sight.

None of us generate light in the visible region of the electromagnetic spectrum. We are not brilliant objects (please take no offense) like the sun; rather, we are illuminated objects like the moon. We make our presence visibly known by reflecting light to the eyes of those who look our way. It is only by reflection that we, as well as most of the other objects in our physical world, can be seen. And if reflected light is so essential to sight, then the very nature of light reflection is a worthy topic of study among students of physics. And in this lesson and the several that follow, we will undertake a study of the way light reflects off objects and travels to our eyes in order to allow us to view them.

This very principle can be extended to the task of viewing the image of an object in a plane (i.e., flat) mirror:

In order to see the image of an object in a mirror, you must sight at the image; when you sight at the image, light will come to your eye along that line of sight.

The image location is thus located at that position where observers are sighting when viewing the image of an object. It is the location behind the mirror where all the light appears to diverge from. In the diagram below, three individuals are sighting at the image of an object along three different lines of sight. Each person sees the image due to the reflection of light off the mirror in accordance with the law of reflection. When each line of sight is extended backwards, each line will intersect at the same point. This point is the image point of the object.

This principle can be illustrated in a Physics class using a 5-foot plane mirror and a pair of large cylinders. One cylinder is placed in front of the mirror and students from different locations in the room are asked to sight at its image. The second cylinder is then aligned along the line of sight and readjusted until it is in line with each person's line of sight. Regardless of who is viewing the image and from where they are viewing the image, each sight line must intersect in the same location. It is possible that the second cylinder is aligned with one student's line of sight but not with another student's. If this is so, then the cylinder is not placed at the exact location of the image.

the cylinder position is adjusted until it is located at the position where all students in the classroom can see it extending above the mirror and in line with the image that each student sees when looking in the mirror. Only, then can we conclude the cylinder is located at the image position.

Since there is only one image for an object placed in front of a plane mirror, it is reasonable that every sight line would intersect in a single location. This location of intersection is known as the image location. The image location is simply the one location in space where it seems to every observer that the light is diverging from. Regardless of where the observer is located, when the observer sights at the image location, the observer is sighting along a line towards the same location that all other observers are sighting. The perpendicular distance from this image location to the mirror is equal to the perpendicular distance from the object location to the mirror. In fact, the image location is directly across the mirror from the object location and an equal distance from the mirror.

Of course, it is possible that certain individuals in the room will be unable to view the image of an object in a plane mirror. Because of the person's position relative to the image position and to the extremities of the mirror, the person is unable to detect a ray of light reflecting to their eye as they sight at the image location. This does not mean that there is no image. Indeed, any object positioned in front of a plane mirror (or even to the side of the plane mirror) has an image regardless of whether there are people positioned in an appropriate location to view it. In the diagram below, there is an image of an object located on the other side of the mirror. However, Ray Zuvlite is unable to view the image due to his position in the room. Ray is certainly able to sight in the direction of the image location. However, the light from the object is unable to reflect off the mirror in accordance with the law of reflection and travel to his eye along his line of sight. Since light from the object does not make it to his eye, Ray is unable to see the image of the object in the mirror.

So why is an image formed by a plane mirror? An image is formed because light emanates from an object in a variety of directions. Some of this light (which we represent by rays) reaches the mirror and reflects off the mirror according to the law of reflection. Each one of these rays of light can be extended backwards behind the mirror where they will all intersect at a point (the image point). Any person who is positioned along the line of one of these reflected rays can sight along the line and view the image - a representation of the object.

This principle of image formation is often applied in a Physics lab. Suppose that a mirror is placed on a sheet of paper that is placed on top of a piece of cardboard. A pin is positioned in an upright position (and held in place by the cardboard) at a location in front of the mirror. A student can sight along a line at the image of the pin from a variety of locations. With one eye closed, a straightedge is used to assist in drawing the lines of sight. These lines of sight are drawn from a variety of sighting locations. Each line of sight can be extended backwards beyond the mirror. If the sight lines are drawn correctly, then each line will intersect at the same location. The location of intersection of all sight lines is the image location. Validation of the accuracy of your sighting and ray tracing can be accomplished by measuring angles of incidence and angles of reflection on the diagram. These should be equal for each individual sight line. That is, angle A should equal angle B; angle C should equal angle D; and angle E should equal angle F. Finally, the object distance can be compared to the image distance; these should also be equal.

In the case of plane mirrors, the image is said to be a virtual image. Virtual images are images that are formed in locations where light does not actually reach. Light does not actually pass through the location on the other side of the mirror; it only appears to an observer as though the light is coming from this location. Whenever a mirror (whether a plane mirror or otherwise) creates an image that is virtual, it will be located behind the mirror where light does not really come from. Such images are formed on the same side of the mirror as the object and light passes through the actual image location.

Besides the fact that plane mirror images are virtual, there are several other characteristics that are worth noting. The second characteristic has to do with the orientation of the image. If you view an image of yourself in a plane mirror (perhaps a bathroom mirror), you will quickly notice that there is an apparent left-right reversal of the image. That is, if you raise your left hand, you will notice that the image raises what would seem to be it's right hand. If you raise your right hand, the image raises what would seem to be its left hand. This is often termed left-right reversal. This characteristic becomes even more obvious if you wear a shirt with lettering. For example, a shirt displaying the word "NIKE" will read "EKIN" when viewed in the mirror; a shirt displaying the word "ILLINOIS" will read "SIONILLI;" and a shirt displaying the word "BOB" will read "BOB." (NOTE: Not only will the order of letters appear reversed, the actual orientation of the letters themselves will appear reversed as well. Of course, this is a little difficult to do when typing from a keyboard.) While there is an apparent left-right reversal of the orientation of the image, there is no top-bottom vertical reversal. If you stand on your feet in front of a plane mirror, the image does not stand on its head. Similarly, the ceiling does not become the floor. The image is said to be upright, as opposed to inverted.

Students of Physics are usually quite intrigued by this apparent left-right reversal. Exactly what is happening to cause ILLINOIS to read as SIONILLI? And why is the reversal observed in the left to right direction and not in the head to toe direction? These questions urge us to ponder the situation more deeply. Let's suppose for a moment that we could print the name of your favorite school subject on your shirt and have you look in the mirror. We all know that when you look in the mirror, you will see the letters SCISYHP written on the shirt of your image - the reversed form of PHYSICS. But can we really say that the word appearing on your shirt is the word PHYSICS (with the letters un-reversed)? The answer is no! (But you don't have to believe it yet. Keep reading ... and pondering.)

To further explore the reason for this appearance of left-right reversal, let's suppose we write the word PHYSICS on a transparency and hold it in front of us in front of a plane mirror. If we look at the image of the transparency in the mirror, we would observe the expected - SCISYHP. The letters are written reversed when viewed in the mirror. But what if we look at the letters on the transparency? How are those letters oriented? When we face the mirror and look at the letters on the transparency, we observe the unexpected - SCISYHP. When viewed from the perspective of the person holding the transparency (and facing the mirror, the letters exhibit the same left-right reversal as the mirror image. The letters appear reversed on the image because they are actually reversed on the shirt. At least they are reversed when viewed from the perspective of a person who is facing the mirror. Imagine that! All this time you thought the mirror was reversing the letters on your shirt. But the fact is that the letters were already reversed on your shirt; at least they were reversed from the person who stands behind the T-shirt. The people who view your shirt from the front have a different reference frame and thus do not see the letters as being reversed. The apparent left-right reversal of an image is simply a frame of reference phenomenon. When viewing the image of your shirt in a plane mirror (or any part of the world), you are viewing your shirt from the front. This is a switch of reference frames.

A third characteristic of plane mirror images pertains to the relationship between the object's distance to the mirror and the image's distance to the mirror. For plane mirrors, the object distance (often represented by the symbol do) is equal to the image distance (often represented by the symbol di). That is the image is the same distance behind the mirror as the object is in front of the mirror. If you stand a distance of 2 meters from a plane mirror, you must focus at a location 2 meters behind the mirror in order to view your image.

A fourth and final characteristic of plane mirror images is that the dimensions of the image are the same as the dimensions of the object. If a 1.6-meter tall person stands in front of a mirror, he/she will see an image that is 1.6-meters tall. If a penny with a diameter of 18-mm is placed in front of a plane mirror, the image of the penny has a diameter of 18 mm. The ratio of the image dimensions to the object dimensions is termed the magnification. Plane mirrors produce images that have a magnification of 1.