P30 Unit C – EMR Reflection and Refraction

Name: ______________

Date: ______________

Reflection: (pg 653-656 in Pearson Physics)

Light travels (**propagates**) in straight lines through a medium that is uniform (i.e.: glass that is the same density, air that is the same temperature). This movement is called **rectilinear propagation.** Like other waves, when light hits (or is **incident**) on a flat, smooth surface, it undergoes reflection.

Terms used for Reflection:

Recreate figure 13.28 of regular reflection on page 654 of your text. Then, define the terms below:

a) Incident Ray: ____

____

b) Reflected Ray____

____

c) Normal Line: ____

____

d) Angle of Incidence:____

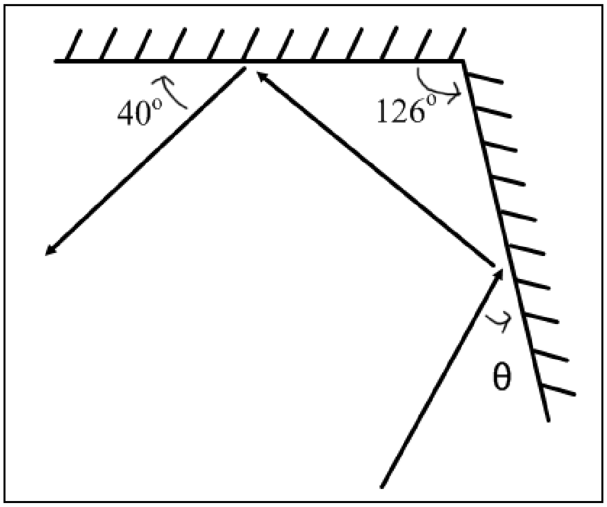
____

e) Angle of Reflection:____

____

Light follows the **law of reflection.** The law of reflection is defined as:

Use the following diagram to answer the next question.



NR A wave is incident on a reflective corner as shown above. The angle θ in the diagram is _______°.

(Record you answer, ignoring significant digits, on the answer sheet provided.)

Images:

When you look into a plane (flat) mirror, it appears that your reflection is *behind* the mirror. This type of image is said to be a **virtual image**. Optically, there is no difference between a virtual image and a **real image**; that is, your eye can not tell the difference between the two.

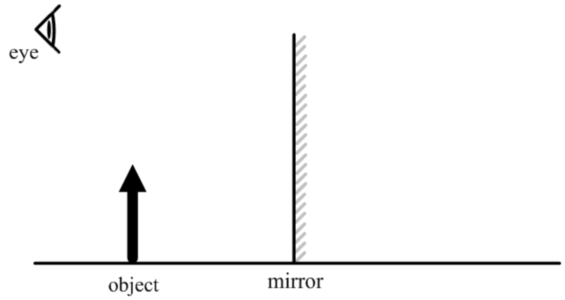
Question: How can you determine between a real image and a virtual image?

____

____

____

A virtual image is produced by **virtual rays**. In a diagram, virtual rays are indicated using dotted lines.

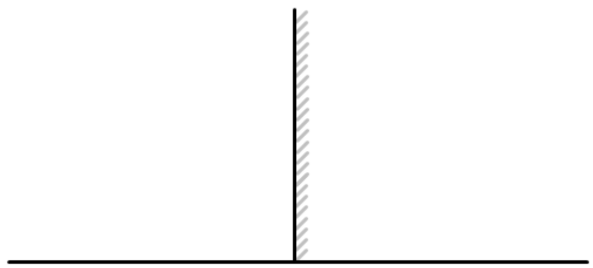


Draw at least two rays to determine what the virtual image will look like.

Practice Problem:

LD is checking himself out in a plane mirror. He can see his entire image from head to toe. Nice.

a) Draw a ray diagram of the virtual image produced.



b) How much of the mirror is really needed for LD to see his entire image? Explain.

Image Characteristics:

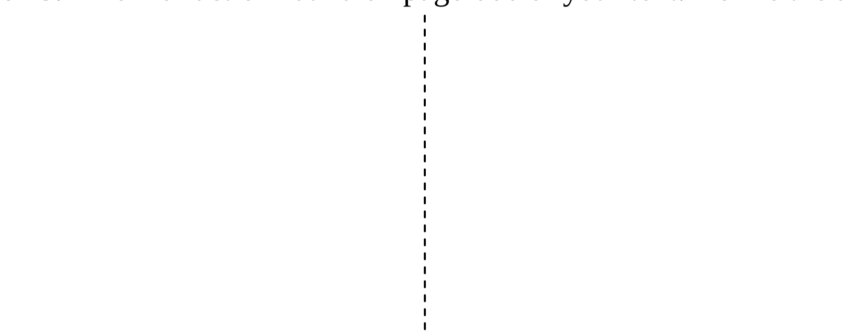
There are four general characteristics that describe an image. These will become very important when we start to look at curved mirrors later, so take some time to go over them now:

Image Characteristic	**Description**
magnification	
attitude	
position	
type	

Refraction (pg 666-674)

Refraction is similar to reflection, except when a ray refracts, only part of the ray bounces off of the incident surface. The other part travels into the surface. When the ray travels into the surface, it does so at a different angle than which it was incident. The light will also change its speed, depending on the **refractive index** of the medium.

Recreate figure 13.44 for refraction found on page 666 of your text. Define the additional terms below.



a) Refracted Ray:____

____

b) Angle of Refraction:____

____

c) Index of Refraction:____

____

Different **mediums** (the material light travels through) will allow light to travel through them at different speeds. This slowing of light effect was first observed by Fizeau in an experiment used to measure the speed of light through water.

To determine the index of refraction of a material, the following formula is used (pg 666):

Where:

n =

c =

v =

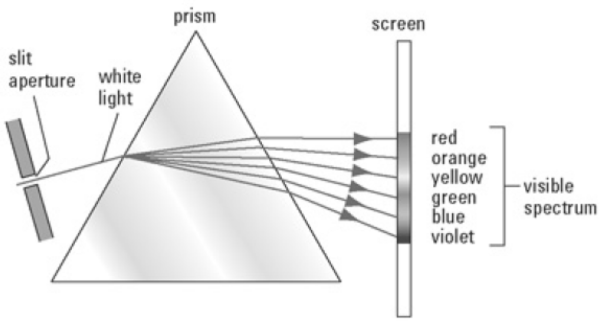
Question: Could the index of refraction for a medium be a negative number? Could it be less than 1?

____

____

____

A list of indexes is given on page 667 of your text. Notice that the indexes for a vacuum and for air are different, but the difference is negligible. For this reason, unless told otherwise, you may set the index of refraction for air equal to 1 for most calculations. Also note that the indexes are for a specific wavelength of light (in this case, yellow light), however, the difference between different wavelengths is relatively small, so this variation is usually ignored in practical problems, or the light is said to be **monochromatic**, meaning it is made up of only one colour and wavelength. However, *it is important to recall that different wavelengths of light refract differently when considering breaking light into its different wavelengths in a prism*.



Newton was the first to explain that white light (a combination of all the colours and their representative wavelengths) could be broken through **dispersion** using a prism, and put back together through **recomposition** by either focusing the individual colours through a lens or spinning a coloured disk (pg 676).

Light bends either towards or away from the normal line as it enters a different medium.

If light passes from a medium of ________ refractive index to a medium of ________ refractive index, it bends towards the normal line.

If light passes from a medium of ________ refractive index to a medium of ________ refractive index, it bends away from the normal line.

The amount the light bends is dependent on the medium the light is passing from and into. Dutch mathematician Willebroad Snell determined a relationship between the incident angle, refracted angle and indexes of refraction of a ray of light:

Snell's Law of Refraction: (pg 668)

Where:

θ_1 = ____________________________

θ_2 = ____________________________

n_1 = ____________________________

n_2 = ____________________________

Note that Snell's law appears in a slightly different form when considering the incident medium (the medium the light is coming from) is air, as the index of refraction for air is about 1. This more general form of the equation, found on page 668, is the one found on your formula sheet and is good for refraction between any two materials.

When a wave of light is incident on a more dense medium (higher index of refraction), the wave slows down. According to the universal wave equation ($v = f\lambda$), this must mean that either the frequency or wavelength must also change. Experiment shows that the frequency of the light (number of crests of the wave passing a given point per second) *does not change* upon entering the more dense medium. This must mean that the wavelength (distance between crests) does change.

Note that if we are using the universal wave equation and the concepts of wavelength and frequency to successfully describe light, then light must behave like a wave!

The full expansion of Snell's Law follows as (pg 670 or formula sheet):

Where:

λ_1 = ________________________

λ_2 = ________________________

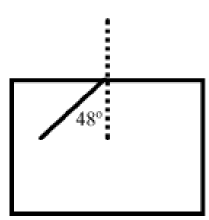
v_1 = ________________________

v_2 = ________________________

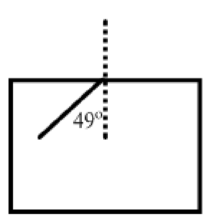
Total Internal Reflection (pg 672):

As light moves from a more dense medium into a less dense medium (such as moving from water to air), the light is bent away from the normal. This means that the angle of refraction is greater than the angle of incidence. This can lead to a phenomenon called **total internal reflection.**
Consider three blocks of glass, each having n = 1.325. If light is directed through them at the following incident angles into air, we can determine the angle of refraction for each block.

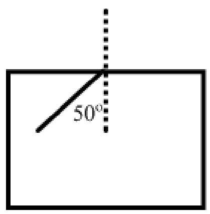
Ex) Determine the angle of refraction for each block.



*Note: in this block, the light will be refracted out of the block.



*Note: In this block, the light is refracted at a 90° angle. This means that light will not leave the block. When the angle of refraction is 90°, we say the incident light has reached the **critical angle**.



In the last example, it is not mathematically possible to determine the angle of refraction. This is because there is no refracted light: all of the light is reflected back into the plastic. This is an example of **total internal reflection**.

Critical Angle: the minimum angle of incidence that produces an angle of refraction of 90° from the normal.

Practice Problems:

A beam of monochromatic light is directed from a block of plastic (n = 1.45) into air. Determine the critical angle needed for total internal reflection.

Determine the index of refraction of a substance that has a critical angle of 42.0° when traveling into a vacuum.

The speed of light in a clear liquid is 1/3 that of the speed of light. Determine the critical angle of the liquid.

On a particular day, the index of refraction of a 5 MHz radio signal in Earth's atmosphere is 1.81. The critical angle for this radio signal is __________°.

You should be familiar with a few applications of total internal reflection, such as

- ☐ Diamonds (pg 672)
- ☐ Fiber Optic Cables (pg 673)
- ☐ Porro Prism in binoculars (pg 674)

Take some time to read these sections and be ready for some problems based on these topics.