2009-10 PreAP Light and Optics 4

Slim Jim is walking by a long flat mirror (plane mirror). His image is always exactly in front of his body, even when he moves beyond the mirror.   When he looks around the edge of the mirror, the image of his legs are still attached to his upper body.   When he is to the right of the mirror Slim Jim can't see himself, Slim Kim can see him. The diagram at the right shows why.

Mirror

Mirror

Kim   Jim
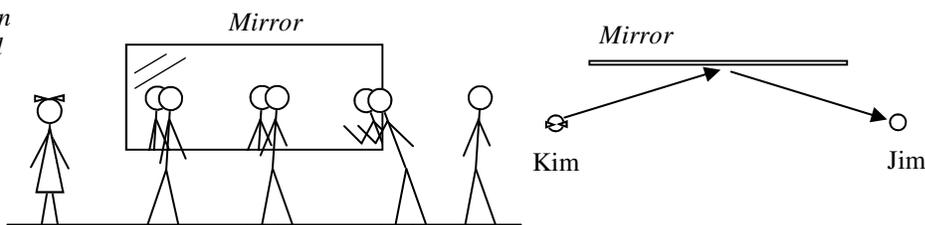
1.   In both diagrams above show where Jim's image is when he is to the right of the mirror. For the right diagram continue the straight line from Kim thru the mirror. Make it dotted to show that it is not real when it goes into the mirror.

2.   Think about yourself when looking in a mirror. You reach your hand close to the mirror. Where is your image's hand? Is it closer or farther from the mirror than your image's body?

3.   A.   Use the diagram at the right to find the index of refraction of the transparent material.

     B.   Using the table of indexes of refractions, what material is this?

     C.   What is the speed of light in this material?

Light Source

Transparent material
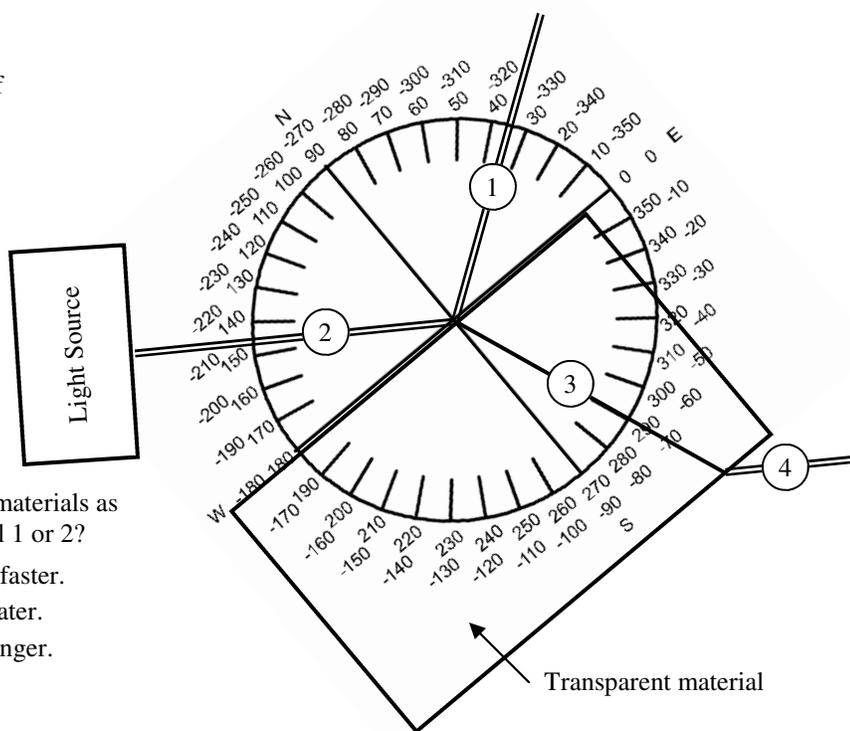
4.   Light passes between two materials as shown at the left.   Material 1 or 2?

Material 1

Material 2

     A.   _____ Speed of light is faster.
     B.   _____ Frequency is greater.
     C.   _____ Wavelength is longer.
     D.   _____ n is smaller.
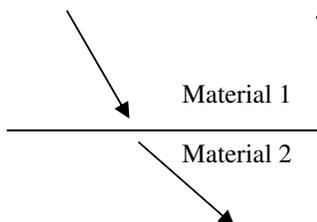
This next set of questions requires you to use multiple equations and the one on the last homework.

5.   480 nm light passes from air into a substance that has an index of refraction of 1.8.
     A.   Calculate the speed of light in the new substance.

     B.   Calculate the wavelength of light in the new substance.

     C.   Calculate the energy of the light in air (*See previous HW for the equation*).

6.   Compared to the previous 480 nm photon, how much energy does a 550 nm photon have?

7.   So, to increase the energy of a photon do you want a short or long wavelength?

8. Light is traveling at an angle of 42° in water.
   What is its angle in air?

9. Light is traveling at an angle of 55° in water.
   What is its angle in air?

For those of you that missed class, read the following:
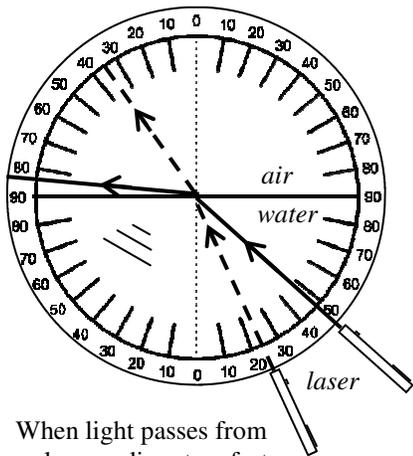
When light passes from a slow medium to a fast medium (like water to air), the light always bends away from the normal and the angle gets bigger. Eventually the refracted light approaches 90°, the surface of the water.
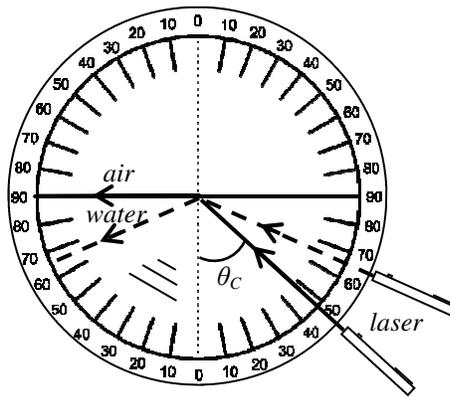
At the **critical angle** (θ_C) the light refracts at 90°, parallel to the surface. Past θ_C (*example below*) he light reflects back into the slower medium. This is known as **total internal reflection**.
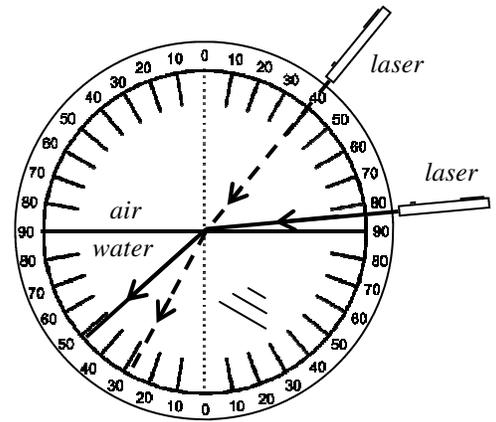
When passing from fast to slow mediums (like air to water) light bends toward the normal, meaning the angle in the slower medium will ALWAYS be smaller. This is why **there is no critical angle from fast to slow mediums.**

To find the critical angle (θ_C) we use Snell's Law and set θ_2 equal to 90°.

$$\text{Slow} \quad \text{Fast}$$
$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$
$$n_1 \sin \theta_C = n_2 \sin 90$$
$$n_1 \sin \theta_C = n_2 1$$
$$\boxed{\sin \theta_C = \frac{n_2}{n_1}}$$

Critical Angle —Past this angle light reflects back into a slower medium.

Critical Angle $\longrightarrow$ $\mathbf{\sin\theta_C = \frac{n_2}{n_1}}$
$\longleftarrow$ Index of Refraction in second medium
$\longleftarrow$ Index of Refraction in first medium

Only if $n_1 > n_2$ (slow to fast).

Example: What is the critical angle as light passes from water to air?

$n_1 = 1.33$ (from water)	$\sin \theta_C = \frac{n_2}{n_1}$
$n_2 = 1$ (to air)	$\sin \theta_C = \frac{1}{1.33} = 0.752$
$\theta_C = ?$	$\theta_C = \sin^{-1}(0.752) = 48.8°$

10. Substance 1 has an index of refraction of 1.68. Substance 2 has an index of refraction of 2.4.
    A. In which substance does light travel faster?
    B. In which case would there be a critical angle: from substance 1 OR from substance 2?

11. Calculate the critical angle from light as it passes from a diamond to water.

35°
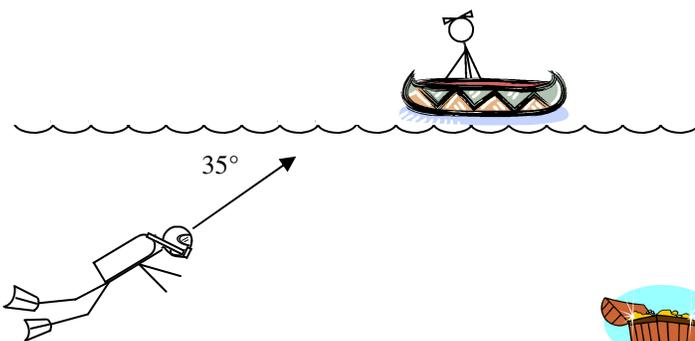
12. Slim Jim is also a diver. Jim finds a treasure chest and wants to signal Slim Kim in the boat above. He can see the bottom of the boat poking thru the surface of the water, but he can't see Kim. Why?

L | R
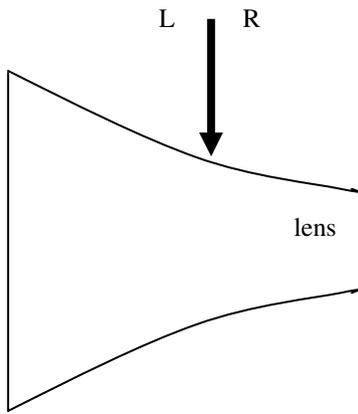
lens

13. A ray of light is passing from air into a lens. Draw the path of the light ray as it passes into and out of the glass lens. To make this easier at each of the boundaries draw two dotted lines for the normal and the straight path. Then decide if the light ray will bend toward or away from the normal.

From your "Lens/Mirror Equation and Magnification" notes.

14. A. Label the diagram with p, q, h, and h'. Be sure to mark them with + or −.
    A. Is the image real or virtual?
    B. Why?

    C. Will the magnification be a positive or negative number?

B   D   F

A   A   G

C   E

4 cm   R   R

10   20   30   40   50   60   70   80   90
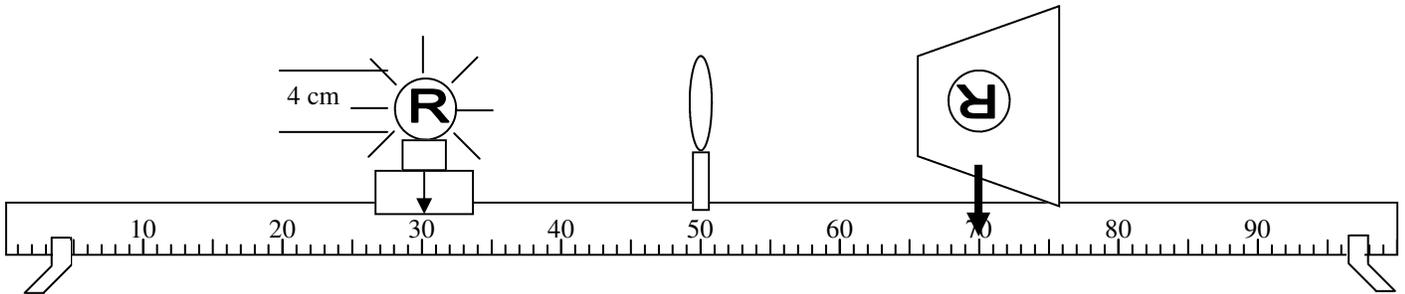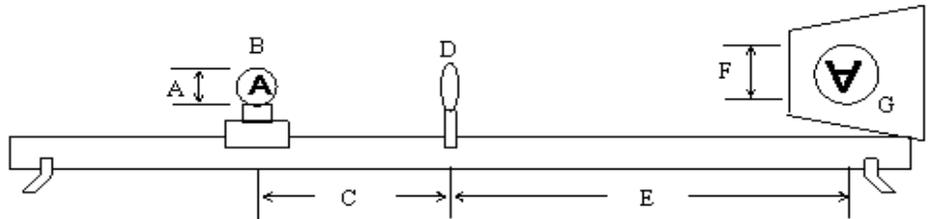
15. Use the diagram above to answer the following:
    A. p =   B. q =   C. h =
    D. Calculate the focal length for this lens.

    E. Calculate the magnification of the lens.

    F. Calculate the size of the image.

16. For the image at the right give the following.
    A. What kind of device?
    B. Convergent or divergent?
    C. Which side is real?
    D. p =
    E. q =
    F. h =
    G. h' =
    H. real or virtual image?
    I. Calculate f and M.

lens

4 cm   R   ᴚ   8 cm

15 cm   30 cm