Optics Review Name: _____

Answer the following questions and show all work where needed.

1. A light ray travels from one medium into another. What would the conditions of the mediums need to be for the ray to bend toward the normal?
   The first medium would need to be less dense and the second medium would to be more dense for the light to bend/refract toward the normal.

2. A light ray passes from air into glass. Describe what happens to the speed of the light ray during this change.
   Speed of light decreases as optical density increases. Glass has a higher optical density than air and so light travels through it slower than air.

3. What is the relationship between the speed of light and the index of refraction of a transparent material?
   The closer the index of refraction is to 1.00, the faster the speed of light. Light is fastest in a vacuum. The higher the index of refraction, the slower the speed of light and the more optically dense the material.

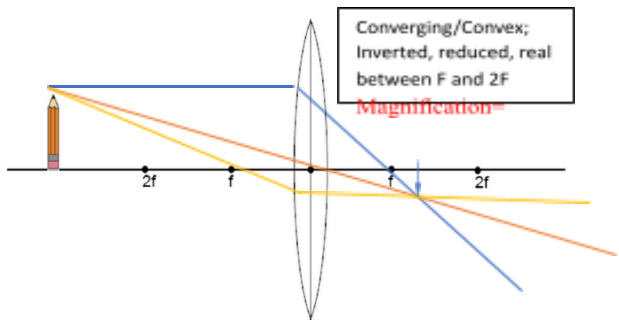
4. Does refraction ***always*** occur when light passes from air into a glass object? Explain.
   No, if light passes from air to glass at a 90 degree angle then refraction will not occur. Light will refract if it passes from one medium to another at an angle below 90 degrees to the normal. Check out this PhET simulation (click on intro) to see how: Bending Light 1.1.35 (colorado.edu)

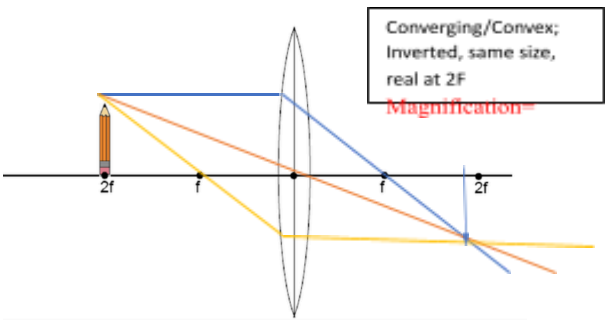
5. A ray of light enters the top of a glass of water at an angle of 36˚ with the vertical/normal. What is the angle between the refracted ray and the vertical/normal? (n_{glass}=1.50)
   $(1.00)\cdot\sin(36^\circ)=(1.50)\cdot\sin(\theta)$ $\sin(\theta)=\frac{1.00\cdot\sin(36)}{1.50}=0.391857$ $\theta=\sin^{-1}(0.391857)=23.1^\circ$

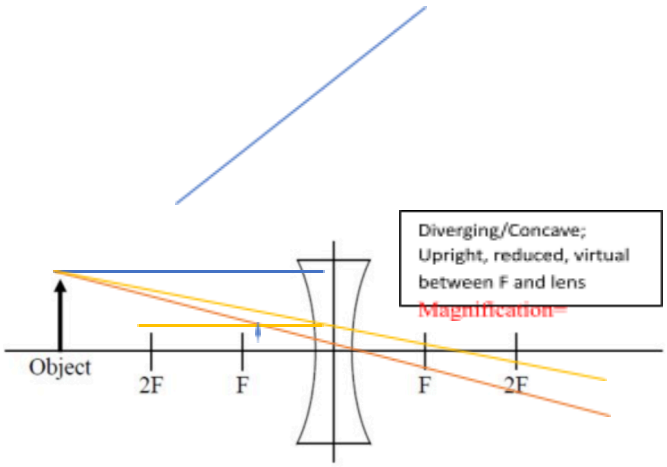
6. Nephrite jade was once used virtually everywhere by Neolithic man for polished stone weapons. Nephrite jade was also important in ancient oriental art. Suppose light passes from air at an angle of incidence of 59.2° into a thin ornate handle of a nephrite jade vase on display at a museum refracting the light at an angle of 32.2˚. What is the index of refraction for nephrite jade?
   $(1.00)\cdot\sin(59.2^\circ)=n\cdot\sin(32.2^\circ)$ $n=\frac{1.00\cdot\sin(59.2)}{\sin(32.2)}=1.61$

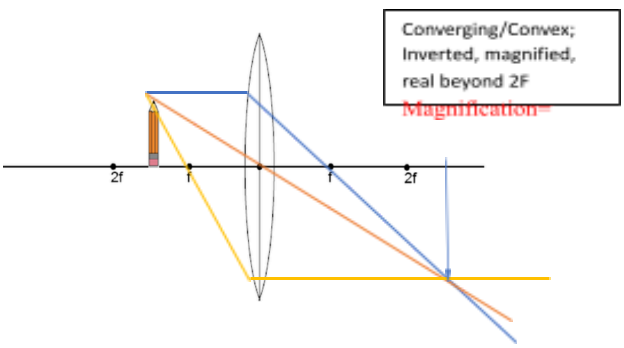
7. Which type of lens could you use to start a fire by focusing the sun's image? Describe how you would position the lens.
   You would want to use a converging (convex) lens to converge all of the sun's light rays into one focal point. That focal point gets exposed to all the light rays at one point which allows you to burn things using the sun's light.

8. Complete the ray diagrams below. Identify the lens type, image orientation, image size, and if the image is real or virtual.

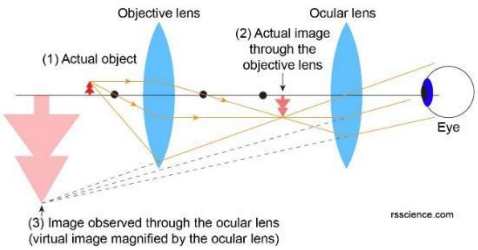








9. There are two converging lenses in a compound microscope. Why is the image still inverted?



The objective lens first creates a real inverted image that appears between the objective and ocular lens.

The ocular lens then creates a magnified virtual image that is still inverted from the real image the objective lens originally created.

10. Light moves from glass into a substance of unknown refraction index. If the critical angle for the glass is 46° and the index of refraction for the glass is 1.5, what is the index of refraction of the other substance?

$\sin(46^\circ)=\frac{n_r}{1.5}$ $n_r=1.5\cdot\sin(46^\circ)=1.08$

11. The largest uncut diamond had a mass of more than 600 g. Eventually, the diamond was cut into several pieces. Suppose one of those pieces is a cube with sides 1.00 cm wide. If a beam of light were to pass from air into the diamond with an angle of incidence equal to 75.0°, the angle of refraction would be 23.3°. From this information, calculate the index of refraction and the critical angle for diamond in air.

Index of refraction: $(1.00)\cdot\sin(75.0^\circ) = n\cdot\sin(23.3^\circ)$ $n = \frac{(1.00)\cdot\sin(75.0)}{\sin(23.3)} = 2.44$

Critical Angle: $\sin(\theta_c)=\frac{1.00}{2.44} = 0.409836$ $\theta_c=\sin^{-1}(0.409836)=24.2^\circ$

12. A microscope slide is placed in front of a converging lens with a focal length of 3.6 cm. The lens forms a real image of the slide 15.2 cm behind the lens. How far is the lens from the slide? What is the magnification?

$d_o = ?$ $d_i=15.2\text{cm}$ $f = 3.6\text{cm}$ $\frac{1}{d_o}+\frac{1}{15.2}=\frac{1}{3.6}$ $\frac{1}{d_o}=\frac{1}{3.6}-\frac{1}{15.2}$ $\frac{1}{d_o}=0.212$ $d_o=4.72\text{cm}$

Magnification $=-\frac{15.2}{4.72}=-3.22$

13. Where must an object be placed to form an image 12 cm in front of a diverging lens with a focal length of 44 cm? What is the magnification?

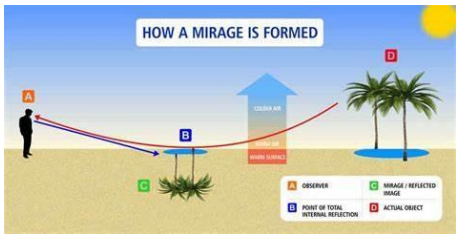
$d_o = ?$ $d_i = -12\text{cm}$ (in front of lens) $f = -44\text{cm}$ (because it is a diverging lens)

$\frac{1}{d_o}-\frac{1}{12}=-\frac{1}{44}$ $\frac{1}{d_o}=-\frac{1}{44}+\frac{1}{12}$ $\frac{1}{d_o}=0.0606$ $d_o=16.5\text{cm}$

Magnification $=-\frac{-12}{16.5}=+0.727$

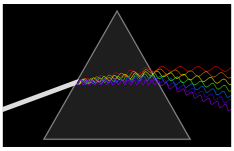
14. What are the conditions necessary for a mirage? How do these conditions differ to make an inferior mirage vs. a superior mirage? Describe how these two types of mirages differ.

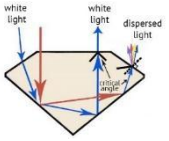
For a mirage to occur, there must be a difference in temperature in the air. An inferior mirage occurs when the air right above the hot ground is hot and there is cooler air above. This causes an inverted image to result. A superior mirage occurs when the air right above water is cooler but there is warmer air above on a hot day. This causes the image to "float" above the object.



15. A diamond shows flashes of color when it is moved around under a bright white light. How do you explain the appearance of colors?

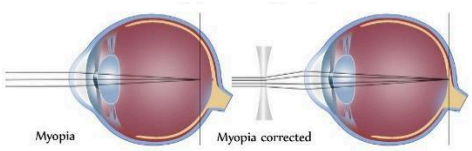
Diamonds have a higher refractive index compared to air and light tends to get trapped inside them causing total internal reflection. Eventually the light does escape but the white light is dispersed/separated into its component colors and then you see flashes of those colors.

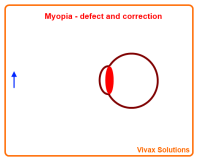




16. Cal is having a hard time seeing things far away. Identify the name of his vision problem, explain what is happening inside the eyeball that creates this problem and identify what kind of lens would fix this vision problem and why.

Cal is suffering from myopia which is often caused by an elongation of the eyeball. This causes images to converge right in front of the retina instead on the back of the retina. This problem can be resolved by using a diverging lens because it will diverge the light slight before it reaches the eye so that when it does converge in the eye, it does so further back.





17. Which of the following colors of light would be most refracted by a prism: red, green, yellow, blue? Explain your choice.
Shorter wavelengths are refracted more than longer wavelengths. Red has the longest wavelength and blue has the shortest wavelength of the colors listed. Blue will refract/bend the most.