# Refraction and Lenses Learning Guide

1. When the path of a ray of light bends towards the normal, what happens to the speed of light? *it decreases*
2. As a ray of light passes from glass into air, which way will it bend? *away from the normal*
3. As light passes from air into a more optically dense medium such as glass or water, what happens to the wavelength of the light? *it decreases*
4. Is the frequency of light changed by refraction? How can you tell? *No—there is no change in color*
5. Define index of refraction. *the ration of the speed of light in a vacuum to the speed of light in the substance*
6. A ray of light enters a transparent material (from air) at an angle of $40.0^o$ and refracts at an angle of $26.0^o$. Determine the index of refraction. *using Snell's Law:* $n_r = \frac{\sin 40.0^o}{1\ \sin 26.0^o} = 1.47$
7. If light is incident at an angle of $25.0^o$ on the surface of water, calculate the angle of refraction. ($n$ = 1.333 for water) $\theta_r = \sin^{-1}\left(\frac{1\sin 25^o}{1.33}\right) = 18.8^o$
8. When light is passing from a medium with a high index of refraction to one with a lower index of refraction at the critical angle, what is the angle of refraction? *$90^o$*
9. If the light is incident at a greater angle what happens? *total internal reflection*
10. Describe the lenses (number and type) needed for a compound microscope and the images produced by each lens. *2 converging lenses objective produces magnified, inverted real image; eyepiece produces magnified virtual image still inverted.*
11. How is the refracting telescope different from the microscope? *same type lenses and images, but object is farther away so longer focal lengths are used in the telescope.*
12. What optical phenomenon is responsible for the creation of mirages? *refraction of light due to the atmosphere*
13. How is air temperature involved in mirages? *layer of warm air near the ground, being less densethan cooler air above, refracts light from the sky bending its path upward .*
14. Why does dispersion separate the colors of white light in raindrops or prisms? *index of refraction for water, glass, most plastic depends on wavelength*
15. Which is greater, the index of refraction for blue light or red light? *greater for blue than red*
16. What is chromatic aberration and how can it be reduced with lenses? *since different colors are refracted at different angles, they will focus at different distances from the lens. Can be corrected by using compound lenses made from different types of glass.*
17. Describe the images that can be formed with a converging lens in terms of size, location and image type. *when $d_o < f$, image is virtual and magnified on the same side of the lens as the object; when $d_o > f$, image is real, inverted and on the opposite side of the lens. if $f < d_o < 2f$, image is magnified and beyond 2F; if $d_o = f$, image is same size at 2F; if $d_o > 2f$, image is reduced and between F and 2F*
18. Describe the images that can be formed with a diverging lens in terms of size, location and image type. *all images are virtual, reduced in size and between F and the lens on the side if incoming light.*
19. What type of image is produced by a magnifying glass? *as normally used to magnify objects, it is a virtual image.*
20. An object 5 cm high is placed 20 cm from the center of a convex (converging) lens with a focal length of 10 cm. Describe the image height, location and orientation. You may calculate this or support your answer in other ways. *20 cm = 2F so image will be at F on the other side of the lens, inverted and the same size*

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*21.* The same 5 cm object is moved to a point 15 cm from the lens. Calculate the image location and height. What type of image is it? $d_i = \left(10^{-1} - 15^{-1}\right)^{-1} = 30cm$ $h_i = 5cm\left(\frac{30cm}{15cm}\right) = 10cm$; *a real image (inverted)*

*22.* The 5 cm object is now moved to a point 8 cm from the lens. Calculate the image location and height. What type image is it? $d_i = \left(10^{-1} - 8^{-1}\right)^{-1} = -40cm$ $h_i = 5cm\left(\frac{40cm}{8cm}\right) = 25cm$; *a virtual image (upright)*

23. Using the information in question 20, calculate the image size and location if the lens is diverging (concave) instead of converging. What type image is it? *virtual image*

$d_i = \left(-10^{-1} - 20^{-1}\right)^{-1} = -6.7cm$; $h_i = 5cm\left(\frac{6.7cm}{20cm}\right) = 1.7cm$

24. Draw the ray diagrams on the lens ray diagram worksheet.

Multiple Choice Questions (From old tests)

C 1. Refraction occurs (A) only with light waves (B) at any, unpredictable time (C) when a wave changes speed (D) only at a wave front (E) all of the above

B 2. When you see a mirage on the road that looks like a wet spot, you are most likely seeing (A) water (B) light from the sky (C) a figment of your imagination (D) hot air

D 3. Dispersion occurs when white light is (A) reflected from a curved mirror (B) refracted by the atmosphere (C) bent by layers of hot air in the atmosphere (D) refracted by a glass prism

A 4. A rainbow occurs because (A) sunlight is refracted by water in the raindrops (B) sunlight is selectively absorbed by water in the raindrops (C) sunlight falls on different size raindrops (D) different color raindrops arrange themselves in bands of color (E) none of the above

B 5. The separation of light into colors arranged according to their frequency is called (A) diffusion (B) dispersion (C) diffraction (D) refraction

C 6. The critical angle for a light from the bottom of a swimming pool shining upward toward the pool's surface is the angle (A) at which some light is reflected form the surface (B) at which all light is reflected out of the pool (C) where light is refracted so it just skims the pool surface (D) 90 degrees.

A 7. When a beam of light emerges from water into air, the average light speed (A) increases (B) decreases (C) remains the same

D 8. If the index of refraction for a material is 2.0, that means the speed of light in the material is (A) 3.0 x $10^8$ m/s (B) 2.0 x $10^8$ m/s (C) 2.0 m/s (D) 1.5 x $10^8$ m/s (E) 6.0 x $10^8$ m/s

B 9. The principle behind the operation of fiber optics is (A) interference (B) internal reflection (C) dispersion (D) diffraction

D 10. A beam of light travels fastest in (A) glass (B) water (C) transparent plastic (D) air (E) its average speed is the same in each of the above

E 11. A converging lens (A) will bend parallel rays of light so they cross at a single point (B) is thicker in the center than at the edges (C) will converge parallel rays of light (D) refracts parallel rays of light (E) all of the above

A 12. The focal point for a diverging lens (A) is on the same side of the lens as the oncoming rays of light (B) is on the opposite side of the lens as the oncoming rays of light (C) does not exist

A

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_____ 13. An image of a distant object formed by a single converging lens (A) is real (B) is virtual (C) is magnified (D) is right side up

__A__ 14. An image formed by a single diverging lens (A) is virtual (B) is upside down (C) can be projected on a screen (D) is larger than the object When drawing a ray diagram, a ray that is parallel to the principal axis that strikes a lens will (A) be refracted through 2F (B) pass through the lens without being refracted (C) be refracted through the focal point (D) be refracted through the center of the lens

__C__ 15. If an object is located between the focal point and a converging lens, the image will be (A) upside down (B) real (C) larger than the object (D) all of the above (E) none of the above

__A__ 16. Farsighted people need to wear glasses that contain (A) converging lenses (B) diverging lenses (C) neither converging nor diverging lenses

__A__ 17. The eyes of nearsighted people focus light from distant objects (A) in front of the retina (B) behind the retina (C) at the retina

__B__ 18. Chromatic aberration occurs because different colored light rays (A) focus at different places after reflection from a mirror (B) refract at different angles when passing through a lens (C) pass through different part of a lens (D) none of the above

__B__ 19. A magnifying glass is usually a (A) diverging lens (B) converging lens (C) combination of diverging and converging lenses

__B__ 20. The image received by the retina in your eye is (A) right-side up (B) upside down (C) virtual (D) not really an image at all