**Refraction and Lenses Review**

From <http://www.physicsclassroom.com/reviews/refrn/refrnprint.cfm>

**Part A: Multiple Choice**

1. The best definition of refraction is \_\_\_\_.

a. passing through a boundary b. bouncing off a boundary

c. changing speed at a boundary d. changing direction when crossing a boundary

2. The liquid carbon tetrachloride has an index of refraction of 1.461. At what speed does light travel through CCl4? (c = 3 x 108 m/s)

a. 4.38 x 108 m/s b. 2.05 x 108 m/s c. 4.461 x 108 m/s d. 1.461 x 108 m/s

3. A ray of light in air is incident on an air-to-glass boundary at an angle of 35.0 degrees with the normal. If the index of refraction of the sample of glass is 1.61, then what is the angle of the refracted ray within the glass with respect to the normal?

a. 20.9 degrees b. 21.7 degrees c. 56.4 degrees d. 67.4 degrees

4. If the critical angle for total internal reflection inside a certain transparent material is found to be 38.0 degrees, then what is the index of refraction of the material? (Air is outside the material).

a. 0.616 b. 1.27 c. 1.51 d. 0.1.62

5. Carbon disulfide is a liquid with an index of refraction of 1.63. It is poured into a container made of crown glass (n = 1.52). What is the critical angle for a ray that is incident on the liquid-to-glass surface?

a. 89.0 degrees b. 68.8 degrees c. 21.2 degrees d. 4.0 degrees

6. A beaker of crown glass having an index of refraction value of 1.52 is filled to the rim with liquid carbon tetrachloride (n=1.46). A ray of light approaching the glass-to-air boundary has an angle of incidence of 40.0°. What is the angle of refraction within the CCl4?

a. 26.1° b. 38.1° c. 42.0° d. 77.7°

7. A light ray in air is incident on an air-to-glass boundary with an angle of incidence of 45.0 degrees and is refracted in the glass with an angle of refraction of 30.0 degrees. What is the index of refraction of the glass?

a. 2.13 b. 1.74 c. 1.23 d. 1.41

8. A ray of light traveling through air is incident at an angle of 32.0 degrees to the surface of a rectangular block of clear plastic (n = 1.42). The ray passes through the block and exits from the opposite side into air. At what angle to the normal of that surface does it exit?

a. 21.9° b. 22.5° c. 45.4° d. 48.8°

9. Consider a light ray that passes from air into a plate of glass and back out into the air. Which statement regarding light speed is accurate?

a. The light in the air before entry is moving faster than when in the glass; it travels slowest after exiting the glass.

b. The light travels faster in the air than in the glass; the speed in the air is not affected by traveling through the glass.

c. The light travels faster in the glass than in the air; the speed in the air is not affected by traveling through the glass.

d. The light speed in the air is less after the light exits the plate of glass; but the speed in the air (before and after entering glass) is greater than the speed in the glass.

10. When a ray of light in air reaches the boundary with a plate of glass at an angle of incidence of 0°, the light is \_\_\_\_\_.

a. totally reflected

b. totally transmitted into the plate of glass

c. partially reflected but mostly transmitted into the plate of glass

d. mostly reflected but partially transmitted into the plate of glass

11. A ray of light in glass is approaching the boundary with air at an angle of incidence that is less than the critical angle. Which statement accurately describes the behavior of this light ray?

a. All of the light will be transmitted across the boundary and enter the air.

b. All of the light will be reflected off the boundary and remain within the glass.

c. Part of the light will be reflected off the boundary and part will be transmitted across the boundary.

12. A ray of light in glass is approaching the boundary with air at an angle of incidence that is greater than the critical angle. Which statement accurately describes the behavior of this light ray?

a. All of the light will be transmitted across the boundary and enter the air.

b. All of the light will be reflected off the boundary and remain within the glass.

c. Part of the light will be reflected off the boundary and part will be transmitted across the boundary.

13. A light ray in air is approaching the boundary with glass (n=1.52) and refracts with an angle of refraction of 27.0°. What was the original angle of incidence for this light ray?

a. 17.3° b. 25.6° c. 41.0° d. 43.6°

14. Upon passage through a triangular prism, a light ray is observed to be dispersed into its component colors, affectionately known as ROYGBIV. Which color of light would be observed to refract the most from its original path?

a. green b. orange c. red d. violet

15. A light ray in air strikes a block of glass (n = 1.52) while traveling perpendicular to its surface. What behavior will be observed at the boundary?

a. There will be some partial reflection of the light, but mostly transmission with an angle of refraction of 0°.

b. There will be some partial reflection of the light, but mostly transmission with an angle of refraction of 41.1°.

c. There will be some partial reflection of the light, but mostly transmission with an angle of refraction of 90°.

16. Suppose that total internal reflection occurs at the boundary of air and water. Which of the following will be true?

a. None of the light energy will be reflected at the boundary.

b. All of the light energy will be refracted at an angle of 90°.

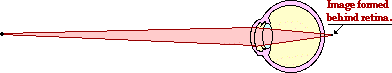
c. None of the light energy will be transmitted across the boundary.

d. All of the light energy will pass across the boundary, traveling along the normal line.

17. Light traveling through air approaches the boundary with a block of glass. The part of the light that is transmitted across the boundary will not change its \_\_\_\_\_.

a. speed b. wavelength c. direction d. all of these apply

For **Questions #18 - #20**, consider the diagram below.



18. This person suffers from the problem of \_\_\_\_.

a. nearsightedness b. farsightedness c. cataracts d. delusions

19. This problem could most easily be corrected by the use of a(n) \_\_\_\_.

a. converging lens b. diverging lens c. achromatic lens d. good night's sleep

20. If the image was formed in front of the retina rather than behind the retina, then the person would need to correct the vision problem by using a

a. converging lens b. diverging lens c. achromatic lens d. alarm clock

21. Which of the following statements best describe the cause of dispersion of white light into its component colors?

a. Light travels with different speeds in different materials.

b. Light rays bend different amounts when entering different materials.

c. The component colors of white light travel at different speeds in the same medium.

d. Light changes color when it crosses a boundary; sometimes it changes into many different colors.

22. A 4.0-cm tall object is positioned 30.0 cm from a converging lens. The focal length of the lens is 20.0 cm. The image of the object will be positioned \_\_\_\_\_ cm from the lens and have a height of \_\_\_\_\_ cm. (**NOTE**: A negative height indicates an inverted image.)

a. 12.0 cm and 6.0 cm b. 60.0 cm and 2.7 cm

c. 60.0 cm and -8.0 cm d. 100. cm and -6.0 cm

23. A converging lens has a focal length of **f**. An object is placed a distance from the lens that is less than **f**. Which of the following accurately describe the orientation, size and type of resulting image?

a. upright, magnified, virtual b. upright, reduced, virtual

c. inverted, magnified, real d. inverted, reduced, virtual

24. The focal length of a diverging lens is -15 cm. An object is positioned less than 15 cm from the lens. Which of the following accurately describe the orientation, size and type of resulting image?

a. upright, magnified, virtual b. upright, reduced, virtual

c. inverted, magnified, real d. inverted, reduced, virtual

25. A converging lens has a focal length of 20.0 cm. An object is placed along its principal axis and 60.0 cm from the lens. The resulting image distance is \_\_\_\_\_ cm and the magnification is \_\_\_\_\_.

a. 15.0 cm and -0.25 b. 15.0 cm and -4.00

c. 30.0 cm and -0.500 d. 30.0 cm and -2.00

26. An object is placed at a distance of 6.0 cm from a thin converging lens along its axis. The lens has a focal length of 9.0 cm. What are the values, respectively, of the image distance and magnification?

a. -18 cm and 3.0 b. 18 cm and 3.0

c. 3.0 cm and -0.50 d. -18 cm and -3.0

27. A light bulb is positioned along the principal axis of a converging lens and located 24.0 cm away. The lens produces a real image of the bulb 8.0 cm from the lens. What is the focal length of the lens?

a. 6.0 cm b. 12.0 cm c. -12.0 cm d. 16.0 cm

28. A light bulb is positioned along the principal axis of a converging lens and located 40.0 cm away. A virtual image is formed at a location that is 50.0 cm from the lens. What is the focal length of the lens?

a. 22.2 cm b. 45.0 cm c. -200.0 cm d. 200. cm

**Part B: Multiple-Multiple Choice**

29. Which of the following statements are true of converging lenses? Identify all that apply.

a. Converging lenses are thicker at the center than they are at the edges.

b. If the bottom half of a converging lens is covered, then the top half of the image will not be visible.

c. Converging lenses only produce real images.

d. Converging lenses can produce images that are both magnified and reduced in size.

e. Converging lenses only produce inverted images.

f. Converging lenses have a + focal length.

g. The images formed by a converging lens can be located on either side of the lens relative to the object.

30. Which of the following statements are true of diverging lenses? Identify all that apply.

a. Diverging lenses are thicker at the center than they are at the edges.

b. If the bottom half of a diverging lens is covered, then the bottom half of the image will not be visible.

c. Diverging lenses only produce virtual images.

d. Diverging lenses can produce images that are both magnified and reduced in size.

e. Diverging lenses only produce upright images.

f. Diverging lenses have a - focal length.

g. The images formed by a diverging lens can be located on either side of the lens relative to the object.

31. Which of the following statements are true of real images? Identify all that apply.

a. Real images are inverted.

b. Real images as formed by lenses are located on the opposite side of the lens from the object.

c. Real images are magnified in size.

d. Real images are only formed by converging lenses and never formed by diverging lenses.

e. An image of a real object is formed; the image distance (s' or di) for real images is a + value.

f. An image of a real object is formed; the image height (h' or hi) for real images is a + value.

g. Real images have a - magnification value.

32. Which of the following statements are true of virtual images? Identify all that apply.

a. Virtual images are always upright.

b. Virtual images as formed by lenses are always located on the same side of the lens as the object.

c. Virtual images are only formed by diverging lenses and never formed by converging lenses.

d. Virtual images are always smaller than the object.

e. An image of a real object is formed; the image distance (s' or di) for virtual images is a - value.

f. An image of a real object is formed; the image height (h' or hi) for virtual images is a - value.

g. Virtual images have a - magnification value.

33. Several characteristics of images are described below. Determine whether these images are real or virtual and whether they are formed by converging lenses, diverging lenses or either type. (In all cases, assume that the object is an upright and *real* object.)

a. Image is upright and magnified.

b. Image if upright and reduced in size.

c. Image is inverted and magnified.

d. Image has a negative s' (di) value.

e. Image has a negative h' (hi) value.

f. Image has a positive h' (hi) value and a magnification value greater than 1.

34. Which of the following statements are true of total internal reflection (TIR)? Include all that apply.

a. TIR can only occur when light approaches a boundary and is incident within the more dense media.

b. TIR can only occur when the angle of incidence is greater than the critical angle.

c. TIR causes a portion of the light to refract along the boundary and the rest to be reflected.

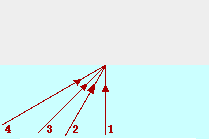
d. When TIR occurs, the reflected light follows the law of reflection.

e. If TIR occurs at the boundary of water and air, then the light must be within water and heading towards the boundary with air.

f. If TIR occurs at the boundary of glass and air, then it is possible that the light is traveling within air and heading towards the glass.

**Part C: Diagramming and Analysis**

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| --- | --- | --- | --- | --- |
| 35. The diagram below shows four incident rays traveling through water (n = 1.33) and approaching the boundary with air (n=1.00). For each incident ray, draw the corresponding reflected ray; then calculate the angle of refraction and draw the corresponding refracted ray. Label or color code your reflected and refracted rays to distinguish them from each other and to match them to the incident ray. | **Ray** | **Angle of**  **incidence** | **Angle of**  **reflection** | **Angle of**  **refraction** |
| 1 | 0.0 deg. | \_\_\_\_\_\_\_ | \_\_\_\_\_\_\_ |
| 2 | 30.0 deg. | \_\_\_\_\_\_\_ | \_\_\_\_\_\_\_ |
| 3 | 45.0 deg. | \_\_\_\_\_\_\_ | \_\_\_\_\_\_\_ |
| 4 | 60.0 deg. | \_\_\_\_\_\_\_ | \_\_\_\_\_\_\_ |

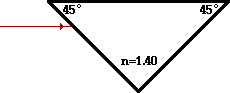


36. In the diagrams below, construct refracted rays to indicate the direction that the light rays bend upon crossing the boundary.

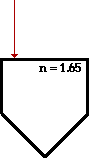
|  |  |
| --- | --- |
| If light travels faster in medium 1 than in medium 2, then upon entering medium 2, the light will bend towards from the normal. | If the index of refraction of medium 1 is greater than medium 2, then upon entering medium 2, the light will bend away from the normal. |
|  |  |

37. Use Snell's law, a protractor and a straight-edge to trace the path of light through the following objects.

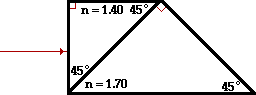
a.



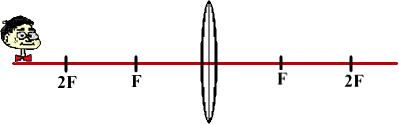
b.



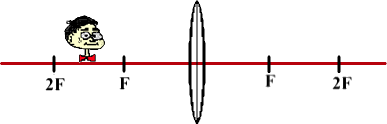
c.



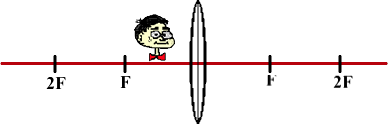
38. Construct ray diagrams to show where the images of the following objects are located. Draw in the complete image (approximated by an arrow) and describe its characteristics (real or virtual, enlarged or reduced in size, inverted or upright).



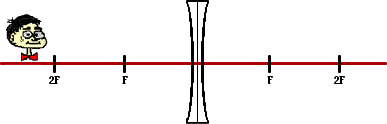
**Real or Virtual?** **Magnified or Reduced?** **Upright or Inverted?**



**Real or Virtual?** **Magnified or Reduced?** **Upright or Inverted?**



**Real or Virtual?** **Magnified or Reduced?** **Upright or Inverted?**



**Real or Virtual?** **Magnified or Reduced?** **Upright or Inverted?**

**Part D: Problem-Solving**

39. The speed of light in a vacuum is 3.00 x 108 m/s. Determine the speed of light through the following materials.

a. air (n=1.00)

b. ethanol (n=1.36)

c. crown glass (n=1.52)

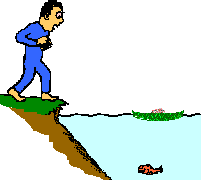
d. zircon (n=1.91)

e. diamond (n=2.42)

40. Bruno is standing upon the edge of the water with his high-powered laser gun, waiting to zap the next visible fish with a burst of laser light. Frieda deFish, located a distance of 2.17 m out from shore, hopes to hide from view by ducking behind a small lily pad. If Bruno's laser is located 0.850-m above the ground and the lily pad is 1.39 m from shore, then to what depth below the water must Frieda descend in order to be hidden from view? (Given: nwater = 1.33)



41. Frieda deFish, disturbed at Bruno's militancy, pulls out a laser of her own. She temporarily ducks out from her cover and aims it upwards at an angle of 26.5-degrees at Bruno's nose. If Bruno's nose is 1.34-m above the water's edge and if Frieda is a distance of 0.91 m below the water's surface, then how far out from shore must Frieda be to have a direct hit?



42. Determine the critical angle for the following boundaries:

a. air - crown glass (n=1.52)

b. air - diamond (n=2.42)

c. crown glass (n=1.52) - diamond (n=2.42)

d. air - Lucite (n=1.40)

e. air and a material through which light travels at a speed of 2.10 x 108 m/s

43. A lens produces an upright image of an object. The image is reduced in size by a factor of 3.00 when the object is a distance of 16.9 cm from the lens. Determine the focal length.

44. A thin lens has a focal point located 19.7 cm from the lens surface. When the object is placed at a specific location, the virtual image it produces is one-fourth the size of the object. Determine the object distance. (Careful of your sign on f.)

45. A thin lens has a focal point located 16.8 cm from the lens surface. Determine the object location that would produce an inverted image that is exactly five times larger than the object.

46. A thin lens has a focal point located 16.8 cm from the lens surface. Determine the object location that would produce an upright image that is exactly five times larger than the object.