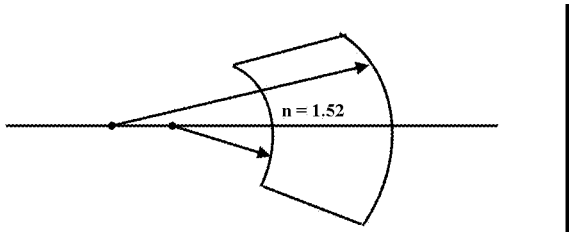


**Part I.** Refraction of light problems.

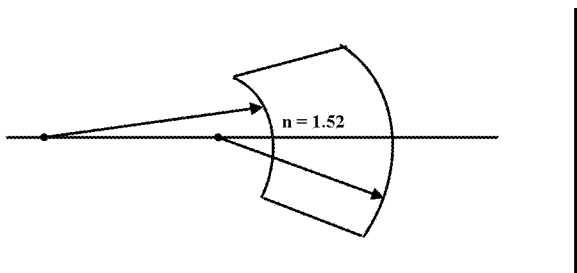
1. A converging lens has a focal length of 20.0 cm. If it is placed 50 cm from an object, at what distance from the lens will the image be?
2. The focal length of a lens in a box camera is 10.0 cm. The fixed distance between the lens and the film is 11.0 cm. If the object is to be clearly focussed on the film, how far must it be from the lens?
3. An object 8.0 cm high is placed 80.0 cm in front of a converging lens of focal length 25 cm. a) Using the lens and magnification equations, determine the image position and its height. b) By means of a scale ray diagram, locate the image and determine its height.
4. A lamp 10.0 cm high is placed 60.0 cm in front of a diverging lens of focal length  $f = 20.0$  cm. a) Using the appropriate equations, calculate the image position and the height of the image. b) By means of a scale ray diagram, locate the image and determine its height.
5. A typical single lens reflex (SLR) camera has a converging lens with a focal length of 50.0 mm. What is the position and size of the image of a 25 cm candle located 1.0 m from the lens?
6. A converging lens with a focal length of 20.0 cm is used to create an image of the Sun on a paper screen. How far from the lens must the paper be placed to produce a clear image?
7. The focal length of a slide projector's converging lens is 10.0 cm.
  - a) If a 35.0 mm slide is positioned 10.2 cm from the lens, how far away must the screen be placed to create a clear image?
  - b) If the height of a dog on the slide film is 12.5 mm, how tall will the dog's image be on the screen?
  - c) If the screen is then removed to a position 15 m from the lens, by how much will the separation between film and lens have to change from part (a)?
8. A candle is placed 36 cm from a screen. Where between the candle and the screen should a converging lens with a focal length of 8.0 cm be placed to produce a sharp image on the screen?
9. An object 5.00 cm high is placed at the 20.0 cm mark on a metre stick. A converging lens with a focal length of 20.0 cm is mounted at the 50.0 cm mark. What are the position and size of the image?
10. A camera lens has a focal length of 6.0 cm and is located 7.0 cm from the film. How far from the lens is the object positioned if a clear image has been produced on the film?
11. A lens with a focal length of 20.0 cm is held 12.0 cm from a grasshopper 7.00 mm high. What is the position and size of the image of the grasshopper?
12. A projector is required to make a real image, 0.5 m tall, of a 5.0 cm object placed on a slide. Within the projector, the object is to be placed 10.0 cm from the lens. What must be the focal length of the lens?
13. A 3.0 cm flower is placed 40.0 cm from a lens with a focal length of 10.0 cm. What is the position, size, and type of image?
14. An object 7.9 cm high is placed at the 35 cm mark on a metre stick. A converging lens with a focal length of  $f = 25$  cm is mounted at the 95 cm mark. a) What is the distance of the image from the optical centre? b) What is the size of the image?
15. A child wants to magnify an ant by a factor of 15.0. The magnifying glass she holds has a focal length of  $f = 75.0$  mm. To get this magnification, how far from the ant should she hold the magnifying glass?

16. A projector, with a focal length of  $f = 14.4\text{mm}$  produces an inverted, enlarged image of a squirrel. If the squirrel is to be enlarged by a factor of 25.0, what must be the separation between the lense and the slide of the squirrel?
17. What is the focal length of lens which has a radius of curvature of 6.00 cm on one side and 12.0 cm on the other side? Both sides are convex and the index of refraction is 1.60.
18. What is the focal length of a plano-convex lens with a radius of curvature of 12.0 cm? The index of refraction of the lens is 1.40.
19. What is the focal length of a plano-concave lens with a radius of curvature of 12.0 cm? The index of refraction of the lens is 1.40.
20. What is the focal length for a lens if both radii are 20.0 cm, the index of refraction is 1.20, and:
  - a) both sides are convex.
  - b) both sides are concave.
  - c) one side is convex and the other is concave.
21. A double convex lens ( $n = 1.50$ ) has radii of curvatures of 18.0 cm.
  - a) What is the focal length in air?
  - b) What is the focal length in water?
22. A converging meniscus flint glass lens has a focal length of 26.5 cm. What is its convex radius if its concave radius measures 8.0 cm?
23. What are the radii of curvature of a double convex Plexiglas lens ( $R_1 = R_2$ ) that has a focal length of 30.0 cm?
24. What is the radius of curvature of a double concave Plexiglas lens ( $R_1 = R_2$ ) that has a focal length of  $-30.0\text{ cm}$ ?
25. Someone has two double convex lenses ( $R_1 = R_2$ ). One is made of crown glass and the other is made of diamond, and each have a focal length of 10.0 cm. What is the radii of curvatures for each lens?
26. What is the index of refraction of a diverging meniscus lens of focal lenth  $-15.5\text{ cm}$ , and has a concave radius of 5.0 cm and a convex radius of 12 cm
27. A person has two identically shaped lenses, one is made of Plexiglas and the other zircon. Which lens has the greater focal length and by what factor?
28. A plano-concave flint glass lens has a focal length of  $-16.0\text{ cm}$  in air. Material of what index of refraction should the lens be placed into to have a focal length of  $+16.0\text{ cm}$ ?
29.
  - a) What is the focal length of a double convex glass lens ( $R_1 = R_2$ ) of radius 20.0 cm for violet light? The index of refraction for violet light is 1.532.
  - b) What is the focal length of the same lens for red light? The index of refraction for red light is 1.513.
30. A converging lens has a focal length of 20.0 cm If it is placed 50 cm from an object, at what distance from the lens will the image be?
31. The focal length of a lens in a box camera is 10.0 cm. The fixed distance between the lens and the film is 11.0 cm. If the object is to be clearly focussed on the film, how far must it be from the lens?
32. An object 2.0 cm high is placed 8.0 cm from the focal point of a double convex lens made of quartz. The lens has a radii of curvature of 20.0 cm and 5.0 cm. Calculate the position and size of the image.

33. What is the focal length of the following lens? Is it converging or diverging?



34. What is the focal length of the following lens? Is it converging or diverging?



**Answer List**

1.  $d_i = 33.3 \text{ cm}$
2.  $d_o = 110 \text{ cm}$
3. a)  $d_i = 36 \text{ cm}; h_i = -3.6 \text{ cm}$
4. a)  $d_i = -15 \text{ cm}; h_i = 2.5 \text{ cm}$
5.  $d_i = 5.3 \text{ cm}; h_i = -1.3 \text{ cm}$
6.  $d_i = 20.0 \text{ cm}$
7. a)  $d_i = 5.10 \text{ m}$
8.  $d_i = 12 \text{ cm}$  and  $d_o = 24 \text{ cm}$ ; or  $d_i = 24 \text{ cm}$  and  $d_o = 12 \text{ cm}$
- b)  $h_i = -62.5 \text{ cm}$
- c)  $0.13 \text{ cm}$
9.  $d_i = 60.0 \text{ cm}; h_i = -10.0 \text{ cm}$
10.  $d_o = 42 \text{ cm}$
11.  $d_i = -30.0 \text{ cm}; h_i = 1.75 \text{ cm}$
12.  $f = 9.1 \text{ cm}$
13.  $d_i = 13.3 \text{ cm}; h_i = -1.00 \text{ cm}$ ; real image
14. a)  $d_i = 43 \text{ cm}$
- b)  $h_i = -5.6 \text{ cm}$
15.  $d_o = 70.0 \text{ mm}$
16.  $d_o = 15.0 \text{ mm}$
17.  $f = 6.7 \text{ cm}$
18.  $f = 30.0 \text{ cm}$
19.  $f = -30 \text{ cm}$
20. a)  $50 \text{ cm}$
- b)  $-50 \text{ cm}$
- c)  $f = \infty$
21. a)  $f_{air} = 18 \text{ cm}$
- b)  $f_{water} = 70 \text{ cm}$
22.  $R_{convex} = 5.5 \text{ cm}$
23.  $R = 30.6 \text{ cm}$
24.  $R = -30.6 \text{ cm}$
25.  $R_{crown} = 10.4 \text{ cm}, R_{diamond} = 28.4 \text{ cm}$
26.  $n = 1.55$
27. Plexiglas has the greater focal length by a factor of  $f_{plex} = 1.80f_{zircon}$
28.  $n_{material} = 4.71$
29. a)  $f_{violet} = 18.8 \text{ cm}$
- b)  $f_{red} = 19.5$
30.  $d_i = 33.3 \text{ cm}$
31.  $d_o = 110 \text{ cm}$
32.  $d_i = 18.1 \text{ cm}$
33.  $f = -4.13 \text{ cm}$ . It is a diverging lens.
34.  $f = 19.7 \text{ cm}$ . It is a converging lens.