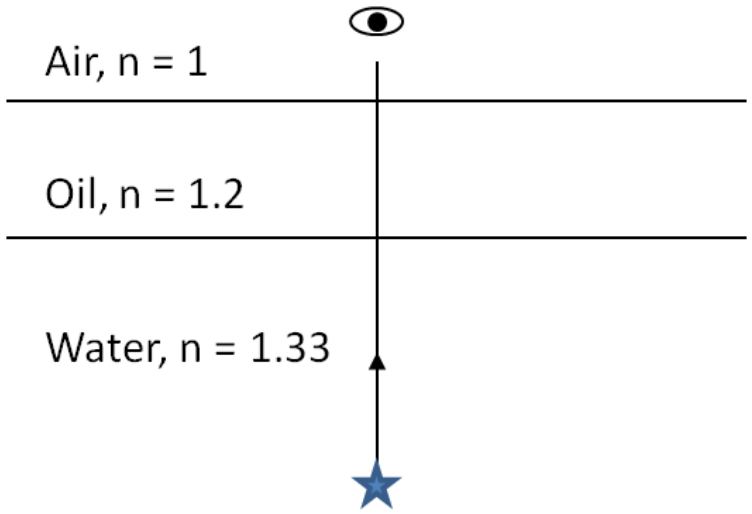
2.7 PROBLEMS

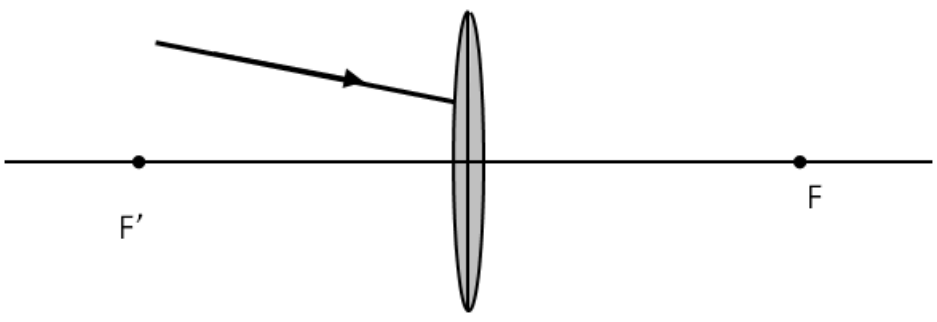
Problem 2.7.1. A small light bulb is at the bottom of a tank that has a layer of water and a layer of oil as shown. Determine the apparent depth of the bulb as seen from near normal. Use a ruler to measure the distance(s).

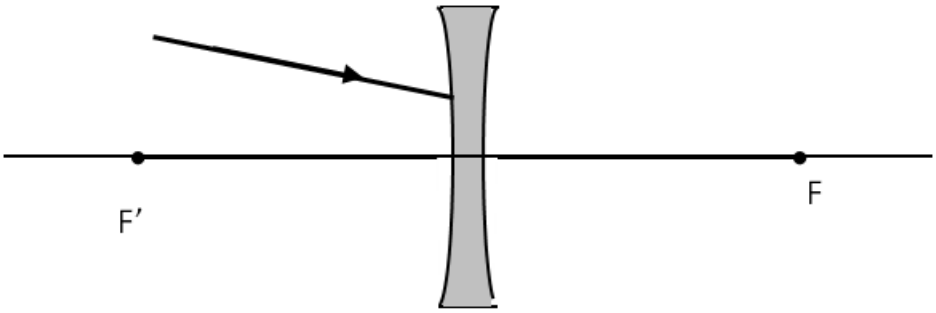
Ans: Let O_1 and O_2 be the water(n_1)/oil(n_2) and oil(n_2)/air(n_3) interfaces. Let P be location of the bulb and Q be the location of the final image.

$$O_2Q = \frac{n_3}{n_2}\left[O_2O_1 + \left(\frac{n_2}{n_1}\right) O_1P_1\right].$$

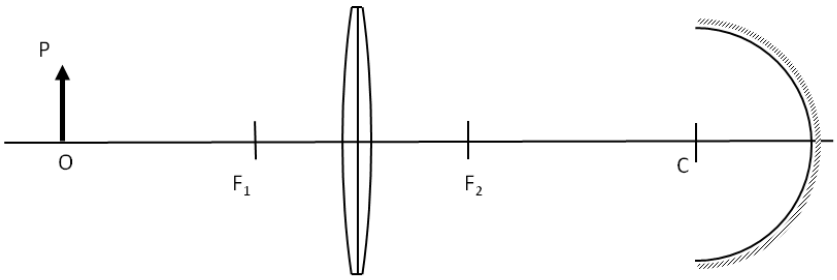


Problem 2.7.2. Trace rays to find which way the given ray will emerge after refraction through the thin lens. Assume thin lens approximation.





Problem 2.7.3. Copy and draw rays to find the final image.



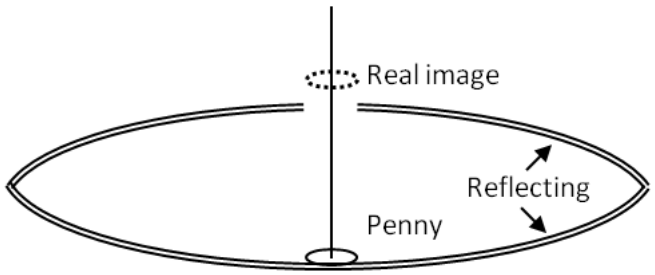
Problem 2.7.4. A concave mirror of radius of curvature 10 cm is placed 30 cm from a thin convex lens of focal length 15 cm. Find the location and magnification of a small bulb sitting 50 cm from the lens by using the algebraic method. Ans: 12 cm to the left of the mirror, $m = 3/5$.

Problem 2.7.5. An object of height 3 cm is placed at 25 cm in front of a converging lens of focal length 20 cm. Behind the lens there is a concave mirror of focal length 20 cm. The distance between the lens and the mirror is 5 cm. Find the location, orientation and size of the final image.

Problem 2.7.6. An object of height 3 cm is placed at a distance of 25 cm in front of a converging lens of focal length 20 cm, to be referred to as the first lens. Behind the lens there is another converging lens of focal length 20 cm placed 10 cm from the first lens. There is a concave mirror of focal length 15 cm placed 50 cm from the second lens. Find the location, orientation and size of the final image. Ans: 27 cm in front of the mirror, $m = 0.6$, h_i= 1.76 cm, orientation same as the object.

Problem 2.7.7. An object of height 2 cm is placed at 50 cm in front of a diverging lens of focal length 40 cm. Behind the lens there is a convex mirror of focal length 15 cm placed 30 cm from the converging lens. Find the location, orientation and size of the final image. Ans: Image 11 cm behind the mirror, $m = 0.1$, $h_i = 0.2$ cm.

Problem 2.7.8. Two concave mirrors are placed facing each other. One of them has a small hole in the middle. A penny is placed on the bottom mirror. When you look from the side, a real image of the penny is observed above the hole. Explain how that could happen.



Problem 2.7.9. A lamp of height 5 cm is placed 40 cm in front of a converging lens of focal length 20 cm. There is a plane mirror 15-cm behind the lens. Where would you find the image when you look in the mirror?

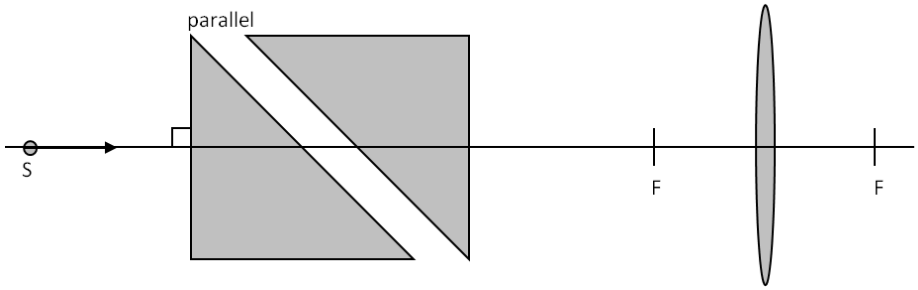
Problem 2.7.10. Parallel rays from a far away source strike a converging lens of focal length 20 cm at an angle of 15 degrees with the horizontal direction. Find the vertical position of the real image observed on a screen in the focal plane. Ans: 5.4 cm from the axis.

Problem 2.7.11. Parallel rays from a far away source strike a diverging lens of focal length 20 cm at an angle of 10 degrees with the horizontal direction. As you look through the lens, where in the vertical plane the image would appear? Ans: 3.5 cm from the axis.

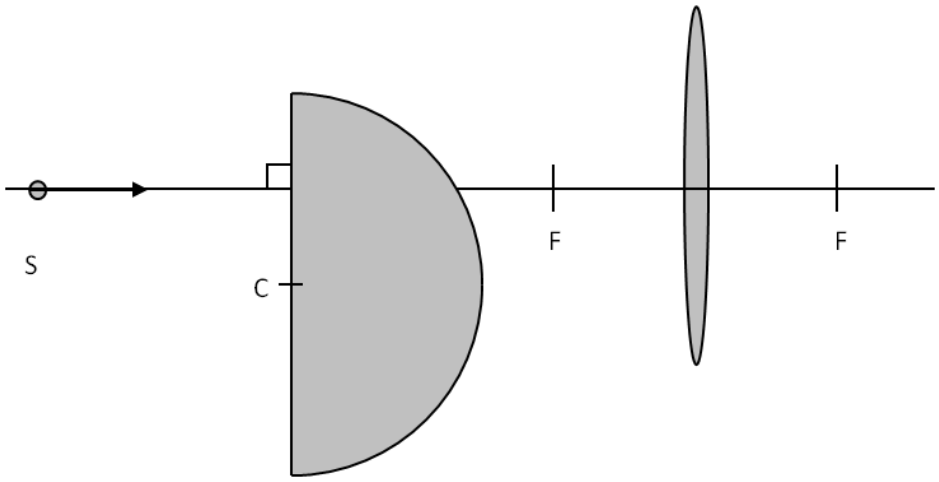
Problem 2.7.12. A light bulb is placed 10 cm from a plane mirror, which faces a convex mirror of radius of curvature 8 cm. The plane mirror is located at a distance of 30 cm from the vertex of the convex mirror. Find the location of two images in the convex mirror. Are there other images? If so, where are they located?

Problem 2.7.13. A point source of light is 50 cm in front of a converging lens of focal length 30 cm. There is a concave mirror at a distance of 25 cm behind the lens. Where does the final image form, and what are its orientation and magnification?

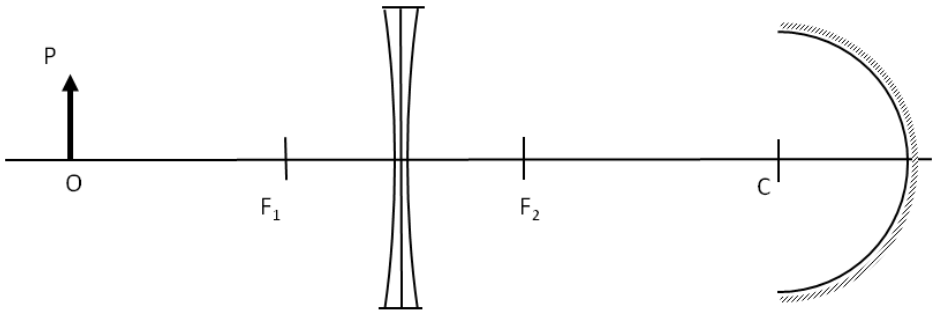
Problem 2.7.14. Copy and trace to find how a horizontal ray from S comes out after the lens. Use $n_{\text{glass}} = 1.5$ for the prism material.



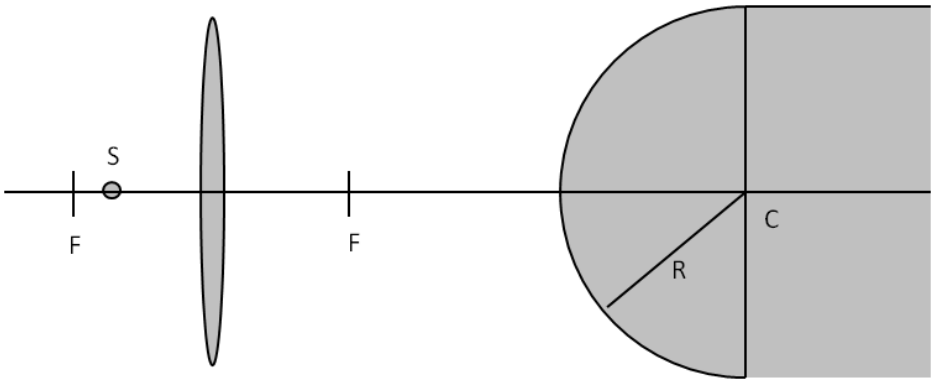
Problem 2.7.15. Copy and trace how a horizontal ray from S comes out after the lens. Use $n = 1.55$ for the glass.



Problem 2.7.16. Copy and draw rays to figure out the final image.



Problem 2.7.17. By tracing or using algebraic method find the place inside the glass where rays from S converge as a result of refraction through the lens and the convex air/glass interface. Use a ruler to estimate the radius of curvature.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