Physics 464/564

Homework #4 Due April 30, 2009
Ray tracing

1. The figure shows a ray striking a spherical surface at the point A of angular position $\varphi = 40^o$ with respect to the center C of the sphere. Here $s_o = 40$ cm, R= 10 cm.

a) Using the Snell's law, find the position s_i of the point Q at which the refracted ray AQ crosses the optical axis. Few previous steps may be needed:

Find the different angles α, β, Ψ, shown in the diagram.

Once the angles are found, calculate the magnitude of the segment |CQ|

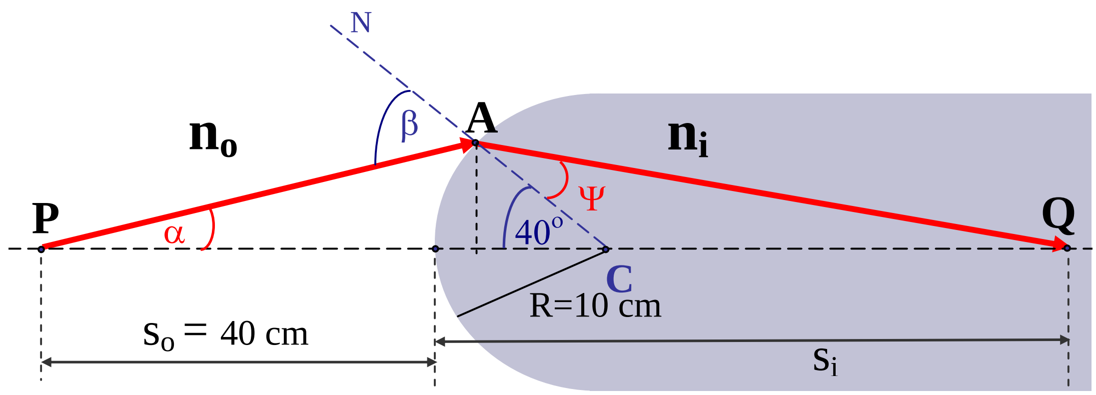


Fig. 1 *Imaging an object by a* ***convex*** *spherical surface. C is the center of the spherical surface of radius R. Assume n_i=1.33 and n_o=1 Figure is not drawn to scale.*

b) Consider the fixed positions of P and Q found in part a) above.

Let $\mathcal{OPL}$(PXQ) be the optical path length of the ray PXQ (see Fig. 2 below.) According to the variational principle we expect the ray PAQ to be stationary

Plot $\mathcal{OPL}$(PXQ) vs φ. A few discrete values of φ will be OK, with some finer values of φ around $\varphi = 40^o$.

Note: The exact value for s_i found in part a) is not critical. For a given values of s_o and s_i there should be a stationary state (reflected in the max or minimum of the OPL as a function of φ.)

c) We also expect the ray PVQ to be stationary

Plot $\mathcal{OPL}$(PXQ) vs φ. A few discrete values of φ will be fine, with some finer values of φ around $\varphi = 0^o$)

Notice the paraxial approximation can not be used here.

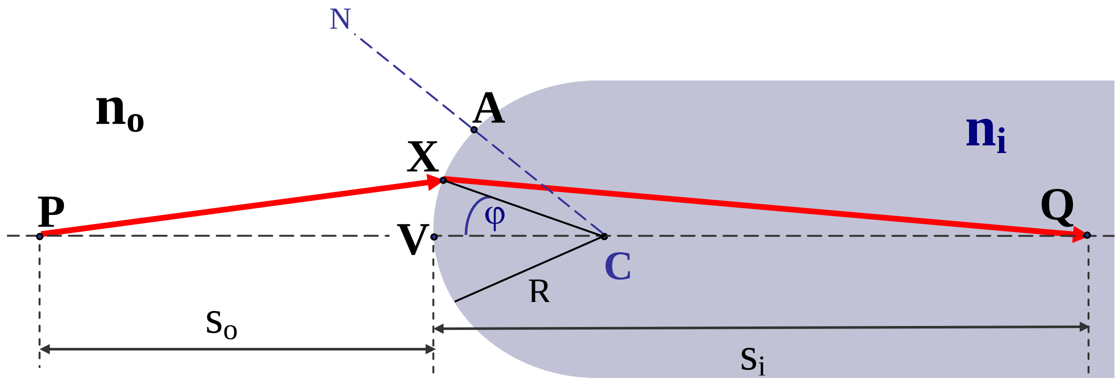
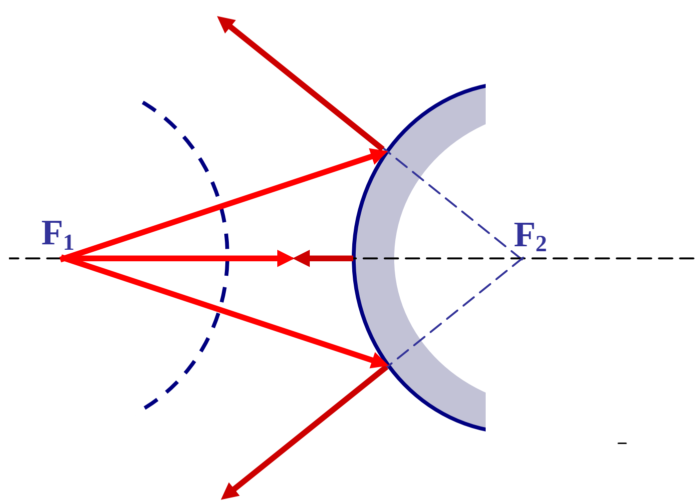


Fig.2

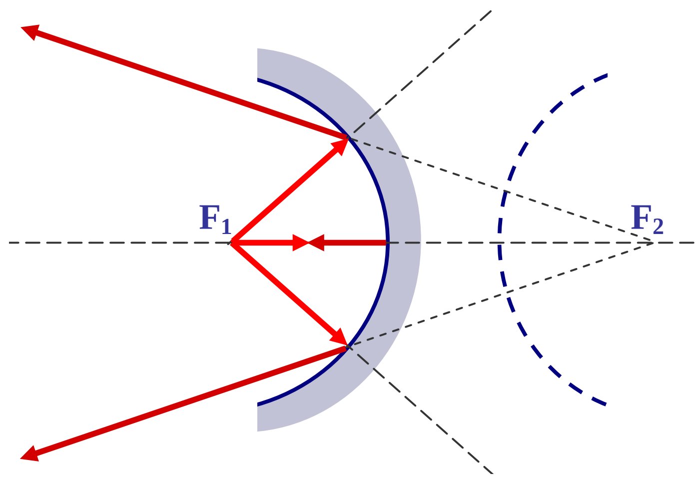
ASPHERICAL MIRRORS

2. Consider hyperbolic mirrors.

2A Convex hyperbolic mirror. Justify the following ray tracing using the variational principle,

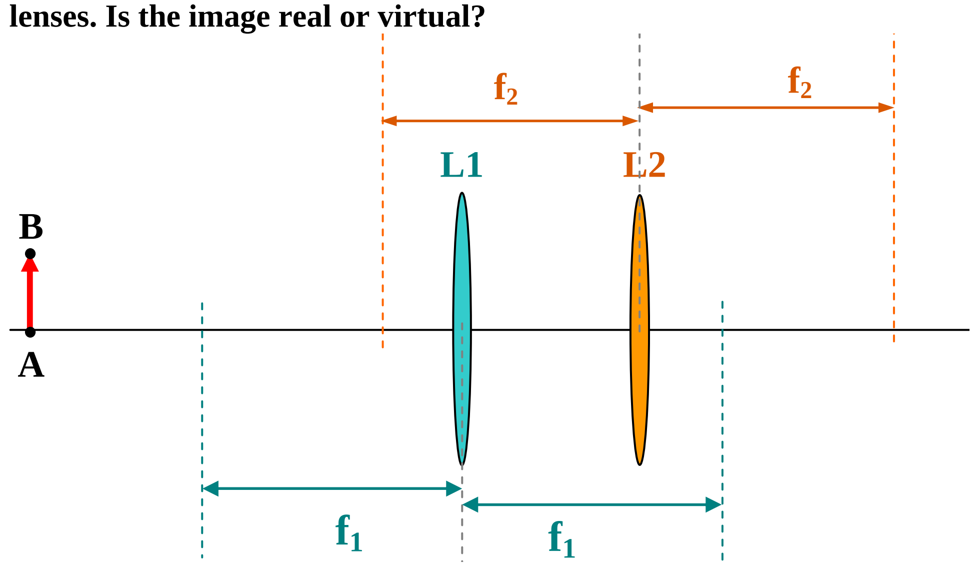


2B Concave hyperbolic mirror. Justify, using the variational principle, the following ray tracing

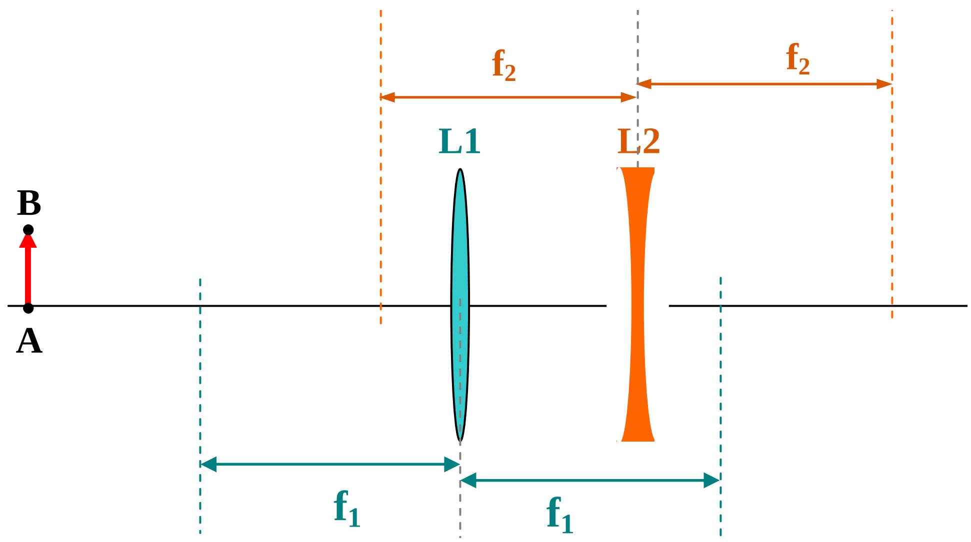


IMAGING THROUGH THIN LENSES

3. 3A Use ray tracing to find the image of the object AB through the two positive lenses. Is the image real or virtual?



3B Use ray tracing to find the image of the object AB. One lens is positive the other <u>negative</u>. Is the image real or virtual?



4. Consider a thin positive lens L_1. Using ray tracing diagrams, show that if a second lens L_2 is placed at the focal point of L_1 the magnification does not change. [That is a good reason to wear glasses (whose two lenses are different) at the correct distance from the eye.