# Physics 464/564

**Due 04-28-09** **Homework #3**

## Aspherical Refracting Surfaces

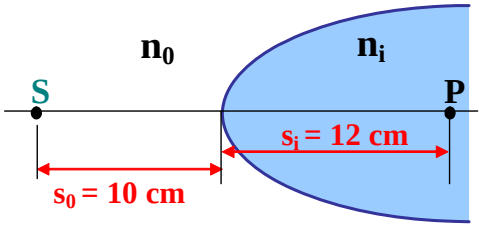
### The Fermat's Principle, the principle of reversibility, and the perfect imaging of two conjugated points

**1**. This question is about designing a refracting (oval) surface that would produce a perfect imaging (aberration free) of a point **S**. Such perfect image of point S is denominated here **P**. The points **P** and **S** are called conjugate points with respect to that particular refracting surface.
The way to set up the problem is to follow Fermat's principle: every ray that starts at S, refracts at the surface, and ends up at P, is required to take the same transit time. These rays are said to be *isochronous*.
Draw, **to scale**, the corresponding oval surfaces for the case $s_0$=10 cm and $s_i$= 12 cm.

**a)** $n_0 = 1$, $n_i = 1.2$

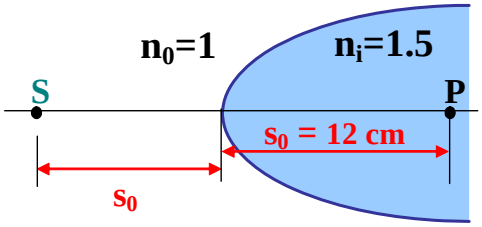
**b)** $n_0 = 1$, $n_i = 1.5$

**c)** $n_0 = 1$, $n_i = 3$




Ideally, place all the plots in just one graph (that is, point V for all the ovals being the same.)
**Note:** The aberration-free imaging so achieved applies only to the object point S at the correct distance from the lens (the refracting oval surface) and on axis. For nearby objects (around S) imaging is not perfect.

**2**. Draw, **to scale**, the corresponding oval surfaces,




**a)** $s_0$ = 5 cm

**b)** $s_0$ = 25 cm

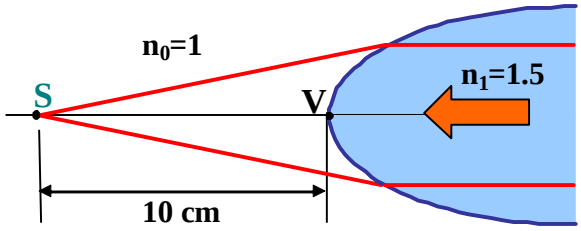
**c)** $s_0$ = 50 cm

Ideally, place all the plots in just one graph (that is, point V for all the ovals being the same.)

**3.** 3A We wish to focus an incident collimated light beam toward a point located 10 cm away from the vertice point V using a hyperboloid lens.

a) Find the corresponding parameters, eccentricity *e* and focal length *f* , of the corresponding hyperboloid.
Graphically identify the location and corresponding coordinates of all the principal parameters (vertice, the two focal points, directriz.)

b) Write down the Cartesian equation of the hyperboloid.
(Although you are free to choose the origin of coordinates at any place, you may want to follow the one suggested in the lecture notes.)




**4.** 3A We wish to focus an incident collimated light beam toward a point located 10 cm away from the vertice point V using a ellipsoidal lens.

a) Find the corresponding parameters, eccentricity *e* and focal length *f* , of the corresponding ellipsoid.
Graphically identify the location and corresponding coordinates of all the principal parameters (vertice, the two focal points, directriz.)

b) Write down the Cartesian equation of the ellipsoid.
(Although you are free to choose the origin of coordinates at any place, you may want to follow the one suggested in the lecture notes.)