Homework # 1
due Wednesday Sep 29 at 5PM

Reading: Hecht 4.3, 4.5, 5.1, 5.2, 5.4

Problems:

1. Prove the Law of Reflection from a mirror (p. 98 in Hecht) using Fermat's principle.

2. Prove that a parabolic mirror surface focuses all incoming parallel rays to a single point F (see Figure 1).

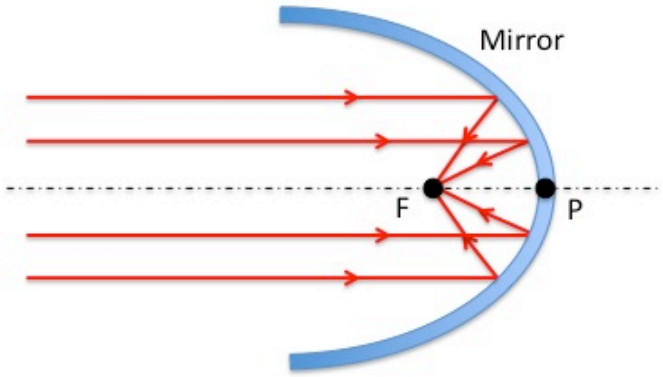

Figure 1

3. Transmission through planar plates.
(a) Use Snell's law to show that a ray entering a planar plate of thickness d and refractive index n_1 (placed in air; $n \sim 1$) emerges parallel to its initial direction. The ray need not be paraxial. Derive an expression for the lateral displacement of the ray as a function of the angle of incidence θ. Explain your results in terms of Fermat's principle.
(b) If the plate instead comprises a stack of N parallel layers stacked against each other with thicknesses $d_1, d_2, \ldots, d_N$ and refractive indexes $n_1, n_2, \ldots, n_N$, show that the transmitted ray is parallel to the incident ray. If θ_m is the angle of the ray in the mth layer, show that $n_m \sin\theta_m = \sin\theta, m = 1,2,\ldots$

4. A point light source is embedded a distance h below the surface of diamond with index of refracion n = 2.4 (Fig. 2). Assume that the source emits light in a spherically symmetric fashion (*i.e.* uniformly in all three spatial dimensions). Using ray optics,

derive what fraction of the light emitted by the source is transmitted through to the air (top side of diamond). (Since we have not covered reflection coefficients for non-normal incidence, assume there is no reflection at the interface until the critical angle is reached).