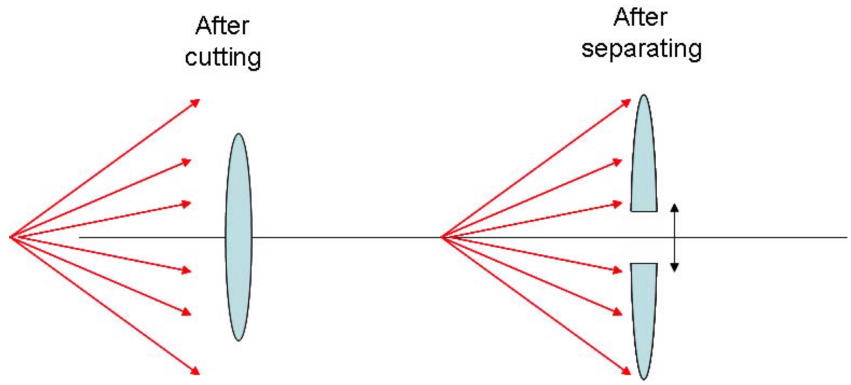
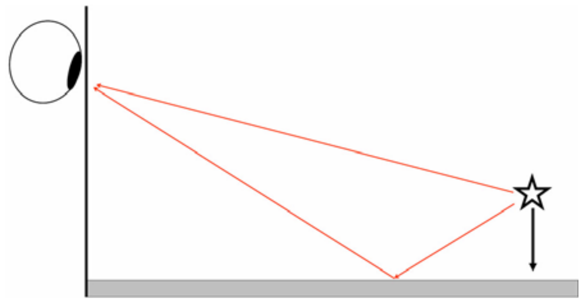
SIMG-455 Homework #5 Due 5/1/2008 (Th)

1. A lens with $f = +200\,\text{mm}$ is sawn in two pieces through a plane cutting through the optical axis (i.e., the cut is along a diameter). A point source S of monochromatic light with $\lambda = 500\,\text{nm}$ is placed on the optical axis at a distance $z_1 = 400\,\text{mm}$ from the lens. The half lenses are gradually moved apart; each creates an image of the point source that are mutually coherent. The light is observed on a screen placed at a distance $z_2 = 1000\,\text{mm}$ from the lens. Determine the width of the interference fringes observed on the screen if the lenses are moved apart by a distance of $0.5\,\text{mm}$. ((Hint, problem is easy if you look at it correctly)



2. A monochromatic star with $\lambda_0 = 460\,\text{nm}$ is setting over a smooth ocean surface. Assume that we are located at the equator and the star is on the celestial equator, so that the star path is perpendicular to the ocean surface. Some of the starlight travels directly to the observer and some is reflected from the surface. Describe qualitatively and quantitatively what is observed at the observation plane as a function of both space and time; include a sketch of the pattern observed at one time and indicate what happens as the star approaches the horizon. Possibly useful information: the earth rotates 360° in 24 hours, so the star appears to move 15° in one hour.



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3. *Newton's rings* is the name given to the interference pattern observed when a plano-convex lens is placed (convex side down) on an optical flat and illuminated by monochromatic (or nearly monochromatic) light. In one such example the diameter of the first bright is 2 mm.
   a. If the radius of curvature of the convex surface is 4 m, then determine the wavelength λ_0 of the illumination.
   b. If the space between the glass surfaces is filled with water $\left(n = 1.33 \cong \frac{4}{3}\right)$, determine the diameter of the first bright ring.
4. The radius of curvature of the convex surface of a plano-convex lens is $r_1 = 2\,\mathrm{m}$. The lens is placed convex side down on the *concave* surface of a plano-concave lens with $r = 4\,\mathrm{m}$. The lenses are illuminated from above with light with $\lambda_0 = 625\,\mathrm{nm}$.
   a. Describe the pattern observed; a sketch would be helpful
   b. Find the diameter of the third bright ring in the interference pattern of the reflected light.
5. A two-aperture apparatus may be used to measure the index of refraction of gases. The apertures are separated by d and illuminated from the left by monochromatic plane waves with wavelength λ_0. The resulting pattern is observed on a screen located a distance L from the aperture plane. Two identical glass containers are placed just after the apertures; the lengths of both chambers along the axis of symmetry are identically ℓ.
   a. With both chambers evacuated (i.e., both are "filled with vacuum"), describe what is observed on the screen.
   b. If a gas is admitted into one of the two chambers, describe what happens to the pattern; be specific about any directions involved.
   c. Use the results of (a) and (b) to find an expression for the refractive index n of the gas.