MASSACHUSETTS INSTITUTE OF TECHNOLOGY

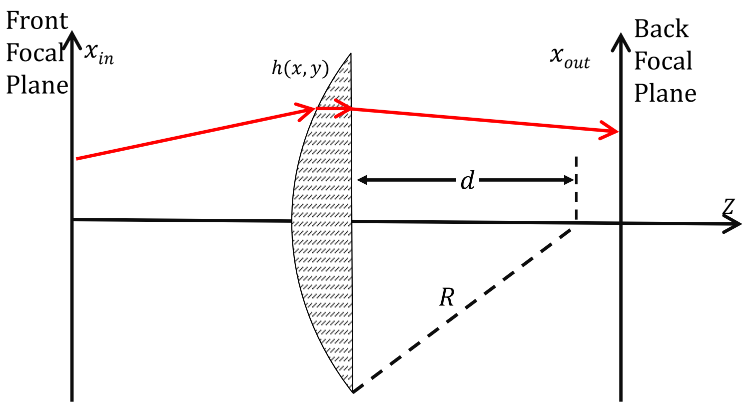
2.71/2.710 Optics **Spring '14**

HW3 Posted Mar 12, 2014, Due March 19, 2014

1. **Optical Path Length Calculation using a Thin Lens:**
   The optical path through a plano-convex lens at a given point (x, y) is proportional to its index of refraction n and thickness $h(x, y)$:

$$h(x, y) = \sqrt{[R^2 - (x^2 + y^2)]} - d$$

where R is the radius of curvature and d is the distance from the flat surface to the center of radius.



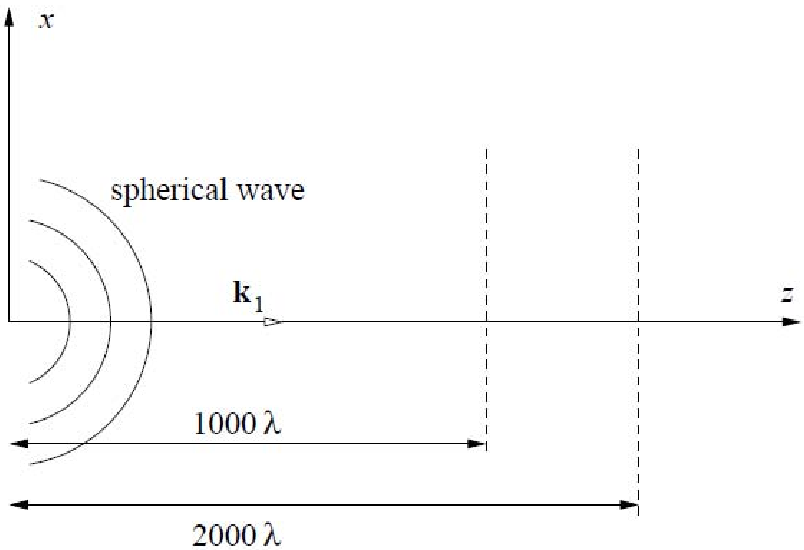
a) Using the thin lens approximation, find distance of the front and back focal plane.
b) For an arbitrary ray $\begin{pmatrix} x_{in} \\ \theta \end{pmatrix}$ originated at the front focal plane, calculate the total optical path length when it arrives at the back focal plane.
c) Under paraxial approximation, compare your result of b) with the optical path length of a chief ray $\begin{pmatrix} x_{in} \\ -x_{in}/f \end{pmatrix}$.
d) Plot the phase fronts associated with the two rays in b) and c) before and after the lens. What is your observation?

2. A plane wave and a spherical wave, both of the same wavelength λ, are co-propagating as shown on the next page.

a) Describe the interference pattern that would be observed on a plane perpendicular to the z axis at a distance of 1000λ away from the origin of the spherical wave.

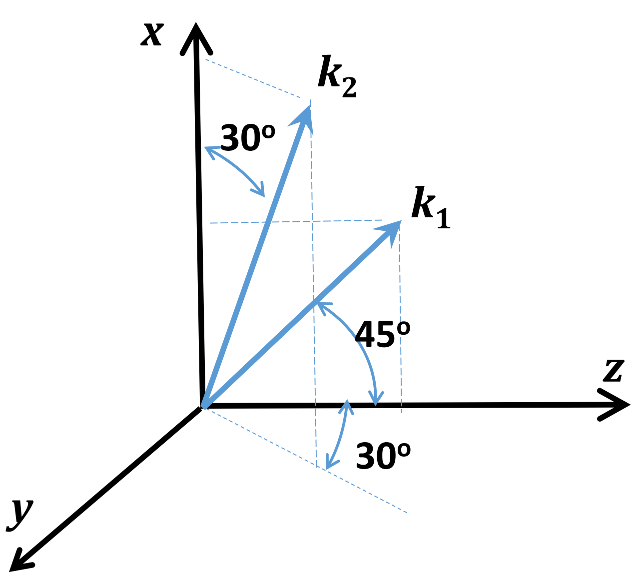
b) Repeat for the plane located 2000λ away from the origin of the spherical wave.

c) What do you observe? Explain in physical terms.



d) What is the relationship between your result and a Michelson interferometer with a lens inserted in one of the two arms?

3. Two plane waves of the same wavelength λ, *a*re propagating along the directions of wave vectors $\mathbf{k}_1$, $\mathbf{k}_2$ as shown in the figure below.

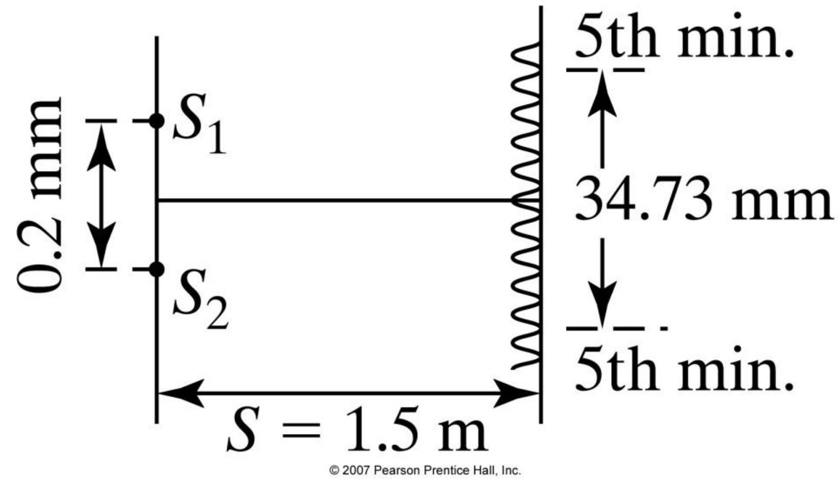


a) Describe the interference pattern that would be observed on the *xy*- plane.

b) Describe the interference pattern that would be observed on a plane parallel to *xy* but one wavelength λ away towards the positive *z* direction.

c) Describe the interference pattern that would be observed on the *yz*- plane.

4. (Pedrotti 7-7) In a Young's double slit experiment, narrow double slits 0.2mm apart diffract monochromatic light onto a screen placed 1.5 m away. The distance between to fifth minima on either side of the zeroth order maximum is measured to be 34.73 mm. Determine the wavelength of the light.



5. (Pedrotti 8-1) When one mirror of a Michelson interferometer is translated by 0.0114 cm, 523 fringes are observed to pass the cross-hairs of the viewing microscope. Calculate the wavelength of the light source.