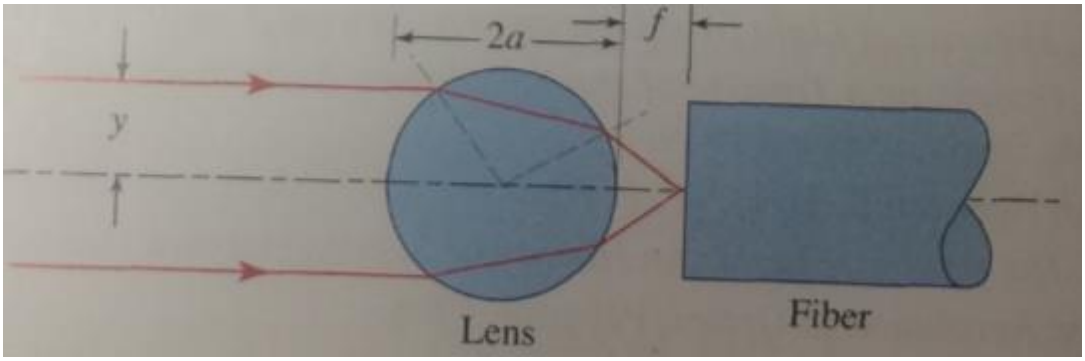
ECE 460: Optical Imaging

Homework2: Due 02/25/2020

Refer textbook, Fundamentals of Photonics (2nd edition), Saleh and Teich

1. 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≈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 of a stack of N parallel layers stacked against each other with thickness $d_1, d_2, \ldots, d_N$ and refractive indices $n_1, n_2, \ldots, n_N$, show that the transmitted ray is parallel to the incident ray. If θ_M is the angle of the ray in the m^{th} layer, show that $n_m \sin\theta_m = \sin\theta$, m=1,2,…
2. Lens in water: Determine the focal length f of a biconvex lens with radii 20cm and 30 cm and refractive index n=1.5. What is the focal length when the lens is immersed in water (n=4/3)?
3. Numerical aperture of a cladless fiber: Determine the numerical aperture and the acceptance angle of an optical fiber if the refractive index of the core is n_1=1.46 and the cladding is stripped out (replaced with air n_2≈1).
4. Fiber Coupling Spheres. Tiny glass balls are often used as lenses to couple light into and out of optical fibers. The fiber end is located at a distance f from the sphere. For a sphere of radius a=1mm and refractive index n=1.8, determine f such that a ray parallel to the optical axis at a distance y=0.7 mm is focused onto the fiber, as illustrated in Fig below



5. Find the principle planes of the ball lens in problem 4 (both in air and water)
6. Ray transfer matrix of a lens system: Determine the ray transfer matrix for an optical system made of thin convex lens of the focal length f and a thin concave lens of focal length -f separated by a distance f. Discuss the imaging properties of this composite lens.

7. Ray transfer matrix of a GRIN plate: Determine the ray-transfer matrix of a SELFOC plate (i.e., a graded index material with parabolic refractive index $n(y) = n_0\left(1 - \frac{1}{2}\alpha^2 y^2\right)$ of thickness d.