Phys 531 Assignment 1 Due September 5

1. Saleh and Teich Exercise 1.2-1, pg. 10.

2. Saleh and Teich Exercise 1.2-3, pg. 14. You should obtain a non-differential equation satisfied by points (y, z) on the surface of the interface. You don't need to simplify the equation to any particular form, but it should contain no unspecified parameters.

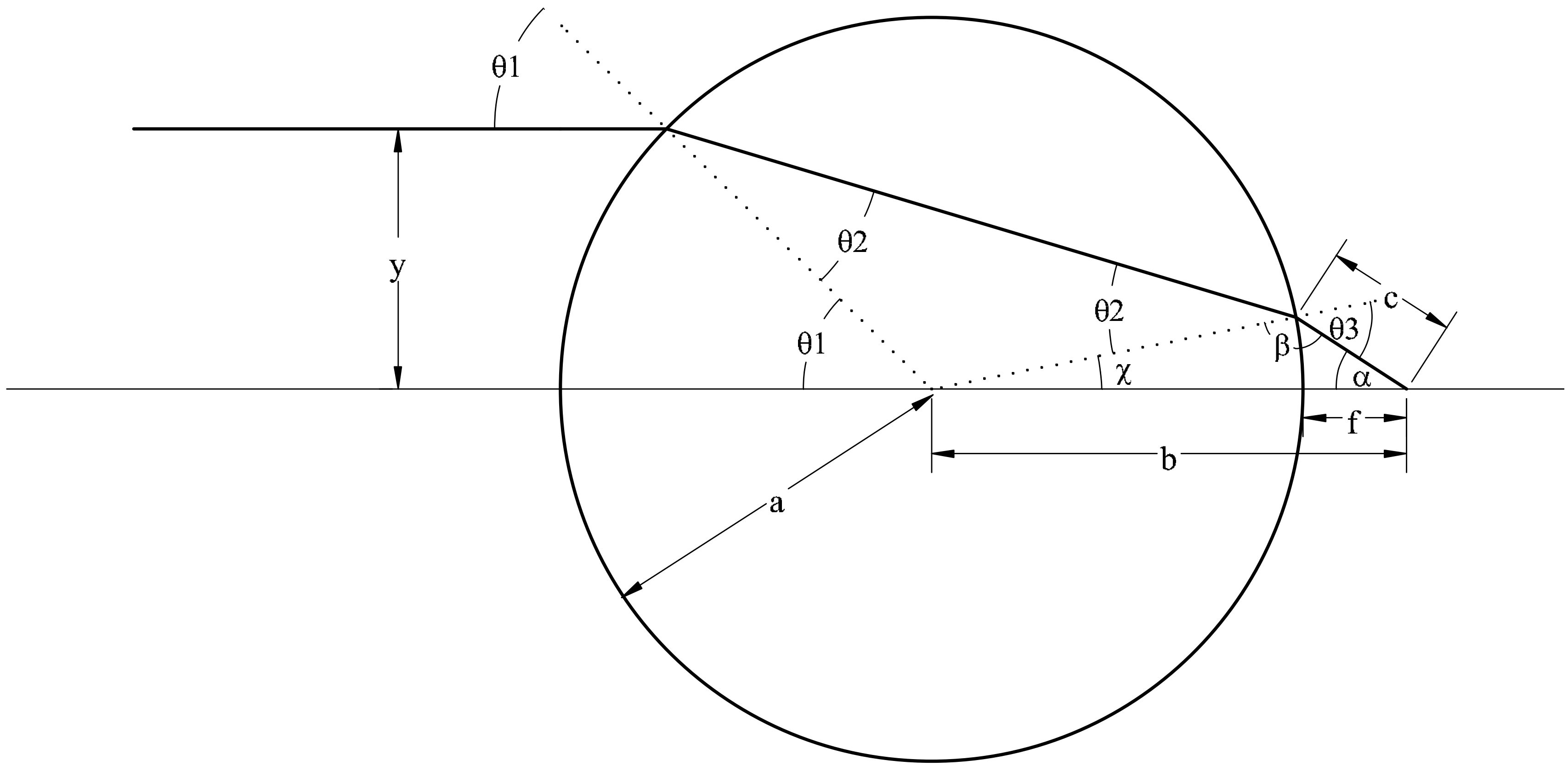
3. Saleh and Teich Exercise 1.4-1, pg. 28. Try to express the "special features" of the systems in terms of focusing or imaging properties, not just the obvious mathematical properties. For instance, in part (a), you show that collimated input rays are focused to a single point. Other properties might be that points at the input are imaged to points on the output, or that rays emitted from points at the input are collimated. (Collimated light has parallel rays.)

4. Saleh and Teich Problem 1.2-2, pg 39. Figure 1.2-13 illustrates a biconvex lens.

5. (a) A ball lens is just a glass sphere used as a lens, often used to focus collimated input rays. See for instance Saleh and Teich Figure P1.2-4 on pg 39. Calculate the focal length f_0 (measured from the rear vertex) of a ball lens of radius a and index of refraction n when used to focus paraxial rays. Note that a ball lens is not thin. You may either use the matrix techniques of Section 1.4 or the interface equations (1.2-8) or (1.2-9) for your solution.
(b) If a ball lens has radius 1 mm and index $n = 1.5$, find the focal length f for a horizontal input ray a distance $y = 0.7$ mm above the optic axis. Since $y \approx a$, the paraxial approximation does not hold here. The problem can be solved several ways, but I'm including a figure on the back with labels for some of the angles and distances I found useful. You might also recall the Law of Sines, which states that for the triangle α, β, χ shown,

$$\frac{\sin\alpha}{a} = \frac{\sin\beta}{b} = \frac{\sin\chi}{c}.$$

(c) The deviation of (b) from the paraxial result is attributed to aberrations of the lens, specifically spherical aberration in this case. A common way to measure aberration is by the difference $f_0 - f$, termed the longitudinal spherical aberration or LSA. Another is by the distance of the nonparaxial ray from the optic axis at the plane of the paraxial focus, termed the transverse spherical aberration or TSA. Find the LSA and TSA for the ray in (b).



θ1
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y
θ2
θ1
θ3
c
β
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α
f
b
a