BIOMICROSCOPY I – MICRO-561

Exercise Series 1

Suggested reading: "Fundamentals of Photonics" by Saleh & Teich 2nd Ed. Chapter 1

Problem #1

Consider a spherical boundary with a radius **R** between two media of refractive index n_1 and n_2 (shown in Figure 1). By convention R is positive for a convex boundary and negative for a concave boundary. Derive the relationship between θ_1 and θ_2 (under paraxial approximation). Hint: Apply Snell's law and use geometry.

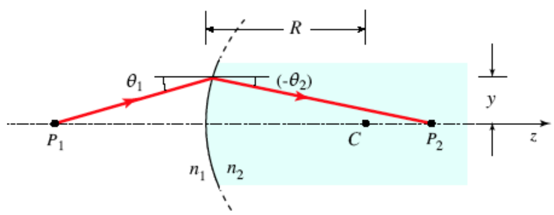

Figure 1

Problem #2

A spherical glass lens (shown in Figure 2a), can be regarded as a combination of two spherical boundaries: air-to-glass and glass-to-air. The lens is defined by the radii $\mathbf{R_1}$ and $\mathbf{R_2}$ of its two surfaces, its thickness **Δ**, and the refractive index **n** of the material. This lens is called thin when $\Delta \rightarrow 0$. In this case we can neglect light propagation in medium so that the height at which the incident rays enter the lens is same with the height that the rays exit (figure 2b and 2c). The focal length of a thin spherical lens in air is given by:

$\frac{1}{f} = (n-1)(\frac{1}{R1} - \frac{1}{R2})$

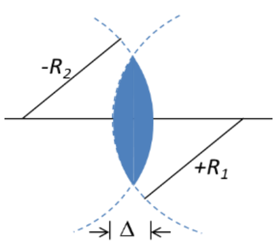

Figure 2a

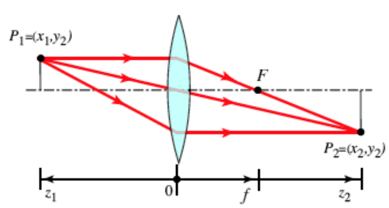

Figure 2b

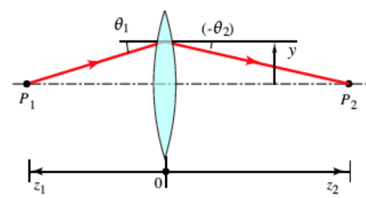

Figure 2c

By using the result of problem 1 and the definition of focal length for a thin lens (given above) show that:

1) The angles of the refracted and incident rays (shown in Fig. 2b) are related by: $\theta_2 = \theta_1 - \frac{y}{f}$

2) The imaging condition (shown in Fig. 2c) is given by: $\frac{1}{z_1} + \frac{1}{z_2} = \frac{1}{f}$

Problem #3

Determine the focal length of a planar-concave lens (n=1.5) having a radius of curvature of 10 cm.

Problem #4

Show that a glass (n=1.5) lens immersed in water (n=4/3) has 4 times the focal length it would have if immersed in air.

Problem #5

Show that for thin lens imaging problem we can write

a) The imaging equation as follows:
$x_o x_i = f^2$ (also known as Newtonian form)

b) The magnification (ratio of image height to object height) as follows:
$M = - s_i/s_o$