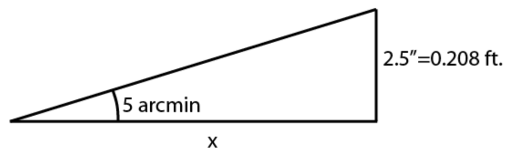
OPTI 535 Homework 1 Solutions

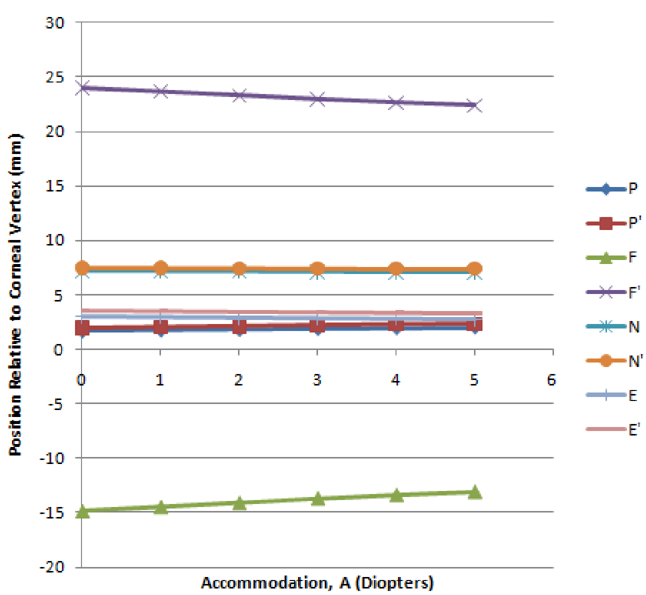
1. Two men in masks run out of a bank with a bag full of money. They jump into a car and make a getaway. You witness all of these events and fortunately have 20/20 vision. If the 20/20 E on a standard eye chart subtends 5 minutes of arc, how far away from the getaway car can you be in order to read the license plate and report it to the police?

A character on an Arizona license plate is 2.5” tall. From the geometry of the system

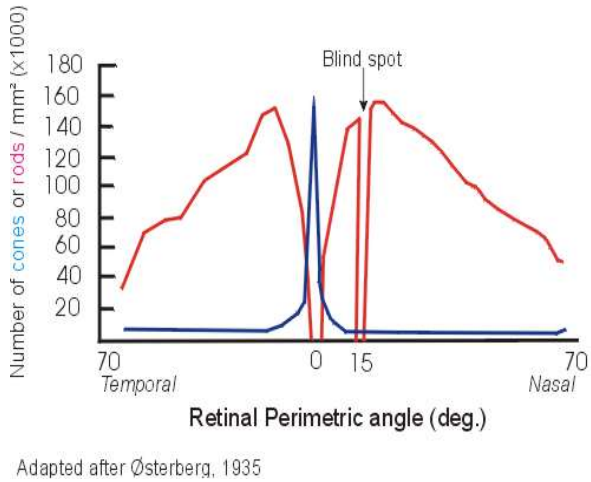


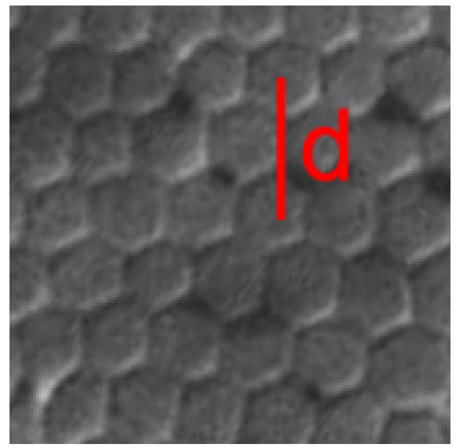
$$x = \frac{0.208\text{ ft}}{\tan\left((1/12)^\circ\right)} = 143\text{ ft} = 43.6\text{ m}$$

2. Plot the positions of the Cardinal Points (F, F’, P, P’, N, N’) and the positions of the entrance and exit pupils (E, E’) for the Arizona Eye Model as a function of accommodative amplitude A. Use 0 D ≤ A ≤ 5 D.



3. Osterberg measured the density of photoreceptors in the retina and provided the following plot. In the fovea, there are 160,000 cones/mm^2. Based on this result, what is the diameter of each cone? If the cones are hex-packed as shown in the figure below, what is the separation, d, between alternating rows of cones? What is the angular subtense of d relative to the rear nodal point of the eye?





If the cone density is 160,000 cones/mm^2, then

$$160{,}000(\text{Area of cone}) = 1\ \text{mm}^2$$

or

$$160{,}000(\pi r^2) = 1\ \text{mm}^2,$$

where r is the radius of a single cone. Solving for r gives

$$r = \frac{1}{\sqrt{160{,}000\pi}} = 0.0014\ \text{mm}.$$

So, the diameter of a cone is 2.8 μm.

Based on the geometry of the hex-packed cones,

$$d = 2\sqrt{3}r = 4.85\ \mu\text{m}.$$

If the rear nodal point is 16.684 mm from the retina, then the angular subtense of d is

$$\theta = \tan^{-1}\left[\frac{0.00485}{16.684}\right] = 0.0167° = 1.0\ \text{arcmin}$$