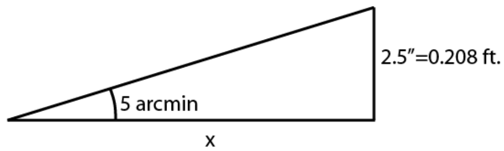
OPTI 435/535 Homework 1

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*



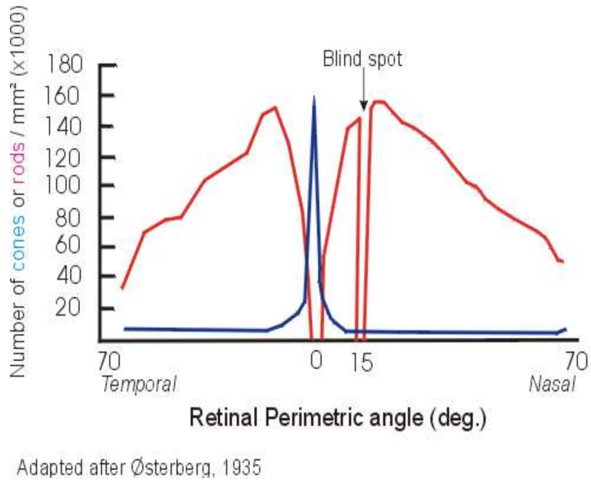
$$x = \frac{0.208ft}{tan[(1/12)°]} = 143ft = 43.6m$$

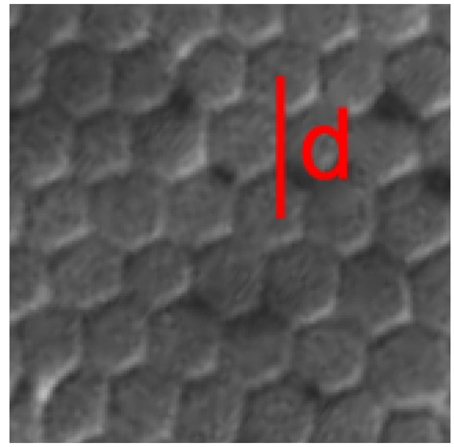
2. This question deals with Far Points, Near Points, and the amplitude of accommodation. If you have perfect vision, assume your Far Point is at infinity and find your Near Point. This can be accomplished by taking something with small print and seeing how close you can bring it to your eye before it blurs out. If you are near-sighted, find your Far Point and Near Point. For the Far Point remove your glasses or contacts, look at an object with fine detail and move away from the object until the details blur. For the Near Point, use the technique described above. If you are far-sighted, finding your Far Point is more challenging since it is behind your head, so we'll just do the following: wearing your spectacles or contacts, assume you Far Point is at infinity and find your Near Point by the technique described above. What is your amplitude of accommodation?

   Let's suppose you are near-sighted and without your glasses or contacts, you find your Far Point is 33cm from your face and your Near Point is 10cm from your face. In this case, your amplitude of accommodation is

$$A = \frac{1}{0.1m} - \frac{1}{0.33m} = 7D$$

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 two rows of cones? What is the angular subtense in units of arcmin of d relative to the rear nodal point of the eye?





If the cone density is 160,000 cones/mm², then

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

or

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

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

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

So, the diameter of a cone is $2.8\mu m$.

Based on the geometry of the hex-packed cones,

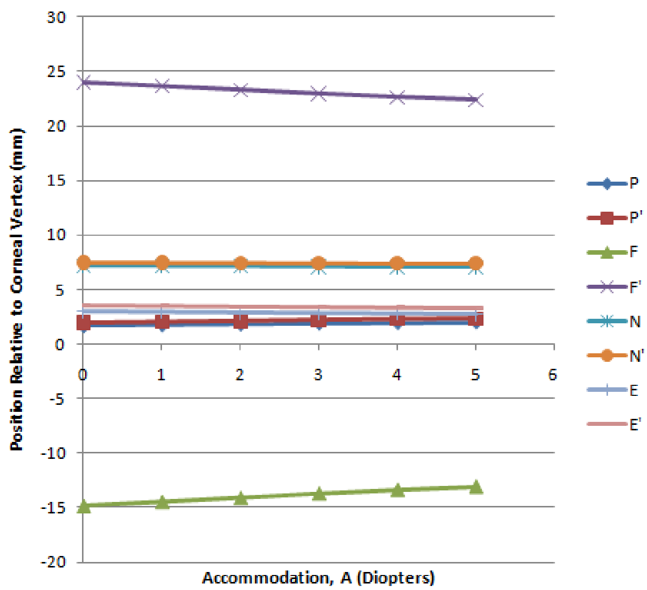
$$d = 2\sqrt{3}r = 4.85\mu m$$

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

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

Graduate Students only.

4. Using your favorite raytracing package (or a brick chart, if you prefer), 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 $0D \leq A \leq 5D$. Find the position of the object point conjugate to the retina for each level of accommodation.



The model is set up so that the object point conjugate to the retina is a distance $1/A$ *from the anterior cornea. For example, for* $A = 1D$*, the object point is at 1m. For* $A = 2D$*, the object point is at 0.5 m. The separation between the anterior cornea and the front principal plane is usually ignored since it is so small compared to the object distance.*