EE 119 Homework 5

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(Please submit your answers in EE119 homework box located in 240 Cory Hall)

1. After conquering Sartaul (East Turkestan, today's northwestern China and central Asia), Genghis Khan organized and held the Mongolian traditional festivities called, "Naadam", which included, "Three most manly games". These games were wrestling matches, horse racing, and archery. According to the Genghis Khan's script (Mongolian record), Esunge (one of Genghis Khan's marksmen) consistently hit targets (coins with D ~ 8cm) that were 535 meters away and won the archery competition. In fact, many Mongolian marksmen during the Genghis Khan's period were able to hit targets that were 500 meters away.

   (a) What is the diffraction-limited object size (at 535 meters) imposed by the numerical aperture of Esunge's eyes (if his eyes are diffraction-limited optics)? Use 3 mm for the iris diameter and 550 nm for the wavelength. Is it possible for him to see the coins with D ~ 8cm at 535 meters? Or, is it impossible due to the diffraction limit?
   (b) If Esunge was able to clearly see the targets (coins with D ~ 8cm) that were 535 meters away, what is the maximum separation (in mrad) allowed between the cone cells in his fovea? How does this compare with the average separation found in modern humans?
   (c) What is the visual acuity of Esunge's eyes?

2. Using the information on the eye discussed in class, compute the approximate size (in millimeters) of the image of the Sun as cast on the retina. Assume the Sun has a radius of 695000km and is roughly 150 million kilometers away.

3. After playing X-box games for the entire summer break, Rosie realized that she could not focus clearly on an object that was more than 15 cm away.

   (a) What must be the power of corrective lens should be used to correct her vision?
   (b) Assuming the eyeball is 2.5cm in length, without corrective lenses, how far away from the retina is the image coming to a focus for an object at an infinite distance? The refractive index of the eye is 1.336.

4. Rosie's grandpa has a near point at 75cm. Assume his eyeball is 2.0 cm long, and in this model, assume the refractive index of the eye is 1.

   (a) How much power does his eye have when focused on an object at infinity?
   (b) How much power does his eye have when focused at 75cm?

(c) How much accommodation is required to focus on an object at 75cm?
(d) What power corrective lens should be used to enable the grandpa to focus at the comfortable reading distance of 25cm?

5. Rosie has recently become very interested in photography and wants to take some cool pictures of her colleague, Nikhil, racing on his new racing motorcycle bike. Believing and following the advice of a BestBuy shop-assistant, she spent half of her salary buying a new digital camera from the shop. According to the shop-assistant, the camera's shutter speeds are 1^{-1}, 2^{-1}, 4^{-1}, 8^{-1}, 16^{-1}, 32^{-1}, 64^{-1}, 125^{-1}, 250^{-1}, 500^{-1}, and 1000^{-1} s, and the aperture stops (F-stops) are 2, 2.8, 4, 5.6, 8, 11, and 16. As a practice, she is taking pictures of cars running on the street in front of Cory Hall.

   (a) She took a picture of cars running at 30 mph (with 1/16 s and f/16) and found that the image is blurred. Now she decided to use a faster shutter speed 1/32 s to obtain a sharper image. What should be the corresponding aperture stop (F-stop) for a same exposure?
   (b) If the camera is a diffraction-limited system (which is generally not the case for most consumer cameras), what is the resolution-limited angle at the new setting? Use λ = 550nm, and assume the typical focal length of lens used in camera is 50mm.
   (c) If the new setting found in part (a) is barely good enough to take a sharp picture of cars on the street (30mph), can Rosie take sharp pictures of Nikhil racing on his motorcycle bike at a speed of 150 mph with her newly bought camera? Assume that the required shutter speed is inversely proportional to the speed of motion, which means that the new shutter speed will have to be faster than (1/32x5)s. Find the settings required to take sharp pictures of Nikhil racing on his bike.