EE119 Homework 5

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1. The radius of Saturn's rings is approximately 1.2×10^5m. Saturn itself has a radius of 6×10^4 m. Saturn is 1.5 $\times 10^9$ m away from the Earth. You can assume that the light coming from saturn is approximately 500 nm. How big a lens would you need for your telescope to be able to resolve Saturn's rings?

2. A microscope has an entrance pupil with a radius of 2 cm. The specimen is located 1 cm from the objective lens.

   (a) What is the numerical aperture of the microscope?

   (b) Two cells that are incoherently emitting green light (530 nm) are located at the center of the objective. How close together can these cells be so that they are resolvable by the Rayleigh criterion?

   (c) Repeat parts (a) and (b) for a microscope with entrance pupil that has a radius of 5 cm. By how much does the resolution improve?

3. A nearsighted person cannot focus clearly on an object that is more than 15 cm away.

   (a) What power of corrective lens is needed be used to correct his vision?

   (b) Assuming the eyeball is 2.5 cm in length, without corrective lenses, how far away from the retina is the image for an object at an infinite distance coming to a focus ?

4. A farsighted person has near point at 75 cm. Assume the eye is 2.0 cm long.

   (a) How much power does the eye have when focused on an object at infinity?

   (b) How much power does the eye have when focused at 75 cm?

   (c) How much accommodation is required to focus on an object at 75 cm?

   (d) What power corrective lens should be used to enable the patient to focus at the comfortable reading distance of 25 cm?

5. An optical process called lithography is used for making integrated circuits. Assume the optical system has a reduction factor of 4X (makes the image 4X smaller than object).

   (a) Assuming the optical system is diffraction limited, what is the image resolution of a system that uses a DUV laser at 193nm, and NAimage = 0.85.

   (b) What is the corresponding resolution on the object side?

   (c) Immersion lithography has been proposed to make smaller features on integrated circuits. Immersion lithography will place water (n=4/3) between the last optical element and the image plane. What is the new resolution of the same system from part (a)?

6. Compute the approximate size (in mm) 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. The power of the eye is 58.6 diopters.

7. After conquering Sartaul (East Turkestan, todays 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 Khans script (Mongolian record), Esunge (one of Genghis Khans marksmen) consistently hit targets (coins with 8 cm diameter) that were 535 m away and won the archery competition. In fact, many Mongolian marksmen during the Genghis Khans period were able to hit targets that were 500 m away.

   (a) Esunge's eyes have a 3 mm iris diamter. Assuming his eyes are a diffraction -limited optic, what is the smallest separation of yellow-green objects 535 m away that that he can resolve? Use 550 nm for the wavelength. Do not assume that $\sin(\theta) = \tan(\theta) = \theta$. Is it possible for Esunge to see the 8 cm coins with at 535 m? Or is it impossible due to the diffraction limit?

   (b) If Esunge was able to clearly see the targets (coins with D 8 cm) that were 535 m away, what is the maximum separation (in mrad) between the cone cells in his fovea? How does this compare with the average separation found in modern humans, which is 0.3 mrad?

   (c) What is the visual acuity of Esunges eyes?