RESOLUTION PROBLEMS

More difficult problems are indicated with an asterisk.

1. A low vision patient can just see a sixty foot letter when it is held ten feet from his eye. What would be his Snellen acuity? What is the smallest letter he could see at the end of the testing lane, twenty feet away?

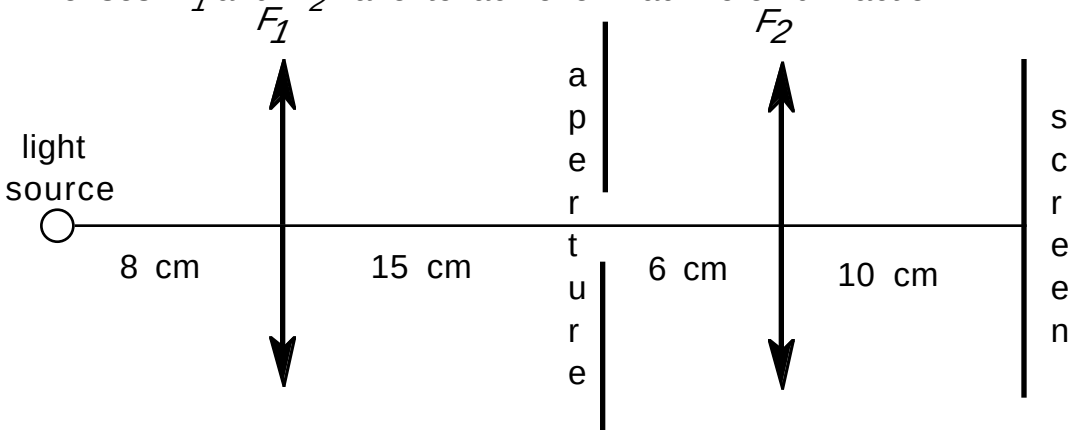
2. What is the resolving power of an eye with entrance pupil 9 mm in diameter for light of 479 nm wavelength? What is the corresponding visual acuity?

3. What is the resolving power of an eye with entrance pupil 4 mm in diameter for light of 500 nm wavelength? What is the corresponding visual acuity?

4. A glaucoma patient being treated with pilocarpine has miotic pupils two millimeters in diameter. What is the best Snellen acuity that patient can achieve? Would this be likely to represent a significant decrease in vision? (Do the calculation with light of 550 nm wavelength.)

5. An optical system has a 0.34' angle of resolution. What is the minimum distance two point sources of light 503 m away must be separated to be resolved by the system?

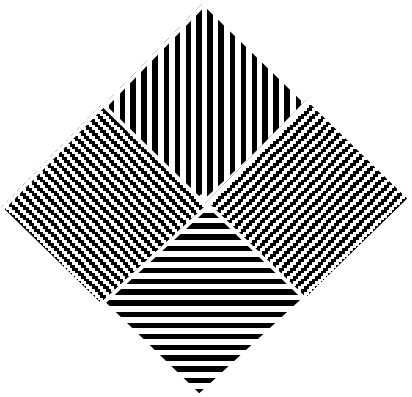
6.* In the optical layout diagrammed below, what power must the lenses F_1 and F_2 have to achieve Fraunhofer diffraction?



7.* Optometrists often rule out refractive causes of diminished visual acuity by having the patient look through a pinhole aperture about two millimeters in diameter. This works well with patients having worse than 20/30 acuity but not with patients having better than 20/30 acuity. Why?

8. A patient with 6/8 visual acuity looks at a pattern of black and white stripes projected onto a screen three meters away. What is the smallest center-to-center separation of stripes which the patient will be able to perceive as stripes instead of a uniformly illuminated field? What is the spatial frequency (line pairs per centimeter) of the pattern which may just be resolved?

9.* Abraham van Helsing, the famous optometrist, observes that the patient who has come to his office this evening has a pupil in the shape of a vertical slit like that of a cat or pit viper. This is an unusual circumstance, but not unknown in Dr. van Helsing's practice. He asks the patient to look at a target like that below which van Helsing projects with a zoom projector which can continously vary the target size. (Assume all parallel lines are equally spaced). The target is made smaller and smaller until the patient can see the lines in only one of the diamonds. Assuming the patient has no astigmatism and has isotropic ocular media and diffraction limited optics, which diamond will it be? Why?



ANSWERS

1. 10/60; 120 ft letter

2. 6.493×10^{-5} rad=0.00372°=0.22' of arc. In English units this is 20/4 acuity and in metric units this is 6/1 acuity.

3. 1.525×10^{-4} rad=0.00873°=0.52' of arc. In English units this is 20/10 acuity and in metric units this is 6/3 acuity.

4. 1.15 minutes of arc ≅ 20/23 Snellen acuity. Since most patients have around 20/20 acuity, the pupil constriction represents no significant limitation of vision, assuming the media of the eye are clear.

5. Converting the resolving angle to radians, 9.890×10^{-5}rad=0.34'. Using the diagram to find separation distance *y*,

503 m

y=(503 m)(9.89×10^{-5} rad)=4.97 cm.

6. Light entering and leaving the system must be collimated so that the source must be at the anterior focus of F_1 and the screen must be at the secondary focus of F_2. That means that F_1=100/(8 cm)=+12.5D, and F_2 =100/(10 cm)=+10D.

7. From Rayleigh criterion, minimum angle of resolution is given by MAR=1.22λ/*b*, where λ is wavelength and *b* entrance pupil diameter of an optical system. Using 550 nm light, the MAR through a 2 mm pinhole is MAR=1.22(0.000550 mm)/(2 mm)=0.0003355 rad=1.2' of arc. This corresponds to 20/[1.2x20]=20/24 visual acuity. Thus the patient's visual acuity has to start off significantly worse than 20/24 for the pinhole to improve it since the diffraction limit on acuity through the pinhole is 20/24.

8. 1.16 mm, 8.6 cycles per centimeter

9. The asymmetric pupil will produce greatest blur along its narrowest direction, so horizontal stripes which will be "smeared" vertically will be least blurred, the vertical stripes which will be "smeared" horizontally will be the most blurred, and oblique stripes will be somewhere in between. Hence the horizontal stripes will be visible after the chart is zoomed to small too see the others.