1. Derive Snell's law using the fact that the number of wave fronts arriving at a material interface equals the number that transmits through it. The wave fronts are perpendicular to the direction that the light travels with speed $v = c/n$. Please draw a good figure labeling relevant dimensions.

2. Consider light entering the end of an optical fiber in air as shown in the figure. Assume that the end is perpendicular to the axis of the fiber and that the index of refraction is $n = 1.5$. What is the maximum angle $\theta$ that results in the trapping of the light within the fiber via total internal reflection on the fiber walls?

3. A beam of unpolarized light is sent through two crossed polarizers as shown in the figure. No light transmits through the system. You insert a third polarizer between the two polarizers.
   (a) At what angle should the transmission axis of the inserted polarizer be rotated relative to the first polarizer to maximize the final intensity?
   (b) How does the final intensity compare with the initial intensity?

4. The overhead projector in our classroom is designed to image a 25cm page onto a screen 2.5m-wide screen at a distance of about 4m.
   (a) How far away is the lens from the page?
   (b) What is the focal length of the lens?
   (c) Make a ray diagram.

5. An elderly woman sees faraway objects clearly when her eyes are relaxed. However, her eyes have lost flexibility and cannot accommodate for object distances shorter than 60cm.
   (a) Please design some 'reading glasses' that will help her to see things clearly for distances as short as 25cm. Give the focal length of the required lens.
   (b) What is her new far point?
   (c) Draw a ray diagram for the imaging of the lens of the glasses (ignoring the eye).

6. The accommodation limits for nearsighted Nick's eyes are 16.0cm and 45.0cm (closest and farthest he can see). When he wears his glasses, he is able to see faraway objects clearly with his eyes relaxed. At what new minimum distance is he able to see objects clearly?
7. A Keplerian telescope is constructed with two positive lenses, focal lengths $f_{\text{objective}} = 50\,\text{cm}$ and $f_{\text{eyepiece}} = 10\,\text{cm}$.

(a) What should the separation between the lenses be and what is the angular magnification of the telescope?
(b) You decide to 'misuse' the telescope and look at an object only $9.25\,\text{m}$ away. As you look into the eyepiece, how far in front of the eye is the image?

8. Two narrow and parallel slits are illuminated with coherent light having a wavelength of $500\,\text{nm}$.

(a) If the spacing between two consecutive fringes on a screen $3\,\text{m}$ away is $3\,\text{mm}$, what is the separation between the slits?
(b) Make a graph of the intensity on the screen as a function of position. Label the peak intensity in terms of the intensity that would occur from one slit alone.

9. Determine the angle at which $20\,\text{nm}$ light diffracts (in 1st order) when it transmits through a grating with $200\,\text{nm}$ spacing.

10. A soap bubble has an index of $n=1.3$. The bubble is thinnest near the top, and there is no reflection from that region when it is very thin. A series of colorful fringes are seen in the reflection from the lower part of the soap film where it has gradually greater thickness. How thick is the film at the first bright red fringe ($\lambda = 600\,\text{nm}$) near the top?

11. You are suspicious that some calipers give incorrect readings when measuring very small objects. You decide to check the calipers using a HeNe laser with wavelength $633\,\text{nm}$. The calipers form a single slit which you place in the laser path. The light emerging from the slit travels $332\,\text{cm}$ to a wall where you see the diffraction pattern shown in the figure. At the wall, you carefully measure the distance between the minima indicated in the figure and find it to be $12.6\,\text{cm}$. What is the slit width of the calipers?

12. You are looking at two stars known to be about $25$ lightyears away (a lightyear is a unit of distance). You find that you are just able to resolve them by eye.

(a) How far apart are the stars laterally if the pupil of the eye is $0.4\,\text{cm}$? Take the wavelength to be $500\,\text{nm}$.
(b) The lens of the eye has a focal length of about $2\,\text{cm}$. Draw a scaled diagram of the intensity distribution from each star that appears at the retina. For a 'well engineered' eye, which you happen to have, what is the approximate separation (not angular) of receptors?

13. It is a good idea to review multiple-choice quiz questions since there will be three similar questions on the exam.