Practice Problems for Exam #4

1. At the end of this list of questions you will find several grids you can use for drawing ray diagrams. You should use them for the first three problems. For the first problem you are to construct a ray diagram that shows the reflection of a 3 foot tall object that is 5 feet from a flat mirror. Your diagram should show at least two rays and the image.

2. A 2cm high object is 6cm in front of a mirror that has a focal length of 4cm. Draw a ray diagram and also use the mirror equation to find the location and height of the image.

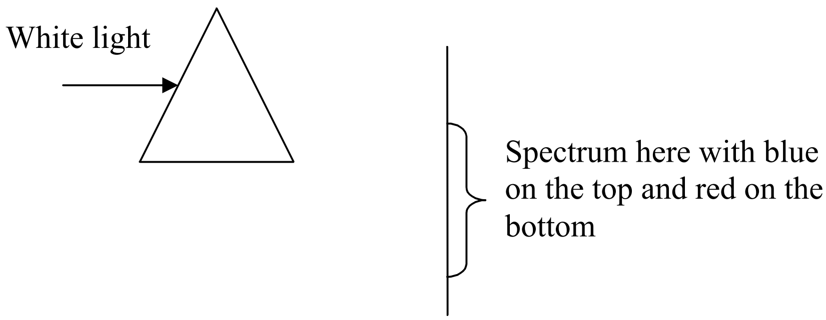
3. A 3cm high object is placed to the left of a lens with focal length -10cm. The magnification is 0.25. Find the distance to the object and the distance to the image. Do this with the thin lens equation and then, using your object distance, make a ray diagram to check your image distance.

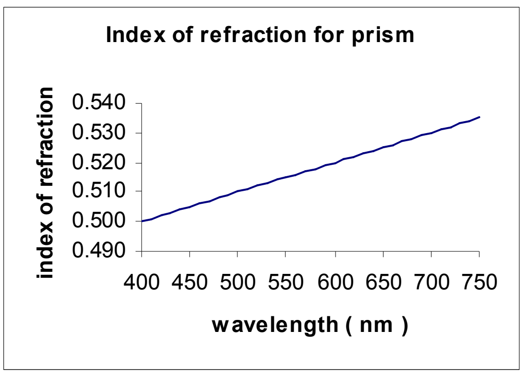
4. A telescope of the sort we discussed in lecture has a magnification of 10 and a tube length of 110cm. What are the focal lengths of the objective lens and the eyepiece?

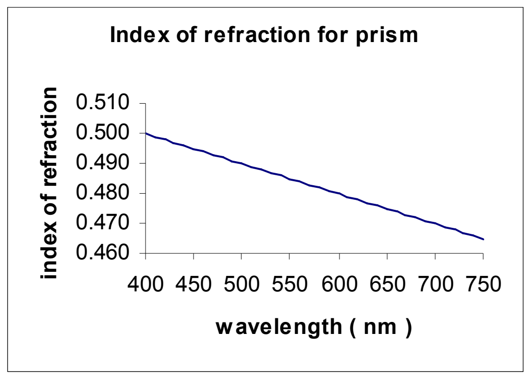
5. A layer of oil floats on a pool of water. The oil layer is several inches thick. Light in the oil strikes the oil-water surface at an angle of 60.0° with respect to the surface. It is seen to pass into the water at an angle of 65.6° with respect to the surface. If the index of refraction for water is 1.33, find the index of refraction or the oil.

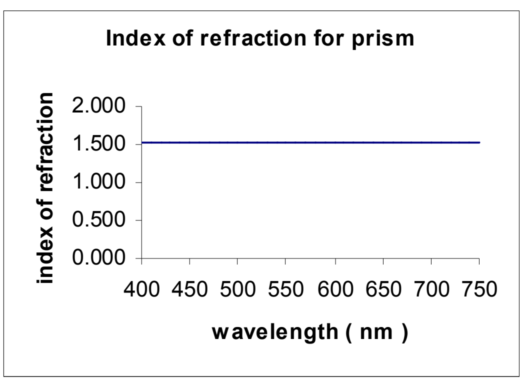
6. In your experiment with the Michelson Interferometer you measured the index of refraction for air. Suppose that the following information is at your disposal. There are identical glass cells in each arm of the spectrometer and they each start filled with air at atmospheric pressure. Each is 2.000cm long. Your interference pattern shows a bright spot at the center because each of your paths is exactly the same. Now you slowly remove all of the air from one of your cells and you count the number times your interference pattern shifts from bright to dark and back to bright. If the index of refraction for air is 1.00024, how many shifts from bright to dark and back to bright did you see? Your answer need not be an integer. The wavelength of your light in vacuum is 500.0nm.

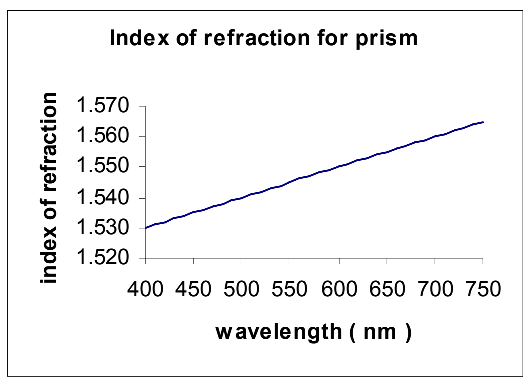
7. White light shines onto a prism as shown below. On the screen to the right you see a spectrum of colors as indicated. On this basis alone, which graph of index of refraction vs. wavelength could be correct?







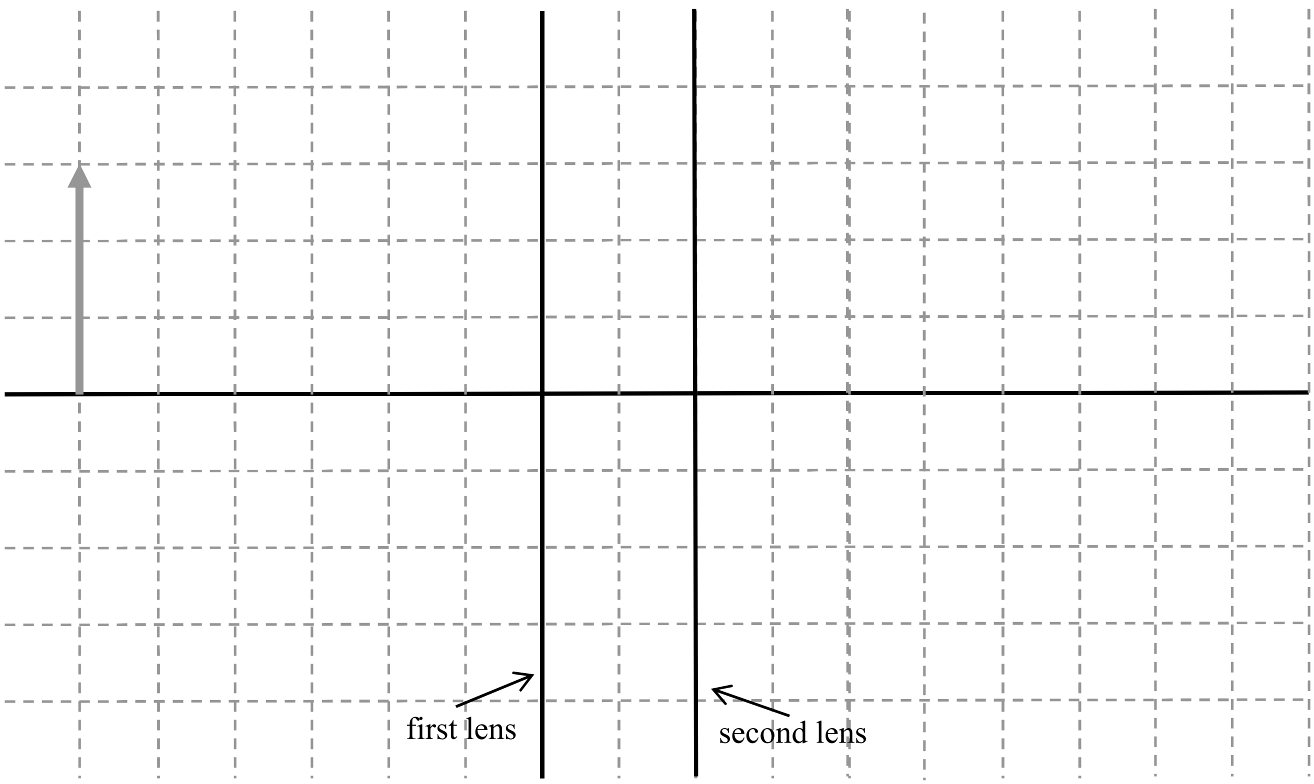




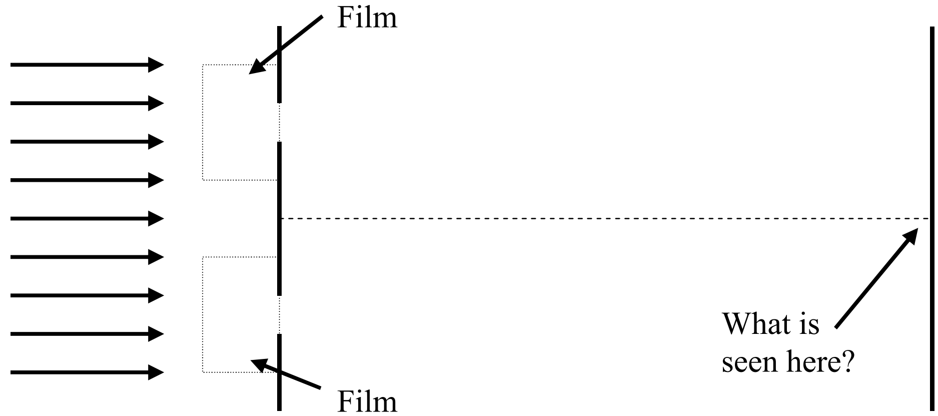
8. A thin coating of a plastic with index of refraction 1.2 is attached to a thick sheet of glass with index of refraction 1.4. The coating must be at least 10µm thick if it is not to peal off. What is the thinnest acceptable film that will not reflect 514.5nm light? Please give your answer to a total of 5 digits. Think of the light coming from the left in air. It then encounters the film and finally the glass. We want no 514.5nm light reflected into the air.

9. Fermat's Principle of Least Time can be used to derive Snell's Law. In a purely qualitative way, use Fermat's principle to explain why light should bend toward the perpendicular to the surface when it leaves a material with a small index of refraction and enters a material with a large index of refraction. Do not appeal to Snell's law in your answer.

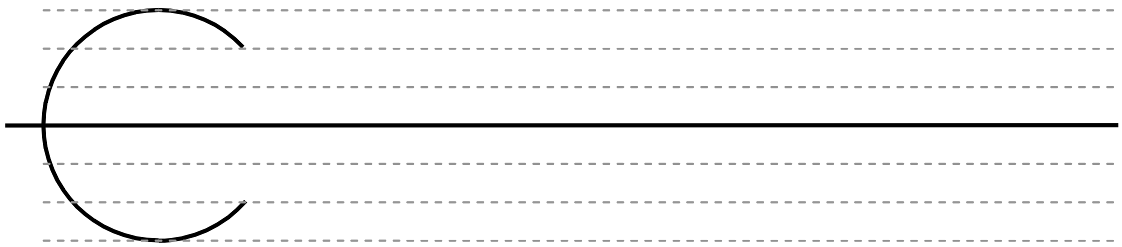
10. Each square in the diagram below represents 10.0cm. The first lens to the right of the object has a focal length of negative 30.0cm. The second lens to the right of the object has a focal length of 80.0cm. Find the size of the final image, where it is located, and state whether it is erect or inverted and real or virtual. You are to draw a careful ray diagram and also to compute the answer using the thin lens formula. Be sure that you check to see that your answers agree.

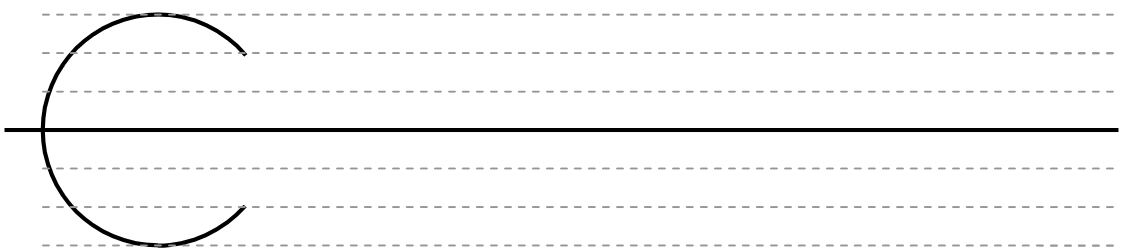


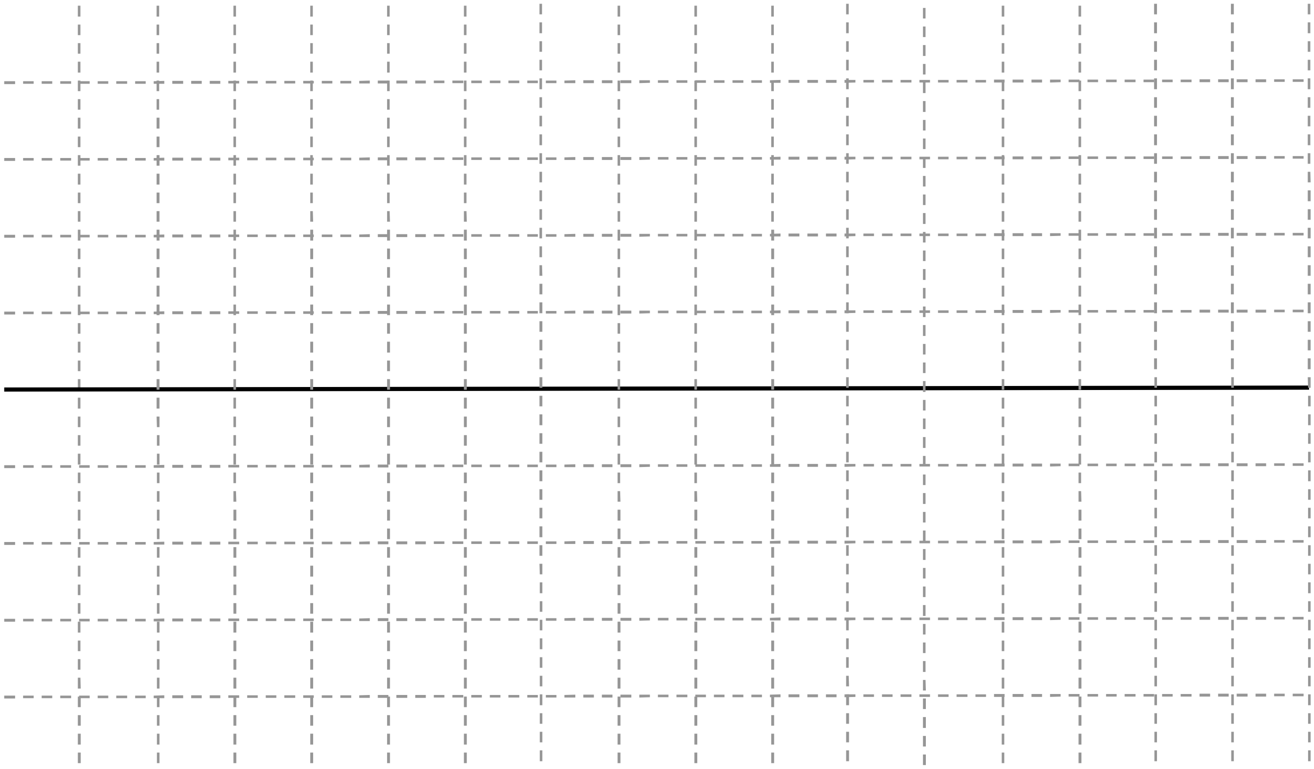
11. In a Young's two slit experiment one slit is covered with a film of transparent material that is 1800nm thick with and index of refraction of 1.50. The other slit is covered with a film of transparent material that is also 1800nm thick with an index of refraction of 2.00. One now illuminates the slits with 600nm light and looks straight across from the slits to that place on the screen that, absent the two films, has the center bright spot. Is that place now bright or dark? Of course, you are to carefully show your reasoning. Do not attempt to simply start off with some formula; you have no formula that applies to this problem.

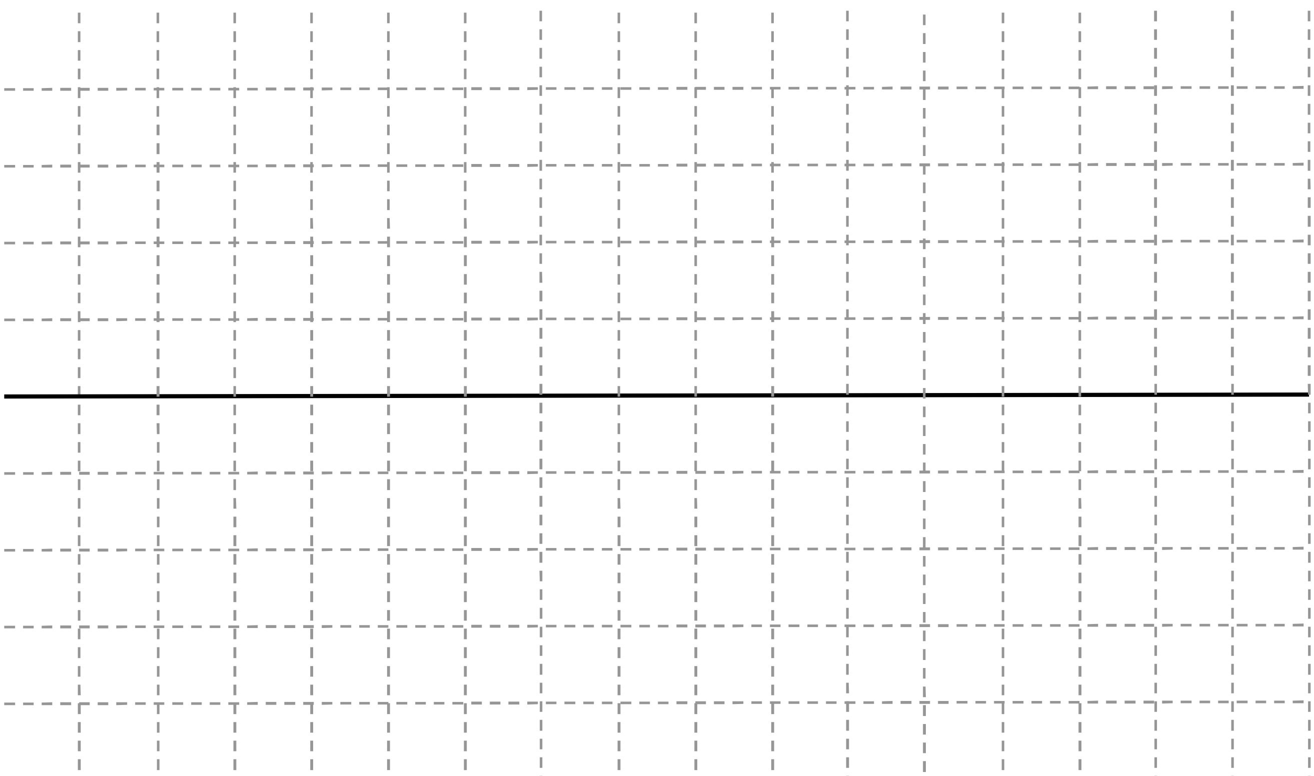


12. Below are the beginnings of two drawings of an eye. Let us suppose that this is a far sighted eye. In words and with a careful diagram, show what the problem is in the top picture and how it is corrected with glasses in the second picture. Be sure that you show the correct refractions of light beams when they encounter lenses.









1. Draw one ray parallel to the optical axis. It reflects straight back. Draw a second ray at any other angle and use the law of reflection. Trace the rays backward until they meet 5 feet behind the mirror.
2. 12cm from the mirror and -4cm high
3. Object distance is 30cm and image distance is -7.5cm
4. 100cm and 10cm
5. $n_{oil} = 1.10$
6. The difference in the number of waves that fit into twice the distance across the cell when it is full of air and when it is evacuated is 19.2. So you see the pattern shift 19.2 times.
7. Lower right graph
8. 10.183μm
9. Refer to your lecture notes for this one. I would draw a picture with a straight line path and then one bent in either direction. Note that small index of refraction means fast light speed. Longer distance in fast medium but shorter distance in slow medium can help but the other way around cannot possibly reduce the total transit time. So the path that bends toward the perpendicular line must be the only choice.
10. The first image is 10cm high and 20cm to the left of the first lens. The second image is 20cm high and 80cm to the left of the second lens. It is erect and virtual.
11. Solve for $N_A - N_B$. The result is 1.5 so you will see a dark spot.
12. In the first picture show parallel light rays coming to a focus behind the retina. Then correct the problem with a converging lens in front of the eye. Be sure that both the corrective lens and the lens of the eye refract the light toward the optical axis!