Assignment IX, HONS 158 (Honors Physics II)
Spring 2016
Due 4/4/16 at start of class
Counts Double!

As always, please put your answers on separate paper.

1. A 14 foot long, nearsighted python is stretched out perpendicular to a plane mirror, admiring its reflected image.
   a) If the greatest distance that the snake can see clearly is 25 feet, how close must the python's head be from the mirror so that it can see the reflection of its tail?
   b) If they python wanted to get glasses to improve his far point and so that he could see at least 40 feet away, what prescription would the python need? (in diopters).
2. Approximate the eye as a single thin lens 2.70 cm from the retina. What is the eye's near-point distance if the smallest focal length the eye can produce is 2.20 cm?
3. Laser light with a wavelength $\lambda = 683$ nm illuminates a pair of slits at normal incidence. What slit separation will produce first-order maxima at angles of $\pm 32^\circ$ from the incident direction?
4. What width single slit will produce second order diffraction minima at angles of $\pm 43^\circ$ from the central maximum with $\lambda = 470$ nm light?
5. How many dark fringes will be produced on either side of the central maximum if green light ($\lambda = 553$ nm) is incident on a 8.00 μm wide single slit?
6. A light source has two distinct wavelengths ($\lambda = 430$ nm [violet] and $\lambda = 630$ nm [orange]). The light strikes a diffraction grating with 450 lines/mm at normal incidence. Identify the colors of the first *eight* interference maxima on either side of the central maximum.

7. Red light ($\lambda = 685$ nm in air) is incident from air onto a thin film of soap. This thin soap film has $n = 1.33$ and turns out to be non-reflective at normal incidence for 685 nm light (in air). The reason that this is a non-reflective surface is that the light reflected off of the front of the soap layer destructively interferes with the reflected light off of the back of the soap layer.

   a) Find the 3 smallest thicknesses (greater than 0) that this soap layer might have so that this non-reflective property exists. (Hint – remember that the wavelength of the light inside the soap layer may not be the same as air!).

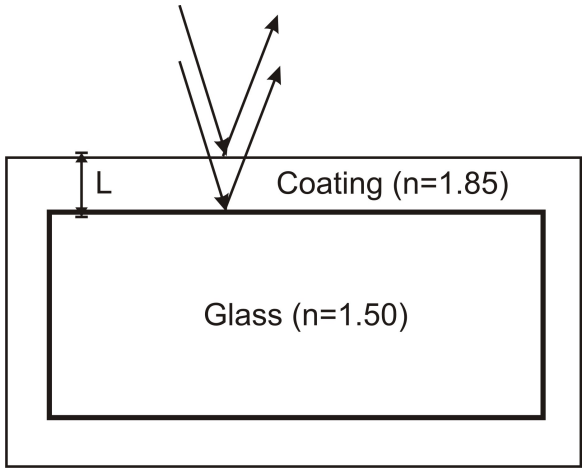
   b) For the smallest thickness found in part (a), find the wavelengths of colors in the visible spectrum (in air!) that would be strongly reflected by this soap film (if any exist).

   c) For the largest thickness found in part (a), find the wavelengths of colors in the visible spectrum (in air!) that would be strongly reflected by this soap film (if any exist).

8. One way to make cheap jewelry appear to be more "spectacular" is to coat them with a layer of a material with a different index of refraction to increase the total reflectivity in the visible wavelengths. Assume that some jewelry is made out of glass with $n = 1.50$. To make it more reflective, it is coated with another material with $n = 1.85$.

   a) What is the minimum coating thickness L required to ensure that green light with $\lambda = 550$ nm (in air) reflects with perfectly constructing interference from the coating and the glass jewelry itself? Assume that the light is normally incident (even though it isn't drawn that way in the picture).

   b) What would L be if we wanted the jewelry to be particularly reflective for red light with $\lambda = 685$ nm (in air)?



9. Let's say you want to make a spy-camera. Because you don't want people to realize you are taking pictures of them, you want there to be an anti-reflective coating on your lens (so that sunlight, for example, doesn't reflect off your lens and give your position away to others looking in your general direction). Let's treat the sun's light as monochromatic light with a wavelength of 580 nm in air. Your camera lens is made out of glass with $n = 1.50$. You are constrained to have an anti-reflective coating with thickness 2 μm, but you can control the value of the index of refraction to have any value you want between $n = 1$ and $n = 1.5$. You are only concerned with reflection at normal incidence. What values of n would be acceptable to you? (You should find 3 values).

10. Let's say you want to use a telescope to look at yellow light ($\lambda = 580$ nm). Two dimes are placed 1 meter apart on the moon. What is the minimum diameter of a telescope mirror you would need, according to the Rayleigh criterion? (Note – even this is too optimistic, since the atmosphere will make add an additional obfuscation that we're not accounting for).

11. A satellite mounted spy camera is designed to try and read the numbers on a car's license plate. If the numbers on the plate are 5.0 cm apart, and the spy satellite is at an altitude above the Earth's surface of 150 km, what must be the diameter of the camera's aperture? (Assume light with a wavelength 550 nm).

12. A diffraction grating has a total of 1200 lines etched into it (at equal spacing); the total size of the diffraction grating is a 2 cm x 2 cm square. (The lines are etched parallel to the the sides of the square). You send light from a source that has both $\lambda = 680$ nm and $\lambda = 578$ nm through this grating and look at the resulting spots on a wall that is 3 meters behind the grating. How far away is the resulting $m = 1$ red spot from the corresponding $m = 1$ yellow spot?