Assignment X, PHYS 112 (General Physics II)
Fall 2020
Due via pdf upload to OAKS prior to Friday, November 13th at 10:00 AM

General instructions:
For this, and all other homework assignments, please turn in your solutions with all supporting work; answers without supporting work will not earn credit. You do not need to upload the sheet with the questions on it, but please clearly number your problems and circle or box your final answers. I encourage you to collaborate with classmates to discuss how to approach a particular question, but the mathematical steps to generate your final answer on your submitted work should be your own. If I see the same simple mistake on multiple homework assignments, I will take off more points for that error than I normally would. Please include *words* in your answers. When you get answer keys back from me, you'll see that there are explanations, ideas, commentary, and thought processes included – not just a set of equations one after another. Finally, please ensure that all numerical answers have units.

Since several people in class asked for this, here are some suggested (but ungraded) extra problems from the textbook for practice: (All problems out of Halliday, Resnick, and Walker, 10th Extended Edition, "Fundamentals of Physics"). (I chose all odd-numbered problems since the answers to those problems are in the back of the book and that's a good way to check if your practice is accurate.) No need to turn these in, but if you are looking for extra things you can work on if you want to practice problem solving some more, here's what I would advise.

Chapter 35, question 1
Chapter 35, problems 1, 7, 9, 15, 19, 21, 35, 37, 39, 53, 55, 85, 89, 91, 101, 103
Chapter 36, problems 1, 5, 7, 9, 19, 21, 35, 37, 39, 45, 47, 51
Chapter 37, questions 1, 3, 11
Chapter 37, problems 1, 5, 9, 11, 17, 19, 23, 27, 29, 31

1. 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 $\pm 32°$ from the incident direction?

2. 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? (Assume the screen is as large as you need it to be or even bent into a semicircular arc if you prefer).

3. 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. (In other words, as you examine angles starting from $\theta = 0$ towards $\theta = 90°$, you will see a sequence of violet and orange spots. What order do they appear in as you traverse from $\theta = 0$ to $\theta = 90°$?)

4. 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).

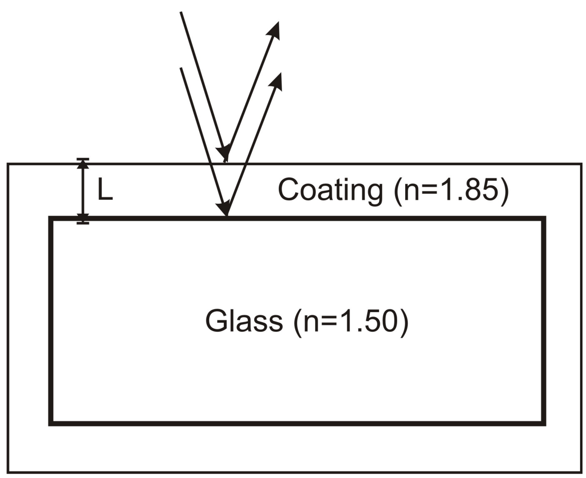
   c) For the largest thickness found in part (a), find the wavelengths of colors in the visible spectrum (in air!) that would be strongly reflected by this soap film (if any exist).

5. 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 add an additional obfuscation that we're not accounting for).

6. 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)?



7. 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).

8. 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).

9. 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 one of 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 apart are the resulting $m = 1$ red spot and the corresponding $m = 1$ yellow spots?

10. You are on a meteor with a clock on it that is screaming past Earth with speed v. You are wearing a wrist-watch and it appears (to you) that 1 second elapses on your watch in the same time that 1 minute elapses on Earth. Assuming your watch is running correctly, how fast does the meteor move with respect to Earth? (Write your answer as a decimal multiple of c). Keep at least 5 digits of decimal precision.

11. A strobe light in a club flashes on and off once every 0.2 s as measured by the DJ in the club. How much time elapses between the strobe light as measured by an astronaut in a spaceship moving towards earth with a speed of $0.65c$?

12. You and a friend travel through space on *identical* spaceships. Your friend informs you that he has made some length measurements and that his ship is 150 m long but that your's appears to him to only be 120 meters long.

    a) From your point of view, how long is your friend's ship?

    b) From your point of view, how long is your own ship?

    c) From your point of view, haw fast is your friend's ship moving with respect to your ship?

13. Two asteroids head straight for Earth coming from the same direction (with respect to Earth). Their speeds relative to earth are 0.85c for asteroid 1 and 0.70c for asteroid 2. Find the speed of asteroid 1 relative to asteroid 2. (Assume all motion is in 1 dimension).