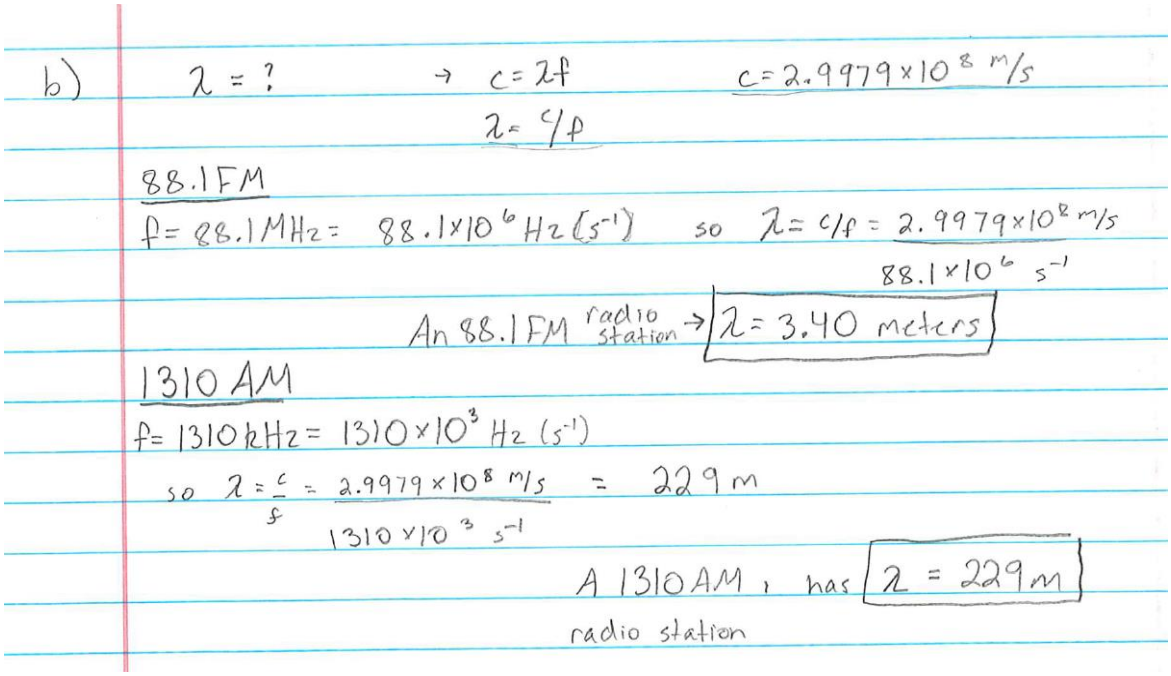
Theoretical Physics
Prof. Ruiz, UNC Asheville
Chapter 0 Homework. Intro Physics

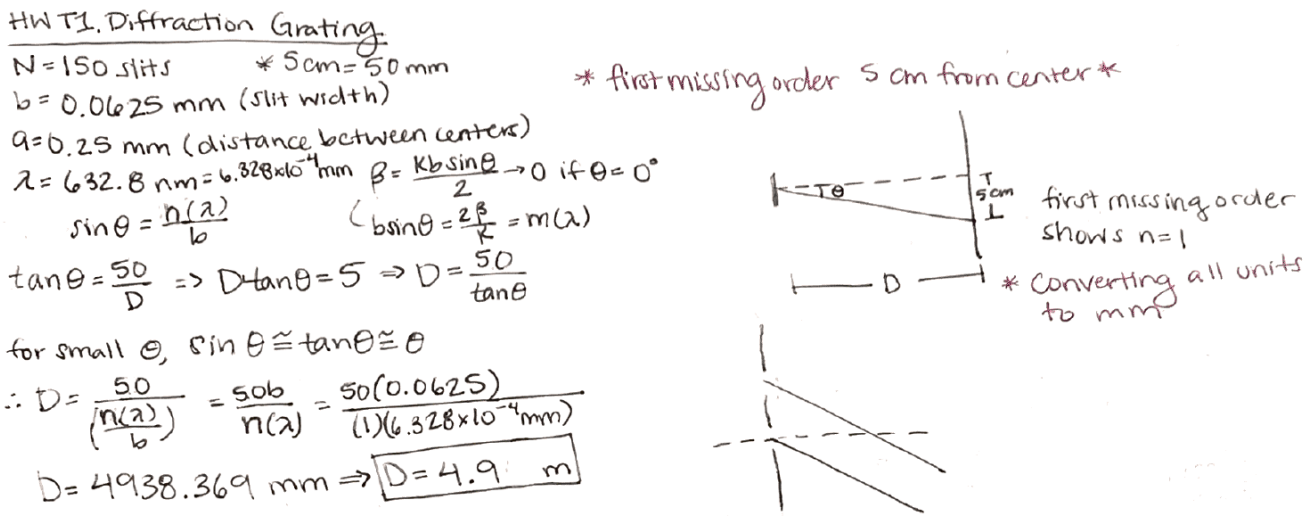
Homework Protocol. The first thing to do is to develop a procedure where you can scan in your homework with the following requirements. First watch the Homework Video Guide: LINK.

1. State the Problem. Always state the problem in some way. It can be brief.

2. Do Not Cross Out. Do on scrap paper first. Be neat. See the two examples below.



3. Communicate. Flow of work should be obvious. See examples on this page.



4. **Scan Should Be Neatly Readable.** See student examples on the previous page.

5. **Scan File Size.** The file size should be less that 25 MB.

6. **File Size Name.** Chapter Letter, Underscore, Your Last Name.
   Example: Marie Curie doing Homework P would be P_Curie.pdf
   First Chapter is 0. So the filename for this assignment would be 0_Curie.pdf

7. **Grading Rubric.** Here is the rough guide I use.
   +4 for stating the problem and showing all steps with occasional comments,
   +4 for mathematical and notational accuracy,
   +2 for neatness (which includes proper handwriting size and legibility).

8. **Can I Work with Others?** Yes, but your homework must look different – your own. Never copy homework as that would constitute plagiarism and have to be graded as a zero. UNCA requires instructors to report all such cases to the Administration. What about when the homework is suspiciously close to someone else's work? In that case, I would give the benefit of doubt to the student and accept, but I cannot ever write a letter of recommendation for those students because I do not know who is the creative source.

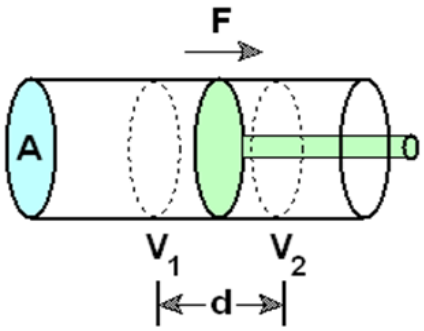
Here is a great homework-communication question to ask yourself. Are you doing the homework for yourself just to get it done or are you preparing a report to creatively communicate your work to others? Employers want to hire the person that can communicate effectively. The employer will not care as much that you worked it out for yourself but instead, care that others can easily understand what you did.

Excellent Communication by UNCA Physics Major Samantha Creech.

Hunting for Ghost Particles: Building the Next Neutrino Telescope. Astrophysics Presentation. UNCA 2029 Fall Undergraduate Research Symposium. Video Link.

HW-01. Combinatorics. There are 5 people in a family and they have two tickets for the movies. Therefore, only 2 of the 5 family members can go the movies and the other three must stay at home. How many different ways are there for two of the family members to be chosen to go to the movies.

HW-02. Work and the Ideal Gas. An ideal gas has volume V_1 and expands pushing a piston on with force F so that the final gas volume is V_2. Refer to the diagram. The distance d lies along the x direction.

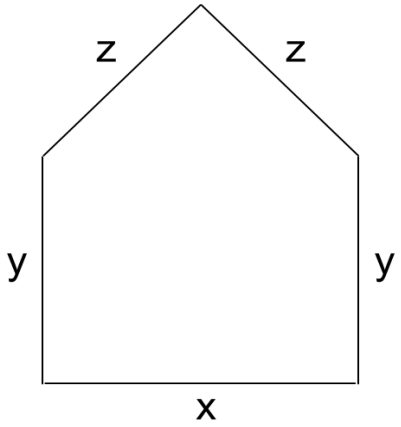


a) Show that the work $W = \int F dx$ done by the gas in going from V_1 to V_2 can be expressed as $W = \int P dV$, where P is the pressure of the gas at the moment and V is the volume at the same moment.

b) For the particular situation where the temperature of the gas is constant with temperature T_0 show that the work done by the gas is given by the formula

$$W = nRT_0 \ln \frac{V_2}{V_1} .$$

HW-03. Undetermined Multipliers I. You have 100 meters of fence and want to enclose the largest pentagon you can where the slanted sides are equal (as illustrated in the figure) where an isoceles triangle sits on top of a rectangle. You will set up the problem here to use the method of Lagrange Undetermined Multipliers and finish the solution in HW-04.



First express the area as a function of x, y, and z.

$$A = A(x, y, z)$$

The area needs to be maximized.

$$dA = \frac{\partial A}{\partial x} dx + \frac{\partial A}{\partial y} dy + \frac{\partial A}{\partial z} dz = 0$$

But you can't set the individual partials to zero since the dx, dy, and dz are not all independent due to the constraint on the amount of fence.

Perimeter Constraint. The perimeter is $P = P(x, y, z) = \text{const}$.

$$dP = \frac{\partial P}{\partial x}dx + \frac{\partial P}{\partial y}dy + \frac{\partial P}{\partial z}dz = 0$$

But you can't set the individual partials to zero since the dx, dy, and dz are not all independent.

Undetermined Multiplier. Now introduce the undetermined multiplier λ and do the following subtraction.

$$dA - \lambda dP = (\frac{\partial A}{\partial x} - \lambda \frac{\partial P}{\partial x})dx + (\frac{\partial A}{\partial y} - \lambda \frac{\partial P}{\partial y})dy + (\frac{\partial A}{\partial z} - \lambda \frac{\partial P}{\partial z})dz = 0$$

Now you can set the individual partials to zero due to do the freedom in choosing λ to make it work. Show that

$$\frac{\partial A}{\partial x} - \lambda \frac{\partial P}{\partial x} = 0 \text{ leads to } y + \frac{2z^2 - x^2}{2\sqrt{4z^2 - x^2}} = \lambda ,$$

$$\frac{\partial A}{\partial y} - \lambda \frac{\partial P}{\partial y} = 0 \text{ leads to } x = 2\lambda \text{, and}$$

$$\frac{\partial A}{\partial z} - \lambda \frac{\partial P}{\partial z} = 0 \text{ leads to } \frac{xz}{\sqrt{4z^2 - x^2}} = 2\lambda .$$

HW-04. Undetermined Multipliers II. As we continue from HW-03, you have four equations

$$y + \frac{2z^2 - x^2}{2\sqrt{4z^2 - x^2}} = \lambda \qquad x = 2\lambda \qquad \frac{xz}{\sqrt{4z^2 - x^2}} = 2\lambda \qquad P = x + 2y + 2z = 100$$

with four unknowns: x, y, z, and λ. Use the first three equations to show that

$$x = 2\lambda , \; y = (\frac{3 + \sqrt{3}}{3})\lambda \text{ , and } z = \frac{2\lambda}{\sqrt{3}} .$$

Then bring in the fourth equation $P = x + 2y + 2z$ to show that $\lambda = \frac{(2 - \sqrt{3})}{2} P$. We will assume that the perimeter of fence is known to four significant figures, i.e. P = 100.0 meters. Now use the fact that P = 100.0 meters to find x, y, and z to four significant figures. As an example, you will find that $y = 21.13 \text{ meters}$.