Lab 9:

Practicum

<u>The Diffraction and Interference of Light in an Interferometer</u>

PHYSICS 204, John Jay College of Criminal Justice, the CUNY

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<u>*DO NOT HANDLE THE MICHELSON INTERFEROMETER WITHOUT GLOVES ON*</u>

<u>Understanding Wave Interference:</u>

1. Place 2 wave plots on transparent film on top of each other so that the peaks of one are perfectly lined up with the valleys of the other. One wave plot has, therefore, a phase 'delay' (or 'head-start') of $\pi \; radians$ relative to the other wave plot. If a phase delay were to start getting any larger than $\pi \; radians$, then it would start get closer to 2 $\pi \; radians$ and, the 'delayed' start would, in fact, start getting nearer and nearer to the next pulse to come along (from the other source). Hence, two wave motions that differ in phase by $\pi \; radians$ are called ***out-of-phase****)*.

   ******   A) Draw how they are aligned.***

   B) Predict how the resultant wave of this interaction will appear compared to the original waves (it may help to draw your predicted resultant wave in a different color overlaying the 2 interacting waves). In at least one complete English sentence of your own words, defend your prediction – or scrutinize it and raise any possible reason you might not be entirely confident of it. You are welcome to choose this latter approach particularly if you are not confident: Confidently explain why not!

2. Now, place the waves on top of each other with the peaks perfectly aligned (so they appear as one - *completely* ***in-phase****)*.

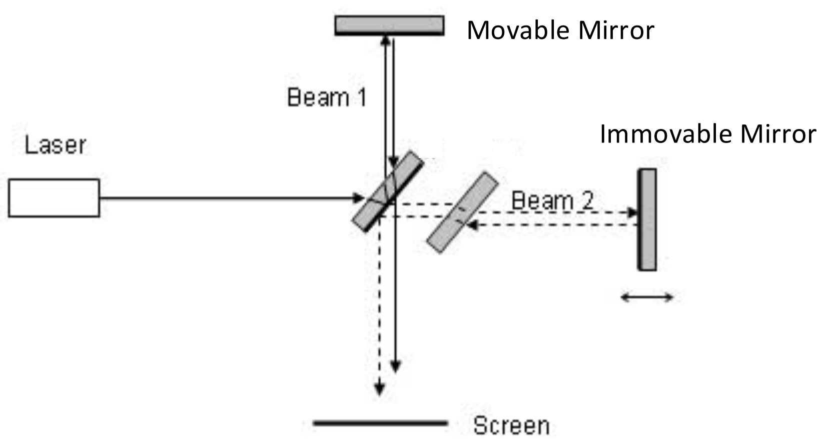
   ******Again, draw how they are aligned. Predict how the resultant wave of this interaction will appear compared to the original waves (it may help to draw your predicted resultant wave in a different color overlaying the 2 interacting waves). Defend your prediction.***

3. Then, move the waves into an orientation where the peaks and valleys are neither completely aligned nor completely inverted with respect to each other; this condition is known as ***partially out-of-phase***.

   ******One last time, draw how these partially out-of-phase waves are aligned. Predict how the resultant wave of this interaction will appear compared to the original waves (it may help to draw your predicted resultant wave in a different color. . . Defend your prediction.***

4. An interaction between two waves along the lines described above are generally known by four terms: ***maximum constructive interference***, ***maximum destructive interference***, ***partial destructive interference***, and ***partial constructive interference***.
   ******Based on your predictions, assign one of these titles to each of the above situations (you'll notice one will remain unused).***
   ******If, based on this terminology, you want to provide (an) updated prediction(s) do so now, but keep record of your original predictions. If you did, why did you change your prediction?***
5. Recalling the definition of wavelength, start the waves in a position of maximum destructive interference. Then shift the top sheet's wave to the right until it reaches the next point of maximum destructive interference. How many wavelengths did you have to shift it to reach that point (may be fractional i.e. 1/4λ, 2λ, etc.)?
   ******________λ between points of maximum destructive interference***
6. Repeat step 5 substituting points of maximum constructive interference.
   ******________λ between points of maximum constructive interference***

<u>Using Interference to Find the Wavelength of a Laser:</u>



<u>Example Setup</u>

7. Using the large black knob (coarse adjustment for the movable mirror) on the front of the interferometer and the small silver knob (fine adjustment for the movable mirror) on the side, adjust the movable mirror position to ~35mm on the scale. (This will be slow going; be gentle and patient).
8. Set up the laser in the ring stand so that the beam goes through the beam splitter and reflects off the approximate center of both mirrors and so that one of the reflected beams lies along the axis of the laser. You should also now see 2 red dots on the round accessory viewing screen. First you must ensure the immovable mirror is aligned: using a piece of paper or your hand locate where the laser beams are reflecting back by the laser. Once you have located where the

beams are reflecting back, use the small black knobs on the backs of the 2 mirrors to see which of the reflected dots of light is being reflected from the immovable mirror. Then use the knobs on the rear of the immovable mirror to reposition the beam so that it is reflecting straight back into the laser/beam's origin. *DO NOT LOOK DIRECTLY INTO THE LASER* After the immovable mirror has been aligned, no further adjustments to it should be made.

9. Now you must coarsely align the movable mirror: Looking at the 2 spots of light on the viewing screen, use ONLY the knobs on the rear of the movable mirror to combine the 2 spots of light (i.e. only 1 of the spots of light will be moving for the combination).
10. Carefully replace the viewing screen with the telescope, with the wider gnarled side away from the body of the interferometer. Place a white board with a piece of paper a good distance away from the telescope (approximately perpendicular to the exiting laser beam) and turn the gnarled portion until the beam looks like two sharp intense points of light. Again use the movable mirror knobs to combine the 2 light spots. Now zoom out with the telescope until you can discern 2 close rough bull's-eye patterns relatively clearly on the paper (the larger the easier to align).
11. Now fine adjustment of alignment: carefully and gently combine the 2 rough bullseyes so precisely that they become 1 and you observe a horizontal thick line formation developing over the previous bullseyes' position. If you have reached proper alignment you should observe that when you turn the silver knob on the side of the interferometer to move the movable mirror on the track the horizontal lines will appear to be cycling/moving up or down dependent on the direction you move the mirror. This part of the alignment can take time, be patient, it is a very precise practice and requires a bit of practice and finesse.
Using your analysis from above, relate the concepts of interference to the pattern you see. Give a cause-effect statement showing their relationship (e.g. hunting season causes a decrease in deer population but, during off-season, the deer population thrives).
12. *On the paper, mark the position of one of the lines in the horizontal pattern. Note where relative to the line you marked so that when counting lines movement you can count keeping that relative position in mind for consistency and precision/accuracy.*

13. Using teamwork, have one person slowly rotate the silver (fine adjustment) knob in order to manipulate the horizontal position of the movable mirror in one direction. Make sure to keep track of where on the knob you start (marking-wise: i.e. the starting mirror position). You will be measuring the distance the mirror travels by counting the markings you pass. The silver knob is segmented into 100 divisions, each of which represents 0.0001mm. Have another person simultaneously observe the movement of the horizontal lines projected on the paper. If you initially marked out a dark line, count the number of dark lines to pass through the mark. If you began with the intense line do the same but with the intense lines. Once the tenth ring to pass reaches the marking, with closest approximation to the original band's position, stop turning. Record the distance travelled by the movable mirror as observed via the markings on the fine adjustment knob (as described above, to the 0.00001mm).

Distance Travelled by the Movable Mirror (as observed via the silver knob):________mm

*14. ***Assume that the distance travelled by the mirror mimics the movement of the **lines** in the interference pattern:*

Use the data collected and your findings from earlier in order to find the wavelength of your laser (in nm). Your final finding for wavelength must consist of a RANGE of possible values, not simply one particular value. That is, you must account for measurement uncertainty.

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Final FINDING/CONCLUSION for Final Exam:

On a Fresh sheet of paper, write a brief abstract for this investigation. The abstract must consist of complete sentences that fluidly and coherently responds to the following questions. The abstract must provide answers to all these questions, but must be written as a formal document; it should not present any of the questions explicitly nor with numbers:

15. What is a suitable and specific Research Question for this experiment?

16. Providing a RANGE of possible values, what is the answer to this Research Question?

HINT: Calculated Laser Wavelength: ______________nm +/- __________nm

17. How did your method for data collection lead to the FUNCTION you found and used in order to answer the Research Question?