Modifying the Optics Laboratory for Greater Conceptual Understanding

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Our goals...

- We want students discovering optical physics through experimentation for an upper undergraduate level course
  - Students predict and test their predictions as opposed to students following cookbook like procedures.

- We also want students to develop greater independence in the laboratory.
  - We want students to use their new understanding of optics to accomplish a project with minimal instructor involvement
    - The students design their own experiment (equipment layout, analysis, etc.)
    - This requires familiarity with the equipment

Some of the hurdles we had to work around

- Giving too many instructions runs counter to fostering student independence
- To perform a reasonably complex optical experiment, students must have certain basic skills, such as…
  - Handling/cleaning optics
  - Use of lenses
  - Knowledge of imaging systems
  - Using mirrors for alignment
  - Maintaining polarization after reflections
  - Use of wave plates and other polarization optics.
- Not all investigations lend themselves to this approach; we had to select certain key topics.

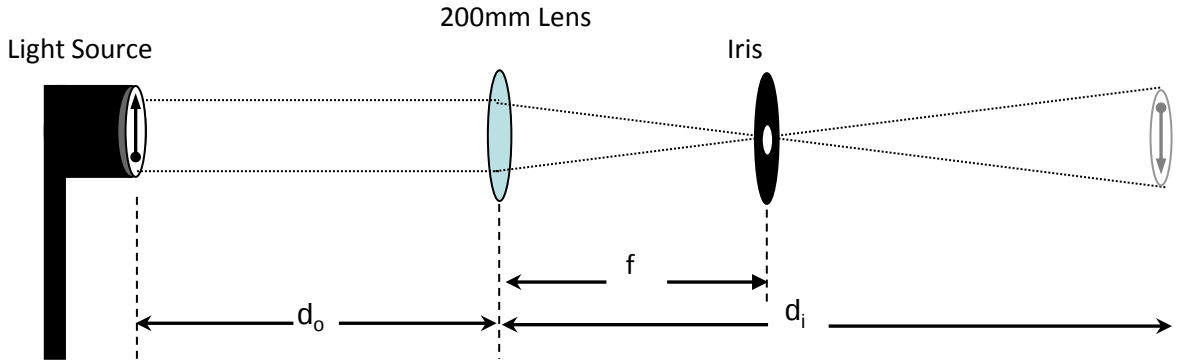
Lab Schedule

Week 1	Lab Intro (cleaning optics)
Week 2	Point and extended sources. Adapted from "Tutorials in Physics," McDermott and Schaffer
Week 3	Refraction
Week 4	Image formation
Week 5	Lens 1 (real image formation)
Week 6	Lens 2 (predicting image location)
Week 7	Lens 3 (virtual images)
Week 8	Reflections and alignment
Week 9	Curved mirrors vs. lenses
Week 10	Polarization 1 (Linear polarizers and half-wave plates)
Week 11	Polarization 2 (Quarter-wave plates and elliptic polar.)
Week 12	Polarization 3 (Polarization and reflections)
Week 13-16	Optics Project

Lab Write Ups available at http://users.ipfw.edu/masters/

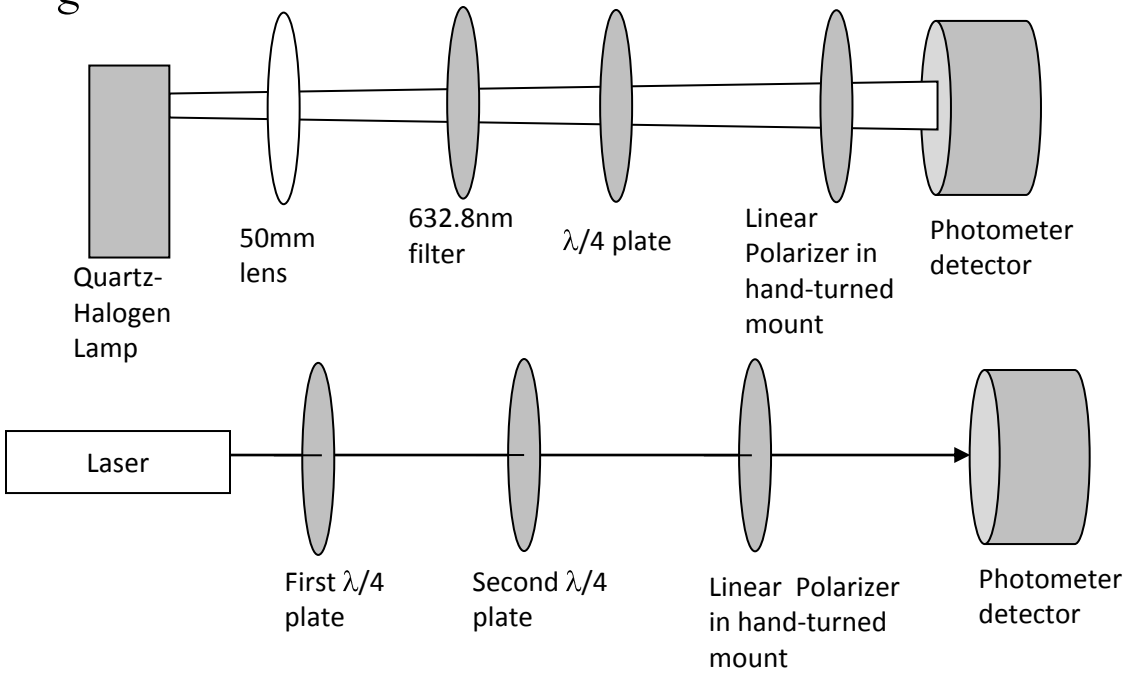
Some of the ways our investigations differ from others

- Extensive use of webcams
  - Taking pictures of images
  - Examining how images form on webcams
  - Using webcams to locate where the image forms
- Discovery based approach that confronts student misconceptions
  - For example, some students believe an iris placed at a focal point will have no effect on the image (see student sketch)

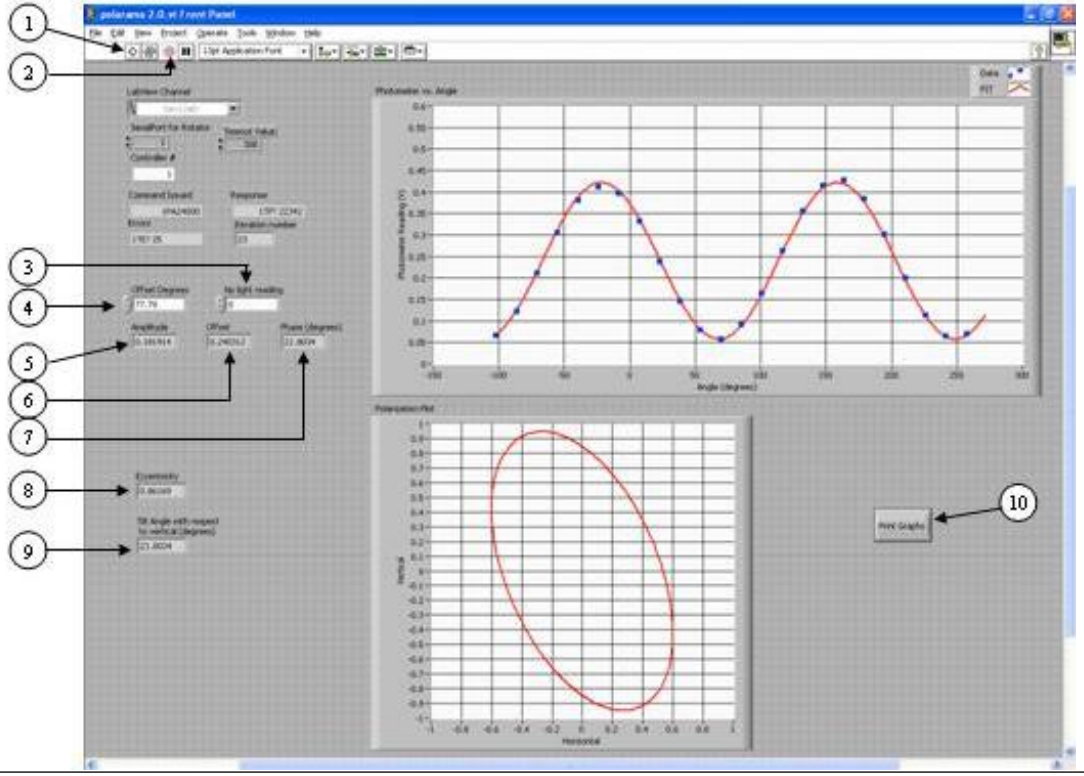


Polarization Investigations

- Use of a polarizing beam splitting cube to diagnose linear polarizations
- Discovery based activities to determine the effects caused by half-wave and quarter-wave plates.
- Examination of the differences between unpolarized light and circularly polarized light



- In order to shorten the duration of the laborious task of turning a linear polarizer and then determining the elliptical polarization, we interface a rotation stage to a computer through a program we named “Polarama 2.1”. Polarama determines the shape of the light’s elliptical polarization. The method used in the program is explained in the investigations (i.e., the program is not a black box)



Conclusion

- We developed a set of labs geared to an upper level optics course
  - The labs are discovery based and focus on various student misconceptions
  - These labs are available at http://users.ipfw.edu/masters/

- Information about some of the tutorials used in the lecture part of our optics sequence will be presented in LD07