Experimental Optics

Course Number: PHYS342
Schedule: Tuesdays, 1:10-4:00 PM
Instructor: Christina Othon
Office: #233, Science Tower
Office Hours: Monday 9:30-10:30; Wednesday 2:00-4:00, by appointment
Course Website: on Moodle
E-mail: cothon@wesleyan.edu
Telephone: 685-2107

This is an experimental optics course, designed to provide students with a foundation in geometric optics and laboratory techniques. The course will introduce topics such as laser operation, ray tracing, diffraction, interference, and polarization.

It is the policy of Wesleyan University to provide reasonable accommodations to students with documented disabilities. Students, however, are responsible for registering with Disabilities Services, in addition to making requests known to me in a timely manner. If you require accommodations in this class, please make an appointment with me as soon as possible so that appropriate arrangements can be made. The procedures for registering with Disabilities Services can be found at http://www.wesleyan.edu/deans/disability-students.html.

Course Prerequisites: Students should have previously taken courses in introductory physics.

Required Materials: Laboratory notebook. There is no required text. Laboratory handouts are available at the class website. Please printout and read the lab guidelines prior to class.

Suggested Reference Texts: Optics, by Eugene Hecht, Addison Wesley.

Laboratory Notebooks: Students are required to keep a complete and neat record of all laboratory experiments. Notebooks are to be collected periodically at the end of class for grading. Notebooks will be graded and returned to students at the following class period.

Laboratory Reports: Two formal laboratory reports are required. The first can be chosen from any of the first 5 experiments. The first lab report is due by Nov. 4th. The second must be the final project report. The second laboratory report is due by Dec. 13th. See attached description for content and evaluation of the lab reports.

Final Project: Students are required to complete a final project, the potential topics for study will be provided. Students are expected to design a research plan, implement the plan, and analyze the results of their observations. Further details of the final project will be given at a later date.

Incompletes: There will be no incompletes, no make-up labs, and no extensions.
**Grading:** Grades are based on the total number of points earned on laboratory notebook evaluation, laboratory reports, and the final project. Your course grade will be computed as follows.

- Laboratory Notebooks: 75%
- Laboratory Reports: 25%

**Sep 6 Organizational Meeting & Introduction**
**Sep 13 #1 Geometric Optics I: Laser Beam Manipulation**
**Sep 20 #2 Geometric Optics II: Lenses and Imaging**
**Sep 27 #3 Diffraction I: Circular Objects**
**Oct 4 #4 Diffraction II: Slits**
**Oct 11 #5 Interference I: Michelson Interferometer**
**Oct 18 **Fall Break, No Lab**
**Oct 25 Lab #5 continued**
**Nov 1 #6 Polarization**
**Nov 8 Lab #6 continued**
**Nov 15 #7 Interference II: Spectroscopy**
**Nov 22 Lab #7 continued**
**Nov 29 #8 Project of your choice (possible topics will be announced later)**
**Dec 6 Lab #8 continued**
Guidelines for Laboratory Notebook

The laboratory notebook is one of the most basic and essential tools for experimental work. It is primarily for the experimenter's own use, but another person with a similar background should be able to understand and duplicate any experiment, data, and observations by following the lab notebook details alone.

Students are to obtain a notebook exclusively for this course. **Notebooks must be bound and pages should be numbered consecutively.** Grid lined paper is preferable. A neat, organized and complete lab notebook will serve as a record of what was done, and provide the necessary information to write your laboratory reports. Notebooks should be written in pen. One should use all pages. Do not leave any blank pages.

**Table of Contents Page Format**
Use page 1 of the notebook for a table of contents for the notebook, with a format as shown below.

<table>
<thead>
<tr>
<th>Exp. #</th>
<th>Title of Experiment</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Laser Beam</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Lenses</td>
<td>8</td>
</tr>
</tbody>
</table>

**Experiment Record Format**
For each experiment, you are to adhere to following format which involves seven parts. Each experiment is to be started on a new page with the following information at the top of every page.

Date       Exp. #       Experiment Title       Name

Then on the **first page of each experiment** list the names of any partners that worked on this experiment with you. **Make sure you include all information that will be necessary for use in the final write up.** Then start on the following page with:

1. **Objectives**: Briefly state the major goals of the experiment.

2. **Preliminary**: State your approach to the experiment, i.e., how you intend to achieve the objectives. This should include a brief summary of theory, a few important equations, and/or a reference to some relevant text.

3. **Procedure**: Give essential details on how the experiment was conducted. **DO NOT recopy the hand-out material.** Make sure that this information is complete. You will need this information to complete your laboratory reports. **Be sure you include all information you will need in order to repeat the same types of measurements.**
4. **Data:** The data should be inserted in the procedure description so that it appears near the corresponding procedure. Tabulate data wherever possible to make it easy to read.

5. **Calculations and Results:** Work out one example of each type of calculation. Start with the equation, then substitute in the values with the correct units then calculate the answer. If the same equation must be used repeatedly tabulate the results. Include percent errors and percent deviations. Be aware of the precision of your data and watch the significant digits of the final results.

6. **Questions?** Whenever a specific question is asked. Write the question followed by the answer. You must answer all questions posed in the laboratory guidelines.

7. **Conclusions:** Write scientific conclusions about the results of the experiment. Base your conclusions on what you actually did, not on what you think you should have done. Be factual and concise. Do not conclude something unless your results actually support that conclusion. Remember a scientific conclusion is a statement about the behavior of some physical system based on the observation of facts. Did the experiment confirm or disprove any scientific theories or laws? Was the accuracy within the expected limits for the measuring equipment used?

**CONTENT REQUIREMENTS:**
The laboratory notebook must answer the following questions in at least one part of the report. You can use this as a checklist.

1. **WHAT WAS DONE?** This includes the approach to the problem or project, as well as the experimental procedure. If tests are conducted using a piece of equipment, clearly identify that device and give theoretical or nameplate characteristics. Another person should be able to repeat the experiment using only the information in your notebook.

2. **WHO DID IT?** List all members of the lab group, including yourself, at the beginning of the write-up.

3. **WHEN WAS IT DONE?** It must be obvious or any reader when the experimental work was performed. Date all entries in the notebook. It is possible that a single experiment may have 2 or 3 different dates. Do not leave blank spaces and never "back-date" notebook entries.

4. **WHAT WERE THE RESULTS?** Data must be distinguished from calculated values. It should be obvious which measuring instrument yielded which data. Examples of each type of calculation must be given. Graphs must have titles, labels and scales are required for both axes.

5. **WHAT DOES IT MEAN?** Make observations and draw conclusions from the results of your work. Be precise and concise. Compare your results to the theoretical (give reference). Specifically why do you believe or disbelieve the results? Discuss errors relative to the accuracy of the measurement equipment.

**Be neat and concise,** Graphs and computer printouts must be taped or glued into the notebook at the appropriate point in the description. All statements must be complete sentences and be written using correct English grammar and spelling.

**Graphs must be large enough to be easily read,** If values are to be read off the graph then the graph should usually be full page size. **All graphs and Tables should have**
appropriate titles and labels. If a graph has multiple curves each one should be clearly identified. It must be clear which physical variable each curve represents. Scales on graphs should be identified including the proper units. The scale increments should be multiples of 1, 2, or 5. One exception to this is scales for angles measured in degrees where multiples of 15, 30, 45, or 90 may be used. The scale should be adjusted so that few if any leading or trailing zeros are required in the printed scale values. e.g. plot in µm, mm or cm instead of m to fit the range of values to be plotted.

Evaluation of Notebooks

<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neatness, general organization, spelling, etc.</td>
<td>20%</td>
</tr>
<tr>
<td>Content (completeness of description of work, quality of data presentation etc.)</td>
<td>40%</td>
</tr>
<tr>
<td>Conclusions and answers to specific questions</td>
<td>40%</td>
</tr>
</tbody>
</table>
Laboratory Reports

The purpose of formal laboratory reports is to disseminate the results of your experimental endeavors. These are analogous to theses and journal articles you will be required to write in your future careers. The purpose of a laboratory report is not to rehash exactly what was written in your laboratory notebook. It is a stand alone document that should introduce a novice to the topic of study, engage that person’s interest, provide all necessary background and supporting information, describe the experiment in enough detail to allow the interested reader to comprehend the procedure used, understand the import of such experiments, and if the reader is trained in a similar field they should be able to repeat the experiment and arrive at the same conclusions. This document is a narrative, and should not contain a list of steps such as the laboratory procedures does (as such it should not be a copy of the lab handouts). Your lab report should be formatted as follows (guidelines are based directly on those of the American Institute of Physics journal guidelines).

The Manuscript, including the abstract, references, and captions, should be set up 8-1/2 x 11 in. pages with 1” margins. It should be carefully proofread by the author. The manuscript must be in good scientific American English; this is the author's responsibility. **Number all pages in single sequence beginning with the title and abstract page.** The title page should contain the title of the article, the names and affiliations of the authors, and a short abstract. Parts of the manuscript should be arranged in the following order: title, author, date, abstract, text, and references. Papers should not be lengthened by unnecessary descriptions and repetitions, but neither should authors use a telegraphic style detrimental to the clarity and understanding of the paper.

**Manuscripts must never exceed 10 double-spaced pages (aim to be more concise without leaving out important details).** An abstract limited to about 100 words is required. The limitation of text includes allowances for equations, tables, and figures.

The **Title** should be as concise as possible but informative enough to facilitate information retrieval.

The **Abstract** should be limited to about 100 words and should be self-contained (contain no footnotes). It should be adequate as an index (giving all subjects, major and minor, about which information is given), and as a summary (giving the conclusions and all results of general interest in the article). The abstract should be written as one paragraph and should not contain displayed mathematical equations or tabular material.

**Authors’ names** should preferably be written in a standard form for all publications to facilitate indexing and avoid ambiguities. Include your name first, followed by your lab partner. Each lab partner is responsible for their own lab reports.

**Text** should consist of the following four sections **Introduction, Materials and Methods, Results, and Concluding Remarks.** Each section should be clearly labeled. The introduction should be a concise narrative outlining the background of the experiment and should include a theoretical basis for the experiment to be conducted. The introduction is where you explain to the reader what? and why? you are conducting the experiments. The materials and methods section is where an author should outline how? the experiments were conducted. This section should include all materials necessary to set up the apparatus as well as all procedures used to collect the data. The results section is where the author should discuss the data collected, and comment on any trends or observations based upon these results. The concluding remarks is where the author reflects upon the experiment and discusses any improvements that could have been made, the relationship to future works, or the importance of such discoveries. In essence the concluding remarks should answer, **why anyone should care about this work?**
Equations should be punctuated and numbered on the right. Use "exp" for complicated exponents.

Notation must be legible, clear, compact, and consistent with standard usage. All unusual symbols whose identity may not be obvious must be identified the first time they appear, and at all subsequent times when confusion might arise. Superscripts are normally set directly over subscripts; authors should note where readability or the meaning requires a special order.

References and footnotes are treated alike. They must be numbered consecutively in order of first appearance in the text and should be given in a separate double-spaced list at the end of the text material. Reference should be made to the full list of authors, rather than to first author followed by an abbreviation such as et al. References within tables should be designated by lowercase Roman letter superscripts and given at the end of the table. For the proper form, see recent issues of this journal.

Separate Tables (numbered with Roman numerals in the order of their appearance in the text) should be used for all but the simplest tabular material; they should have captions that make the tables intelligible without reference to the text. The structure should be clear, with simple column headings giving all units.

General Guidelines for Preparing Figures:

- Number figures in the order in which they appear in text.
- Label all figure parts with (a), (b), etc. Avoid any large disparity in size of lettering and labels used within one illustration.
- Prepare illustrations in the final published size, not oversized. The maximum published width for a one-column illustration is 3-3/8 inch (8.5 cm). Figures can be prepared as two column figures if needed. Each illustration should be prepared for 100% reproduction in order to avoid problems arising from large reductions in size.
- Ensure that lettering and lines are dark enough, and thick enough, to reproduce clearly, especially if reduction is necessary. Remember that fine lines tend to disappear upon reduction.
- Figures may appear embedded in the text as they are referred to, or at the end of the text on separate pages (if the latter is the case, count each figure as 1/6 of a page).

Evaluation of Laboratory Reports

General Organization and Presentation 10 pts.
Grammar and Spelling 10 pts.
Quality of Scientific Writing 10 pts.
Content (completeness of description of work, quality of data presentation etc.) 15 pts.
Conclusions 5 pts.

Total 50 pts.

*A good source for tips on scientific writing can be found at:
http://www.treesmapsandtheorems.com/X0301.php