Modern Optics I and II
Physics 3410/6750
Fall Semester 2004

Instructor:  Professor Clayton C. Williams
Office: 302 JFB
Telephone: 585-3226; email: clayton@physics.utah.edu
Office hours: Tuesday 3-4 pm, Wednesday 3-4 pm, or by arrangement

Class Website: http://www.physics.utah.edu/~woolf/3410.html

Lectures: MTW 2-2:50 pm, JFB 209
Laboratories: Friday 9-1 pm, Friday 2-6pm

Important Dates
Class starts: Wednesday, August 25, 2004
Last day to drop class: Friday, September 3, 2004, withdraw: Friday, September 24, 2004
Last class: Wednesday, December 8, 2004
Final examination: Wednesday, December 15, 2004. 1-3 pm, in JFB 209

Additional Calendar Dates
Labor Day Holiday  Monday, September 6, 2004
Fall Break  Thurs., Friday, October 7,8
Thanksgiving Break  Thurs., Friday, November 25,26


Lab Teaching Assistants:
Vladimir Burtman: phone 581-8889, email: burtman@physics.utah.edu
Josh Kennedy: phone 587-7634, email wjk@physics.utah.edu
John Viner: phone 581-5232, email: jmv@physics.utah.edu

Grader:  Qian Yue, phone: 635-5853, email: sandyboy@sohu.com
Course Overview
Optical principles, effects and instruments impact many areas of science, technology and everyday life. Optics is a beautiful part of physics, many parts of which can be understood without extensive mathematics. The aim of this course is to teach the basic principles and some of the practical aspects of classical and modern optics. The course integrates classroom teaching, demonstrations, homework and practical laboratory experience. The laboratory provides students with an opportunity to independently observe and verify many of the basic optical principles.

Course Mechanics
Prerequisite: Engineering physics sequence or equivalent (Phys 2210,2220)
Lectures: Lectures will cover the background required to do the laboratory work.
Laboratory: Tenlab experiments will be performed. Late reports will receive reduced credit.
Homework: Homework problems will be given approximately weekly.
Exams: Two midterms and a comprehensive final exam will be given.

Grading
Student grades will be based upon problem sets, laboratory reports, and exams as shown below.

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
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</thead>
<tbody>
<tr>
<td>Problem sets</td>
<td>20%</td>
</tr>
<tr>
<td>Lab reports</td>
<td>30%</td>
</tr>
<tr>
<td>Midterm exams</td>
<td>25%</td>
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<tr>
<td>Final exam</td>
<td>25%</td>
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</tbody>
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Graduate students (6750) are required to prepare a 3 page report summarizing a recent article in optics, and provide 10 minute presentation to the class. Articles must be approved by Professor Williams (3rd week), reports due (12th week), presentations (last 2 weeks of class).

Laboratory and Lab Schedule – Fall 2004

<table>
<thead>
<tr>
<th>Week</th>
<th>Friday</th>
<th>Saturday</th>
<th>Laboratory / Exam</th>
<th>Lab Manual (week #)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27-Aug</td>
<td>28-Aug</td>
<td>First Class: Aug 25, No Lab</td>
<td></td>
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<tr>
<td>2</td>
<td>03-Sep</td>
<td>04-Sep</td>
<td>No Lab</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>10-Sep</td>
<td>11-Sep</td>
<td>Lab 1: Plane Surfaces &amp; Prisms</td>
<td>Week 1</td>
</tr>
<tr>
<td>4</td>
<td>17-Sep</td>
<td>18-Sep</td>
<td>Lab 2: Curved Surfaces</td>
<td>Week 2</td>
</tr>
<tr>
<td>5</td>
<td>24-Sep</td>
<td>25-Sep</td>
<td>Lab 3: Lenses and Imaging Instruments</td>
<td>Week 3</td>
</tr>
<tr>
<td>6</td>
<td>01-Oct</td>
<td>02-Oct</td>
<td>Lab 4: First Advanced Set</td>
<td>Week 4</td>
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<tr>
<td>7</td>
<td>08-Oct</td>
<td>09-Oct</td>
<td>Midterm Oct 6, Fall Break</td>
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<tr>
<td>8</td>
<td>15-Oct</td>
<td>16-Oct</td>
<td>Lab 5a,b: Polarization</td>
<td>Week 5</td>
</tr>
<tr>
<td>9</td>
<td>22-Oct</td>
<td>23-Oct</td>
<td>Lab 5c,d: Polarization</td>
<td>Week 5</td>
</tr>
<tr>
<td>10</td>
<td>29-Oct</td>
<td>30-Oct</td>
<td>Lab 6: Interference</td>
<td>Week 6</td>
</tr>
<tr>
<td>11</td>
<td>05-Nov</td>
<td>06-Nov</td>
<td>Lab 7: Diffraction &amp; Interference</td>
<td>Week 7</td>
</tr>
<tr>
<td>12</td>
<td>12-Nov</td>
<td>13-Nov</td>
<td>Lab 8: Diffraction Patterns</td>
<td>Week 8</td>
</tr>
<tr>
<td>13</td>
<td>19-Nov</td>
<td>20-Nov</td>
<td>Midterm Nov. 17, Lab 9: Interferometry/AO</td>
<td>Handout</td>
</tr>
<tr>
<td>14</td>
<td>26-Nov</td>
<td>27-Nov</td>
<td>Thanksgiving Holiday</td>
<td></td>
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<tr>
<td>15</td>
<td>03-Dec</td>
<td>04-Dec</td>
<td>Lab 10: Spectroscopy/AO/Light speed</td>
<td>Handout</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td>Last class Dec 8</td>
<td></td>
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<tr>
<td>17</td>
<td></td>
<td></td>
<td>Final Exam: Dec 15, 1 pm JFB 209</td>
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General remarks and rules about the optics lab and course

This laboratory course attempts to teach optics by integrating classroom teaching, demonstrations, and a maximum of practical involvement on the side of the student—all done in a special work- and lecture-room. One of the motivations for this course and its particular format is the significant role of optical technology, instrumentation, research methods and applications in all fields of science, a role that continues to further expand. The aim of this course is to lead you, as directly as possible, into the "real world" of optics with its great achievements and promises for application, and--in a more general way--to train and motivate your independent ability for experimentation, observation, and understanding of physical phenomena. In order to organize and make successful an enterprise like this—which is more complex than a traditional course—a reasonable structure of rules, given below, must be supplied and followed. Please read them carefully, and cooperate!

Optics Laboratory

1) The required lab reports do not have to be lengthy or fancy write ups—but they should be reasonably organized, readable, and honest accounts of your lab work. Complete the write up of each section of the lab, before moving on. In order to finish on time, you will find that you come prepared for the lab session (having read the description and thought about it). A typical lab report should contain the following aspects:

   1. Objective – 5%
   2. Description of method, what was done (figure) – 15%
   3. Record of measurement and raw data* - 30%
   4. Analysis (equations, figures) – 30%
   5. Observations, Uncertainty, discussion of errors – 15%
   6. Statement of conclusion, what was learned  5%

*In many cases, the data can directly be recorded graphically on linear or polar diagram paper, plotting the appropriate dependency, and giving you the advantage of immediate check on the quality of the data.

2) The lab instructions include several symbols to clearly point out certain aspects. They have the following meaning:

Sections that are in a frame contain background information and should be read and the questions answered before the lab. Obtain additional information from the lecture and the book. If you have questions ask the T.A.

Note: 30min. before the lab might be too late to start reading the lab instructions

您 should definitively write something about the following in your report

 showModalToastInfo( {
   toastTitle: 'Note: 30min. before the lab might be too late to start reading the lab instructions

 showModalToastInfo( {  
   toastTitle: 'You should definitively write something about the following in your report

 showModalToastInfo( {  
   toastTitle: 'A ray diagram is required. Especially important in Week III.'
3) We realize that the given lab instructions are often quite detailed and "cook-book type" but we have learned from experience that many students need these detailed instructions. Everybody however is encouraged to attempt alternative and individual approaches to the given problems (as long as they are clearly defined and spelled out). Beyond this we encourage anybody who is more adventurous to branch out or depart from the prescribed path of experiments and to plan and perform alternative experiments of his own design (they may even involve some available equipment items, not supplied). The only condition is that you check out and discuss your plan with a TA before attempting it and get his advice and approval.

4) Don't be too shy to contact the TA's for assistance when you have problems in understanding the experiments and their procedures. Don't lose valuable lab time by making lengthy mistakes from which you don't learn much. The TAs will not do the work and solve all problems for you, but they should always be available to check out your procedures, to advise and to guide you on the right way.

5) The equipment you use is of good quality, and should be handled with care and caution. An important part of the care lies in the cleaning up and ordering of your work place at the end of the lab period. Always put the optical elements back into the supplied containers, order and unplug your setup, and shift it to the front side of the table, so that the desk space can be used during the lectures which are in between the lab periods.

6) All students are expected to attend their scheduled lab periods and do the project at these times, when a TA is present and can assist and give advice. In special cases you can do extra lab work during the week outside the scheduled lab and lecture times, but only if you check this out and arrange it with the TA.

7) The grades you get for the lab are not only based on the points obtained in the lab-reports, but also on the “general” impression you make. So don’t be grade-point oriented. The intention of the laboratory part is to give you some hands-on experience with optical equipment and phenomena. Please use the opportunity to experiment around, even if no points are given for it. Remember: The lab should be fun.

B. Other Matters

1) Homework problems are given normally each week and must be handed in at the beginning of lecture one week later. Do not follow the temptation to copy solutions from friends or books. These problems will prepare you for the examinations (which have a much greater value).

2) Examinations will cover material given in class, in problem sets and from the laboratories. Emphasis in these exams will lie more on your understanding of the concepts and phenomena of optics than on memorizing and mathematical treatment of complicated formulas.
CONTENTS OF LECTURE

1) LIGHT PROPAGATION, REFLECTION AND REFRACTION AT PLANE SURFACES
   Reflection Law, refraction, Snell's Law, Fermat’s principle, prisms, dispersion.

2) LIGHT REFLECTION AND REFRACTION AT SPHERICAL SURFACES
   Refraction at spherical surfaces, thin lens, imaging, thin lens combinations, apertures, mirrors, spherical mirrors, thick lens and combinations.

3) OPTICAL INSTRUMENTS
   Human eye, magnifying glass, compound microscope, refractive and reflective telescopes, adaptive optics.

4) LENS ABERRATIONS
   Chromatic, spherical, coma, astigmatism...

5) ELECTRO-MAGNETIC WAVE OPTICS

6) LIGHT POLARIZATION
   Polarization by reflection, dichroism, light scattering, birefringence, circular and elliptical polarization, optical activity, field- and stress-induced polarization, photon-picture of polarization.

7) WAVE INTERFERENCE AND DIFFRACTION

8) HOLOGRAPHY
   Principle of holography, white light holograms, applications--like three dimensional information storage, multi-colored holograms, pattern recognition, holographic interferometry.

9) LASERS
   Physical principles, laser cavity and modes, different types of lasers (gas, chemical, molecular, solid state, dye, semi-conductor lasers).

10) LASER APPLICATIONS
    Fiber optics and communications, laser directionality, "optical radar", lunar experiment, pressure of laser light, non-linear optics (short outlook).