111 B Advanced Syllabus

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111-Lab Faculty Instructors

<table>
<thead>
<tr>
<th>Faculty Instructor</th>
<th>Course</th>
<th>Office</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hartmut Haeffner</td>
<td>Experimentation Lab</td>
<td>301H LeConte</td>
<td>(510) 664-4299</td>
<td><a href="mailto:hhaeffner@berkeley.edu">hhaeffner@berkeley.edu</a></td>
</tr>
<tr>
<td>Kam Biu Luk</td>
<td>Experimentation Lab</td>
<td>427 LeConte Hall</td>
<td>(510) 642-8162 or (510) 486-7054</td>
<td><a href="mailto:k_luk@berkeley.edu">k_luk@berkeley.edu</a></td>
</tr>
<tr>
<td>William Holzapfel</td>
<td>Instrumentation INS</td>
<td>433 LeConte Hall</td>
<td>(510) 642-5036</td>
<td><a href="mailto:swlh@cosmology.berkeley.edu">swlh@cosmology.berkeley.edu</a></td>
</tr>
</tbody>
</table>

11B-Advanced Lab GSI Student Instructors

<table>
<thead>
<tr>
<th>Graduate Student Instructors</th>
<th>GSI new office: 275 LeConte; Lab phone: 642-1937</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeremy Axelrod (20)</td>
<td>ADV</td>
</tr>
<tr>
<td>Franklin Liou (20)</td>
<td>ADV</td>
</tr>
<tr>
<td>William Tokumaru (20)</td>
<td>ADV</td>
</tr>
</tbody>
</table>

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111 Lab Staff Research Engineer 3 and 111-Lab Manager

| Donald Orlando | 282E LeConte Hall | Phone: 642-5328 (with Voice Mail) | Email: phylabs@berkeley.edu |

Please contact Don Orlando about any equipment, electronic, or computer problems in the 111-Lab. We want you to enjoy your time in the Physics 111-Lab.

Unit credit

- Three (3.0) units of Advanced Lab are required for the Physics major.
- You can also enroll for additional semesters at 1.5 to 3.0 units each (see a faculty or Don Orlando).

Course Lab Information
• **Lab location:** 282 and 286 LeConte Hall

• **Lab hours:** Mondays 12-4pm and Tuesday-Friday 1-5pm

• **Lab phone:** 624-1937 (No answering machine)

The Physics Department Colloquium is on Mondays from 4:15-5:15pm in 1 LeConte Hall; all students are strongly encouraged to attend. Also, tea and cookies are served (for a small fee) at 4pm every day in 375 LeConte Hall.

1. All course materials are available from the [Experimentation Lab Site](#) or the [Instrumentation Lab](#).
2. Optical Pumping is a required experiment for all students.
3. What to do first: Fill Out the Signature Card on-line on bCourses. This is located on bCourses [16] on the Home Page. Make sure your picture is available on the Berkeley bCourses [16] Web site. If NOT bring to class a Passport photo and give it to Don Orlando. Download your copy of the [Error Analysis Lab](#)(EAX), sign up for your first experiment in the lab, get reprints from Library Site and watch the [111-Lab videos](#) about your experiment online.
4. Please purchase before coming to class your own personal USB 8GB THUMB Drive for file storage.
5. For Lost & Found, see Donald Orlando phylabs@berkeley.edu [13]
6. Read [Physics Campus Computer Policy](#)

### Texts: Required

- Bevington, *Data Reduction and Error Analysis*, 3ed, 2003 [22]

These texts are good references and available on reserve in the [Physics 111 Library Site](#) on campus. Please note that you can access the texts only via the campus-network. To set up access from outside the campus see [http://www.lib.berkeley.edu/Help/proxy.html](http://www.lib.berkeley.edu/Help/proxy.html).

### Advanced Lab Due Dates

#### Advanced Laboratory Experiments

- [Links to all available Physics 111-Lab videos](#)
- Note that all videos can be seen on the on-line. Note: the safety videos have paper work attached to it that you must sign and turn into the 111 staff.
- References located on the [Physics 111 Library Site](#)
- You must present one an oral report on an experiment you have completed! So plan what experiment you do for an oral report. All other reports will be in written form.
- Note there is NO eating or drinking in the 111-Lab anywhere except at the bench with the BLUE stripe around it in rooms 282 & 286 LeConte.

Remember you need to complete one (1) oral presentation and turn in three (3) written reports per semester and the error analysis exercise to pass this course.

**NOTE:** You can do OPT and MOT or MNO in the same time slot, but you Must Signup and Complete Optical Pumping first and then complete Atom Trapping or Magneto Optical.

<table>
<thead>
<tr>
<th>Experiment Name</th>
<th>First Lab</th>
<th>Abbreviation</th>
<th>Days Allotted</th>
<th>Sign up Consecutive Days needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atomic Force Microscope (AFM)</td>
<td>No</td>
<td>AFM</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>Atomic Physics (Balmer Series &amp; Zeeman Effect)</td>
<td>X</td>
<td>ATM</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>Atom Trapping with Rubidium (See Note Above) Λ*</td>
<td>No</td>
<td>MOT</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>Beta–Ray Spectroscopy</td>
<td>X</td>
<td>BRA</td>
<td>7</td>
<td>Not Available</td>
</tr>
<tr>
<td>Brownian Motion in Cells</td>
<td>X</td>
<td>BMC</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>CO2 Laser λ</td>
<td>X</td>
<td>CO2</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>Compton Scattering</td>
<td>X</td>
<td>COM</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>Gamma–Ray Spectroscopy</td>
<td>X</td>
<td>GMA</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>Hall Effect in a Plasma</td>
<td>X</td>
<td>HAL</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>Hall Effect in a Semiconductor</td>
<td>X</td>
<td>SHE</td>
<td>7</td>
<td>Yes</td>
</tr>
</tbody>
</table>
$ = You will do some LabView programming  \( \lambda \) = Lasers used

### Advanced Lab Report Due Dates

<table>
<thead>
<tr>
<th>Report Due Dates</th>
<th>Spring 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>0. Error Analysis Exercise – EAX</td>
<td>11:50 pm, January 28</td>
</tr>
<tr>
<td>1. Oral* or written 1st Lab</td>
<td>11:50 pm, February 16</td>
</tr>
<tr>
<td>2. Oral* or written 2nd Lab</td>
<td>11:50 pm, March 14</td>
</tr>
<tr>
<td>3. Oral* or Written 3rd Lab</td>
<td>11:50 pm, April 11</td>
</tr>
<tr>
<td>4. Written 4th Lab</td>
<td>11:50 pm, May 9</td>
</tr>
</tbody>
</table>

*Your first, second or third lab must be an oral Report. All other reports are written.

You must sign up for one oral report before the due date.

NOTE: Reports must be submitted online in PDF format, through Bcourses (scan your document in 1st at the library or other program then upload to Bcourses).

YOU MUST TURN IN ALL REQUIRED WORK TO PASS THIS COURSE.

LATENESS POLICY: NO REPORT PAST THE DATE AND TIME OF THE LAST DUE DATE WILL BE ACCEPTED.

Radiation rings and locker keys are all due by the final day of the lab class. Turn them into room 286 LeConte Hall staff.

If you have any questions about the course please contact the faculty or Don Orlando.

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### Course Material Fee

To offset the cost of expendable items of the Physics 111B-Lab course, students of the Physics 111B-Lab must pay a Course Materials Fee (CMF) of $165.00. CMF is a kind of fees approved under the authorities contained in the policies of the Office of the President (October 2014) and the Berkeley Campus (October 2009). The fees are assessed after the fifth week of classes in Fall and Spring, and will be included in the students' CARS (Campus Accounts Receivables System) statements.

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### General

The goal of the advanced lab is to become familiar with experimental physics research. It is a test run as an experimental physicist with all responsibilities. This includes learning how to conduct meaningful experiments, mastering important experimental instrumentation and methods, analyzing data, drawing meaningful conclusions from them and presenting your results in a succinct manner. For this, you will conduct four experiments and one error-analysis exercise. Every student must complete the Optical Pumping experiment, then you can choose from 19 other experiments in the lab.

Note that there is NO eating or drinking in the 111-Lab anywhere, except in rooms 282 & 286 LeConte on the benches with the BLUE Stripe around it. Thank You from the Staff.

### Learning Goals

- Learn how to think as an experimentalist
- What am I trying to find out? Why?
- What does my experiment do? What piece of equipment does what? How?
- How precisely/accurately do I need to know something in my experiment?
- What aspect of my experiment and of the background physics is central, and what is peripheral?
- How trustworthy is my measured result?
What might have caused statistical errors in my measurement? What might have caused systematic errors in my measurement? How can I honestly and convincingly estimate the effect of those errors?

Learn how to communicate science

Remarks

There will be a lot of hard work and frustration, but it is a very rewarding experience, and worth the effort. Often there is no satisfactory solution to a particular problem. Thus you will not be penalized for not getting the correct answer, rather your grade will depend on how systematically you approach the tasks and solve the inevitable problems. The lab is equally challenging to the teaching staff who may not be familiar with all the experiments. Note that the goal of this course is not to teach you the right answer but to instruct you how you can figure out the answers. We are here to help and to guide you in this process. We will teach you problem-solving strategies, for instance, by asking questions rather than giving you the answer you might actually seek.

What you do in this course

Complete 5 assignments to receive a grade in this course (1 EAX, 3 written, 1 oral report) Reports will be submitted online through Bcourses.

- EAX: Error analysis exercise
  - Look for assignment and background materials online
  - Please read one of the recommended texts on statistics. It will help you immensely in the long run. Do not just be a "write-up reader."
  - Complete problem set

Complete all reports on 4 labs, plus error analysis

- Choose and sign up for a time slot on an experiment
- Read lab manual and background materials, watch videos, go over pre-lab questions before coming to class, look at the apparatus before your first assigned day.
- Pre-lab before first day with GSI or Prof. Mid-lab sometimes.
- Written report submitted on due date, online. Oral report done days after due date.

Choosing Experiments

There are about 20 experiments available for this semester, covering a wide range of fields in Physics, such as atomic physics, condensed-matter physics, optics, nuclear and particle physics. Each experiment has instructions accessible via the navigation bar at the top of the web site but refrain from using them as a recipe. You will be much better off by understanding what you are doing rather than following instructions. You must do four experiments and the exercise on error analysis (the latter in the first week of class) to complete the course requirement. One of the four experiments must be Optical Pumping; the other experiments are divided into two groups based on their overall effort. Please note also that we will take the level of difficulty of the individual experiment into account when we grade; in particular, we expect you to go into much more detail for the "easy" experiments.

You can sign up for the first experiment on the first day of class. For the following labs, we will announce a day from when on you can sign up for the next experiment. Sign up will be by groups as determined on the first day of class. The order of the group will rotate through so that every group will have a good chance to choose at least once their favorite experiment. The first group can start signing up at 1pm, the 2nd at 2, the 3rd at 3 and 4th group at 4pm.

Spring 2016, we have the following sign-up days and orders:

lab #1: Jan. 19, group B,C,D,A
lab #2: February 4, group C,D,A,B
lab #3: March 1, group D,A,B,C
lab #4: March 28, group A,B,C,D

Organization

- You perform experiments with a lab partner. You work together on the experiment. However, the main part of your data analysis and all or your written/oral report must be your own work.
- You must sign up to do an experiment in one of the assigned slots. You cannot split your time between multiple slots. The sign-up list is in LeConte 286 next to the door.
- You sign up for Lab 1 on the first day. You sign up for later labs on later days (it will be announced).
- You sign up by sign-up groups see above
- Some of you will have to start Lab N before turning in the report for Lab N-1.
- If you turn in EAX or a lab report after its due date, you will incur a late penalty.

Preparation for each experiment

- Prepare to do the pre-lab at least one day prior to starting your experiment. Otherwise you might loose valuable experimenting time.
- Download the write-up of the experiment from the wen site page.
- Read some of the references and the write-up.
- Watch the appropriate videos for the experiment and any lecture series or safety videos that are available. Attention: some of the videos may be out of date and the apparatus and the procedure may have changed. However, the key is to learn the concepts and experimentation.
- For some experiments, either a laser or radiation safety training is required. Take the required training course and the quiz.

The pre-lab questions are there to help you to identify the most critical concepts for successful experimentation. Use them as a guide of what to read about. Prepare to answer the pre-lab questions orally in the lab. Do not hesitate to contact the staff in the lab if you encounter difficulties with the subject. We might not answer your questions directly but we will help you to find the answers. The better you can describe your problems, the better we can help. Thus: think and discuss among yourselves first before you ask.
In the Laboratory

For successful experimentation, you must have a good understanding of the underlying physics. The pre-lab questions are there to guide you towards the important concepts and we require you to go over them with the teaching staff before starting to do the experiment. You do need to turn in and show your written answers to the pre-lab questions, but you must demonstrate a sufficient understanding of the physics related to the questions; otherwise you will not be allowed to start the experiment.

Before experimenting:
- get familiar with the apparatus.
- ask yourself questions before taking any action.
- be patient and careful. Safety is essential.
- DO NOT ABUSE any piece of equipment.
- if there is any issue, talk to the teaching staff or Don.
- you must be proactive when working together.
- Plan ahead: take some measurements and quickly analyze the data to get some idea whether you are heading in the right direction, then take more data

Reports

You must complete one oral report per semester on an experiment see Oral Report Guidelines and view the How to do an Oral Report Video. All other reports are in written format (see Written Report Guidelines).

All written reports as of Jan. 2016 must be submitted online through Bcourses.

Oral report (20 minutes presentation + ~10 minutes questions)
- You must give exactly one oral report for one of the first three labs.
- You must sign up for which lab you will do the oral report during the first week(s) of the semester.
- Watch the video on how to prepare an oral report.
- Hand in the signed pre-lab page and show the faculty instructor copies of your data and analysis.
- You can either use the white board or any kind of software tool for presentation.
- 10 points will be deducted for every 10 minutes late for giving your oral report.
- While we expect a coherent and well-structured presentation, be prepared that questions will be discussed as they come up during your presentation.

Written report (less than 15 double-spaced pages): Note All reports must be submitted online as of Jan. 2016, through Bcourses.

Please read here: http://experimentationlab.berkeley.edu/ReportGuidelines

Some advice on writing the report:
- Latex is a free powerful word processor that is popular among the physicists and mathematicians. Thus, we encourage you to use it to write your report, but we accept any reasonable format.
- We encourage you to analyze your data with MATLAB which is available in the lab; otherwise consider Octave or SciPy as an alternative to MATLAB.
- You don't need to provide long derivations.
- You should cite references in the text. For example, to cite a paper: J. Last, Phys. Rev. Lett. volume number, page number (2013); to cite a book: J. Last, title of the book, page, publisher (2012).
- You should only provide relevant information: think what a student in your position needs to know to understand what you did.

If you encounter difficulties with the analysis or physics, do not hesitate to contact the staff in the lab; we are there to help you.

Safety

Use common sense and think before acting.
1. No food or drink is allowed in the lab except for the specified area marked with blue tapes.
2. Some experiments that use radiation or lasers will require safety training.
3. View the Radiation Safety Video on YouTube. Then get a pink Radiation Safety form from a 111-Lab staff person. Fill it out & sign the form for getting a Radiation Ring. Also, complete the Radiation Safety Training. After completion of the training, turn in all forms to Don Orlando or a teaching staff.
5. Complete the read and sign laser training Laser Safety Training

Grading

Your final semester grade will be determined from the total points you receive for the reports where we will take the difficulty of each experiment into account. Each of the four lab-reports is graded on a 0 to 100 point basis, while for the error analysis report you can receive up to 50 points. There are many factors that go into determining the grade that a report receives, but we offer the following rough grading guidelines, where >50% is considered a passing grade:
- Excellent (80% - 100%): Student completed most parts of the experiment, and report demonstrates a clear understanding of each part and the overall picture. The report is easy to follow (would be clear to another student), and is complete without being padded. Report contains complete error analysis, and contains no or few mistakes.
- Average (60% - 80%): Student completed most parts of the experiment, and report demonstrates a general understanding although student may appear
confused over some points. Analysis is difficult to follow, and conclusions drawn from the data are not clearly stated.

- Poor (40% - 60%): Student completed major parts of the experiment, but fails to draw conclusions from the data. Report is difficult to follow, and contains many errors.
- Insufficient (0% - 40%): Student fails to demonstrate an understanding of what the experiment is about and/or major parts of the report are missing.

You must have given an oral report. Remember that students who are missing work will be assigned a grade of "F" for the semester, and that no reports will be accepted after the last due date.

Note also that you must have turned in all four reports and the error analysis report on the deadline of the last report.

Pick up your report in the lab. We try to return your graded report in a timely fashion, i.e., in two weeks. For feedback on presentation style, we encourage you to go through the report together with the GSI/faculty who graded it.

**Lateness**

All written reports are due by 4 pm on the due date, except the last report which is due by 1 pm on the due date. Ten (10) points will be deducted for each started week past the due date. No report will be accepted past 1 pm on the due date of the last lab report, no exceptions. Getting a late start on your report is no excuse for turning in the report late.

**Plagiarism**

Both the University and the 111 Lab staff take the subject of plagiarism very seriously. Please make sure you understand completely the following and ask questions if ever in doubt: "All data that you present in your reports must be your own. All written work that you submit, except for acknowledged quotations, is to be in your own words. Work copied from a book, webpage (including the experimental instructions), from another student's report, or from any other source without proper citation will, under University rules, earn the student a grade of "F" for the semester, and possible disciplinary action by the Student Conduct Committee." Note that a proper citation requires that you mark clearly which text/illustration has been copied from as well as the source of it. This is most easily done by adding a note of the form "Illustration taken from Ref. [<number>] below the illustration indicating which reference this excerpt belongs to. In case you quote a text, put the quoted text in quotation marks and add the reference number after the text.

**Working Together**

You will probably take your data with a partner, and may work together on analyzing these data. But each person must write his or her own report and submit it to 111 Lab Staff for grading. The text of your report, graphs, figures, and derivations of equations must be your own. (This includes graphs generated using standard software: you must each make your own). Please be sure to acknowledge any sources that you use in your reports, and be careful not to copy another's work.

**End of the semester**

All materials and reports are due by the last due day, no exceptions. Any graded Lab Reports not picked up by the first week of the subsequent semester will be thrown away. Please make sure you return your radiation ring if you use one. Please complete course evaluations and let us know how we can make improvements.