

Intermediate Physics Laboratory I & II: Syllabus

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I. GOALS OF THE COURSE

- To learn to make careful observations of physical systems, independent of preconceived theoretical models.
- To learn how to keep a well-written scientific notebook.
- Exposure to experiments and instrumentation in several different fields of physics, including at least some that you have not encountered in other courses.
- To learn and experience the typical working methods of a modern research laboratory. Most crucially, this means working successfully together in groups towards common goals.
- To learn to make effective oral presentations, and to learn to write in the genre appropriate to a physics journal, and to experience the revision process.
- To improve the quality of your writing.
- To deepen your understanding of data analysis and error propagation.

Structure of the course

You will collaborate in small groups (typically two to four people depending on the composition and wishes of the students in the course); for the most part you will be graded on the results produced by your group, just as we are in the “real world” of research. The groupings of collaborators may be changed during the semester if needed.

As a group member you will participate in four to five research projects—this is an intensive, fun, moderately-paced course with a tight schedule. Each research project has four phases:

1. **Initial research and planning for the experiment.** This will typically require some research at the library, on the net, or through your

own notes from past courses, as well as an examination of the apparatus as hand. Before proceeding to take data, I will likely have an oral interview with each group to assess the depth of their initial research.

2. **Lab work** For each project, there will be one partial lab session (the day of the initial presentation) and two to four full lab sessions. You are expected to have preliminary results by the end of the second full lab session.
3. **Final presentation.** At the conclusion of each experiment, the group will give a 10-minute oral presentation of its results. This presentation is modeled on an invited talk at a physics conference.
4. **Final report.** One week after the final presentation, the group must present me with marked-up drafts of the final report, and two days later the final version must be handed in. These reports should closely follow the guidelines for a manuscript to be submitted to a well-known physics journal such as *The American Journal of Physics* or *Physical Review Letters*. A template which you can use is downloadable from the course website.

How can you possibly do a good job on all of these presentations and reports? By operating the same way as real research groups – by dividing the work among the group members, while maintaining joint responsibility of all group members for all work produced. Thus for each project, one group member will have primary responsibility for the laboratory notebook. A second group member will have primary responsibility for the 10-minute final presentation, and will give this presentation. The third and fourth group members (if there are such people) will work together to produce the first and later drafts of the report, and will be listed as its first authors. These primary responsibilities will rotate among the group members on a schedule we will establish together, so each person gets to try their hand at each task.

It cannot be too highly stressed, however, that the entire group must participate in the creation of, and approve the final form of, each presentation and report. Whoever is giving a presentation for the group, must first give one or more “dry runs” to the other group members so they can suggest changes, and the other members must not be shy

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about requesting major or minor revisions as required to reflect well upon the group! Similarly, the first author of a report must give his first draft to the other members to “mark up”, and the first author should expect to see a lot of red ink from all the other authors. This is the way research groups operate.

The project folder

For each project, a separate loose-leaf folder will be kept by the group – I will supply these folders. Everything to do with the project will go in the folder; I will want to look at the folder at intervals, and collect it at the end of the project. The project folder should contain at least the following:

- (a) Handouts on the project I give you.
- (b) Photocopies of relevant articles that I have told you to read, or that the group has found.
- (c) The viewgraphs for the final presentation (print them if done on computer)
- (d) The first, rough draft of the report as marked up by the other group members.
- (e) The final report as submitted.

Note that these are all materials that the group would normally produce in the course of doing the project. I am simply asking you to collect them all in one location.

Laboratory Notebook

Maintaining an organized, detailed, and legible laboratory notebook is an extremely important aspect of performing scientific research. An ideal laboratory notebook is one in which—even years after performing the experiment—would allow you to easily reconstruct the experiment and the analysis.

General Rules:

- Use spiral or solid bound cross ruled notebook - no loose pages.
- Number your pages (for cross referencing).
- Do not erase - cross out instead and use a pen. Do not remove pages.
- Attach printouts, charts, etc. permanently.
- Do not try to save space.
- Date and sign each entry.

Content & Stylistic Guidelines

- Introduction to experiment - try to formulate what you want to measure.
- Draw a schematic of the experimental setup, showing the wiring diagram, what is measured, etc.

- Use tables to record data, name each entry, and show the units.
- Include an uncertainty for every measured quantity. Data with no uncertainty is meaningless.
- Always record raw data - if you process the data put the processed value into the table.
- Make plots of your data while you take it. Try to plot straight lines.
- If you use the computer to sort/process your data - make a printout and staple/glue it into the notebook. You might want to attach a cd with your data.
- When you take data report experimental conditions (meter readings, like applied voltages, currents, temperature, humidity, etc.)
- When relevant, note what time you begin a data collection run, or turn on heaters, etc...
- Note estimates of errors: systematic and random.
- Note peculiarities - you never know - they might be important later.

Assessment

Your grade in this course will be based on assessments in several areas:

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|--|---------|
| • Written Lab Reports | 600 pts |
| • Final Oral Presentations | 100 pts |
| • Lab Notebook | 100 pts |
| • Misc. Exercises | 100 pts |
| • Final Exam (5/08/08: 1:30-3:30 pm) | 100 pts |
| • (for Physics 242 only: Your final exam will be an oral exam) | |

Attendance

Since this is a lab based course, and you will be working together as a team, your attendance in class is very important. Missing more than two class sessions in the semester will reduce your course grade by one letter grade per class missed. If you miss more than four sessions, you will be asked to leave the class.

II. INFORMATION FOR PRESENTATIONS

At the large conferences held several times per year by the American Physical Society, any researcher is allowed to present his results in a 10-minute “contributed” talk. These talks are usually given with the aid of transparencies or computer based presentations. The audience does not interrupt the speaker, but there is a two minute question-and-answer period at the end. This is the model we will use for the presentations in iLab. Ten minutes is a very short time, and the trick is to successfully communicate the necessary points to your audience before the time is up. Here are a few guidelines for your presentations, taken directly from the APS website, from which I have selectively deleted irrelevant portions:

APS Guidelines for contributed talks

APS meetings are one of many programs offered by the Society to advance and diffuse the knowledge of physics. The opportunity to present an abstract at an APS meeting is a privilege which entails a responsibility on the part of the author to present his/her research in a polished, clear and succinct manner. This applies to both oral presentations (i.e. delivery and supporting A-V) and poster presentations. The Guidelines for First-time Speakers and Session Chairs is published to assist authors presenting for the first time and session chairs in making the best presentations possible, and to enhance the quality of APS meetings.

Speaker Guidelines

Step back from the details of your research and think about what your audience might like to learn from your work. Keep it simple - remember, less is more.

Organization

Your talk should include:

1. Statement of hypothesis and purpose of the research
2. Description of methods of investigation
3. Inclusion of data collected and what was learned
4. Conclusions based on the data collected
5. Emphasis on significance and highlights of the research.

Audio-Visuals

1. Supporting audio-visuals must be concise, uncluttered and readable from a distance.

2. Audio-visuals should amplify your oral presentation, not duplicate it.
3. Choose the medium that will optimally display your information - don't use words if a picture will convey it more clearly (graphs, tables, charts, etc.)
4. Make sure that graphs (I changed this part)
 - (a) use fonts of large enough size to be readable;
 - (b) have axes labels with units, and error bars as appropriate;
 - (c) are not overly cluttered.

Delivery

1. Prepare notes that highlight the salient points of your talk.
2. Practice the delivery of your talk several times prior to your presentation along with your slide or transparency sequence being sure to fit your talk into the time allocated to you.
3. Use simple sentences; avoid jargon, highly specialized vocabulary and unfamiliar abbreviations.
4. Think about questions you might be asked about your work and be prepared with well-thought out answers, being mindful of the limited time for Q and A.

POLICY AND GUIDELINES ON USE OF LCD PROJECTORS

The responsibility for a smooth, technically trouble-free presentation ultimately rests with the presenter. The APS is not responsible for the security of personal laptop computers. The APS does not encourage the use of LCD projectors for contributed talks (12 minute talks). The presentation schedule must be maintained, and as is too often the case, the set-up of the laptop/projector can be problematic, using up valuable presentation time. Speakers who do plan to use LCDs must do the following: bring your own laptop computer, power cord, and any proprietary cords required for your computer. visit the Speaker-Ready room provided by APS to run through the presentation to ensure a smooth and technically trouble-free presentation. Testing your presentation in the Speaker-Ready room prior to your presentation is strongly recommended to minimize equipment compatibility difficulties. **Bring a back-up vu-graph presentation** in case there are set-up difficulties with the LCD equipment.

III. EVALUATION OF PRESENTATIONS

Evaluation Rubric

Date: _____

Group Members (presenter circled):

Experiment: _____

- Starts with title, list of collaborators, brief outline.
 - Viewgraphs are clear, informative, well labeled, professional-looking.
 - Oral presentation is clear and well-delivered, filling specified time period of 10 minutes.
 - Physics content: Does the presentation discuss the essential physics to be explored, rather than just pulling formulas from books and papers? Are the physics assertions made correct? Does the discussion of the physics motivate the experiment that was done?
 - Description of the experiment: Is a clear description given of what was done? Are clear diagrams of the apparatus presented where appropriate? Are the experimental protocols followed described in sufficient, but not excessive, detail? Were the experimental procedures appropriate to the goals of the experiment?
 - Presentation of data: Are real data shown? Are data well-presented (such as well-labeled graphs, with error bars as appropriate)?
 - Error analysis: Are the largest sources of error identified and treated quantitatively? Are convincing arguments (such as order-of-magnitude estimates) presented for ignoring smaller sources of error?
 - Presentation of results and conclusions: Are the main results and conclusions highlighted at the end of the talk? Are possible improvements to the experiment briefly discussed?
 - Input from all group members demonstrated by: (a) Freedom from obvious typos and mistakes, which shows that all members carefully reviewed the presentation; (b) Discussion after the presentation – all group members should actively participate.
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The above text is the rubric I will use in assessing your presentations. Each of the above categories is evaluated on a scale of 1-5, with 3 indicating a fully satisfactory (but not outstanding) performance; 2 indicates some elements we are looking for are absent. Not all of these categories will be equally applicable to all experiments. This is an evaluation of the group effort, not just the presenter, and considers both the presentation and the discussion that follows.

Keep in mind that the purposes of your presentations are:

- (a) To tell us what you did and why. Do not assume that your audience already knows the physics that you have had to learn to do the experiment. Do not assume your audience knows anything at all about the experimental setup. Show at least some real data to make your audience believe you really did an experiment.
- (b) To convince your always-skeptical audience that you understand the main sources of uncertainty in your results.
- (c) To present your results in an honest, straightforward way. Do not oversell by pretending to measure results that you really didn't; do not undersell by failing to extract all the possible value from your data and observations.

IV. INFORMATION FOR LAB REPORTS

Like the oral presentations, the lab reports for iLab are based on a research model. The lab report will be in precisely the form required for a manuscript submitted to a well-known research journal, The American Journal of Physics (AJP). The only difference will be the length: your reports will be no more than 6 typed pages (like this document!) including figures and references. Please look at some issues of AJP (in the library or online) to get a better feel for the style and content expected in a research paper – it is rather different from lab reports you may have done in the past. The purposes of the report are the same as for the final presentation, which I repeat here:

- (a) To describe what you did and why. Do not assume that your reader already knows the new physics that you have had to learn to do the experiment. Do not assume your reader knows anything at all about the experimental setup. Show at least some real data to make your reader believe you really did an experiment.
- (b) To convince your always-skeptical reader that you understand the main sources of uncertainty in your results.
- (c) To present your results in an honest, straightforward way. Do not oversell by pretending to measure results that you really didn't; do not undersell by failing to extract all the possible value from your data and observations. Of course, any omissions or errors that came to light during the final presentation must be dealt with correctly in the final report.

It is extremely important in scientific report to have correct and appropriate references; a report of this length would typically have five to ten references. The purpose of the references is to back up assertions made in the text, and to give proper credit to work done by others. Therefore:

- (a) Whenever you repeat a formula or other statement from an article or book, make a reference to the article or book. References may also be made to other printed matter such as instruction manuals.
- (b) If you get some important information from an expert, make a reference to that person as follows: [1] Joe Shmoe, private communication.
- (c) Do not make reference to your own lab notes. Your readers assume that statements about your own experiment are backed up by well-organized original data and notes that you could produce upon demand. The only way to learn the appropriate use of references is to look through some actual journal articles.

Procedures. The designated “report writer” for the group will produce the first draft of the report, and will appear in the byline as the first author. The first draft will be given to the other group member(s), who will edit it. I want to see these edited drafts on the date under “Draft Report” in the schedule handed out. The first round of editing, if done seriously, will always result in many changes, large and small - otherwise the other group members are not contributing enough to the report. **I expect to see substantial editing of the first drafts from other group members; not just minor changes.**

On the next page is a form I will use to evaluate final reports – use this as a check-list as you prepare them. You may see sample papers online by using the Web of Science link on the course homepage and looking up any articles in the American Journal of Physics.

Evaluation of Final Report

Date: _____

Experiment: _____

Group Members (Primary Authors circled):

*Each of the following categories is evaluated on a scale of 1-5, with 3 indicating a fully satisfactory (but not outstanding) performance; 2 indicates some elements I am looking for are absent. Not all of these categories will be equally applicable to all experiments. **This is an evaluation of the group effort, not just the first author.***

- Conforms to length limit (6 pages, including figures, captions and references).
 - Conforms to style guidelines. Has, in this order: Title, Authors, Institution, Abstract, Text, and List of References. Meets typographical requirements of the guidelines, in particular for references in the text, and for the list of references at the end.
 - Abstract: Clearly and briefly states what was done, and what the results were. Can stand on its own as a useful summary of the report.
 - Introduction, physics background: Is the physics background information justifying the experiment presented in a brief, but useful manner? Are the physics assertions made correct? Does the discussion of the physics motivate the experiment that was done?
 - Description of the experiment: Is a clear description given of what was done? Are clear diagrams of the apparatus presented where appropriate? Are the experimental protocols followed described in sufficient, but not excessive, detail? Were the experimental procedures appropriate to the goals of the experiment?
 - Presentation of data: Are real data shown? Are data well-presented (such as well-labeled graphs, with units and error bars as appropriate)? Are data tables and graphs well labelled? Do data tables give uncertainties on measured quantities?
 - Error analysis: Are the largest sources of error identified and treated quantitatively? Are convincing arguments (such as order-of-magnitude estimates) presented for ignoring smaller sources of error? Does every measurement have an associated uncertainty?
 - Presentation of results and conclusions: Are the main results and conclusions highlighted at the end of the report? Are possible improvements to the experiment briefly discussed?
 - References: Are references made where appropriate? Do the references contain the information needed for readers to retrieve them?
 - Figures: Are the figures clear, informative, and well labeled? Do they include all needed information, while omitting extraneous and irrelevant information? Do the figure captions provided useful information? Could a reader get a rough idea of what was done by just looking at the figures and reading the captions?
 - Input from all group members demonstrated by: (a) Freedom from obvious typos and mistakes, which shows that all members carefully reviewed the report; (b) Edited drafts.
 - General depth: does the report show clearly that the group has asked probing questions while conducting the experiment and composing the report? Do they attempt to ask and answer questions that go beyond a straightforward “get the result and move on” attitude?
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