PHY340/350 Professional Skills

Physics graduates are in demand because they can

- solve problems;
- analyse numerical data;
- retrieve, assimilate, use and communicate information quickly and effectively;
- work effectively as part of a team.

This module is intended to help you develop these skills. This semester, you will learn techniques for finding information on a particular topic, assessing its reliability, and communicating what you have learned to others. You will also learn new methods of analysing and presenting data. You will apply these techniques, working as part of a team, to solve a problem in some area of physics research. Next semester will focus on techniques of problem solving, including methods of estimating answers even in the absence of precise, reliable input data.

Why is this important?

1. **These skills are essential for all practising physicists.** You may not learn much new physics in this module, but you will learn how to make better use of the physics you already know.
2. **These skills will help you get a job.** Interviewers will often ask you to solve problems, especially estimation-type problems, during the interview, because problem-solving skills are what they are looking for (see above). They will also often ask you to give examples of times when you worked effectively as part of a team. This module will help you to deal with questions like these.
3. **These skills transfer well to other fields.** Not all of you are going to end up as practising physicists or astrophysicists. If you move into IT or commerce, it is unlikely that being able to solve the quantum mechanical harmonic oscillator or describe the evolution of a class B star is going to be of much value to your career, but skills in problem-solving, team-working and information retrieval certainly will be.
4. **These skills will be useful in other modules.** Much of the work you will do in this module translates directly into your third and fourth year project(s), and improving your problem solving skills should also improve your exam marks.

This may be the most important module you take in your entire third year.

Themes in semester 1

Team-working skills

Each of you will be assigned to a team of about six people. Each team is assigned a problem relating to an area of research in the department: astrophysics, particle physics, semiconductors, soft condensed matter or theory. You will need to apply the skills you will be learning in the lectures to address these problems. Working as a team, you have far more resources than you would if you were tackling the problem as individuals—but to maximise this advantage, you need to learn to work *effectively* as a team. This will include:

- making best use of your individual talents—for example, assigning any subtasks that require computational data analysis to your best programmer, and anything that requires an analytical solution to your best mathematician;
- maintaining a good working relationship within the team—you do not have to like one another, but you do need to be able to work together;
- coordinating the work, so that you do not have three people doing task A while nobody tackles task B;
- communicating with each other, so that every team member knows what the status of the work is, and how his or her individual subtask fits in;
- effective record-keeping, including notes of decisions made at meetings, so that nobody loses track of who is supposed to be doing what by when;
- identifying and dealing with issues as they arise—for example, assigning more effort to a subtask which has turned out to be more difficult than originally anticipated, or chasing up a team member who has missed a reporting deadline.

The effectiveness of your teamwork will form part of the assessment for semester 1. You will be provided with tools to make it easier to document how your team worked, for example by giving you somewhere to record notes of team meetings and recording who contributed to your final report. There will also be an element of peer assessment, i.e. the members of each team will be given an opportunity to record their views on which of their fellow team members contributed most.

Information retrieval skills

Quick, efficient retrieval, assimilation and use of *reliable* information on a particular topic is one of the most useful skills any graduate can possess. Not only is it essential in preparing for a new project, but it can save you or your employers a great deal of time and money—for example, if you find that a preliminary study you were planning to do is not necessary because the result you needed has already been published; if you find that the design of your new experiment will not work because of some property of the materials you plan to use; or if you discover that a proposed patent application will not succeed because related work—"prior art", in patent-speak—exists in the published literature. Therefore, the ability to do a quick but thorough *literature search* on a particular topic is a key skill for any physics student.

There is no denying that the Internet has made conducting a literature search easier, but it cannot do all the work for you. The critical issues that you must address in compiling a literature search include:

- Is the information *reliable*? Has it come from trustworthy sources? Is it backed up by evidence?
- Is the information *complete*? Have you missed any important papers, perhaps because they did not use the exact keyword that you searched for?
- Is the information *up to date*? Are you sure that the results quoted have not been superseded by more recent measurements?

Answering these questions requires that you *critically assess* the sources you have found, and that you develop skills in using the material you find in an initial search to refine your search criteria—for example, if you have found a source that appears trustworthy but possibly out of date, how can you use that source to see if more recent results exist? Websites are usually regarded as unreliable, both because there is no editorial control of the web (anyone, however unqualified, can construct a website) and because the contents of a particular web page are not necessarily stable (the information that is on that page *now* may not be the same as what was there when you consulted it, if indeed the page still exists at all)—how can you identify the rare cases when web-based information is actually the best available, or, if not, can you use the website to find a more reliable source?

The best way to conduct a literature search depends on the field in which the topic lies: for example, particle physics and astrophysics both make heavy use of the eprint server arXiv, and so looking for an arXiv eprint is often the best way to find a recent result in these areas, but other disciplines do not necessarily upload all publications to the arXiv, so more general search databases such as Web of Science may be more appropriate.

In the lecture course for semester 1, we will cover how to conduct a literature search and how to assess the trustworthiness and reliability of the material you have found. A report on a literature search will form part of the assessment for semester 1.

Data analysis skills

Analysing data is one of the core skills that employers—and other physicists—expect of physics graduates. It is also likely to play a key role in your third and fourth year projects. While you have made a start in developing your data analysis skills in the first and second year labs and/or programming courses, the lectures in this semester will introduce you to more sophisticated techniques appropriate for more complicated data.

The topics that will be covered in the lectures include:

- statistical and systematic errors;
- probability and statistics for data analysis;
- linear and non-linear fitting;
- limits and confidence intervals.

We will also cover the *presentation* of data. Effective presentation of data is crucial to communicating the results of your data analysis. Excel spreadsheets, while adequate for their intended purpose, do not support publication-quality graphics: the styles are too limited, and even simple things like the proper display of scientific notation (e.g. 10^5, not 1.E5) appear to be unachievable. Excel is also inadequate as a tool for fitting functions to data: it can manage to fit a straight line to data points that all have the same uncertainty, but that is the limit of its inbuilt features[1].

Semester 1 assessment

The assessment for semester 1 will be based on four criteria:

1. your team's report of the literature search element of your group problem;
2. your team's report on the data analysis element of your group problem;
3. your contribution to your team's work as assessed by your record of contributions made to the group wiki/bulletin board on MOLE;
4. your contribution to your team's work as assessed by the other members of your team.

Elements 1 and 2 are marks awarded to the team, and will contribute respectively 16⅔% and 33⅓% of your mark for PHY340/350 (i.e. they will be weighted 1:2). Elements 3 and 4 will be used to modify the team's mark to reflect your individual contribution: the mark will be scaled

[1] "Add Trendline" does not count because it does not return the uncertainties in the fit parameters. It is therefore completely useless for scientific purposes.

up for people who have contributed more than the team average, and down for those who have contributed less. Note that anyone who is found not to have *participated* in the work of their team (did not show up to team meetings, did not make contributions to the group wiki/bulletin board on MOLE, is rated as not participating by other team members) will score zero: there is a big difference between failure to make a *useful contribution* (which can unfortunately happen, even if you attend all the meetings and put in the hours—for example, suppose the code you wrote for your section of the data analysis has bugs in it that you can't find, and at the last moment another team member with better coding skills writes an independent program that does the job: you worked hard, but nothing you did is going to make it into the final report) and failure to participate; in the former case, you should expect a share of the team score, but not in the latter.

Literature search assessment

The literature search element of your problem will ask you to find published work relevant to a specific issue or issues. Your task is to write a short report on those issues based on the available literature. The assessment of the literature search will be based on:

- the quality of your literature search (does it cover the topic well; are the cited sources of appropriate quality; do the cited sources reflect the *current* state of play?), based on the reference list of your report [35%];
- how well you have assimilated and understood your sources, based on the content of your report [35%];
- how well you have referenced your sources (are the references cited in a standard style, either AIP or Harvard; are they appropriately referred to in the text?), based on the text and reference list of your report [15%];
- the style and presentation of your report (correct grammar and spelling; formal English style; appropriate layout; lack of typographical errors) [15%].

Data analysis assessment

The data analysis task will require you to use the skills you have learned in the taught component to analyse data relevant to one of the fields of research in the department. The data may be real or simulated, and the nature of the analysis will depend on the particular problem. As with the literature search, you are asked to write up your results in a short scientific paper, and the assessment will be based on this report. The assessment criteria are:

- the correctness of your analysis (have you used a valid method, got a defensible answer, taken proper account of statistical and/or systematic errors as appropriate?) and the clarity of your explanation, based on the content of your report [50%];
- the presentation of your data and results (have the data been presented in the most appropriate way; are plots and figures of publication quality, with suitable legends, captions, and so forth; are numerical results quoted to appropriate precision; are uncertainties quoted correctly?), based on the content of your report [30%];
- the general style and presentation of your report, including formal English style, spelling and grammar; appropriate layout; lack of typographical errors; correct referencing of sources if required [20%].