The First Year Physics Laboratory
http://www.phas.ubc.ca/~phys109/LearningGoals.html

The first year laboratory component of PHYS 107/109/Sci1 takes advantage of unique features of doing physics in a laboratory setting. Most importantly you will discover that science is not simply a static body of concepts and mathematics, but is based on empirical observation and experimentation. The laboratory is not primarily motivated by the aim to teach particular physics concepts or to reinforce what is taught in lectures and tutorials. Instead, the goal is to leave you with skills and attitudes that will be of value no matter what your later academic path may be. You will learn how to make observations and measurements, how to build models that fit those measurements, and derive meaning from the success or failure of those models. You will also learn a variety of technical skills including the use of particular equipment, carrying out well-established techniques, keeping thorough laboratory notes, a wide range of computer skills, statistical methods and the ability to communicate results and ideas. This environment beyond the textbook also brings in two key features of the real world: measurement uncertainty and the complex mix of phenomena that can often be taking place simultaneously in an experiment.

Learning Goals

Making Measurements

Most fundamentally, you will learn how to take measurements, something which embraces a range of skills and attitudes in addition to learning how to use specific equipment and procedures. The emphasis will be on the most broadly applicable skills. At the end of Phys 107/109/SciOne, you will be able to:

1. identify the variables that might control the phenomenon being studied in an experimental situation
2. control experimental variables during an experiment
3. define:
    a. mean
    b. standard deviation
    c. experimental/systematic uncertainty
    d. statistical uncertainty
4. assign appropriate dimensional units to all measured quantities
5. determine the precision of a measurement
6. attach an experimental uncertainty to any measured value, including:
    a. estimating uncertainty by studying distributions in the data
    b. calculating uncertainty for the special case of a Poisson distribution
    c. determining uncertainty due to noise (e.g., in electronics)
    d. ascertaining uncertainty due to instrumental precision
7. identify and categorize the sources of uncertainty in a measurement
8. design measurements that minimize the sources of uncertainty
9. apply tactics for efficient data collection, including:
    a. covering a wide variable range quickly, when possible
    b. evaluating data early and adjusting choices 'on-the-fly'
    c. evaluating whether or not magnitudes, units, and precision of results are reasonable

Modelling Data

You will also learn an essential step in the association of empirical measurements with theory, which is modelling data. This includes building an awareness of how data sets can differ from one another, the acquisition of some technical skills, and the ability to make connections between discrete data and mathematical functions. At the end of Phys 107/109/SciOne, you will be able to:

10. define:
    a. linear growth
    b. exponential growth
    c. exponential decay
    d. power law behaviour
    e. power law scaling
11. create a two-dimensional scatter plot of data on linear scales
12. create a histogram
13. provide a verbal description of any given two-dimensional scatter plot of data on linear scales
14. linearize:
    a. exponential distributions, by using semi-log plots
    b. power law distributions, by using log-log plots and power law scaling
15. extract meaning from the slope and intercept of data which has been linearized

Statistics and Data

Furthermore, you will learn some of the basic and proper statistical treatments of data and models. This includes understanding how and when to apply certain calculations, and also the development of your ability to make evaluations of your data and models based on these calculations. At the end of Phys 107/109/SciOne, you will be able to:

16. calculate:
    a. the mean of a data set
    b. the standard deviation of a data set
    c. the uncertainty in the mean of a data set
17. weigh the relative importance of numbers that have differing uncertainty
18. recognize whether numbers with an associated uncertainty are in agreement with one another or not
19. calculate the reduced chi square statistic, which entails:
    a. a weighted, linear least-squares fit to a straight line
    b. a weighted, non-linear least-squares fit to a model
        i. and, from each, extract meaning and numerical values with uncertainties of the fit parameters
20. calculate the uncertainty in slope of a linear model
21. judge whether or not a model fits a data set

Higher Level Skills and Attitudes

Lastly, you will develop some beneficial habits of the mind. These are meta-skills that might be considered the next level in your ability to handle an experiment. At the end of Phys 107/109/SciOne, you will be able to:

22. offer a plausible modification or further tests when confronted by a disagreement with an expected model

23. devise experiments to search for and correct hidden systematic errors when confronted by a disagreement with an expected model
24. develop a new experiment that further tests a successful model after having drawn a conclusion from an experiment
25. write a concise summary of an experiment