Experimental Data Analysis Lab

**PHYS 391 - Fall 2015**

[http://pages.uoregon.edu/dlivelyb/phys391/](http://pages.uoregon.edu/dlivelyb/phys391/)

*Updated Tues, 15-Sept-2015*

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**Instructor**  
Dean ('Dr. D.) Livelybrooks, with help from Dr. Elsa Johnson and Prof. Greg Bothun

**Lab Assistant**  
Bishara Korkor

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**Office Hours:**  
W/Th 9:00-10:00

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**Office Hours:** TBA

**Lecture**  
Tu 3:30-4:50 Willamette 318

**Labs**  
Fridays at 11:00 or 14:00

*Introduction to Error Analysis, 2ed*, Taylor (required)

**Textbook**  
*Getting Started with MATLAB*, Pratap (recommended, not required), or a similar text/web page about python

**Overview**

This course will introduce the basic concepts of data analysis and practical techniques for implementing them incorporating methods of scientific computation. Half of the course will emphasize the theoretical foundation of data analysis with lectures and homework assignments, while the other half will focus on the practical application of analyzing data acquired as part of lab assignments. Development of programming techniques for performing data analysis and data visualization will also be stressed using MATLAB or python (your choice). The following topics will be covered:

- Measurement Uncertainty and Error Propogation
- Statistical Inference
- Scientific Programming for data import, plotting, analysis and interpretation
- Gaussian Distribution and Confidence Levels
- Least Squares and Linear Regression
• Binomial/Poisson Distributions
• Astronomical Image Data Processing and Analysis
• Time Series Acquisition and Fourier Transforms
• Analysis of Arctic Sea Ice Data

Grading

Course grades will be based on five bi-weekly homework assignments, the first involving programming to import and analyze data, then 3 from Taylor (40%), and a final assignment involving programming and using Fourier transforms. Five bi-weekly lab assignments (60%) complete the assigned work. There will be no examinations (midterm or final) for this course, so it is important for students to turn in all assigned work when it is due. Late assignments will either be significantly penalized or not accepted at the instructor’s discretion. The final lab assignment will be due during finals week in place of a final examination.

In order to pass the course, you must complete all of the labs! It is also noteworthy that not completing all homework assignments will reduce your point total, resulting very likely in a significantly lower grade.

Grades will be awarded based on the departmental grading policy. Modifiers (+/-). I may adjust the grade boundaries depending upon the final distribution so that students with similar scores will receive similar grades.

Syllabus

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture Topic (350 Will.)</th>
<th>Lab (in Rm. 17) (due following Tuesday)</th>
<th>Homework (due following Weds at noon)</th>
<th>Reading</th>
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</thead>
<tbody>
<tr>
<td>Week 1 9/28-10/2</td>
<td>No Lecture this week</td>
<td>Lab 1: Coding to read, plot and analyze data</td>
<td></td>
<td>if you are new to programming, check out the Code Academy</td>
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<tr>
<td></td>
<td></td>
<td>(data file link here)</td>
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<td></td>
<td>(ipython tutorial here)</td>
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<tr>
<td>Week 2 10/5-10/9</td>
<td>About Scientific Programming (Dr. Elsa Johnson) Lecture Thursday, 8-Oct.</td>
<td>Continue working on lab 1 and HW 1</td>
<td>HW1</td>
<td>Taylor Ch.1-3</td>
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<tr>
<td>Week 3 10/12-10/16</td>
<td>Lecture Thursday, 15-Oct (assuming Dr. D's research cruise returns on time)</td>
<td>Lab 2: Brownian Motion (starts 10-16)</td>
<td>HW2</td>
<td>Taylor Ch. 4</td>
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Normal Distribution, Weighted Average, some words about lab writeups (cf ==>)

1. background;  
2. histogram;  
3. histogram + table with analysis )

Taylor Ch. 5, 6-7

Lab 3: Counting Statistics  
HW3  
Taylor Ch. 8

Lab 4: Fourier Transforms  
HW4  
FFT Handout

Taylor Ch. 10

Lab 5: Forecasting Arctic Sea Ice Coverage  
HW5

Taylor Ch. 11

This syllabus is tentative, and is subject to change as the quarter progresses.

MATLAB or python

One of the goals of this course is for you to develop the skills to properly undertake non-trivial data analysis of large data samples. There are many different tools available to do this, including the programming 'language du jour' python.

You can learn scientific programming and complete assignments for this course using either MATLAB or python. MATLAB is relatively easy to learn, very powerful, and widely used in Science and Engineering disciplines, but does cost money to install on your computer (student version is ~$80). Python's main advantage is that it is free to install on your computer. There are also many 'packages' of pre-programmed functions and scripts available for use with python, a
few of which are emphasized in this course (for example, in Lab 1). Python and MATLAB are somewhat similar, though python's environment takes more effort to set up.

MATLAB and python are good examples of 'procedural programming', and the general techniques learned in this course can easily be transferred to the language or tool of your choice later. MATLAB is widely (and freely) available at the University of Oregon on UO-owned computers, including those in our lab in Room 17, Willamette Hall. We have also loaded python on those computers. Some possibilities are listed on the MATLAB Information page. You will need to use either python or MATLAB extensively in this course, so you should invest some time in the first two weeks to make sure you have a working computing environment which you can use and you are happy with.

Probably the best place to start to install python on your computer is SciPy.org or Anaconda.

**Lectures**

(will be posted)

**Homework**

Homework will typically be assigned every other week and due on the following Weds by noon in the turn-in box, bottom of SW stairs to Willamette basement. The homework will mostly be problems from Taylor forcing you to work through a particular concept 'by hand' at least once. Supplimental problems to exercise your MATLAB skills may also be assigned.

ALL HW ASSIGNMENTS DUE BY NOON.

- [HW 1- Coding a physics simulation](#) (due Oct 14, assignment related directly to Lab 1)
- [HW 2 - Statistical Inference](#) (due Oct 21)
- [HW 3 - Linear Regression](#) (due Nov 4)
- [HW 4 - Binomial and Poisson Distributions](#) (due Nov 18)
- [HW 5 - Fourier Transforms](#) (due Dec 2)

**Labs**

Lab assignments will be made every two weeks and will be due on Tuesday during weeks when homework is not due. It is expected that you will work on your labs during the two weeks before they are due. Assigned lab times will be available when TAs or I will be in room 17 to provide support and advice, although you are free to work on the labs whenever you have time available [although AVOID THURSDAYS, AS PHYS 290 LAB USES THE ROOM THEN]. You will be expected to work with a partner, although each member of the lab group is expected to turn in their own material including the data analysis and any associated code.

Formal write-ups will not be required, although I do expect you to keep a lab notebook which clearly shows the work you have done. I really want to see proof that you did the lab and understood the material. Neatly organized notes taken during the lab itself, answers to the
questions posed in the lab writeup, plus a short summary giving the main quantitative results in
your notebook is perfectly adequate. If you are very sloppy in your notes, you may also turn in a
longer printed write up, but please get into the habit of taking neat legible lab notes. Either way,
please turn in your lab notebook (legible or not) on Tuesday in class. For labs with significant
computer work, your M-files and supplemental material should be emailed to me directly as
well.

For an upper-division course, the university expects students to spend one hour in class and two
hours out of class for each credit. While each student will vary, you should expect on average to
put this much time into this course. In particular, you should not expect to complete all of the lab
work during the scheduled lab times each week, although you certainly should be able to collect
all of the necessary data during that time. Make sure you do not try to start your lab assignments
at the last minute. Most students who struggle in this course simply don't invest enough time in
completing the labs.

ALL LAB ASSIGNMENTS DUE BY NOON.

- Lab 1 - Data upload, plotting, and analysis (programming) lab (due Oc 14) ([Here's a
direct link to Elsa's data file])
- Lab 2 - Brownian Motion (due Oct 28)
- Lab 3 - Counting Statistics (due Nov 11)
- Lab 4 - Fourier Transforms (due Nov 25)
- Lab 5 - Analysis of Climate Change Data (here is more about noisy data) (due Finals
  Week on Dec 8 by 5pm)

**Academic Honesty**

There is arguably a grey area between working together collaboratively on a homework
assignment or lab, and just copying somebody else's work. In general, however, it is usually very
apparent to the people involved whether a student is really contributing to a result, or just
copying from others. Copying answers and passing them off as your own work, either from
another student or from any other source is no different from plagiarism and will be dealt with
according to the UO rules and procedures for academic misconduct.

You are responsible for all the work you turn in for this course. You are encouraged to work with
others to help your understanding, but anything you write down on your homework or you lab
assignments needs to be your own work. You can certainly collect data with your lab partner and
discuss the methods for analyzing the data and even compare your results, but all written and
code work must be your own. Please note that THIS MEANS EACH STUDENT SHOULD
TURN IN THEIR OWN CODE ASSIGNMENTS TO THE INSTRUCTOR, I WON'T ACCEPT
'GROUP' CODE ASSIGNMENTS.