**PHYS 391: Experimental Data Analysis Lab**

**Dr. Dean Livelybrooks (‘Dr. D.’)**

*Winter 2022*

Lectures: TR: 10:00 - 11:50*, 350 Willamette

Labs: Fridays: 11:00-12:50 or 14:00-15:50, 17 Willamette

(*note: all times on this syllabus are U.S. Pacific*)

**Email:** dlivelyb@uoregon.edu  
**Office:** 225 Willamette Hall  
**Office hours:** Mon: 14:00 (2pm) & Friday: 09:00 and by appointment

**TA: Paul Andreini:**

**Email:** pra@uoregon.edu  
**Office:** 271 Willamette Hall  
**Office hours:** TBA

**Overview**

Scientists routinely employ the basic statistical concepts of data analysis and ‘reduce’ raw data into formats useful for interpretation. This process entails developing practical techniques for their implementation and 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 computationally ‘reducing’/analyzing data acquired or provided as part of lab assignments. Development of student programming skills for performing data analysis and data visualization will also be stressed using python or MATLAB (your choice). The following topics will be covered:

- Measurement uncertainty and error propagation
- Statistical inference
- Scientific programming for data import, plotting, analysis and interpretation
- Gaussian distribution and confidence levels
- Least squares and linear regression
- Binomial/Poisson distributions
- Simple computational simulations of physics phenomena
- Brownian motion
- Radiation and counting
- Time series acquisition and Fourier transforms
- A final lab presentation to the class, with a choice of topics (astrophysics, climate data, or radiation counting)

**Learning Goals**

- Develop fundamental understanding of Gaussian and other statistics applied to data
- Hone or develop scientific programming skills, including:
  - programming for computational simulations of simple physical systems
  - coding to read data from files and sort or filter into meaningful 'chunks'
  - programming to recast data into reduced versions for interpretation
  - development of more sophisticated data plotting skills
• Gain experience interpreting data tables and graphs, to include images, time series
• Explore practical limitations of discrete data sets
• Use Fourier Transforms to recast time series into forms useful for spectral analysis

**CANVAS:** To access course materials and lectures PDFs (after presentation), log into canvas.uoregon.edu using your DuckID to access our class. If you have questions about accessing and using Canvas, visit the Canvas support page (https://service.uoregon.edu/Client/2030/Portal/Requests/ServiceDet?ID=38635) Canvas and Technology Support also is available by phone or live chat: 541-346-4357 | livehelp.uoregon.edu

**Course website (Canvas):** https://canvas.uoregon.edu/courses/193159

**Grading**
Course grades will be based on five bi-weekly homework assignments from Taylor (40%), and five bi-weekly lab assignments (50%). There will also be a participation component for the lectures and labs (10%). There will be no examinations (midterm nor 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 is for your group to present your lab results to the rest of the class on the day of the last lecture (March 10).

*In order to pass the course, you must complete all of the labs!*

Grades will be awarded based on the departmental grading policy, and students can assume that 90% will earn an A, 80% will earn a B, 70% will earn a C, 60% will earn a D, and below this will result in a failing grade. Modifiers (+/-) will be applied for scores within a few percent of these boundaries. I may adjust the grade boundaries depending upon the final distribution so that students with similar scores will receive similar grades.

**Prerequisite:** None

**Credit Hours:** 4

**Required Text:** Introduction to Error Analysis, 2ed, Taylor, ISBN 093570275X 9780935702750 0935702423 9780935702422

**Lecture, reading and assignments schedule:**

<table>
<thead>
<tr>
<th>Week: Date</th>
<th>Lecture Topic</th>
<th>Lab</th>
<th>Homework</th>
<th>What's due*</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: 4-Jan-2022</td>
<td>Measurement Uncertainties</td>
<td>1: Ball drop simulation</td>
<td>1: Measurement uncertainties</td>
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<td>Taylor Chpt 1-2</td>
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<tr>
<td>1: 6-Jan-2021</td>
<td>Setting up for python (or Matlab) with Dr. D. or GE-TA Paul</td>
<td>1: Ball drop simulation</td>
<td>1: Measurement uncertainties</td>
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<td>Taylor Chpt 3</td>
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<td>2: 11-Jan-2021</td>
<td>Coding, including for loops: if statements, statistical inference</td>
<td>1: Ball Drop Simulation</td>
<td>1: Measurement uncertainties</td>
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<td>Taylor Chpt 4</td>
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<tr>
<td>Date</td>
<td>Description</td>
<td>HW/Due Details</td>
<td>Reference</td>
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<td>2: 13-Jan-2021</td>
<td>NO LECTURE</td>
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<tr>
<td>3: 18-Jan-2021</td>
<td>Coding: the command line, reading files</td>
<td>2: Speed of Light</td>
<td>Lab 1 due 10am</td>
<td>Taylor Chpt 5.</td>
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<td>3: 20-Jan-2021</td>
<td>Normal distribution</td>
<td>2: Speed of Light</td>
<td>Lab 2 due 10am</td>
<td>Taylor Chpt 6-7</td>
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<td>4: 25-Jan-2021</td>
<td>Weighted averages</td>
<td>3: Brownian Motion</td>
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<tr>
<td>4: 27-Jan-2021</td>
<td>Linear regression</td>
<td>3: Brownian Motion</td>
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<td>5: 1-Feb-2021</td>
<td>Open Topics</td>
<td>3: Brownian Motion</td>
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<td>5: 3-Feb-2021</td>
<td>Fourier Transforms 1</td>
<td>3: Brownian Motion</td>
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<td>6: 8-Feb-2021</td>
<td>Binomial distribution &amp; random walks</td>
<td>4: Fourier Transforms</td>
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<tr>
<td>6: 10-Feb-2021</td>
<td>Fourier Transforms 2</td>
<td>4: Fourier Transforms</td>
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<td>7: 15-Feb-2021</td>
<td>Poisson distribution &amp; counting statistics</td>
<td>4: Fourier Transforms</td>
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<td>7: 17-Feb-2021</td>
<td>Discrete Fourier Transforms (bit of theory)</td>
<td>4: Fourier Transforms</td>
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<td>8: 22-Feb-2021</td>
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<td>8: 24-Feb-2021</td>
<td>Radiation Counting</td>
<td>5: Choice: Radiation Counting; Astronomical Image Data Processing; or; Visiting Santa Claus in a Canoe</td>
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<td>9: 1-Mar-2021</td>
<td>Astro Image Processing</td>
<td>5: Choice: Radiation Counting; Astronomical Image Data Processing; or; Visiting Santa Claus in a Canoe</td>
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**python (or Matlab):**

One of the goals of this course is to give you the skills to properly do non-trivial data analysis of large data samples. There are many different tools available to do this, but we had to pick something, and we are going to use python (or Matlab if you wish). Python is relatively easy to learn, very powerful, and widely used in Science disciplines. Python is also a good example of 'procedural programming', and the general techniques learned in this course can easily be transferred to the language or tool of your choice later. Python is widely (and freely) available. You will need to use Python 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. Rather than using python directly, we will emphasize use of Jupyter Notebooks, which will provide a more structured environment and give you a convenient way to turn in your lab assignments. If you are new to programming, you may want to look at some of the python tutorials linked from the python resources page.

**Homework**

Homework will typically be assigned every other week on Tuesday and due on Thursday of the following week at the start of class. The homework will mostly be problems from Taylor encouraging you to work through a particular concept 'by hand' at least once. Supplemental problems to exercise your python skills may also be assigned. Please turn in your homework as a PDF file (or Jupyter notebook file when appropriate) through Canvas. There are several free apps available for your phone that make this very convenient.

**Find all homeworks and related material under Canvas:Files:Homeworks**

- **HW 1 - Measurement Uncertainties** (due Jan. 13 at 10am)
- **HW 2 - Statistical Inference** (due Jan. 27 at 10am)
- **HW 3 - Linear Regression** (due Feb. 10 at 10am)
- **HW 4 - Binomial and Poisson Distributions** (due Feb. 24 at 10am)
- **HW 5 - Fourier Transforms** (due Mar. 3 at 10am)
**Labs**

Lab assignments will be made every two weeks and will be due on certain Tuesdays. 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 the GE-TA will be in room 17 to provide support and advice, although you are free to work on the labs whenever you have time and when they are available (generally NOT on Thursdays). You can work with a partner or group, although each member of a lab group is expected to turn in their own, original material including the data analysis and any associated code. This lab arrangement may change due to Covid restrictions, so please pay attention to announcements and discussion in class for more accurate information.

Formal lab write-ups will not be required, although I do expect you to keep notes that clearly show the work you have done. For each lab assignment, you will be asked to turn in a Jupyter notebook answering the questions posed in the lab writeup, any notes you take about the work you did in the lab, and the solution to any coding or analysis tasks requested for that lab. This Jupyter notebook needs to be turned in, along with any auxiliary files, using Canvas before class on the Tuesday when due. If you use an alternate version of python, for example the Spyder interface or Matlab’s equivalent, then do comment your code heavily to address questions and explain how your code works. Getting used to ‘commenting’ your code in any case (Jupyter, Spyder, Matlab) is a very good idea in general—you may want to reuse a well-built function in a few months or years and may not remember how you set it up.

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.

(Find all lab handouts and related material under Canvas:Files:Labs)

- Lab 1 - Ball Drop Simulation (due Jan. 18 at 10am)
- Lab 2 - Speed of Light (due Jan. 25 at 10am)
- Lab 3 - Brownian Motion (due Feb. 8 at 10am)
- Lab 4 - Radiation Counting (due Feb. 22 at 10am)
- Lab 5 - Fourier Transforms (PRESENTATIONS in class on March 10)

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**A few things to help you succeed in this course**

1. Attend class every week.
2. Participate and engage in every class activity.
3. When questions arise, send us an email or visit our office hours.
4. Keep track of all your assignments with the course calendar and transfer everything to your personal calendar throughout the term so there are no surprises.
5. Work in groups on labs but present your own python notebooks with writeups in your own words.
6. Work in groups on (your choice of) Lab 5, but contribute **equally** to your final lab preparation.
Academic Misconduct

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 (https://dos.uoregon.edu/conduct).

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.

Our policy regarding plagiarism is this. If you do it once, you will receive no credit for that particular assignment. If you collude with another student and submit identical homeworks or lab assignments, you will each be awarded half of the total score you achieved for that assignment. If you are determined to have plagiarized twice, you will be reported to the UO for Academic Misconduct.

Accessibility:
The University of Oregon is working to create inclusive learning environments. Please notify me if there are aspects of the instruction or design of this course that result in disability-related barriers to your participation. You are also encouraged to contact the Accessible Education Center at 541-346-1155 or uoaec@uoregon.edu.

Student Well-being:
University Health Services help students cope with difficult emotions and life stressors. If you need general resources on coping with stress or want to talk with another student who has been in the same place as you, visit the Duck Nest (located in the EMU on the ground floor) and get help from one of the specially trained Peer Wellness Advocates. Find out more at health.uoregon.edu/ducknest.

University Counseling Services (UCS) has a team of dedicated staff members to support you with your concerns, many of whom can provide identity-based support. All clinical services are free and confidential. Find out more at counseling.uoregon.edu or by calling 541-346-3227 (anytime UCS is closed, the After-Hours Support and Crisis Line is available by calling this same number).

Prohibited Discrimination and Harassment
No forms of discriminating, harassing, or hostile behavior in class will be tolerated. Any student who has experienced sexual assault, relationship violence, sex or gender-based bullying, stalking, and/or sexual harassment may seek resources and help at safe.uoregon.edu.
To get help by phone, a student can also call either the UO 24-hour hotline at 541-346-7244 [SAFE], or the non-confidential Title IX Coordinator at 541-346-8136. From the SAFE website, students may also connect to Callisto, a confidential, third-party reporting site that is not a part of the university. Students experiencing any other form of prohibited discrimination or harassment can find information at respect.uoregon.edu or aaeo.uoregon.edu or contact the non-confidential AAEO office at 541-346-3123 or the Dean of Students Office at 541-346-3216 for help. As UO policy has different reporting requirements based on the nature of the reported harassment or discrimination, additional information about reporting requirements for discrimination or harassment unrelated to sexual assault, relationship violence, sex or gender based bullying, stalking, and/or sexual harassment is available at Discrimination and Harassment. The instructor of this class, as a Student Directed Employee, will direct students who disclose sexual harassment or sexual violence to resources that can help and will only report the information shared to the university administration when the student requests that the information be reported (unless someone is in imminent risk of serious harm or a minor). The instructor of this class is required to report all other forms of prohibited discrimination or harassment to the university administration. Specific details about confidentiality of information and reporting obligations of employees can be found at titleix.uoregon.edu.

Mandatory Reporting of Child Abuse
UO employees, including faculty, staff, and GEs, are mandatory reporters of child abuse. This statement is to advise you that your disclosure of information about child abuse to a UO employee may trigger the UO employee’s duty to report that information to the designated authorities. Please refer to the following links for detailed information about mandatory reporting: Mandatory Reporting of Child Abuse and Neglect (https://hr.uoregon.edu/policies-leaves/general-information/mandatory-reporting-child-abuse-and-neglect)