PHY322: data analysis & *Visualization*

Franklin & Marshall College, Department of Physics & Astronomy
Spring 2026

INSTRUCTOR:	Prof. Ryan Trainor	**LECTURES:**	TR 8:30-9:50a HAC 218
OFFICE:	Hackman 227	**OFFICE HOURS:**	TBD

COURSE OVERVIEW:

How do we extract meaning from experimental data and communicate that meaning to others? This course surveys common techniques for data analysis, including data parsing and filtering, model fitting, significance testing, time series and spatial analysis, and other tools from statistics and machine-learning. Emphasis will be placed on the practical application of these methods to datasets from physics, astrophysics, and related fields, as well as the development of figures and presentations to effectively synthesize and communicate results.

TEXTBOOK(S):

- Our primary textbook will be *An Introduction to Error Analysis* by John R. Taylor (3rd ed.)
- We will also have course readings from other sources, including the following texts:
    - *The Visual Display of Quantitative Information* by Edward Tufte (2nd ed.)
    - *Python Data Science Handbook* by Jake VanderPlas (online edition)

COURSE TOPICS & UNITS:

The course will be organized into six units, described below. A tentative schedule of lecture topics within each unit is given on the final page of this syllabus.

1. Principles of visualization & data exploration
2. Statistical models and analyses of univariate data
3. Multivariate analyses, models, and visualization
4. Time series data & Fourier analysis
5. Spatial data and images
6. Introduction to Machine Learning

COURSE GRADING:

Your final grade for this course will be a weighted average of the following categories:

Participation	10%
Homework	20%
Quizzes	10%
Exams	30%
Projects	30%

PARTICIPATION:

Our "lecture" time will feature interactive problem solving and discussion. This work is most effective when students are sharing ideas and listening to the contributions of others in class and preparing for class via the assigned readings. For this reason, a portion of your grade will be based on your participation in and out of class, including course attendance, active engagement with class activities, and completion of pre-class readings and quizzes.

Pre-class reading quizzes will be **due the night before class** so that I can review your responses and respond to common issues before we meet. **Absences will only be excused via prior approval or a documented medical emergency.** Please talk to me if you have concerns about

this portion of your grade—not every student needs to participate in the same ways, and I am happy to work with you to ensure you have opportunities to engage meaningfully in our course.

HOMEWORK:
There will be homework assignments covering lecture and reading material due regularly throughout the class. Homework assignments will include both **conceptual**, **mathematical**, and **computational** components, and they should be submitted online through the Canvas platform by the due date. Late homework will generally incur a 10% penalty per day unless you have an extension on a particular assignment—extensions should be discussed with me **in advance** of the due date. These assignments will be graded based on a combination of completeness and correctness.

Note that discussing ideas for homework solutions with your classmates is highly encouraged: *success in upper division courses and in scientific careers requires collaboration*! However, the work you turn in must reflect *your own understanding* of the material and be written in *your own words*. The consequences for plagiarism can extend to failing the course, and failing to complete the homework will make passing the exams and final very difficult. It will be very important to review and correct your returned homework, as **frequently-missed homework problems may reappear on the quizzes and exams.**

QUIZZES:
There will be short in-class quizzes throughout the semester, which will be based on the types of problems you will have already solved on the homework and participation activities. As with the homework, frequently-missed quiz problems may reappear on the exams, so make sure to review your mistakes.

EXAMS:
There will be two in-class exams scheduled for **Thursday, March 5** and **Thursday, April 23**. Each exam will cover three units of the course (i.e., the second exam will not be cumulative). More details on the exam format will be provided as we approach those dates, but you can expect it to include questions similar to the homework assignments and quizzes.

PROJECTS:
There will be individual projects during the semester and a final project that will be presented during our assigned block during the final exam period. The time and data of this block will be announced by the registrar later in the semester, but it will occur **between April 28 and May 2**. Note that I am not allowed to reschedule the final exam block based on individual student schedules unless approved by the registrar.

ACCESSIBILITY:
Each of you brings unique skills and needs to our course, and I will work to enable each of you to access our course material as fully as possible. Any student with a documented disability should contact the Office of Student Accessibility Services (717-358-3989, 931 Harrisburg Ave - College Square 2nd Floor) to coordinate necessary accommodations. Please remember that accommodations must be requested every semester and testing in the Office of Student Accessibility Services must be scheduled **one week in advance** by the student (note this applies to the quizzes, midterm exam, and final).

See https://www.fandm.edu/office-of-student-accessibility-services for additional details. Along with SAS, I promise to work hard to help you succeed in this course.

STUDENT CODE, CHEATING, AND HARASSMENT:
Students are expected to know and uphold all provisions of the F&M Student Code: https://www.fandm.edu/college-life-manual/student-rights-freedoms-and-responsibilities/the-student-code

Two areas of particular importance are academic honesty and harassment. Note that cheating can result in significant academic consequences. Cheating is broadly defined as submitting another person's work (whether a classmate's or via the internet/AI) as if it were your own. Contributions from other students and material from AI or other resources should be clearly identified as such.

Harassment on the basis of race, color, national origin, age, gender identity, and/or sexual orientation and identity will not be tolerated in our class or on campus. In particular, sexual harassment is unacceptable and unlawful. Sexual harassment is defined as unwelcome sexual advances, requests for sexual favors, and other verbal, nonverbal, or physical conduct of a sexual nature. Note that these definitions of harassment include conduct outside of class and online.

It is the policy of Franklin and Marshall College that all faculty and staff are mandated reporters of sexual misconduct. This policy was enacted to ensure compliance with two laws, the Clery Act and Title IX.

It is important that each student understand how mandatory reporting affects them. Our College Community can help should you experience or observe sexual misconduct on our campus. The Faculty and Staff at Franklin & Marshall care about your safety and believe that it is our obligation to keep you and our campus safe. When a student reports sexual misconduct that has affected them or someone else on campus, we must ensure that the person who was victimized recovers from the event and that it does not happen again.

When a student reports such an incident to faculty or staff it is treated with the utmost privacy, only one person must be told, the Title IX Coordinator, who will determine if the situation creates an ongoing threat and if so, will contact the reporting student before informing anyone else of the event. It is the goal of the College to give the person reporting as much control over the situation and eventual outcomes as possible.

There are a few people on campus who can keep what is told to them completely confidential and all students need to know who they are. The Counseling Service, Health Services and the Sexual Assault Response Line have individuals on staff whose licenses allow them to keep what is told to them completely confidential. The best way to reach any of these resources is to call them directly (Health and Counseling Services:717-544-9051) or call the Sexual Assault Response Line (SARL: 717-560-7311) 24/7. These phone numbers and others, are listed on the yellow stickers on most bathroom mirrors. For questions about the mandated reporter policy or any sexual misconduct issue you may also contact the Title IX Coordinator at 717-358-7178.

PHY 322 Planned* Schedule (Spring 2026)

Wk	Date	Lec	Topic	Unit
1	1/13	1	Introduction, types of data and visualizations	1
1	1/15	2	Tools for effective visualization	1
2	1/20	3	Exploring data in 1D	1
2	1/22	4	Graphical representations of univariate data	1
3	1/27	5	The Gaussian distribution & Monte Carlo	2
3	1/29	6	Statistical comparisons of univariate data	2
4	2/3	7	Outliers & extreme values	2
4	2/5	8	Binomial, Poisson, & Exponential distributions	2
5	2/10	9	Introduction to Bayesian analysis	2
5	2/12	10	Correlation & covariance	3
6	2/17	11	Exploring multivariate data	3
6	2/19	12	Linear regression & data transformation	3
7	2/24	13	Parameter uncertainty	3
7	2/26	14	Bayesian regression & model constraints	3
8	3/3	15	Catch up / review	Exam
8	3/5	16	**Exam 1 (Units 1-3)**	Exam
9	3/10	17	Times series data	4
9	3/12	18	Periodicity & autocorrelation	4

Spring Break (3/14 – 3/22)

Wk	Date	Lec	Topic	Unit
10	3/24	19	Fourier analysis	4
10	3/26	20	Smoothing and convolution	4
11	3/31	21	Spatial analysis and 2D images	5
11	4/2	22	Spectroscopic data in 1D and 2D	5
12	4/7	23	Models and transforms for 2D image data	5
12	4/9	24	Spatial analysis in higher dimensions	5
13	4/14	25	Brief introduction to ML	6
13	4/16	26	Model validation & ML examples	6
14	4/21	27	Catch up / review	Exam
14	4/23	28	**Exam 2 (Units 4-6)**	Exam

Reading Days (4/24 – 4/27)

Finals Block (TBD, 4/28 – 5/2)	**Final Project Presentations**