Semester: Fall 2023

Stony Brook University
Department of Physics and Astronomy
College of Arts and Sciences
PHY 153 "Data Analysis for Physics and Astronomy with Python"
Course Instructor: Prof. Joanna Kiryluk
Section: 01
Office Hours: Tuesdays 9-10am, Thursdays 2-3pm
Place: Math building, level S, classroom 235S
Time: Tuesdays, Thursdays 11.30am-12.50pm
Instructor contact information Joanna.Kiryluk (at) stonybrook.edu, Physics building, office C109.

COURSE DESCRIPTION:
This course is an introduction to statistical data analysis with modern techniques, including the Python programming language on Windows computers. It consists of two parts. Part A will review concepts and methods to characterize experimental data such as averages, variances, standard deviations, errors and error propagation, covariances and correlations. It will discuss the binominal, Poisson and Gaussian distributions, probabilities, confidence intervals, limits, hypothesis testing, chi2 minimization and straight line fitting, and will focus on their practical applications in experimental data analysis. Part B will introduce students with no prior experience in computing programming to the Python language, with emphasis on data-centric applications. This course will include plentiful practical examples and will require extensive use of computers outside the classroom. The aim of this hands-on course is to prepare Physics and Astronomy majors for experimental laboratory work.

Credits: 3
SBC: TECH

Course Topic

Part A: Introduction to Data Analysis

1. Introduction: what is a measurement, random and systematic uncertainties
2. Data characteristics: distribution, mean and variance
3. Graphic representation of data: histograms, plots, linear and logarithmic scales
4. Statistics: binominal, Poisson and Gaussian probability distributions
5. Central Limit Theorem
6. The meaning of sigma
7. Partial differentiation, propagation of small uncertainties
8. Covariance and correlation
9. Least squares method
10. Combining results of different experiments, weighted averages
11. Straight line fit
12. Parameter and distribution testing and comparing results:
    test 3 sigma, chi-squared test, p-values, confidence levels

Part B: Python Programming for Data Analysis:

1. Python from scratch:
    a. [Installation and setup]
    b. IPython: An Interactive Computing and Development Environment
    c. Variables, basic math, types of data, input, print formatting and strings
    d. Decisions, loops, lists, functions, objects, modules
    e. Data files: input and output, file formats
    f. Data wrangling: Clean, transform, merge, reshape
    g. Plotting and Visualization

2. Data analysis modules
    a. NumPy Basics
    b. SciPy Basics

3. Data analysis report
    a. [Latex, Word, Python, etc.]

Course Pre/co-requisites

PHY 133 and a grade of C or better in (either MAT 125 or MAT 131 or MAT 141 or AMS 151 or MAT 171)

COURSE LEARNING OBJECTIVES:

The students' learning objective is to understand technology by gaining a hands-on experience in data analysis with modern computer-based tools, such as the Python programming language, with the goal to prepare (future) Physics and Astronomy majors for experimental laboratory work.

Students will become proficient at working with data in Python by learning the fundamentals of the language to write computer programs to solve data analysis problems. Specifically, they will learn to solve data analysis problems using quantitative statistical methods and will learn how to obtain, and present results quantitatively and graphically. This hands-on course is ideal for (future) Physics and Astronomy majors new to Python.

COURSE REQUIREMENTS:

Attendance and Make Up Policy

Attendance is mandatory. More than 3 absences in class may result in a grade reduction.
Make up exams will be scheduled during regular class hours.

Description and schedule of Required Readings and/or Assignments.

Mandatory Course Material:
1.   "PHY153: Data Analysis for Physics and Astronomy with Python"
        subscription keys required, can be purchased via
        zybooks.com: a digital courseware platform for computer science and STEM courses

        Subscription Instructions:

        Sign in or create an account at learn.zybooks.com

        Enter zyBook code: STONYBROOKPHY153KirylukFall2023

2.   "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", John R. Taylor [3rd edition]

Requirements for written assignments (margins, font, style manual):

None.

Exams

Number and Description of Exams (include dates in meeting schedule section below).
Midterm and term project are mandatory. Make up exams may be scheduled in exceptional cases.

There will be 1 midterm exam. Midterm exam will be given during regular lecture hours.
2 (letter size) pages of handwritten notes will be allowed.
There will be one term project. Students will analyze a data set provided to them by using data analysis techniques and writing a Python computing program.

GRADING:

Final grades will be determined by weighting the various portions of the course as follows:
- 50% attendance and assignments
- 25% midterm exam
- 25% term project

Grades:
- o Weighted average: 95 %   A
- o Weighted average: 90 %   A-
- o Weighted average: 85 %   B+
- o Weighted average: 80 %   B
- o Weighted average: 75 %   B-
- o Weighted average: 70 %   C+
- o Weighted average: 65 %   C
- o Weighted average: 60 %   C-
- o Weighted average: 55 %   D+
- o Weighted average: 50 %   D
- o Weighted average: < 50 %   F

P/NC: If you decide to take the course for **PASS/NO CREDIT**, you must change before the University-imposed deadline. All grades will be accessible via brightspace for this course.

MEETING SCHEDULE
The class will meet two times a week. Assignments due dates are posted on zybooks ("Assignments") course page and/or brightspace. Check both.

Exam Schedule:
Midterm: 10/12/2023
Term project: due date 12/08/2023

CLASS PROTOCOL
No cell phones or other "smart" devices with phone or WiFi capability will be permitted in the exams, unless stated otherwise.

CLASS RESOURCES
Brightspace
SINC Site

Student Accessibility Support Center Statement
If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, 128 ECC Building, (631) 632-6748, or via e-mail at: **sasc@stonybrook.edu**. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and the Student Accessibility Support Center. For procedures and information go to the following website: https://ehs.stonybrook.edu//programs/fire-safety/emergency-evacuation/evacuation-guide-disabilities and search Fire Safety and Evacuation and Disabilities.

Academic Integrity Statement
Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

Critical Incident Management
Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.