ASEN5307 – Engineering Data Analysis Methods - Fall 2023

Instructor	Dr. R. Steven Nerem (Office: AERO 456, Ph. 492-6721, Email: nerem@colorado.edu)
Class Time	TTh 10 – 11:15 am
Class Location	AERO N240
Class Web Page	http://canvas.colorado.edu
Office Hours	2-3 pm Tuesdays or by appointment
Teaching Assistant	Teresa Penya Mercade (tepe2115@colorado.edu)
Required Text	*MATLAB Recipes for Earth Sciences*, 2021, 5th Edition by Martin H. Trauth, Springer ISBN-13: 978-3030384401 Or *Python Recipes for Earth Sciences*, 2022, 1st Edition by Martin H. Trauth, Springer ISBN-13: 978-3031077180 Additional text: https://www.sciencedirect.com/book/9780323955768/environmental-data-analysis-with-matlab-or-python
Grading	Mid-Term Exam (15%), Final Exam (15%), Quizzes (10%) Homework (40%) (10 pts deducted for each day late!) Research Project (20%)
Important Dates	October 17 – In-Class and Take-Home Mid-Term Exam December 7 – Research Projects Due, Presentations December 14 – In-Class and Take-Home Final Exam
Lecture Material	PDF files will be posted on the class website.
Course Overview	Gives students broad exposure to a variety of traditional and modern statistical methods for filtering and analyzing data. Topics include estimation and filtering methods, principal component analyses and spectral analyses. Introduces these methods and provides practical experience with their use. Students carry out problem assignments. Prior knowledge of MATLAB and/or Python is recommended, as programming is NOT taught in this class.

Syllabus – ASEN5307
Engineering Data Analysis Methods

I. Introduction

1. Collecting Data
2. Data Calibration and Interpolation
3. Data Editing
4. Presenting Data

II. Statistics and Error Handling

1. Uncertainties in Measurements
2. Empirical Distributions
3. Theoretical Distributions
4. Hypothesis Testing
5. t-test, F-test, $\chi 2$ test
6. Error Analysis
7. Error Propagation
8. Confidence Intervals
9. Correlation Coefficient
10. Degrees of Freedom
11. Estimation Methods
12. Curve Fitting
13. Interpolating Data
14. Data Smoothing (boxcar, gaussian, Savitzky–Golay)
15. Covariance and Error Analysis
16. Residual Analysis and Data Editing
17. Linear Regression Analysis
18. Bootstrap and Jackknife Estimates

III. Time-Series Analysis

1. Fourier Analysis
2. Harmonic Analysis
3. Blackman-Tukey Spectral Analysis
4. Cross-Spectral Analysis
5. Wavelet Analysis

6.   Analyzing Unevenly Spaced Data
7.   Lomb-Scargle Powerspectrum

IV. Signal Processing

1. Linear Time Invariant Systems
2. Convolution and Filtering
3. Recursive and Nonrecursive Filters
4. Impulse and Frequency Response
5. Filter Design
    a. Running Mean Filters
    b. Lanczos-window Cosine Filters
    c. Butterworth Filters
    d. Frequency Domain Filtering

V. Spatial Analysis of Data Fields
1. Gridding and Contouring
2. Spherical Harmonics
4. Objective Analysis, Kriging
5. Principal Component Analysis (including SVD)
        a. Percent variance explained
6. Independent Component Analysis
7. Empirical Orthogonal Functions

VI. Miscellaneous Topics (as time allows)
1. Introduction to Machine Learning
2. Geophysical Inverse Theory
3. Kalman Filtering

Syllabus Statements

Classroom Behavior

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation, or political philosophy.

For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

Requirements for Infectious Diseases

Members of the CU Boulder community and visitors to campus must follow university, department, and building health and safety requirements and all public health orders to reduce the risk of spreading infectious diseases.

The CU Boulder campus is currently mask optional. However, if masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class. Students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct & Conflict Resolution. Students who require accommodation because a disability prevents them from fulfilling safety measures related to infectious disease will be asked to follow the steps in the "Accommodation for Disabilities" statement on this syllabus.

For those who feel ill and think you might have COVID-19 or if you have tested positive for COVID-19, please stay home and follow the further guidance of the Public Health Office. For those who have been in close contact with someone who has COVID-19 but do not have any symptoms and have not tested positive for COVID-19, you do not need to stay home.

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation

Disability Services determines accommodations based on documented disabilities in the academic environment. If you qualify for accommodations because of a disability, submit your accommodation letter from Disability Services to your faculty member in a timely manner so your needs can be addressed. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance.

If you have a temporary medical condition or required medical isolation for which you require accommodation, please let me know and I will try to accommodate you. Also see Temporary Medical Conditions on the Disability Services website.

Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include but are not limited to: plagiarism (including use of paper writing services or technology [such as essay bots]), cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty.
All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: honor@colorado.edu, 303-492-5550. Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, protected-class discrimination and harassment, and related retaliation by or against members of our community on and off campus.
Visit OIEC for or more information about university policies, reporting options, and support resources. If you believe you may have been subjected to misconduct, email OIEC or call 303-492-2127
Faculty and graduate instructors are required to inform OIEC when they learn of any issues related to these policies regardless of when or where they occurred. This ensures that individuals impacted receive information about their rights, support resources, and resolution options. Visit the Don't Ignore It page to learn more about reporting and support options.

Religious Holidays

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, please let me know at least 2 weeks in advance if you need have any conflicts with your religious observances.

See the campus policy regarding religious observances for full details.