ASEN5307 – Engineering Data Analysis Methods - Fall 2025

Instructor	Dr. R. Steven Nerem (Office: AERO 456, Ph. 492-6721, Email: nerem@colorado.edu)
Class Time	TTh 1 – 2:15 pm
Class Location	AERO N240
Class Web Page	http://canvas.colorado.edu
Office Hours	10-11 am Tuesdays and Thursdays or by appointment
Teaching Assistant	Lluc Busquets (lluc.busquets@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
Grading	Mid-Term Exam (20%), Final Exam (20%) Homework (40%) (10 pts deducted for each day late!) Research Project (20%)
Important Dates	October 7 – Reading Day (no class) October 14 – In-Class and Take-Home Mid-Term Exam December 4 – In-Class and Take-Home Final Exam December 4– Research Projects Due (Canvas Upload) December 9 – 4:30 pm – Research Project Presentations
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

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. Understanding the course's syllabus is a vital part of adhering to the Honor Code.
All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: StudentConduct@colorado.edu. Students found responsible for violating the Honor Code will be assigned resolution outcomes from Student Conduct & Conflict Resolution and will be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or DSinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.
If you have a temporary illness, injury or required medical isolation for which you require adjustment, please contact the instructor.

Accommodation for Religious Obligations

Campus policy requires faculty to provide reasonable accommodations for students who, because of religious obligations, have conflicts with scheduled exams, assignments, or required attendance. Please communicate the need for a religious accommodation in a timely manner. In this class, contact the instructor if you need a religious accommodation. See the campus policy regarding religious observances for full details.

Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information does not always align with how they identify. If you wish to have your preferred name (rather than your legal name) and/or your preferred pronouns appear on your instructors' class rosters and in Canvas, visit the Registrar's website for instructions on how to change your personal information in university systems.

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, marital status, political affiliation, or political philosophy.

Additional classroom behavior information

- Student Classroom and Course-Related Behavior Policy.
- Student Code of Conduct.
- Office of Institutional Equity and Compliance.
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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 protected-class discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner abuse (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who have been subjected to misconduct can contact OIEC at 303-492-2127 or email OIEC@colorado.edu. Information about university policies, reporting options, and OIEC support resources including confidential services can be found on the OIEC website.
Please know that faculty and graduate instructors are required to inform OIEC when they are made aware of incidents related to these concerns regardless of when or where something occurred. This is to ensure the person impacted receives outreach from OIEC about resolution options and support resources. To learn more about reporting and support a variety of concerns, visit the Don't Ignore It page.

Mental Health and Wellness

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS), located in C4C, or call (303) 492-2277, 24/7.

Acceptable Use of AI in This Class

Generative AI may not be used for exams or homework assignments in this course. One of the purposes of this course is to learn how to create data analysis algorithms and test them in Matlab or Python. While Generative AI can often write the code for you, it will take away from what you learn in this course. As Generative AI will become part of your "data analysis toolbox", I will allow limited use in your research projects.