Data Science for ECE

EEL 3850 Section SAXN
Class Periods: TR, period 7-8, (1:55 PM – 3:50 PM)
Location: MAEB 0211
Academic Term: Fall 2023

Instructors:
Dr. Yuheng Bu
- Office: NEB 453/MALA 3123
- Email: buyuheng@ece.ufl.edu
- Office Hours: TR 3:50pm – 4:40pm

Undergraduate Peer Instructor:
- TBA

Course Description
(4 credits) Analysis, processing, simulation, and reasoning of data. Includes data conditioning and plotting, linear algebra, statistical methods, probability, simulation, and experimental design.

Course Pre-Requisites / Co-Requisites
- MAC 2312 (Calculus 2)
- EEL 3834 (Programming I)
- Other: Students are expected to bring a portable computer to class. Students need basic computer programming skills.

Course Objectives (as time allows):
Upon completion of this course, the student should be able to:
- Implement, debug, and deploy Python code
- Generate visualizations to expose meaning in data
- Generate and understand the meaning and uses of summary statistics of data
- Model random phenomena using random variables
- Generate random variables with specified densities or distributions
- Conduct hypothesis tests using simulations and analysis
- Understand and use conditioning to simplify problems
- Estimate parameters of distributions from samples
- Understand dependence and independence among random phenomena
- Use statistical tests to determine or characterize dependence among random phenomena
- Design experiments to understand random phenomena
- Understand the difference between Bayesian statistics and classical statistics
- Use simulation to calculate Bayesian statistics
- Apply linear algebra for data processing and statistical calculations

Materials and Supply Fees
None

Professional Component (ABET):
4 credits of Engineering Science

Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.	High
2. An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs.	High
3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	High
4. An ability to communicate effectively with a range of audiences	
5. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	
6. An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately.	
7. An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty	

Required Textbooks and Software

- *Foundations of Data Science with Python* (online resource)
  - John M. Shea
  - Will be published by CRC Press, 2023

One of the following:

- *Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares*
  - Stephen P. Boyd, Lieven Vandenberghe
  - Cambridge University Press, 2018
  - ISBN: 978-1-316518-96-0
  - The digital pdf version is freely available and is perfectly fine for this course
- *Practical Linear Algebra for Data Science: From Core Concepts to Applications Using Python*
  - Mike X. Cohen
  - ISBN: 1098120574

All required textbooks are available for loan at Marston library. Please find this course on https://ares.uflib.ufl.edu/ares/ to access the Catalogue record. You can also find this information under the icon "Course Reserves" in our Canvas page.

Recommended Textbooks:

- Python Data Science Handbook – Essential Tools for Working with Data
  - Jake VanderPlas
  - O'Reilly Media, 2017
  - ISBN: 978-1-491912-05-8
  - https://jakevdp.github.io/PythonDataScienceHandbook/

- Introduction to Probability
  - Dimitri P. Bertsekas, John N. Tsitsiklis
  - 2nd edition
  - Athena Scientific, 2008
  - ISBN: 978-1-886529-23-6
  - The digital pdf version is freely available and is perfectly fine for this course

Course Schedule (as time allows)

Module 1: Introduction to Data Science and Python

Week 1, Part 1

- What is Data Science?
- Software setup and initialization
- Introduction to JupyterLab and Jupyter notebooks
- Introduction to Python

Module 2: First Simulations, Visualizations, and Statistical Tests

Week 1, Part 2

- Introduction to random module
- First simulations
- Counting and visualizing data (scatter plots, histograms); introduction to numpy and matplotlib
- First statistical tests

Week 2

- Introduction to Pandas
- Loading data from CSV files
- Working with dataframes
- Visualizing multiple data sets: scatter plots
- Partitions
- Summary statistics
- Visualizing multiple data sets: histograms

Week 3, Part 1

- Null hypothesis testing with real data
- Preview of two-dimensional methods

Module 3: Introduction to Probability

Week 3, Part 2

- Outcomes, Sample Spaces, and Events
- Relative Frequencies and Probabilities
- Fair Experiments
- Axiomatic Probability
- (Online) Corollaries to Axioms of Probability

Week 4, Part 1

- Combinatorics

Module 4: Null Hypothesis Significance Testing (NHST)

Week 4, Part 2

- Statistical studies
- General resampling approaches

- Calculating *p*-values
- How to sample from the pooled data
- Example NHSTs
- Bootstrap distributions and confidence intervals
- (Online) Types of errors and statistical power

Module 5: Conditional Probability, Dependence, and Independence

Week 5

- Simulating and counting conditional probabilities
- Notation and intuition
- Definition
- Independence
- (Online) Conditional probabilities and independence in fair experiments
- Conditioning and (in)dependence
- Chain rules and total probability

Module 6: Introduction to Bayesian Methods

Week 6

- Bayes' rule
- Bayes' rule in systems with hidden state
- Optimal decisions in discrete stochastic systems
- Example of Bayesian hypothesis testing and credible intervals

Module 7: Random Variables

Week 7

- Discrete random variables and their simulation; introduction to scipy.stats
- Cumulative distribution and survival functions
- (Online) Poisson random variables
- Continuous random variables and density functions

Week 8, Part 1

- Normal random variables
- (Online) Histograms of continuous random variables and kernel density estimation

Module 7: Expected Value, Parameter Estimation, and Hypothesis Tests on Sample Means

Week 8, Part 2

- Expected value and properties
- Moments; variance and its properties
- Parameter estimation
- Confidence intervals for estimates
- Testing a difference of means
- (Online) Sampling and bootstrap distributions
- (Online) Effect size, power, and sample size selection

Module 8: Decision Making with Observations on Continuous Distributions

Week 9

- Non-Bayesian approaches: maximum-likelihood and likelihood ratio tests
- Point conditioning, total probability, Bayes' rule for continuous random variables

- ML decisions with conditionally Gaussian random variables; application to and simulation of communication systems
- (Online) MAP decisions with conditionally Gaussian random variables

Module 9: Categorical Data, Tests for Independence, and Goodness of Fit for Discrete Distributions

Week 10

- Introduction to categorical data
- Contingency tables and creating a test statistic
- NHSTs for dependence
- Goodness-of-fit NHSTs
- (Online) Goodness-of-tests for matching a distribution

Module 10: Vectors

Week 11

- Introduction to vectors
- Special vectors
- Constant-vector and vector-vector operations
- Special vector-vector operations and applications
- Vector correlation and projection

Module 11: Matrices

Week 12

- Introduction to Matrices
- Matrix-matrix operations; transpose; identity matrix
- Determinant
- Systems of linear equations
- Linear dependence

Week 13, part 1

- Matrix inverses
- Exact and approximate data fitting

Module 12: Multi-dimensional Data

Week 13, part 2

- Summary statistics for n-dimensional data
- Linear regression

Week 14, part 1

- NHSTs for correlation
- (Online) nonlinear regression tests

Module 13: Working with Dependent Data in Multiple Dimensions

Week 14, part 2

- Introduction to jointly distributed random variables
- Eigen decomposition

Week 15

- Principal component analysis (PCA) and application to data reduction/feature extraction

Attendance Policy, Class Expectations, and Make-Up Policy

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:
https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Homework (6)	100 each	30%
In-class Evaluations (10)	100 each	10%
Midterm Exam	100	30%
Final Exam	100	30%
		100%

Homework will be accepted late once, with an automatic 25% reduction in grade.

When students request that a submission (test or homework) be regraded, I reserve the right to regrade the entire submission rather than just a single problem.

Honor statements on tests must be signed in order to receive any credit for that test.

I understand that many of you may have access to at least some of the homework solutions. Time constraints prohibit me from developing completely new sets of homework problems each semester. Therefore, I can only tell you that homework problems exist for your benefit. It is dishonest to turn in work that is not your own. In creating your homework solution, you should not use the homework solution that I created in a previous year or someone else's homework solution. If I suspect that too many people are turning in work that is not their own, then I will completely remove homework from the course grade.

Collaboration on homework is permitted and encouraged unless explicitly prohibited, provided that:
1. Collaboration is restricted to students currently in this course.
2. Collaboration must be a shared effort.
3. Each student must write up his/her homework independently.
4. On problems involving programming, each student should write his or her own program. Students may discuss the implementations of the program, but students should not work as a group in writing the programs.

Students Requiring Accommodations

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Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in

connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.
A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session. Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy
UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment
The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:
• Your academic advisor or Graduate Program Coordinator
• Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
• Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
• Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use
All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy
There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*: https://distance.ufl.edu/state-authorization-status/#student-complaint*.

Grading Policy
Grades (and the corresponding grade points) will be assigned according to the Registrar's official policies (see table below). Grades will be curved. However, an A grade of > 90% is guaranteed an A, > 80% is guaranteed a B, etc. Undergraduate students, in order to graduate, must have an overall GPA and an upper-division GPA of 2.0 or better (C or better). Note: a C- average is equivalent to a GPA of 1.67, and therefore, it does not satisfy this

graduation requirement. Graduate students, in order to graduate, must have an overall GPA of 3.0 or better (B or better). Note: a B- average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement.

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

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