Data Science for ECE

EEL 4930 Section 1954

Class Periods: MWF, period 6, 12:50 PM – 1:40 PM, R, period 6, 12:50 PM – 1:40 PM

Location: LAR 310 (MWF), WEIL 273 (R)

Academic Term: Spring 2020

Instructors:

Dr. John M. Shea
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- Office Hours: Mondays and Thursdays 2:00 PM – 3:30 PM

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- Office Hours: Fridays 10:40 AM – 11:40 AM, or by appointment

Supervised Teaching Student:

Please contact through the Canvas website
- Ying Ma
- Office: NEB 454
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- Office Hours: Wednesdays 11 AM – 12:00 PM

Teaching Assistant:

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- Pham Quan
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- Office Hours: Tuesdays 11:45 AM – 1:40 PM

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)
- 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:
- 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
- Introduction to Probability
    - Dimitri P. Bertsekas, John N. Tsitsiklis
    - 2nd edition
    - Athena Scientific, 2008
    - ISBN: 978-1-886529-23-6

- Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares
    - Stephen P. Boyd, Lieven Vandenberghe

- o Cambridge University Press, 2018
- o ISBN: 978-1-316518-96-0

- Think Stats – Exploratory Data Analysis
  - o 2nd edition
  - o Allen B. Downey
  - o O'Reilly Media, 2015
  - o ISBN: 978-1-491907-33-7

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
  - o Jake VanderPlas
  - o O'Reilly Media, 2017
  - o ISBN: 978-1-491912-05-8
  - o https://jakevdp.github.io/PythonDataScienceHandbook/

- Think Bayes – Bayesian Statistics in Python
  - o Allen b. Downey
  - o O'Reilly Media, 2013
  - o ISBN: 978-1-491945-43-8
  - o https://greenteapress.com/wp/think-bayes/

Course Schedule (as time allows)
Part I: Introduction
Week 1
- Introduction to Python and random module; first simulations
- Counting and visualizing data (scatter plots, histograms); introduction to numpy and matplotlib
- Relative frequency and probability
- (Online) Random experiments, sample spaces, and set operations
Week 2
- Counting and simulation for random draws
- Probability spaces and axioms of probability
- (Online) Corollaries and applications
- Mutually exclusive and statistically independent events

Part II: One-dimensional data
Week 3
- Importing data: Pandas and dataframes
- Summary statistics: average, median, mode, standard deviation/variance; K-means clustering
- Conditional probability and binary hypothesis testing using Fisher's exact test
Week 4
- Binary hypothesis testing using resampling/simulation; p-values and confidence intervals
- Chain rule, total probability, Bayes' rule
- Maximum likelihood (ML) and maximum a posteriori (MAP) decision rules with applications to communications

Week 5

- Discrete random variables and their simulation; introduction to scipy.stats
- Cumulative distribution and survival functions
- Expected value for discrete random variables; moments, mean, variance
- (Online) Poisson random variables

Week 6
- Testing fit of data to discrete distributions
- Continuous random variables and density functions
- Kernel density estimation

Week 7
- Expected value for continuous random variables; moments, mean, variance
- Gaussian random variables and binary hypothesis testing using analytic methods
- Testing whether data comes from distributions: Q-Q plot, skew, kurtosis, Komogorov-Smirnov test
- (Online) Central Limit Theorem

Week 8
- 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
- (Online) Introduction to functions of random variables

Part III: Multi-dimensional data
Week 9
- Introduction to two-dimensional data, vectors, and plotting
- Summary statistics (mean, median, variance, covariance, correlation) and K-means clustering
- Chi-squared tests

Week 10
- Constant-vector and vector-vector operations
- Special vector-vector operations and applications
- Norm, distance, Cauchy-Schwartz and triangle inequalities, angles between vectors

Week 11
- Correlation coefficient for n-dimensional data
- Orthonormal bases and Gram-Schmidt algorithm
- Rotation; introduction to matrices and matrix-vector multiplication

Week 12
- Feature weighting and selection using matrix-vector multiplication
- Matrix-matrix operations; transpose; identity matrix
- Understanding and dealing with dependence in data: linear dependence, systems of linear equations, Gauss-Jordan reduction

Week 13
- Determinants; matrix inverses and their use in solving systems of linear equations
- Jointly distributed random variables; bivariate Gaussians
- Covariance, correlation coefficient, covariance matrix

Week 14
- Linear regression and correlation coefficient
- Nonlinear regression
- Hypothesis testing for correlation

Week 15
- Multi-dimensional Gaussian; covariance matrices
- Orthogonal bases and eigen-decomposition
- Principal component analysis (PCA) and application to data reduction/feature extraction

Attendance Policy, Class Expectations, and Make-Up Policy
- Students are expected to attend class, and graded evaluations (exercises and/or quizzes) will be given during class.
- Students are expected to bring a portable computer to class.
- If you feel a graded assignment or exam needs to be re-graded, you must discuss this with the instructor within one week of grades being posted for that assignment/exam.
  - If approved, the entire assignment or exam will be subject to complete evaluation.
- If an exam must be missed, the student must see the instructor and make arrangements in advance unless an emergency makes this impossible. Approval for make-up exams is much more likely if the student is willing to take the exam early. Any other exam absence will result in the student receiving a zero for that grade. Students who miss pop quizzes or online quizzes will receive zeros for that grade.
- Any student found to have cheated or plagiarized on an exam or assignment will be given a grade of 0 for that exam or assignment and the evidence will be sent to the Provost's Office for the determination of any additional disciplinary action.
  - Unless an assignment is specifically structured as a group project, duplicate assignments written in collaboration with others is not acceptable. Although it is permissible to discuss the homework with others, these discussions should be of a general nature. All work at a detailed level must be done on your own. Students submitting the same or similar solutions to the homework will be considered as having cheated. No statements or actions made by anyone can alter this policy. Please review what constitutes plagiarism: https://guides.uflib.ufl.edu/copyright/plagiarism

Excused absences must be consistent with university policies in the undergraduate catalog (https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx) and require appropriate documentation.

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Homework and projects	100 each	20%
In-class Evaluations	100 each	10%
Participation	100	10%
Midterm Exam	100	30%
Final Exam	100	30%
		100%

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

For more information on grades and grading policies, please visit:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://www.dso.ufl.edu/drc) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation

Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at https://evaluations.ufl.edu/evals. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at https://evaluations.ufl.edu/results/.

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/policies/student-honor-code-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.

Additional requirements and information:
Honor statements on tests must be signed in order to receive any credit for that test.

Collaboration on homework is permitted and encouraged unless explicitly prohibited, provided that:
(a) Collaboration is restricted to students currently in this course.
(b) Collaboration must be a shared effort.
(c) Each student must write up his/her homework independently.
(d) On problems involving programming, each student should write their own program.

Students may discuss the implementations of the program, but students should not work as a group in writing the programs.

 We have a zero-tolerance policy for cheating in this class.

If you talk to anyone other than me during an exam, I will give you a zero. If you plagiarize (copy someone else's words) or otherwise copy someone else's work, I will give you a failing grade for the class. Furthermore, I will be forced to bring academic dishonesty charges against anyone who violates the Honor Code.

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
• Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.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: http://www.counseling.ufl.edu/cwc, 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 Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.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://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints*:* http://www.distance.ufl.edu/student-complaint-process.