EEL 4930 SYLLABUS

1. **Catalog Description:** (3 credits) Analysis of, simulation of, and reasoning about sampled data and random phenomena. Covers statistical methods, probability, simulation, and experimental design.

2. **Pre-requisite:** MAC 2312 (Calculus 2)

   Other: Students are expected to bring a portable computer to class. Students need basic computer programming skills.

3. **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

4. **Contribution of course to meeting the professional component:** 3 credits of Engineering Science

5. **Relationship of course to program outcomes:** EE1- knowledge of probability and statistics, including applications; a,b,e,h,i,j,k

6. **Instructor:** Dr. John M. Shea

   (a) Office: 439 NEB

   (b) Phone: 352.575.0740 (text messaging is okay)

   (c) Email: jshea@ece.ufl.edu

   (d) Web site (personal): http://wireless.ece.ufl.edu/jshea

   (e) Office hours: Mondays 1:45 PM – 3:00 PM, Wednesdays: 4:15 PM – 5:15 PM, or by appointment

7. **Ninja:** Evan Gruda

   (a) Office: NEB 403

   (b) Email: evangruda@ufl.edu

   (c) Office hours: TBD

8. **Meeting Times:** 3rd period, 9:35 AM – 10:25 AM, Monday/Wednesday/Friday

9. **Class/laboratory schedule:** 3 classes/week, 50 minutes each

10. **Meeting Location:** LAR 239

11. **Material and Supply Fees:** None

12. **Textbooks and Software Required:**

    - Jupyter notebook with Python 3.7, numpy, matplotlib, pandas, scipy, etc.: all students will be required to run Jupyter notebook with Python 3 and the libraries listed above, as well as others covered in class. I **strongly** recommend that you install the Anaconda Distribution with Python 3.7. This is a Python distribution that includes python, Jupyter, and most of the libraries required in the class.

      If you need to use a different computer for some time, then you could also use Google Colaboratory for Jupyter+python. However, do not depend on this as your main way to run Jupyter/Python. We will use Jupyter+Python in the class and exams, and not being able to access a cloud resource is not an excuse for not completing work.
    - A. B. Downey, *Think Stats*, O'Reily Media, 2nd ed., 2014.
    - D. P. Bertsekas and J. N. Tsitsiklis, *Introduction to Probability*, Athena Scientific, 2nd ed., 2008 (ISBN 978-1-886529-23-6). (Recommended.)
    - S. Boyd and L. Vandenberghe, *Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares*, Cambridge University Press, 1st ed, 2018 (ISBN 978-1-316518-96-0). (Recommended, available online.)

13. **Course Outline (as time allows):**

Part I: Introduction

- **Week 1**
  - Class overview
  - Introduction to Jupyter, Python, and random module; first simulations
  - Counting and visualizing data (scatter plots, histograms); introduction to numpy and matplotlib
- **Week 2**
  - Relative frequency and probability
  - (Online) Random experiments, sample spaces, and set operations

  - Counting and simulation for random draws

- **Week 3**
  - Probability spaces and axioms of probability
  - (Online) Corollaries and applications
  - Mutually exclusive and statistically independent events

Part II: One-dimensional data

  - Populations and sampling
  - Importing data: Pandas and dataframes
  - Summary statistics: average, median, mode, standard deviation/variance
- **Week 4**
  - K-means clustering
  - Conditional probability and binary hypothesis testing using Fisher's exact test
  - Binary hypothesis testing using resampling/simulation; p-values and confidence intervals
  - Chain rule, total probability, Bayes' rule
- **Week 5**
  - Maximum likelihood (ML) and maximum *a posteriori* (MAP) decision rules with applications to communications
  - Discrete random variables and their simulation; introduction to scipy.stats
  - Cumulative distribution and survival functions
- **Week 6**
  - Expected value for discrete random variables; moments, mean, variance
  - (Online) Poisson random variables
  - Testing fit of data to discrete distributions
- **Week 7**
  - Continuous random variables and density functions
  - Kernel density estimation
  - Expected value for continuous random variables; moments, mean, variance
- **Week 8**
  - Gaussian random variables and binary hypothesis testing using analytic methods
  - Testing whether data comes from distributions: Q-Q plot
  - (Online) Central Limit Theorem
  - Point conditioning, total probability, Bayes' rule for continuous random variables
- **Week 9**
  - ML decisions with conditionally Gaussian random variables; application to and simulation of communication systems

  - (Online) MAP decisions with conditionally Gaussian random variables

Part III: Multi-dimensional data

  - Introduction to two-dimensional data, vectors, and plotting
  - Summary statistics (mean, median, variance, covariance, correlation) and K-means clustering

- **Week 10**
  - Chi-squared tests
  - Constant-vector and vector-vector operations
  - Special vector-vector operations and applications
- **Week 11**
  - Norm, distance, Cauchy-Schwartz and triangle inequalities, angles between vectors
  - Rotation; introduction to matrices and matrix-vector multiplication
  - Feature weighting and selection using matrix-vector multiplication
- **Week 12**
  - 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
- **Week 14**
  - Covariance, correlation coefficient, covariance matrix
  - Linear regression and correlation coefficient
- **Week 15**
  - Nonlinear regression
  - Hypothesis testing for correlation

3. **Attendance and Expectations:** Students are expected to attend class, and graded evaluations (exercises and/or quizzes) will be given during class.

4. **Grading:** Grading will be based on two exams (30% each) and class participation, homework and online quizzes (20%), in-class evaluations(10%), and participation (10%).

   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.

5. **Grading Scale:** Grades (and the corresponding grade points) will be assigned according to the Registrar's official policies. 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. For more information on grades and grading policies, please visit: https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

6. **Make-up Exam Policy:** 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.

7. **Honesty Policy:** All students admitted to the University of Florida have signed a statement of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action.

   This statement is a reminder to uphold your obligation as a student at the University of Florida and to be honest in all work submitted and exams taken in this class and all others.

   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.

   

   I 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.

8. **Accommodation for Students with Disabilities:** Students Requesting classroom accommodation must first register with the Dean of Students Office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation.

9. **UF Counseling Services:** Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:

    - UF Counseling & Wellness Center, 3190 Radio Rd, 392-1575, psychological and psychiatric services.
    - Career Resource Center, Reitz Union, 392-1601, career and job search services.

10. **Software Use:** All faculty, staff and student 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.