Boston University
College of Engineering
ENG EK381 Probability, Statistics, and Data Science for Engineers
Fall 2019
Course Information

Course Staff:

Instructor:	Prof. Hua Wang Office: EMB 128, 15 St. Mary's Street Office Hours: Mon 1:30-2:30pm in EMB 128, 15 St. Mary's St Email: `wangh@bu.edu`
Graduate Teaching Fellow:	Shahabeddin Sotudian Office Hours: Tue 5:30 - 7:00pm in EMB 105, 15 St. Mary's St Email: `sotudian@bu.edu` Rui Liu Office Hours: Fri 9:30 - 11:00am in ENG 410, 110 Cummington Mall (Exception: ENG 202 on 9/27) Email: `rliu@bu.edu`
Graders:	Mrinal Ghosh Email: `ghoshm@bu.edu` Jose Tejeira Carrizo Email:`jtejeira@bu.edu` Jialin Zhu Email: `jlsophy@bu.edu`

Course Schedule:

Lectures:	Mon and Wed 10:10 - 11:55am in SAR 101
Discussions:	Section B0 Wed 6:30 - 7:20pm in EOP 269 Section B3 Wed 4:40 - 5:30pm in PSY B51 Section B4 Mon 4:40 - 5:30pm in PSY B51
Homework Help:	Thu. 7 - 9pm in 15 St. Mary's St, EMB 105

Course Websites:

Website: `http://learn.bu.edu/`

Prerequisites: ENG EK103 Computational Linear Algebra.

Corequisites: CAS MA225 Multivariate Calculus.

Textbook: For this semester, we will be using the **3rd edition** of

- Roy D. Yates and David J. Goodman, *Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers*, John Wiley & Sons.

The publisher has agreed to sell the book through the BU Barnes & Noble bookstore for the reduced price of $81.45, which is much better than the current Amazon price of $148.23. The bookstore also seems to have some used copies available for $61.10. Earlier editions of the book are fine, but the chapter and sections numbers are in some places different.

The textbook has a companion website that includes solutions to odd-numbered problems, MATLAB files and reference material, and other resources:

- `http://bcs.wiley.com/he-bcs/Books?action=index&bcsId=8677&itemId=1118324560`

Grading:

Midterm 1	30%
Midterm 2	30%
Final	30%
Homeworks + Online Quizzes	10%
Bonus	`if` (Homework Score $\geq$ 85%) `then` (+1/3 letter grade)

Homework: Assignments will be due (nearly) weekly with a typical due date of Friday at 5pm in the box outside 15 St. Mary's Street, EMB 128. Requests for late submissions and/or extensions will not be entertained (except under exceptional circumstances, which must be discussed with the instructor).

- *Collaboration policy:* While you may discuss homework problems with other students for clarifying your understanding, you must *independently solve and write* your own solutions. Please get in touch if you are not sure whether the extent of your collaboration with other students is acceptable.

Supplementary Resources: Beyond the course materials available through the website and the textbook, there are many other resources that are useful for learning probability. In a separate information sheet (titled Course Resources), you can find pointers to video lectures, additional textbooks and lecture notes as well as exercises with solutions. You are encouraged to look through these resources to find the best combination of materials that work for your learning style.

Ideal Study Habits: The material in this class can be quite challenging if you do not approach it in the right way. In a separate document (titled Ideal Study Habits), we have compiled some suggestions (from the instructor and past students) on how to organize your time and effort to do well in this class.

Working with Data. Part of the homework assignments will ask students to apply the concepts they have learned to real data sets, using a numerical programming language such as MATLAB.

Core Topics. Each department's section of EK381 is expected to cover the following topics. Examples and motivating applications will be discipline-specific, depending on the section. Note that each topic is broken down into *concepts*. This is how we will organize our thinking about probability throughout the semester (as opposed to formulas, etc.).

1. **Foundations of Probability**
   - Set Theory
   - Sample Space, Outcomes, Events
   - Probability Law
   - Conditional Probability

- Total Probability Theorem
- Bayes' Theorem
- Independence
- Conditional Independence
- Counting Methods
- Independent Trials

2. **Discrete Random Variables**
   - Probability Mass Function (PMF)
   - Cumulative Distribution Function (CDF)
   - Average and Expectation
   - Functions of Discrete Random Variables (RVs) and their Expectations
   - Variance and Standard Deviation
   - Important Families of Discrete RVs
   - Conditioning a Discrete RV by an Event

3. **Continuous Random Variables**
   - Cumulative Distribution Function (CDF)
   - Probability Density Function (PDF)
   - Expectation of Continuous RVs
   - Functions of Continuous RVs and their Expectations
   - Variance and Standard Deviation
   - Important Families of Continuous RVs
   - Conditioning a Continuous RV by an Event

4. **Multiple Random Variables**
   - Joint CDFs, PMFs, and PDFs
   - Marginal PMFs and PDFs
   - Conditional PMFs and PDFs
   - Independent RVs
   - Functions of Multiple RVs
   - Covariance and Correlation
   - Jointly Gaussian RVs
   - Orthogonal Random Variables
   - Conditional Expectation
   - Iterated Expectation

5. **Detection**
   - Binary Hypothesis Testing
   - Maximum Likelihood (ML) Detection
   - Maximum a Priori (MAP) Detection
   - Minimum Mean-Squared Error (MMSE) Estimation
   - Linear Least-Squares Error (LLSE) Estimation

6. **Statistics**
   - Sample Mean and Variance
   - Law of Large Numbers
   - Central Limit Theorem
   - Confidence Intervals
   - Parametric Statistical Testing

7. **Intro to Data Science and Machine Learning**

- Random Vectors
- Training and Test Error
- Basic Classifiers (Nearest Neighbor, Linear)
- Principal Component Analysis (PCA)

8. **Markov Chains**
   - Finite State Automata
   - Markov Property
   - Transition Probabilities
   - Steady State Probabilities
   - State Classification
   - Irreducible Markov Chains
   - Multiple Communicating Classes

Important Dates:

Date	Event
Monday, October 7	**Tentative Date of Midterm 1.**
Monday, November 4	**Tentative Date of Midterm 2.**
Monday, December 16, 9-11am	**Final Exam.**

General Policies:

- *Academic misconduct:* The student handbook defines academic misconduct as follows:

  `Academic misconduct occurs when a student intentionally misrepresents his or her academic accomplishments or hurts other students' chances of being judged fairly for their academic work.`

  This basic definition applies to EK381. If you are ever in doubt as to the legitimacy of an action, please talk to me immediately. The penalty for academic misconduct at BU is severe. For further information on the BU Academic Code of Conduct, visit the following website: `http://www.bu.edu/academics/policies/academic-conduct-code/`

- *Make-up Exams:* There will be no make-up exams. If there is a legitimate reason for missing an exam, then the scores of other exams will be used appropriately to compensate for the missed exam. If there is no legitimate reason provided for missing an exam, a grade of zero will be assigned for the missed exam.

- *Final Exam:* Students must be present for the final exam, except under exceptional circumstances that must be discussed with the instructor at the beginning of the semester.

- *Incomplete grades:* Incomplete grades will not be given to students who wish to improve their grade by taking the course in a subsequent semester. An incomplete grade may be given for medical reasons if a doctor's note is provided. The purpose of an incomplete grade is to allow a student *who has essentially completed the course* and who has a legitimate interruption in the course, to complete the remaining material in another semester. Students will not be given an opportunity to improve their grades by doing extra work.

- *Drop dates:* Students are responsible for being aware of the drop dates for the current semester. Drop forms will not be back-dated.