Introduction to Probability with Applications in Electrical Engineering

EE 3384-002, CRN-15833
Fall 2022

Syllabus

Department of Electrical & Computer Engineering
The University of Texas at El Paso, El Paso, Texas 79968, USA
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Contents

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Monday, August 22, 2022

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1 General Information

- **Course ID:** Introduction to Probability, EE 3384-002, CRN-15833
- **Time:** Monday and Wednesday, 9:00 am – 10:20 am
- **Lecture Room:** Liberal Arts Building 108
- **Prerequisites:** MATH 2313 or MATH 2326 and MATH 3323 each with a grade "C" or better
- **Textbook:** S. M. Kay. *Intuitive Probability and Random Processes Using Matlab.* Springer, New York, NY, 2005 [1]
- **Computational Software:** Matlab® [2] and [3]
- **Instructor:** von Borries – rvonborries@utep.edu
- **Office:** Engineering Building 313
- **Office Hours:** MW 6:00 pm to 7:00 pm (room 313 or Blackboard)
  F 4:00 pm to 5:00 pm (room 313 or Blackboard)
- **Version:** Monday, August 22, 2022

2 Description

Introduction to Probability with Applications in Electrical and Computer Engineering presents an introduction to probability, sets, combinatorics, discrete and continuous random variables, single and multiple random variables, probability and cumulative functions, conditional probability, statistical independence, moments of random variables, and functions of random variables. In addition, the course presents applications of probability in areas such as

quantization, data compression, estimation, detection, clustering, and queueing. Computer simulations provide motivation and facilitate understanding of the theory and applications. EE 3384 has the following prerequisites: MATH 2313 or MATH 2326 and MATH 3323 each with a grade "C" or better.

3 Textbook and Numerical Computation Software

Introduction to Probability with Applications in Electrical and Computer Engineering has two required resources: (1) the textbook by S. M. Kay. *Intuitive Probability and Random Processes Using Matlab*. Springer, New York, NY, 2005 (available at UTEP's bookstore); and (2) the software `Matlab`® for numerical computation and visualization developed by The MathWorks, Inc. [2, `Matlab`® on MathWorks]. If you don't have `Matlab`® installed in your computer, you can get `Matlab`® from the Engineering Technology Center (ETC) at the Engineering building E351D, College of Engineering, located between the Engineering and Classroom buildings on the 3rd floor, http://etc.utep.edu, e-mail: `etchelpdesk@utep.edu`. Alternatively, you can have access to `Matlab`® at https://my.apps.utep.edu/vpn/index.html.

The numerical data simulation and graphic visualization in `Matlab`® software can enhance both teaching and learning of new ideas and concepts in EE 3384.

4 Student Outcomes

Ability to

- solve basic counting problems involving permutations and combination of equally-likely events.
- use elements of set theory and axioms of probability to determine the probability of complex events and apply Bayes' theorem to the solution of conditional probability.
- solve problems involving independent events and independent random variables.
- determine marginal and joint cumulative distribution functions, probability density functions and use them to compute expected values of discrete and continuous random variables.
- solve problems involving Gaussian, uniform, exponential, binomial and Poisson random variables.
- compute probability density functions and cumulative density functions of random variables.
- compute expected values of sums of random variables and the covariance and correlation of pairs of random variables.
- apply numerical simulations to solve problems in probability and random processes.

5 Course Topics

Part I

- Introduction
  - 1.1 Probability
  - 1.2 Types of random variables
  - 1.3 Computer modeling and simulation
  - 1.4 Simulation versus analysis
  - 1.5 Textbook problems
- Computer Simulation
  - 2.3 Importance
  - 2.4 `Matlab`® simulation of random phenomena
  - 2.5 Characteristics of random variables
  - 2.6 Application: digital communications
  - 2A Introduction to `Matlab`®
- Basic Probability
  - 3.3 Set theory basics
  - 3.4 Terminology and axioms
  - 3.5 Properties of the probability function
  - 3.6 Probabilities for continuous sample spaces
  - 3.7 Probabilities for finite samples spaces
  - 3.8 Combinatorics
  - 3.9 Binomial probability mass function
  - 3.10 Application: quality control
- Conditional Probability
  - 4.3 Joint events and the conditional probability
  - 4.4 Statistically independent events
  - 4.5 Bayes's theorem
  - 4.6 Multiple experiments
  - 4.7 Application: cluster recognition

Part II

- Discrete Random Variables
  - 5.3 Definition of discrete random variable
  - 5.4 The probability mass function (pmf) and its properties
  - 5.5 Important probability mass functions
  - 5.6 Approximation of binomial pmf by Poisson pmf
  - 5.7 Transformation of discrete random variables
  - 5.8 Cumulative Distribution Function (CDF)
  - 5.9 Computer simulation
- Expected Values for Discrete Random Variables
  - 6.3 Determining the expected value
  - 6.4 Expected values of some important pmfs
  - 6.5 Expected value for a function of a random variable
  - 6.6 Variance and moments of a random variable
  - 6.7 Characteristic function
  - 6.8 Estimating means and variances
  - 6.9 Application: data compression
  - 6B `Matlab`® code to estimate the mean and the variance
- Multiple Discrete Random Variables
  - 7.3 Jointly distributed random variables
  - 7.4 Marginal pmfs and joint CDFs
  - 7.5 Independence of multiple random variables
  - 7.6 Transformations of multiple random variables
  - 7.7 Expected values
  - 7.8 Joint moments
  - 7.9 Prediction of a random variable outcome
  - 7.11 Computer simulation of jointly discrete random variables
- Conditional Probability Mass Functions
  - 8.3 Conditional probability mass function
  - 8.4 Joint, conditional, and marginal pmfs
  - 8.5 Simplifying probability calculations using conditioning

  - 8.7 Computer simulation based on conditioning
  - 8.8 Applications: modeling human learning

- Discrete N-Dimensional Random Variables
  - 9.3 Random vectors and probability mass functions
  - 9.4 Transformations
  - 9.5 Expected values
  - 9.8 Computer simulation of random vectors
  - 9.9 Application: image coding

Part III

- Continuous Random Variables
  - 10.3 Definition of continuous random variable
  - 10.4 The probability density function (pdf) and its properties
  - 10.5 Important probability density functions
  - 10.6 Cumulative Distribution Function (CDF)
  - 10.7 Transformation of continuous random variables
  - 10.8 Mixed random variables
  - 10.9 Computer simulation
  - 10A Derivation of pdf of a transformed continuous random variable
- Expected Values for Continuous Random Variables
  - 11.3 Determining the expected value
  - 11.4 Expected values of some important pdfs
  - 11.5 Expected value for a function of a random variable
  - 11.9 Estimating means and variances
  - 11.10 Application: critical software testing
- Multiple Continuous Random Variables
  - 12.3 Jointly distributed random variables
  - 12.4 Marginal pdfs and joint CDFs
  - 12.5 Independence of multiple random variables
  - 12.6 Transformations of multiple random variables
  - 12.7 Expected values

  - 12.8 Joint moments
  - 12.9 Prediction of a random variable outcome
  - 12.11 Computer simulation of jointly continuous random variables
  - 12.12 Application: optical character recognition
- Conditional Probability Density Functions
  - 13.3 Conditional probability density function
  - 13.6 Mean of conditional pdf
  - 13.7 Computer simulation based on conditioning
- Continuous N-Dimensional Random Variables
  - 14.3 Random vectors and probability density functions
  - 14.4 Transformations
  - 14.5 Expected values
  - 14.8 Prediction of a random variable outcome
  - 14.9 Computer simulation of Gaussian random vectors
  - 14.10 Application: signal detection

6 Evaluation

Activity	**Content**	**%**
Quizzes	Chapters 1 to 14	10
Participation	(classroom, office hours, Blackboard, e-mail)	10
Exam I	Chapters 1 to 4	25
Exam II	Chapters 5 to 9	25
Comprehensive Final	Chapters 1 to 14	30

Exams I, II and the Comprehensive Final taken in the classroom.

Formulas are part of the material assessed in EE 3384 and formula sheets are not allowed during EE 3384 exams and quizzes. Two important rules for the exams and quizzes are: (1) closed textbook, notes and homework solutions; and (2) turned off electronic devices: calculator, computer, cell phone, smart watch, headphone, etc.

7 Grading

$A = 100 - 90\%$, $B = 90 - 80\%$, $C = 80 - 70\%$, $D = 70 - 60\%$ and $F = 60 - 0\%$.

8 Missed Exams

If you miss Exam I or Exam II without an acceptable excuse you will receive zero points for the missed exam. You may be excused from a scheduled exam time due to serious illness, funeral attendance, courtroom appearance, or a UTEP athletic participation. In the case of a missed exam, you must communicate and submit the appropriate documentation to me no later than ten days after the date of the missed exam. The make-up exam for either Exam I or Exam II is comprehensive (all the material for Exams I, II, and III) on the Friday of the finals' week (tentatively, December 10, 4:00 pm to 6:45 pm). Note that there is no make-up exam for the Comprehensive Final or for more than one missed exam.

9 Grade Assignment for Drops and Withdrawals

If you drop the course before the drop deadline, the grade is "W." However, please note the following regulation stated in the UTEP academic catalog (http://catalog.utep.edu/grad/academic-regulations/registration-and-records/): "... if the student drops after the student-initiated course drop deadline, instructors will determine a grade of "W" or "F" for each course. A grade of W will be considered only under exceptional circumstances and must be approved by the instructor and department chair for the course. A student may need to petition the instructor for a grade of "W" in writing with the necessary supporting documentation."

10 Office Hours

In addition to attending the lectures, plan to use office hours to get most out of EE 3384. Feel encouraged to attend office hours and work with me on the textbook concepts and problems, `Matlab`® simulations, and preparing for the exams and quizzes. I can help you to learn "Probability and Its Applications." You can use office hours to get more information on anything you are struggling with in class. During office hours, I can provide you with an opportunity (1) to carefully walk through an idea and (2) to get answered lots of questions that are specific to your needs, helping you to effectively learn the material. You can also use office hours to get more information on anything covered in class that triggered your interest, that you enjoyed. I will not collect or grade the recommended exercises from the textbook and from past exams; however, note that you should work on all them as part of your study for EE 3384. I can work with you on the recommended exercises using my office's chalkboard and laptop computer (on `Matlab`® simulations). In addition to regular office hours, you can contact me by email 24/7 with questions on the EE 3384 material and I will try to reply and help you as soon as possible.

11 Academic Integrity

Review and comply with the policy on academic integrity available at https://www.utep.edu/student-affairs/osccr/student-conduct/academic-integrity.html.

12 Attendance

Class attendance is mandatory and will be monitored. Any student with more than two unexcused absences will be dropped out of the EE 3384. It is student's responsibility to sign the attendance sheet provided by the instructor for each class.

13 UTEP E-mail Account

To communicate with me, make sure your UTEP e-mail account is working fine. It is your responsibility to have a UTEP e-mail account working properly. By the end of the first week of classes, every student should have received at least one e-mail message from EE 3384. If you detect an e-mail problem (no EE 3384 e-mail message received by the end of the first week of classes), you should request UTEP's Help Desk assistance to fix the problem with your UTEP's e-mail account.

14 Accommodations and Support Services

If you have a disability and need classroom accommodations, please contact *The Center for Accommodations and Support Services (CASS)* at 747-5148, or by email at `cassutep.edu`, or visit their office located in UTEP Union East, Room 106. For additional information, visit the CASS website at `www.sa.utep.edu/cass`.

15 Use of Electronic Devices

The use of cell phones or electronic devices may pose a negative distraction (social media, internet, email) and disrupt classroom discussions. Phones must be silenced during classes, exams, or quizzes, and if you need to answer a call during a class, please step out of the classroom. You can use an electronic notepad for note taking only [4].

16 Copyright Statement for Course Materials

Materials in this course, unless otherwise indicated, are protected by the United States copyright law. Materials are presented in an educational context for personal use and study and should not be shared, distributed, or sold in print or digitally, outside the course without permission.

17 Related Reading and References

You will enjoy reading the following books related to probability and its applications: [5] on statistics, [6] on randomness, [7] on predictions, [8] on a counterintuitive problem, and [9] on the brain and multitasking.

References

[1] S. M. Kay. *Intuitive Probability and Random Processes Using Matlab*. Springer, New York, NY, 2005.

[2] https://www.mathworks.com/help/matlab/getting-started-with-matlab.html. Matlab® documentation.

[3] https://www.youtube.com/user/MATLAB?feature=watch. Matlab® tutorials.

[4] P. A. Mueller and D. M. Oppenheimer. The pen is mightier than the keyboard: Advantages of longhand over laptop note taking. *Psychological Science*, 25(6):1159–1168, April 2014.

[5] D. Salsburg. *The Lady Tasting Tea: How Statistics Revolutionized Science in the Twentieth Century*. Henry Holt and Co., New York, NY, 2002.

[6] L. Mlodinow. *The Drunkard's Walk: How Randomness Rules Our Lives*. Vintage, New York, NY, 2008.

[7] N. Silver. *The Signal and the Noise: Why So Many Predictions Fail - but Some Don't*. Penguin Group USA, New York, NY, 2012.

[8] J. Rosenhouse. *The Monty Hall Problem: The Remarkable Story of Math's Most Contentious Brain Teaser*. Oxford University Press, New York, NY, 2009.

[9] J. Medina. *Brain Rules (Updated and Expanded): 12 Principles for Surviving and Thriving at Work, Home, and School*. Pear Press, Seattle, WA, second edition, 2014.

A Calendar

EE 3384, TR 1:30 pm to 2:50 pm

August

M	T	W	R	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

2022

September

M	T	W	R	F	S	S
			1	2	3	4
	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

2022

October

M	T	W	R	F	S	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

2022

November

M	T	W	R	F	S	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23			26	27
28	29	30				

2022

December

M	T	W	R	F	S	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

2022

- ☐ **Labor Day, UTEP Closed**
  September 5, Monday
- ☐ **Exam I**: September 26, Monday
  Chapters 1, 2, 3, and 4
- ☐ **Course Drop/Withdrawal Deadline**
  October 28
- ☐ **Exam II**: October 31, Monday
  Chapters 5, 6, 7, 8, and 9
- ☐ **Thanksgiving, UTEP closed**
  November 24 to 25
- ☐ **Comprehensive Final**: December 7
  Wednesday, 10:00 am to 12:45 pm
  Chapters 10, 11, 12, 13, 14, and 1 to 9