# 36-217 – Probability Theory and Random Processes

*Summer 2019*

## Instructor


| | Office | Email | Office Hours |
|---|---|---|---|
| Riccardo Fogliato | FMS 317 | rfogliat@andrew.cmu.edu | 1:30-2:30PM Thursday (WEH 3713) |


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|---|---|
| **Lecture** | Monday-Friday 12:00 PM – 1:20 PM (SH 214) |
| **Teaching Assistant** | Yue Li, yuel5@andrew.cmu.edu<br>OH: Monday, Wednesday 2:00PM-3:00PM (WEH 3713) |
| **Optional Texts** | *Mathematical Statistics with Applications*<br>W. Mendenhall, R. L. Scheaffer<br>Duxbury Press, 2008 ($7^{th}$ edition)<br>*Introduction to Probability Models*<br>S. M. Ross<br>Academic Press, 2014 ($11^{th}$ edition) |
| **Website** | http://stat.cmu.edu/ rfogliat/teaching/217/probtheory.html |
| **Prerequisites:** | 21-112 or 21-122 or 21-123 or 21-256 or 21-259 |

*Course Description*

The theory of probability and random processes provides the mathematical tools and formalism needed to model uncertainty in any scientific area. Nowadays, probabilistic models are key for the development and analysis of scientific theories and of many algorithms, with countless applications, ranging from the analysis of network dynamics of circuit failure rates to the development of algorithms for computer vision, statistics, machine learning, image processing, cryptography, system performance assessment, business inventory, marketing, finance, medicine, etc.

This is a first course in probability theory that is designed to provide you with the tools to develop and analyze basic models for describing and studying uncertainty and randomness. By the end of this course, students will

1. possess an adequate background and understanding of basic concepts in probability theory;
2. be able to apply probability terminology and formalism correctly to represent elementary random experiments and quantify uncertainty;
3. be proficient in the calculus-based mathematical skills needed to solve problems in basic probability.

*Course Objectives*

1. **Basic Probability.**
    - Describe the sample space of an experiment using set notation.
    - Find the probabilities of complements, unions, and intersections of events.
    - Use counting tools to enumerate the number of equally likely outcomes of simple experiments.
    - Use the law of total probability and Bayes' Rule to calculate probabilities.
    - Define and identify independence of events.
    - Calculate conditional probabilities of events.
2. **Random Variables.**
    - Describe the random variable associated with a question of interest.
    - Describe and identify discrete and continuous random variables.
    - Use PMFs, PDFs, and CDFs to derive probabilities and quantities of interest.
    - Describe and identify Binomial, Poisson, Geometric, Uniform, and Normal distributed random variables.
    - Calculate expectations for a random variable.
    - Derive quantities of interest from joint distributions of pairs of random variables.
    - Calculate conditional distributions of random variables.
    - Describe and determine independence of random variables.
    - Derive the distributions of functions of random variables.
3. **Advanced Probability Topics.**
    - Describe a Bernoulli process.
    - Calculate the probability of an outcome from a Bernoulli process.
    - Describe a Poisson process.
    - Calculate the probability of an outcome from a Poisson process.
    - Describe a Markov chain.
    - Create a probability matrix for a Markov chain.
    - Use a probability matrix to calculate the probability of an outcome from a Markov chain.
    - Describe the Central Limit Theorem, Weak Law of Large Numbers and Chebyshev's Inequality.

# Administrative Remarks

*Lectures*

**Lecture Notes.** Notes will be made available in PDF format prior to lectures. A given set of notes will generally cover more than one lecture. It is your responsibility to print out materials, if you choose to do so. The notes will not be complete: I will solve the problems during lecture.

**Textbook.** The optional text provides background material that is meant to supplement lectures. Each set of lecture notes indicates what sections of the text you should read if you choose to do so.

**Attendance.** Class attendance is not explicitly required, although it is highly suggested. Moreover, if you miss quizzes your grade will certainly suffer. In introductory classes such as 36-217 it takes time and effort to clearly understand the concepts, so don't procrastinate.

**Miscellaneous.** (a) No student may record or tape any classroom activity without my express written consent (see "Disability Resources," below).
(b) The use of electronic devices during lecture is forbidden. The use of tablets for the purpose of note taking and downloading the course material might be allowed at my discretion.

*Homework, Quizzes, and Tests*

**Homework.** Homework assignments (approximately 8) will be posted on the course website and they will be graded online through `Gradescope`. You will need to provide a clean, easily readable scan of your assignment, either through the use of a scanner or your phone. Homework assignments that are turned in late will not be graded. You will receive a null grade to unintelligible solutions. Homeworks will be graded for correctness and not effort, but partial credit will be given for legitimate attempts. No credit will be given for a correct but unjustified answer. You must bring any missing homework score to my attention within one week of the homework being graded, so check your grades on Canvas often. Feel free to discuss homework assignments with others, but realize that the work you hand in must be your own. Simply copying someone else's work (or any solutions floating around on the web, dark sectors or otherwise) is plagarism; see "Cheating" below.

**Quizzes.** There will be several in-class quizzes. A typical quiz is meant to take 10-15 minutes and will be given at the beginning of class. Calculators will not be allowed for quizzes. All quizzes are closed book and closed notes. The main purpose of the quiz is to test your general understanding of the subject.

**Tests.** There will be three tests. Like the quizzes, all are closed book and closed notes, and calculators are not allowed. Each test covers all the material covered in class. For instance, Test II will cover also Test I's topics.

**Important remarks.** (a) If you cannot take a test at its scheduled time or date, please let me know at least one week beforehand.
(b) If you miss a test without previously contacting me, and/or without having your advisor previously contact me, it cannot be made up.
(c) I will not grant last-minute accommodations because you are sick or because of an emergency without the explicit written/emailed consent of your academic advisor. Contact your advisor first,

and have your advisor contact me directly.

*Miscellaneous*

**Grading.** In this course, we will be using `Gradescope` (as a plug-in tool within Canvas) to grade and provide feedback on homework, quizzes, and exams. This will allow the grader to provide more effective feedback, and it promotes fairer grading practices by facilitating anonymous grading and question-by-question (rather than student-by-student) grading. You will be able to access and review all your (graded) work. To access `Gradescope`, simply log on to our courses Canvas site and click on "Gradescope" in the left navigation menu. Further information on how to use `Gradescope` will be forthcoming as it is received.

It is imperative that you submit high-quality scans of your work, or a LaTeXversion of your work. For instance: if you are writing out your answers by hand, be sure to use a dark pencil and pen, and write clearly; and make sure you scan all pages. Be sure to give yourself extra time at homework deadlines, for instance, to scan your materials. In the end: if a grader cannot see or read your answer to a particular problem, you will get a zero for that problem.

**Cheating.** Cheating or plagarism on homework, quizzes, or tests will be dealt with as allowed under CMU policies: `http://www.cmu.edu/policies/student-and-student-life/academic-integrity.html`. Note that if a problem happens to be a reused one and you copy from a previously posted solution set, you will receive a grade of zero for the assignment the problem is on.

**Disability Resources.** If you require a special accommodation, such as more time to finish exams, please visit the Office of Disability Resources (`https://www.cmu.edu/disability-resources/`) to obtain appropriate documentation. I will make no allowances without documentation.

**Email.** All course-related email should be sent to `rfogliat@andrew.cmu.edu`. I will attempt to respond to it quickly, if it is appropriate to do so. Sending email does not shift any responsibility from you to me; you are still responsible for completing your assignments. In particular, do not send complicated questions or requests via email; replies will not be given for email questions or problems requiring lengthy (more than a couple of sentences) or complicated responses. These types of communications should be done in person. Email communications between you and the instructor/TA must be polite, respectful, and written in clear English.

**Final Grade.** Your lowest grade in the homework assignments and in the quizzes will be dropped. Letter grades will be determined according to the cutoffs (non-integer scores will be rounded) in the table below.

**Grading**

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|---|---|
| Test I | 20% |
| Test II | 20% |
| Final Test | 20% |
| Quizzes | 10% |
| Homework | 30% |

**Letter grades**

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|---|---|
| A | >90% |
| B | 80–89% |
| C | 70–79% |
| D | 60–69% |
| R | <60% |

Depending on the performance of the class, the scale used to determine the final letter score may be curved.

You must receive a C or higher in this course to be eligible to take 36-226 or 36-410.

**Important dates.** The university calendar for the academic year 2018/2019 is available here:
`http://www.cmu.edu/hub/calendar.html`
Make sure to mark on your calendar the following dates.

| Week | Date | What's Happening |
|---|---|---|
| 2 | 27 May (M) | Memorial Day (no classes) |
| 2 | 31 May (F) | Test I |
| 4 | 14 Jun (F) | Test II |
| 6 | 28 Jun (F) | Final Test |
| 1-6 | Wednesdays | Quiz |

## Take care of yourself

Take care of yourself. While classwork might be stressful and tiring, remember to get enough sleep and take time to relax.

If you or anyone you know needs support, consider reaching out to me or to somebody that you trust. Alternatively, Carnegie Mellon has many helpful resources, such as Counseling and Psychological Services (CaPS; 412-268-2922 or `http://www.cmu.edu/counseling/`) or the Re:solve Crisis Network (888-796-8226). If you or someone you know is in a life-threatening situation, however, forego these resources and call the police immediately (8-2323 on campus, 911 off campus).