# Math 40011/50011-001: Probability Theory and Applications

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Office: MSB 372

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Class Hours: TR 2:15-3:30 p.m.
Class Room: *online*

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## Course Description

Probability provides a principled way to quantify uncertainty and randomness. This course introduces the foundational concepts of probability and its applications. Topics include: sample spaces and events, counting, conditional probabilities, Bayes' theorem, random variables, univariate distributions (expectation and variance, Normal, $t$, Binomial, Negative Binomial, Hypergeometric, Geometric, Poisson, Beta, and Gamma distributions), multivariate distributions (joint and conditional distributions, independence, transformations, and Multivariate Normal distribution), law of large numbers, central limit theorem.

## Prerequisites

You should have completed Math 22005 or Math 32051 with a grade of C or better. If you are enrolled in 50011, you must have a graduate standing in Mathematics. Students who do not have the proper prerequisites risk being deregistered from the class. Please contact the instructor if you would like to take the course, but do not satisfy the prerequisite.

## Textbook

J. K. Blitzstein and J. Hwang. *Introduction to Probability, Second Edition*. CRC Press, 2019. (Available online at http://probabilitybook.net/)

## Course Format

The course is offered remotely during August 27, 2020-December 13, 2020. There are recorded video lectures every week. The videos and associated notes will be available on Blackboard. Each week, the instructor will hold online meetings through Blackboard Collaborate Ultra at class hours (i.e., TR 2:15-3:30 p.m.), to answer questions and/or discuss extra examples.

# Course Policy

Important policy for this course is detailed below.

## Grading

Grades will be calculated as follows:

- Homework assignments: 30%
- Midterm exam 1: 20% (Thursday October 1)
- Midterm exam 2: 20% (Thursday November 12)
- Final exam: 30% (Tuesday December 15)

The final letter grades will follow the usual scale: A=90-100; B=80-89; C=70-79; D=60-69; F=0-59. Plus and minus grades will be given at discretion of the instructor.

## Homework

There will be approximately 6 homework assignments that will be posted on Blackboard. Assignments must be uploaded to Blackboard as a **PDF** file. You can either type your homework solutions or write them on papers and upload the scanned version. In any case, please make sure your work is clearly presented.

Assignments are due at the beginning of class hour on the specified date. In general, **NO** late submissions will be accepted. In case of truly exceptional situations (e.g., family emergencies or illness), the instructor may make exceptions and allow late submission. The lowest homework score will be dropped at the end of the semester.

## Exams

There will be three exams: two midterm exams and one comprehensive final exam (dates mentioned above). Each exam will be posted on Blackboard at 12:00 p.m. on the exam day, and you have to upload your solutions as a **PDF** file to Blackboard by 11:59 p.m. the next day (so you have one and a half days to work on the exam). You can either type your solutions or write them on papers and upload the scanned version. In any case, you should make sure your work is clearly presented. Each exam will take approximately 2 hours to finish, but you can spend as much time as you want during the period. The exams are open-book, so you can consult the textbook, notes, etc. during the exam. However, **you are not allowed to discuss with other students and the submitted work must be your own**.

## Re-grades of Homeworks and Exams

All re-grading requests should be made in writing, within one week after receiving a grade. The request should state the specific question that needs to be re-graded, as well as a short explanation of why re-grading is necessary. The new grade may be lower than the original grade.

## Academic Integrity

University policy 3-01.8 deals with the problem of academic dishonesty, cheating, and plagiarism. None of these will be tolerated in this class. The sanctions provided in this policy will be used to deal with any violations. If you have any questions, please read the policy at http://www.kent.edu/policyreg/administrative-policy-regarding-student-cheating-and-plagiarism and/or ask.

## Accommodations for Students with Disabilities

Kent State University is committed to inclusive and accessible education experiences for all students. University Policy 3342-3-01.3 requires that students with disabilities be provided reasonable accommodations to ensure equal access to course content. Students with disabilities are encouraged to connect with Student Accessibility Services as early as possible to establish accommodations. If you anticipate or experience academic barriers based on a disability (including mental health, chronic medical conditions, or injuries), please let me know immediately.

Student Accessibility Services (SAS) Contact Information:

- Location: University Library, Suite 100
- Email: sas@kent.edu
- Phone: 330-672-3391; VP 330-968-0490
- Web: www.kent.edu/sas

## Registration Requirement

The official registration deadline for this course is September 2, 2020. University policy requires all students to be officially registered in each class they are attending. Students who are not officially registered for a course by published deadlines should not be attending classes and will not receive credit or a grade for the course. Each student must confirm enrollment by checking his/her class schedule (using Student Tools in FlashLine) prior to the deadline indicated. Registration errors must be corrected prior to the deadline.

## Withdrawal

The last day to drop without a grade of "W" is September 9, 2020. The last day to withdraw this course is November 4, 2020. Other important Registrar dates can be found at http://www.kent.edu/registrar/registrar-dates-term.

## Tentative Schedule

The schedule is subject to change and will be updated at the course website (tsunghengtsai.github.io/prob-F20), so please check it regularly.

### Week 01, 08/24 - 08/28: Syllabus

*Class begins on August 27.*

### Week 02, 08/31 - 09/04: Probability and Counting

Topics:

- Sample spaces, naive definition of probability, counting
- General definition of probability
- Axioms of probability, properties of probability, inclusion-exclusion

### Week 03, 09/07 - 09/11: Conditional Probability

Topics:

- Definition of conditional probability
- Bayes' rule, law of total probability
- Independence of events, conditional independence

### Week 04, 09/14 - 09/18: Random Variables and their Distributions

Topics:

- Random variables
- Probability mass functions (PMFs), cumulative distribution functions (CDFs)
- Bernoulli, Binomial and Hypergeometric distributions
- Independence of random variables

### Week 05, 09/21 - 09/25: Expectation

Topics:

- Expectations and variances
- Linearity
- Geometric, Negative Binomial and Poisson distributions
- Law of unconscious statistician (LOTUS)

### Week 06, 09/28 - 10/02: Midterm I

*Exam due 11:59 p.m. on October 2 (handed out 12:00 p.m. noon on October 1)*

### Week 07, 10/05 - 10/09: Continuous Random Variables

Topics:

- Discrete vs. continuous distributions
- Probability density functions (PDFs)
- Uniform and Normal distributions

### Week 08, 10/12 - 10/16: Moments

Topics:

- Exponential distribution, memoryless property
- Moment generating functions (MGFs)
- Generating moments with MGFs

### Week 09, 10/19 - 10/23: Joint Distributions

Topics:

- Joint, conditional, and marginal distributions
- Covariance, correlation
- Multinomial and Cauchy distributions

### Week 10, 10/26 - 10/30: Transformation

Topics:

- Transformations, convolutions
- Beta and Gamma distributions
- Order statistics

### Week 11, 11/02 - 11/06: Conditional Expectation

Topics:

- Conditional expectation
- Adam's law, Eve's law

### Week 12, 11/09 - 11/13: Midterm Exam II

*Exam due 11:59 p.m. on November 13 (handed out 12:00 p.m. noon on November 12)*

### Week 13, 11/16 - 11/20: Inequalities and Limit Theorems

Topics:

- Inequalities (Cauchy-Schwarz, Jensen, Markov, Chebyshev)
- Law of large numbers

- Central limit theorem
- Chi-square, Student-$t$, Multivariate Normal

### Week 14, 11/23 - 11/27: Thanksgiving Break

*No class*

### Week 15, 11/30 - 12/04: Markov Chains

Topics:

- Markov chains, transition matrix, stationary distribution
- Google PageRank as a Markov chain

### Week 16, 12/07 - 12/11: Final Review

Topics:

- Review
- A look ahead

### Week 17, 12/14 - 12/18: Final Exam Week

*Exam due 11:59 p.m. on December 16 (handed out 12:00 p.m. noon on December 15)*