STA 130A: Mathematical Statistics: Brief Course

Lecture 1: Introduction and Overview

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Fall 2026, UC Davis

Agenda

- Course overview
- Course logistics, syllabus, and calendar
- A first look at probability: models, outcomes, and events

A motivating dialogue

A: Hey, I have a coin. What is its probability of heads if I toss it once?

B: I don't know, but we will know once you toss it.

A: Yes, but what is the probability that the next toss will be a head?

B: Each toss is different, so we have to wait and see.

A: Ok, out of 100 tosses, on about how many tosses would you expect heads?

B: I told you, sometimes heads, sometimes tails.

A: Suppose I tossed it 100 times and got 60 heads. What is its probability of heads?

B: I would estimate it as $60/100 = 0.60$.

A: Does that mean the next 100 tosses will also give exactly 60 heads?

B: Who knows? The number of heads will vary from sample to sample.

A: How much could the estimate vary? Would more tosses help?

B: ... stop it. Perhaps we need a probability model to quantify that uncertainty.

Probability and statistical inference

Probability is a mathematical language for reasoning under uncertainty

- Long-run relative frequency (of certain outcomes)
- Subjective belief: May not involve repeated trials or reflect instantiated frequency

Either way, both interpretations use the same mathematical rules of probability

Probability and statistics ask complementary questions:

- **Probability:** Given a model, what outcomes should we expect?
  - If a coin is fair and tosses are independent, how likely are exactly 60 heads in 100 tosses?
- **Statistical inference:** Given data, what can we learn about the model?
  - After 60 heads in 100 tosses, how should we estimate the probability of heads p?
  - How can we describe the uncertainty in that estimate?

We will use probability to understand **sampling variability**, then develop **point estimates and confidence intervals**

STA 130A and objectives

STA 130A introduces probability and the foundations of mathematical statistics

- **First part**: probability models, random variables, and limit theorems
- **Second part**: sampling distributions, estimation, and confidence intervals

By the end of the course, you should be able to:

- Translate a question involving uncertainty into a probability model
- Calculate probabilities, expectations, and measures of variability
- Estimate unknown parameters and interpret confidence intervals

Our focus is on understanding **how and why the methods work**

- Connect probability models to the formulas we use
- Explain what a result means and when its assumptions are appropriate

Course logistics

- **Instructor:** Dogyoon Song
  - Email: dgsong@ucdavis.edu
  - Office hours: TBA
- **TA:** Dongchan Kim
  - Email: dockim@ucdavis.edu
  - Office hours: TBA
- **Lectures:** Mon/Wed/Fri 11:00–11:50 AM at Wellman Hall 226
- **Discussions:** Tue 11:00–11:50 AM (Hart 1130) / 12:10–1:00 PM (Olson 147)
- **Online platforms**
  - Course webpage: Lecture notes, homework, and supplementary materials
  - Canvas: Homework submission, solutions, grades, and discussion materials
  - Piazza: Announcements and discussion
  - Email: Private matters only (please **do not** message on Canvas)

Course content & prerequisites

Course content:

- Probability basics
- Discrete and continuous random variables
    - Distributions, expectation, and variance
    - Joint and conditional distributions
    - Moment generating functions
- Limit theorems
    - Markov and Chebyshev inequalities
    - The (weak) law of large numbers
    - The central limit theorem
- Sampling distributions and estimation
    - Chi-square, t, and F distributions
    - Point estimates and confidence intervals

Prerequisites (C- or better):

- One of MAT 016C, 017C, 019C, or 021C
- One of STA 013/013V/013Y, 032, 035B, or 100

These prerequisites are enforced

- If you don't meet prerequisites, please submit a petition ASAP
- Try "Homework 0" for a quick self-assessment

Syllabus walkthrough

Open the Fall 2026 syllabus and follow along:

1. **Basic information (p. 1)**
   - Course staff, meeting times, and course platforms
   - Textbooks: (1) Bertsekas and Tsitsiklis, *Introduction to Probability*, **2nd ed.**; (2) Rice, *Mathematical Statistics and Data Analysis*, **3rd ed.**
2. **Course topics and assessment (pp. 2–3)**
   - Topic sequence, grading scheme, and exam policies
3. **Homework (p. 3)**
   - Submit a single PDF with your written solutions, typed or scanned
4. **Course policies (p. 4)**
   - Discuss ideas and list collaborators, but write your own solutions
   - **AI assistance on graded work is prohibited**
5. **Getting help (p. 5)**
   - Piazza and office hours for course questions, email for private matters
   - If needed, submit SDC accommodation requests early

Grading

- **Homework**: 30%
  - 7 assignments (excluding HW 0), with the best six scores counting
  - Released on scheduled Fridays, due the following Thursday at 11:59 PM PT
    - Exception: HW 7 is due **Tue, Dec 1**
  - **No late homework accepted for any reason**
- **Midterm exams**: 30%
  - Two in-class midterms (**Mon, October 19 & Mon, November 9**)
  - Only the higher score counts (the lower is dropped)
  - **No make-up exams**; a missed midterm receives 0 and can be the dropped score
- **Final exam** (cumulative): 40%
  - **Mon, Dec 7, 3:30–5:30 PM**
- **Participation**: up to 3 **percentage points** extra credit
  - Up to 2 for lecture participation, plus up to 1 on the TA's recommendation

See syllabus for full details

Fall 2026 calendar at a glance

Date	Event
Wed, Sep 23	First lecture
Mon, Oct 19	**Midterm 1, in class**
Mon, Nov 9	**Midterm 2, in class**
Wed, Nov 11	**Veterans Day holiday: no lecture**
Wed, Nov 25	**No STA 130A lecture (course schedule)**
Thu–Fri, Nov 26–27	**Thanksgiving holiday: no discussion or lecture**
Tue, Dec 1	HW 7 due at 11:59 PM PT (exception)
Fri, Dec 4	Last lecture
Mon, Dec 7	**Final exam, 3:30–5:30 PM**

See the syllabus for the homework calendar (all times are Pacific Time)

Getting ready: Homework 0 and course materials

- **Homework 0: self-assessment**
  - Review calculus and introductory statistics, including confidence intervals
  - Problem 4 on double integrals and changes of variables is an **optional preview**
  - Not collected or graded. No solutions will be provided
  - Bring questions to discussion (**Tue, Sep 29**), or to office hours
- **Textbook access**:
  - Find both textbooks in the Canvas Reading List
  - Probability: selected material from BT Chapters 1–5
  - Statistics: Rice Chapter 6 and selected material from Chapter 8
- **Before HW 1**:
  - Check access to Canvas and Piazza

Probability in everyday examples

- Fair coin toss
  - Possible outcomes are Head or Tail; each has probability 0.5
- Fair six-sided die roll
  - Possible outcomes $\{1, 2, \ldots, 6\}$; each has probability $1/6$
- US childbirths[1]
  - About 51.2% of live births in 2023 were recorded as male, and 48.8% as female
  - For a uniformly selected birth from these records, $P(\text{recorded male}) \approx 0.512$
- Commute time
  - Commute may take 30 minutes on average, but can vary with traffic, weather, etc.
- Subjective probabilistic beliefs
  - You may personally estimate the likelihood of a stock price rising or falling, based on your own analysis or expert opinions
  - A scholar may believe an artifact is authentic with probability 90% and fake with 10%

[1] Source: CDC National Vital Statistics Reports, Births: Final Data for 2023

Formalizing probability (Teaser for next lectures)

- **Outcome:** a possible result of an experiment or trial
- **Sample space**: the set of all possible outcomes, often denoted by Ω
  - e.g., $\{H, T\}$, $\{1, 2, 3, 4, 5, 6\}$
- **Event:** a subset of Ω
  - e.g., for $\Omega = \{H, T\}$: $\emptyset$, $\{H\}$, $\{T\}$, $\{H, T\}$
  - e.g., for $\Omega = \{1, 2, 3, 4, 5, 6\}$: $\{6\}$, $\{1, 2\}$, $\{2, 4, 6\}$, ...
- **Probability[2]:** a map P that assigns a number in $[0, 1]$ to each event such that
  - $P(\Omega) = 1$;
  - For pairwise disjoint events $A_1, A_2, \ldots,$ $P\left(\bigcup_i A_i\right) = \sum_i P(A_i)$

Probability theory makes extensive use of set notation and set operations!

[2] A fully rigorous measure-theoretic formulation is beyond the scope of STA 131A

Where we are headed

- **Throughout the course**:
  - Understand foundational probabilistic concepts and notation
  - Learn common probabilistic models and core analytical tools
  - Practice rigorous mathematical thinking in probability theory
- **Next lecture (Fri, Sep 25) and in the first two weeks**:
  - Set theory and probabilistic models
  - Basic probability laws
  - Counting
- **Before next lecture**:
  - Complete "Homework 0" at your earliest convenience and seek help if needed
  - Read the syllabus and preview BT Sections 1.1–1.2