# STAT 158: Design and Analysis of Experiments

"*To consult the statistician after an experiment is finished is often merely to ask him to conduct a post mortem examination. He can perhaps say what the experiment died of*" – R. A Fisher

**Lectures:** Tuesday, Thursday 12:30 – 2pm

**Lab:** Friday 2-4pm
Friday 4-6pm

**Instructor:** Elizabeth Purdom
Office: 433 Evans Hall
Phone: 642-6154 (office)
Email: epurdom@stat.berkeley.edu
Office Hours: Wednesday 1:30 – 3:30pm

**GSI:** Yuval Benjamini
Email: yuvalb@stat.berkeley.edu
Office Hours: Monday 12-2pm, 387 Evans

## Topics:

- Analysis of variance and hypothesis testing
- Randomization
- Factorial designs
- Blocking
- Repeated Measures / Split-plot designs
- Unbalanced Data
- Response surface methodology
- Computer Experiments

## Textbook:

*Introduction to Design and Analysis of Experiments*, G.W. Cobb

Additional supplementary material will be made available through bspace.

## Prerequisites:

STAT 134 and 135 (or consent of instructor). Statistics 135 may be taken concurrently. Statistics 133 is recommended.

## Lab:

Lab time will be spent working on practice problems, how to conduct data analyses in R, and also running experiments.

We assume familiarity with R. If you do not have experience with R, in the first week you should go through online introductions to the programming language (see resources on bspace).

Lab is required. Note that the lab of Apr. 22 will have experiments run during lab necessary for student projects and it is critical that everyone attend.

## Class Activities:

For many designs we will conduct an activity or demonstration in class or section. These will be used to highlight key concepts in design of experiments and therefore class attendance will be important for full understanding. Handouts given in class deal with in-class activities and discussions and will generally not be posted online, unless they cover material not in the book.

## Course Work:

Homework

Homework will be posted to bspace, and will generally be due two weeks later. All homework is due **in lecture**. There will be 6 homework assignments. Homeworks will be a combination of computational exercises and data analysis using the computer. Late homeworks will not be accepted.

Project

There will be one semester-long project where you will conduct your own experiment. It will be done in small groups. The project will be broken up into two parts: an pilot experiment using a factorial design to explore your proposed question and then based on these results a larger more complicated final experiment will be proposed and run. The project will have intermediate steps along the way to help you pace yourself and make sure that your experiment is progressing successfully. The pilot and final project will each be written up. Your grade will be based largely on the two writeups, though the intermediate steps are required and if missed will effect your grade adversely.

You will be graded on the quality of the writeup as well as the quality of the design and analysis. You will not be graded on the outcome of the experiment.

If you feel that there is a problem in your group with regards to how the project is going -- fairly distributing work, etc. -- you may discuss it with me privately so as to find an equitable solution with respect to finishing the project as well as assigning grades.

Helicopter experiment

The last homework will be based on an experiment run partially during the class during the last two weeks (the Helicopter experiment). It is required that you attend these classes unless you discuss with me in advance. While much of the experiment will be run during the class, the experiment will also require outside work as well as a writeup.

Exams

There will be a midterm (March 7$^{th}$ in class) and a final exam (May 16$^{th}$, 3-6pm), each of which will count equally.

Overall score

Your letter grade for the course will be based on the total points for all work in the semester.

- Homework (6): 30%
- Project: 35%
- Exams: 35%

## Policies

*Late Assignments*

Late assignments will not be accepted except with my personal approval, which will be only given for truly extenuating circumstances. I expect any requests to be done as timely as possible.

*Email*

1) If you wish for your email to make it into my inbox, the subject of your email must contain the text "158"
2) I do not explain material over email and will not respond to emails with such requests. Please come to office hours, discussion section, or GSI's office hours (or schedule another time to meet if you have irreconcilable conflicts with the office hours).
3) I respond to email regarding the class roughly once a day, and almost never in the evening nor weekend.

*Academic Honesty Policy*

In fairness to students who put in an honest effort, cheaters will be harshly treated. Any evidence of cheating will result in a score of zero (0) on the **entire** assignment or examination.

Homework must be done independently. If a homework is based on an experiment run in class or section, only the experimental results can be done jointly; answering HW questions about the experiment must be done independently. Obtaining and/or using solutions from previous years or from the internet, if such are available, is considered cheating.

For projects students naturally will work with the students in their group, but no other students.

For exams cheating includes, but is not limited to, bringing notes or written or electronic materials into an exam or quiz, using notes or written or electronic materials during an exam or quiz, copying off another person's exam or quiz, allowing someone to copy off of your exam or quiz, and having someone take an exam or quiz for you.

Incidences of cheating will be reported to Student Judicial Affairs, which may administer additional punishment.

*Disability*

If you need accommodations for any physical, psychological, or learning disability, please speak to me after class or during office hours.

# Syllabus

The following is only a guide, and there is likely to be slight variation as the semester progresses.

The reading described below is a guide to where the relevant material can be found in the book for the subjects described under 'Topic.' It is not a prescription to when **you** should actually read the material; that is left to your discretion.

*†=may not get to topic  *=reading not from book, available on bspace*

| Week | Topics | Class Experiment | Assigned Reading | Assignments Due |
|---|---|---|---|---|
| Jan 21 | Course Logistics<br>Components of an Experiment | Tea Tasting Experiment<br>Anchoring Experiment (in class) | Cobb: 1.1, 4<br>2 NY Times Articles* | |
| Jan 28 | Hypothesis Testing<br>Comparison of two conditions | | Rice, Ch. 11* | |
| Feb 4 | Factors<br>Randomized, Balanced Designs (CR[1]) | | Cobb: 3, 5 | **Tu:** Hw Due<br>Th: Sign up for Groups |
| Feb 11 | Randomized, Balanced Designs with 2 factors (CR[2]) | Rotated J experiment (in section and class) | Cobb: 2, 6 | Th: Hw Due |
| Feb 18 | Factorial Crossing and Factorial designs ($2^3$ and fractional) | | Cobb: 9.1-2<br>Montgomery 7.1-4, 9.1-2*<br>Czitrom article | Th: Initial Proposal due |
| Feb 25 | How many subjects? Power calculations and simulations | | Lenth articles*<br>NO SECTION | Th: Hw Due |
| Mar 4 | Review and Midterm | | | |
| Mar 11 | Blocking designs | | Cobb 1.2-3, 7 | Th: Pilot Writeup Due |
| Mar 18 | Split plot/Repeated Measures (SP/RM)<br>Combining designs | Needle Experiment (in section) | Cobb: 7, 8, 9.3, 13.1 | Th: Hw Due |
| Mar 25 | SPRING BREAK | | | |
| Apr 1 | Detailed Look at Fisher Assumptions and alternatives to F-test | | Cobb: 12<br>Permutations handout* | Tu: Final Proposal |
| Apr 8 | Comparisons, Contrasts and Confidence Intervals | | Cobb: 11.1-3 | Th: Hw Due |
| Apr 15 | Regression and Unbalanced designs† | | Cobb: 14.1<br>Handout* | Th: Protocol Due |
| Apr 22 | Response Curve Methodology | Helicopter (in class) | Stat Labs, Ch. 12* | |
| Apr 29 | Computer experiments† | | Levy article* | Th: HW Due |
| | Final Experiment Writeup Due: Th, May 9th | | Final Exam: Th. May 16, 3-6pm | |