

# Statistics 263/363: Experimental Design

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1:30–3:00 Monday & Tuesday

[statweb.stanford.edu/~owen/courses/363](http://statweb.stanford.edu/~owen/courses/363)

and canvas

To gain understanding from data, we must work against: noise, bias, correlation, interaction and missingness. Often there is nothing we can do about some of those things, because we are just handed data with flaws embedded. Choosing or designing the data gives us much better possibilities. We all know that “correlation does not imply causation”. Without a causal understanding, all we can do is predict outcomes, not confidently influence them. Injecting randomness into the independent variables provides the most convincing way to establish causality (though it is not perfect).

Experimental design is the science of choosing how to gather data. It has a long and continuing history spanning: agriculture, medicine and public health, education, engineering, computer experiments, A/B testing in e-commerce and more.

The design problem forces the statistical investigator to think carefully about the underlying domain topic, its assumptions and costs, benefits, goals and prior history, even more than analyzing prior data does.

## Pre-requisites

Completely deep and thorough understanding of basic probability (e.g. stat 116) and data analysis by regression. You should know those things well enough to explain them to other people, not just have a nodding acquaintance. You should also be able to write your own functions in R or python or Matlab or similar, and make basic use of R. Spreadsheets are not adequate.

## Evaluation

Homework 50%, midterm 25%, project 25%. The project involves carrying out an experimental investigation and writing it up.

## Course materials

They will all be online linked from the web page above or posted to canvas.

## Level

This is a hybrid MS/PhD course. Lectures are at the PhD level. Evaluation is at the MS level. Some of the material touches on open problems and research areas.

## Lecture topics

If we get one or two guest lectures then we will bump or move one of the more specialized lectures to work with the guest's schedule.

Sep 20	Introduction and Neyman-Rubin causal model
Sep 22	A/B testing in online settings
Sep 27	Bandits: upper confidence levels and Thompson sampling
Sep 29	Paired and blocked experiments. Randomization analysis
Oct 04	Factorial experiments: fixed/random/mixed effects. ANOVA tables.
Oct 06	$2^k$ factorial experiments
Oct 11	Fractional factorials
Oct 13	Adjusting for pre-treatment variables and ANCOVA, crossovers
Oct 18	Split plots and cluster randomized trials
Oct 20	Taguchi methods (robust design)
Oct 25	Catchup or summary or guest topic and review
Oct 27	Midterm on material up to class of Oct 18
Nov 01	Designs for response surfaces
Nov 03	Design for $p \gg n$ regression (Hadamard, random balance)
Nov 08	Computer experiments 1
Nov 10	Computer experiments 2
Nov 15	Guest one
Nov 17	Guest two
Nov 29	Experimental / observational hybrids
Dec 01	Summary and voluntary project presentations