STA305H1S/STA1004HS, LEC0201, Winter 2018
Design of Scientific Studies

Instructor: Prof Mark Ebden
Email: mark.ebden@utoronto.ca
Office: SS 6027 CLTA
Office hours: Tuesdays from 3-4 pm, by appointment (click here)

Teaching Assistants: Lu, Debby, and Bo
Office hours in SS B623, at times to be described on the 'Contacts' page in Portal.

Course webpage: Accessible through the learning portal: https://portal.utoronto.ca
Course materials provided on Portal are for the use of students currently enrolled in this course only. Providing course materials to anyone outside of the course is unauthorized use.

Classroom sessions: Tuesday 13:00-14:00 and Thursday 16:00-18:00, in OI G162, from Thursday 4 January to Tuesday 3 April

Course Content

This course will provide an introduction to the fundamental concepts of the design of scientific studies including the design of experiments and observational studies. Students will be become acquainted with statistical methods used to design and analyze experiments and observational studies. In particular this course will cover: experiments versus observational studies, clinical-trial design, comparing several groups using a completely randomized design, randomized blocks, Latin squares, incomplete block designs, factorial designs, causal inference in randomized studies and non-randomized studies, and adjusting for selection bias using propensity-score methods.

The learning objectives of this course are:

- Understand the ideas, principles, and considerations that are common to the design and analysis of scientific studies including the statistical design of experiments and observational studies.
- Develop a statistical toolbox of methods for the design and analysis of experiments and observational studies.
- Identify appropriate uses and interpretations of experimental designs, and observational studies, including their strengths and limitations.

Topics

Experiments, observational studies, and causal inference: Experiments versus observational studies, and causal inference in randomized experiments.

Selection Bias in Observational Studies: Causal inference in randomized experiments versus observational studies. Introduction to the propensity score and three ways to use the propensity score to adjust for selection bias: matching, sub classification, and direct regression adjustment.

Probability and Statistics: Mathematical statistics used in experimental design.

Comparing Several Groups: Comparing several groups in an experimental setting or observational setting and deciding whether differences that are found are likely to be real or due to chance.

Design of Clinical Trials: The design and analysis of clinical trials with continuous or binary variables will be introduced.

Blocking techniques: Blocked designs, Latin squares, randomized incomplete block designs.

Factorial Designs: Factorial, blocked factorial, and fractional factorial designs will be discussed.

Split-unit designs: Split-unit designs will be discussed as an example of restricted randomization in the design of experiments. *If time permits*

Textbooks

There are **no required textbooks** for this course. The following books in the U of T library system are listed in decreasing order of relevance:

1. *Statistics for Experimenters: Design, Innovation, and Discovery.* Box, G.E.P., Hunter, J.S., Hunter, W.G. Wiley 2nd Ed. 2005
2. *Experiments: planning, analysis, and optimization*. Wu, C.F.J., Hamada, M.S. Wiley, 2009, 2nd ed.: http://go.utlib.ca/cat/8598479
3. *Causal inference for statistics, social, and biomedical sciences*. Imbens and Rubin. Cambridge University Press, 2015. http://go.utlib.ca/cat/10127748
4. *Design and Analysis of Experiments*. Dean, A., and Voss, D. Springer. 1999. UofT link to electronic copy: http://go.utlib.ca/cat/2573215
5. *Design of Observational Studies*. Rosenbaum, P. R. Springer 2010. UofT link to electronic copy: http://go.utlib.ca/cat/7890274
6. *Data Analysis Using Regression and Multilevel/Hierarchical Models*, Gelman and Hill, 2007
7. *Clinical Trial Design: Bayesian and Frequentist Adaptive Methods*, G. Yin, 2012.

One copy of reference 1 is on reserve at the Mathematical Sciences Library (Room 6141, 40 St George Street) while this course is running. A small number of copies may be available for purchase at the UofT Bookstore for about $160 each.

Most of references 2 through 7 are available electronically through the UofT library.

The book *Fundamentals of Statistical Experimental Design and* Analysis by Robert Easterling (Wiley, 2015) tries to provide a folksy overview of key concepts; it's not in the U of T library system, despite a recent request.

Evaluation

Undergraduate and graduate students will be evaluated according to the following marking scheme.

Test(s): 40%
Final exam: 60%

Graduate students will be evaluated at the graduate level according to the University Assessment and Grading Practices Policy.

Term test(s) and exam

You are allowed a one-sided 8-1/2"x 11" (standard letter size) aid sheet on the test(s) and a two-sided aid sheet on the final exam. You must bring your student identification to the test(s) and the final exam. You can keep your aid sheet after the test(s), but not after the exam.

You will not need to know R syntax on the test(s) and exam, but you will need to know how to interpret output from R.

Marking concerns

Any requests to have marked work re-evaluated must be made in writing within *one week* of the date the work was returned. The request must contain a justification for consideration.

Missed Tests

- If a test is missed for a valid reason, you must submit documentation to the course instructor.
- If a test is missed for a valid medical reason, you must submit an original copy of the University of Toronto Verification of Student Illness or Injury form to your instructor within two weeks of the test.
- The form will only be accepted as valid if the form is filled out according to the instructions on the form.
- Important: The form must indicate that the degree of incapacitation on academic functioning is moderate, serious, or severe in order to be considered a valid medical reason for missing the term test. If the form indicates that the degree of incapacitation on academic functioning is negligible or mild then this will *not* be considered a valid medical reason.
- If a test is missed for a valid reason then the final exam will be worth that much more of your final grade.
- Other reasons for missing a test will require prior approval by your instructor. If prior approval is not received for non-medical reasons then you will receive a term test grade of zero.

Computing

We will use R for all examples. R is freely available for download at http://cran.r-project.org for Windows, Mac, and Linux operating systems. For the test(s) and exam, you will need to know how to interpret output from R. We will support the use of R to complete the work discussed in class etc.

R Studio is a good integrated development environment to R. It is freely available at www.rstudio.com/products/rstudio/ and resources such as datacamp.com are quite helpful.

If you wish to use R at UofT then you may like to sign up for a CQUEST account. To get an account and find out more information about using CQUEST go to www.cquest.utoronto.ca

In this course it is assumed that students have never used R before. You will be provided with the R syntax for all examples in lecture, which should be sufficient for you to do the work discussed in class etc.

Calculators

You will need a calculator. Any calculator that has logarithmic functions will be sufficient. Calculators on phones or other devices equipped to communicate with the outside world (for example, through the internet or cellular or satellite phone networks) will not be permitted during the term test(s) and the final exam.

You will see from old midterms that manual calculations are a part of this course.

Online Discussion Board

This term you will have the option to use Piazza for class discussion. If you decide not to use Piazza it will not disadvantage you in any way, and will not affect official University outcomes (e.g., grades and learning opportunities). If you choose not to opt-into Piazza then you can ask questions or discuss course material with the instructor or TAs during office hours.

Please read Piazza's Privacy Policy and Terms of Use, taking time to understand and be comfortable with them. They provide for substantial sharing and disclosure of your personal information held by Piazza. If you decide to participate in Piazza, only provide content that you are comfortable sharing under the terms of the Privacy Policy and Terms of Use.

The Piazza system is catered to getting you help quickly and efficiently from classmates, the TA, and the lecturers. Rather than emailing questions to the teaching staff, we encourage you to post your questions on Piazza. To sign up for the discussion forum, click on the link:
https://piazza.com/utoronto.ca/winter2018/sta305hslec0201

Additional help

Need extra help with the coursework? Here are some options:

- For continued class discussion and questions outside of class, try posting on the discussion forums. The instructor and TAs will be monitoring them
- You can visit the instructor or teaching assistants during their office hours
- You may choose to join (or create) an STA305 Recognized Study Group: www.studygroups.artsci.utoronto.ca
- E-mail should only be used for emergencies or personal matters

How to communicate with your instructor

Questions about course material such as:

- How do I do question 3.7 in this textbook?
- What is standard deviation?
- When is the midterm?

can be posted on the discussion forums. If you are shy, questions can be posted anonymously (so that the author is anonymous to other students but not to the instructors).

For private communication, such as "I missed the test because I was ill," e-mail your instructor.

You may post entirely anonymous feedback here. Nobody will receive this except me, and nobody will know who you are.

Academic integrity

You are responsible for knowing the content of the University of Toronto's Code of Behaviour on Academic Matters at www.governingcouncil.utoronto.ca/policies/behaveac.htm. If you have any questions about what is or is not permitted in this course, please do not hesitate to contact your instructor.

Accessibility needs

The University of Toronto is committed to accessibility. If you require accommodations for a disability, or have any accessibility concerns about the course, the classroom, or course materials, please contact Accessibility Services as soon as possible: accessibility.services@utoronto.ca or http://accessibility.utoronto.ca.

Your responsibilities

The classroom sessions for this class are designed to actively engage you in the course material. We hope you'll find them interesting, challenging, fun, and an excellent opportunity to truly learn the material.