STA 305H1/STA1004H1
Design and Analysis of Experiments/Introductory Experimental Design
Syllabus – Fall 2021

Land Acknowledgement
We wish to acknowledge the land on which the University of Toronto operates. For thousandsof years, it has been the traditional land of the Huron-Wendat, the Seneca, and most recently,the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Instructor

Professor Murari Singh

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Office hours: Zoom link posted on the Quercus (13 -14 h, Tuesdays)

Class Time

Teaching Assistants: TBD

Classrooms:

- Classrooms: MS3153 on Wednesday 13:00-14:00 h

    HS 610 on Friday 13:00-15:00 h

- Online lectures and tutorials via zoom until at least 23 September 2021

Course Content

This course will introduce the fundamental concepts of the design of scientific studies including the design of experiments and observational studies. Students will be becomeacquainted with statistical methods used to design and analyze experiments and observationalstudies. In particular, this course will cover experiments versus observational studies, clinicaltrial design, comparing several groups using a completely randomized design, randomized blocks, Latin squares, incomplete block designs, factorial designs, response surface designs, causal inference in randomized 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; direct regression adjustment.

Probability and Statistics

Mathematical statistics used in experimental design.

Comparing Several Groups

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

Power and Sample Size

Power and sample size will be introduced for several designs. Applications will include the design and analysis of clinical trials with continuous or binary endpoints.

Blocking Techniques

Blocked designs, Latin squares, randomized incomplete block designs.

Factorial Designs

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

Experiments with Random factors

Two factor factorial – random effects models, mixed effects models

Split Plot Designs

Split plot designs will be discussed as an example of restricted randomization in the design of experiments.

Response Surface Methods

Response surfaces of first and second orders - method of steepest ascent, designs and analyses

Course Books

Required

- Taback, N. (2019). Design of Experiments and Observational Studies. (https://scidesign.github.io/designbook/)

Recommended

- Design and Analysis of Experiments, 10th Edition, by Douglas C. Montgomery (John Wiley, 2020).

Optional

1. Statistics for Experimenters: Design, Innovation, and Discovery. Box, G.E.P., Hunter, J.S., Hunter, W.G. Wiley 2nd Ed. 2005

2. Design and Analysis of Experiments. Dean, A., and Voss, D. Springer. 1999. UofT link to electronic copy: http://go.utlib.ca/cat/2573215 (http://go.utlib.ca/cat/2573215)

3. Design of Observational Studies. Rosenbaum, P. R. Springer 2010. UofT link to electronic copy: http://go.utlib.ca/cat/7890274 (http://go.utlib.ca/cat/7890274)

4. Experiments: planning, analysis, and optimization. Wu, C.F.J., Hamada, M.S. Wiley, 2009, 2nd ed.

5. Causal inference for statistics, social, and biomedical sciences. Imbens and Rubin. Cambridge University Press, 2015. http://go.utlib.ca/cat/10127748 (http://go.utlib.ca/cat/10127748)

NB: Textbooks 2,3, 5 are available electronically through the UofT library (i.e., electronic copies of both these textbooks are available at no extra cost)

Course Materials, including lecture notes

Course materials are provided for the exclusive use of enrolled students. Do not share them with others. I do not want to discover that a student has put any of my materials into the public domain, has sold my materials, or has given my materials to a person or company that is using them to earn money. The University will support me in asserting and pursuing my rights, and my copyrights, in such matters.

Evaluation

Students will be evaluated according to the following marking scheme.

Assessment	Weight (undergraduates)	Weight (graduates)	Date	Time
Quizzes (15 minutes each) [5 x 2%]	10%	10%	Dates on Quercus	13:00
Term Test #1	20%	15%	Oct. 13	13:00
Term Test #2	20%	15%	Nov. 24	13:00
Project - Draft Proposal	5%	10%	Dec. 4	TBD
Project - Final Report	15%	30%	Dec. 8	23:59
Final Exam	30%	20%	Scheduled by Faculty	

The tests will be written during class time (13:05 – 14:00) in a location to be announced.

Minimum passing mark

The pass mark is 70% for graduate students and 50% for undergraduates.

Term test

The midterm tests will be Quercus Quizzes and will be available during class time on the test days.
- The tests will have multiple choice and/or short-answer questions. Short-answers may require that you upload R output, hand-written answers and/or short videos of yourself. More details on the test coverage will be posted in our website.

Students who are eligible for special test accommodations will be facilitated through the university's Accommodated Testing Services.

You will not need to know R syntax on the tests 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 to the instructor 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 (e.g., illness or personal emergency), then within one week following the assessment you must fill out the absence declaration form on ACORN and then send me an email.

- If a test is missed for a valid reason then half the weight of the test will be shifted to the other midterm and half will be shifted to the final exam. This case, for the undergraduates the other term test will be worth 30% and the final exam 40%. For the graduates, the weights will be 22.5% for the other term test and 27.5% for the final exam.

- If a student misses **BOTH** term tests for any reason, then an oral exam (https://en.wikipedia.org/wiki/Oral_exam) with members of the teaching team will be scheduled at a mutually convenient time in lieu of the two term tests worth 40% for undergraduates or 30% for graduates.

- Students must complete at least one midterm test or oral exam. If a student misses both midterm tests and does not take an oral exam before the end of term, then a grade of zero will be assigned to the term work.

- Other reasons for missing a test will require prior approval by your instructor. If prior approval is not received for a non-medical reason, then you will receive a term test grade of zero.

Late Project Submission

If the draft/propsal project or final project is submitted after the due date then a late penalty of 20% per day (i.e., 24 hours) will be applied to the part of the project handed in late. For example, if the draft/proposal project is submitted after 5 days (including weekend days) then you will receive a grade of zero for the draft/proposal.

Computing

R

We will use R for all examples. R is freely available for download at http://cran.r-project.org (http://cran.r-project.org) for Windows, Mac, and Linux operating systems. For the tests and exam, you will need to know how to interpret output from R.

RStudio

RStudio is a fantastic integrated development environment (IDE) for R. It is freely available at https://www.rstudio.com/products/rstudio/ (https://www.rstudio.com/products/rstudio/)

I am assuming that students have never used R before. I will provide you with the R syntax for all examples in lecture, which should be sufficient for you to complete the practice problems.

You can access RStudio/R through https://jupyter.utoronto.ca/ as well.

Jupyter Notebook

> *The Jupyter Notebook is an open-source web application that allows youto create and share documents that contain live code, equations, visualizations and narrative text (Ref: https://jupyter.org .)*

R can be run in a Jupyter notebook in any web brwoser by logging into https://utoronto.syzygy.ca (https://utoronto.syzygy.ca) with your UTORid.

To get started using R in a Jupyter notebook see this page (jupyterstarter.html)

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 tests or final exam.

Getting Help

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.

Be sure to read Piazza's Privacy Policy (https://piazza.com/legal/privacy) and Terms of Use (https://piazza.com/legal/terms) carefully. Take time to understand and be comfortable with what they say. They provide for substantial sharing and disclosure of your personal information held by Piazza, which affects your privacy. 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 highly catered to getting you help fast 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:// https://piazza.com/utoronto.ca/fall2021/sta305h1

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 regularly. - You can visit your instructor or the teaching assistants during their office hours.

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 the textbook?

- What is standard deviation?

- When is the midterm?

Can be posted on the discussion forums. Questions can be posted anonymously (so that the author is anonymous to other students but not to the instructors), if desired.

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

Use your utoronto.ca e-mail account to ensure that your message doesn't automatically go to a Junk folder and include your full name and student number.

Religious Accommodation

As a student at the University of Toronto, you are part of a diverse community that welcomes

and includes students and faculty from a wide range of cultural and religious traditions. For my part, I will make every reasonable effort to avoid scheduling tests, examinations, or other compulsory activities on religious holy days not captured by statutory holidays. Further to University Policy, if you anticipate being absent from class or missing a major course activity (such as a test or in-class assignment) due to a religious observance, please let me know as early in the course as possible, and with sufficient notice (at least two to three weeks), so that we can work together to make alternate arrangements.

Students with Disabilities or Accommodation Requirements

Students with diverse learning styles and needs are welcome in this course. If you have an acute or ongoing disability issue or accommodation need, you should register with Accessibility Services (AS) at the beginning of the academic year by visiting http://www.studentlife.utoronto.ca/as/new-registration (http://www.studentlife.utoronto.ca/as/new-registration). Without registration, you will not be able to verify your situation with your instructors, and instructors will not be advised about your accommodation needs. AS will assess your situation, develop an accommodation plan with you, and support you in requesting accommodation for your course work. Remember that the process of accommodation is private: AS will not share details of your needs or condition with any instructor, and your instructors will not reveal that you are registered with AS.

Academic Integrity

All students, faculty and staff are expected to follow the University's guidelines and policies on academic integrity. For students, this means following the standards of academic honesty when writing assignments, collaborating with fellow students, and writing tests and exams. Ensure that the work you submit for grading represents your own honest efforts. Plagiarism—representing someone else's work as your own or submitting work that you have previously submitted for marks in another class or program—is a serious offence that can result in sanctions. Speak to me or your TA for advice on anything that you find unclear. To learn more about how to cite and use source material appropriately and for other writing support, see the U of T writing support website at http://www.writing.utoronto.ca (http://www.writing.utoronto.ca). Consult the Code of Behaviour on Academic Matters for a complete outline of the University's policy and expectations. For more information, please see https://www.artsci.utoronto.ca/current/academic-advising-and-support/student-academic-integrity (https://www.artsci.utoronto.ca/current/academic-advising-and-support/student-academic-integrity) and http://academicintegrity.utoronto.ca (http://academicintegrity.utoronto.ca)

Specific Medical Circumstances

If you become ill and it affects your ability to do your academic work, consult me right away. Normally, I will ask you for medical documentation in support of your specific medical circumstances. The University's Verification of Student Illness or Injury (VOI) form is recommended because it indicates the impact and severity of the illness, while protecting your privacy about the details of the nature of the illness. You can submit a different form (like a letter from a doctor), as long as it is an original document, and it contains the same information as the VOI. For more information, please see http://www.illnessverification.utoronto.ca (http://www.illnessverification.utoronto.ca) If you get a concussion, break your hand, or suffer some other acute injury, you should register with Accessibility Services as soon as possible.

Accommodation for Personal Reasons

There may be times when you are unable to complete course work on time due to non-medical reasons. If you have concerns, speak to me or to an advisor in your College Registrar's office; they can help you to decide if you want to request an extension or accommodation. They may be able to provide you with a College Registrar's letter of support to give to your instructors, and importantly, connect you with other resources on campus for help with your situation.

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, and fun, and an excellent opportunity to truly learn the material.

Tentative Weekly Lecture Schedule

For the exact dates of quizzes and the final, please keep visiting the Course page on the Quercus.

Week	Topics
1. Sep 10	**Welcome and Course Design and implementation overview** Introduction to Observational Studies and Designed Studies/Experiments. **Simple Comparative Experiments:** Overview of: Basic Statistical Concepts of population and sample, Standard distributions, Sampling and Sampling Distributions; Inferences About the Differences in Means (Randomized Designs), Hypothesis Testing, Confidence Intervals; (L1: Lecture notes 1)
2. Sep 15 & 17	(Choice of Sample Size); Inferences About the Differences in Means (Paired Comparison Designs); Inferences About the Variances of Normal Distributions (parametric procedures) Review of Mathematical Statistics (using R codes). Comparing Two Treatments in Completely Randomized Designs, (L2, L3)
3. Sep 22 & 24	(Continued) Power and sample size, power via simulation; via randomization distribution (nonparametric procedures). (L4, L5) Quiz 1 (24 September. Topics covered during 10, 15 & 17 September)
4. Sep 29 & Oct 1	(The above might continue) Introduction to causal inference in randomized experiments; Design of observational studies and propensity scores Quiz 2 (1 October. Topics covered during 22 & 24 September) (L6, L7)
5. Oct 6 & 8	Design of observational studies and propensity scores (L8) **Experiments with a single factor in CRD:** Randomized Plan, Analysis of Variance, Example, **(L9)** Mid-session Teaching and Learning Feedback survey
6. Oct 13 & 15 (Oct 11: Thanksgiving Day)	**Term Test #1: October 13 (Topics covered September 10 – October 6)** (CRD continued) Model Adequacy Checking, Determining the Sample Size; Estimation and testing using regression approach

		(L9, L10)
7.	Oct 20 & 22	Comparing more than two groups, multiple comparisons Nonparametric Methods in the Analysis of Variance, The Kruskal–Wallis Test. (L11, L12) Quiz 3 (22 October. Topics covered during October 8, 15, 20)
8.	Oct 27 & 29	Randomized Complete Block Designs, Latin Squares, Balanced Incomplete Block Designs (L13, L14)
9.	Nov 3 & 5	Factorial designs at two levels; Blocking in factorial designs of type 2^k and 3^k (examples) (L15-16 -17) Quiz 4 (5 November. Topics covered during October 22, 27, 29, November 3)
Nov 8 to 12		**Fall Reading Week – No classes**
10. Nov 17&19		Fractional factorial designs of type 2^{k-p}, 3^{k-p} (L15-16-17)
11. Nov 24&26		**Term Test #2: November 24 (Topics covered during October 6 – November 19)** Random Effects Models, The Two-Factor Factorial with Random Factors, Restricted randomization and split- plot designs. (L18, L19)
12. Dec 1& 3		**Response Surface Methodology** Introduction to Response Surface Methodology, The Method of Steepest Ascent, Analysis of a Second-Order Response Surface, CCD and Box - Behnken designs examples (L20) Quiz 5 (3 December. Topics covered during November 5, 17, 19, 26, December 1) Project Draft proposal: 4 December
13. Dec 8		Project Final report: 8 December Final assessment period