STA305H1S: Design and Analysis of Experiments
LEC0101 & LEC0201 – Winter 2025
Course Syllabus

Instructor Contact Information & Course Details

Instructor: Ismaïla Ba (email: ismaila.ba@utoronto.ca)

Class Schedule: Monday 11:00AM – 12:00PM & Wednesday 11:00AM – 1:00PM (LEC0101).
Tuesday 1:00PM – 2:00PM & Thursday 1:00AM – 3:00PM (LEC0201).

Location for Lectures: GB 248 (LEC0101) & MS 3153 (LEC0201)

Course Website: https://q.utoronto.ca/courses/380361 (LEC0101)
https://q.utoronto.ca/courses/380366 (LEC0201)

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, nonparametric methods, Latin squares, incomplete block designs, square lattices, rectangular lattices, factorial designs, causal inference in randomized and non-randomized studies, and adjusting for selection bias using propensity score methods.

Learning Objectives: By the end of the course, all students should be able to:
1. 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.
2. Develop a statistical toolbox of methods for the design and analysis of experiments and observational studies.
3. Identify appropriate uses and interpretations of experimental designs, and observational studies, including their strengths and limitations.
4. Integrate the application with theory of experimental designs and observational studies using R/Rmd tools.

Prerequisite: STA302H1/ STAC67H3/ STA302H5.

Topics

The following topics will be covered in the course:

- **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, square and rectangular lattices. Statistical analysis of data including nonparametric methods in a few cases.
- **Factorial Designs.** Factorial, blocked factorial, and fractional factorial designs will be discussed.
- **Experiments with Random factors.** Two factor factorial – random effect models, mixed effect models.
- **Split plot designs.** Split plot designs will be discussed as an example of restricted randomization in the design of experiments.

Course Materials

Course Content: We have a Quercus course page for this course. All lecture slides and materials will be posted on this Quercus course page. In addition, any important announcements will also be posted in Quercus. Please make sure to check it regularly.

Textbook: **Required** textbooks are

• Design and Analysis of Experiments and Observational Studies using R, by Nathan Taback (A Volume in the Chapman & Hall/CRC Texts in Statistical Science Series),

• Design and Analysis of Experiments, 10th edition, by Douglas C. Montgomery (Wiley).

Optional textbooks include:

• Statistics for Experimenters: Design, Innovation, and Discovery, 2nd edition, by George E. P. Box, J. Stuart Hunter, William G. Hunter (Wiley),

• Design and Analysis of Experiments, by Angela Dean, Daniel Voss (Springer),

• Design of Observational Studies, 2nd edition, by Paul R. Rosenbaum (Springer),

• Experiments: Planning, Analysis, and Optimization, 3rd edition, by C. F. Jeff Wu, Michael S. Hamada (Wiley), and

• Causal inference for statistics, social, and biomedical sciences, by Guido W. Imbens, Donald B. Rubin.

All of the above textbooks are available through the University of Toronto Library: Link to textbooks

Statistical Software: We will be using the R Statistical Software for performing statistical analyses in this course. R is a free software that can either be downloaded onto your personal computer or used in a cloud environment. We encourage all students to use RStudio through the JupyterHub for University of Toronto. This will allow you to login with your official UofT credentials and use RStudio without the need for a local installation and can be run on any device that has access to an internet connection. More information about using RStudio in JupyterHub will be provided early in the term. R code shown in class will be available on the course page and, along with any additional resources, should be sufficient to complete any assessment involving data analysis.

Course components

In-person Lectures: Lectures will be conducted in person. Slides will be available on Quercus.

Office Hours: Instructor and TAs will hold office hours in a combination of online and in-person formats. The office hour schedule and mode of delivery will be posted on Quercus once finalized. It is recommended that you visit office hours whenever you have a question about the material. It is always important to have material clarified as quickly as possible. Don't wait until the last minute to ask your questions!

Quercus Discussion Board: We will use the Quercus Discussion Board as an online discussion forum, which can be accessed through the Quercus course page. **All questions about course material should be posted here** or asked during instructor or TAs office hours. The instructor and TAs will monitor the board and will help answer questions but students are encouraged to answer posts and help their fellow classmates.

Class communication

How your instructor will communicate with you: All communication will be made through Quercus announcements or during lectures. Please ensure that you check Quercus regularly so you don't miss anything important.

Where to send content questions: We will use the Quercus Discussion Board to collect student questions regarding course content, assignments, etc. All questions should be posted here.

When to email the instructor: The instructor will only respond to emails of a private or sensitive nature. If you email the instructor with content related questions, you will be asked to repost your question on the content board so the answer may benefit all students. Should you need to email the instructor about a sensitive or personal nature, please use your official mail.utoronto.ca email, include your full name and student number. **Include your lecture section (e.g. L0101) in the subject line so it is received by the correct person.** Send all course related emails to sta305@course.utoronto.ca. Please allow up to 48 hours for a reply. Emails will not be monitored on evenings and weekends.

A note on email and discussion board etiquette: Please make sure that you communicate politely and respectfully with all members of the teaching team and your fellow classmates. Written communications can sometimes take a tone other than what was intended (e.g. can come off as dismissive, rude or insulting), so make sure you re-read or read out loud your email/post before sending it to make sure it has the tone you intended. For more tips on respectful communication, see professional communication tips. The Quercus discussion board is a teaching and learning tool and therefore should only be used as such. Any posts that detract from the learning goal of the board will be removed to keep the board a safe space.

Course Work, Examinations & Grading

Assignments: There will be four assignments for this course in total. The assignments will involve both mathematical exercises as well as some computing (using R). Two assignments will be due before the midterm and two after the midterm. You must submit the written work individually. Copying (in whole or in part) the work of another student will not be tolerated and will result in disciplinary action (see Academic Integrity section). Assignment due dates will be specified as soon as questions are released (via Crowdmark).

Midterm Test: There will be one IN CLASS midterm test scheduled on February 14, 2025 from 5PM-7PM. More details will be communicated closer to the test date. The test will account for 35% of the final grade.

Final exam: This will be held during the April exam period and will cover all topics.

Grading Scheme:

Assessment	Date due	Percent
Assignments		
Assignment 1	January 31	5%
Assignment 2	February 28	5%
Assignment 3	March 21	5%
Assignment 4	April 4	5%
Midterm Test	Feb. 14 from 5PM-7PM	35%
Final Exam	Scheduled by FAS	45%
Total		100%

Please note that the last day to drop the course without penalty is March 10, 2025.

Late assessment and extension request policy

Extreme Situations/Prolonged Illness: Should a student be experiencing a prolonged illness or other situation that prevents them from turning in their work, they should immediately contact their instructor and College Registrar to inform them of their situation. They should also submit an Absence Declaration form on ACORN or a Verification of Illness (VOI) form that lists every day during which they were incapacitated and unable to work. These documentations should be sent to sta305@course.utoronto.ca. Accommodations will not be considered without a completed declaration or VOI, and will only be considered for extreme circumstances at the request of the College Registrar.

Accessibility-Related Extension Requests: Students registered with Accessibility Services should notify the instructor as soon as possible if additional time is needed on assessments that are eligible for such accommodation. Please notify the instructor by email of your situation and cc your accessibility advisor in the process. The instructor will work with the accessibility advisor to determine an appropriate accommodation for your situation.

Missed assessment policy

If you experience a prolonged absence due to illness or emergency that prevents you from completing any number of assessments, please contact your College Registrar as soon as possible so that any necessary arrangements can be made.

Missed assignments: There will be no accommodations made for missing the assignments.

Missed Term Test: If a student is experiencing a serious personal illness or emergency on the date of the test, the student **must declare their absence on ACORN and notify the teaching team via email no later than one week after the date of the test.** If a student misses the term test for a valid reason then the weight of the term test (35%) will be shifted to the weight of the final exam. In such case, the weight of the final exam will be 80%.

Regrade requests

Regrade requests will be accepted for all assessments. To be considered, you must clearly identify the question you have concerns about, provide a detailed justification for your concern and make specific references to your answer, the feedback you received and to the relevant course material. All regrade requests must be submitted by email no later than one week after the grade for that assessment is released. No regrade requests will be accepted after this deadline. The instructor reserves the right to re-evaluate the entire assessment (i.e., grades may go up, down, or remain unchanged). Please allow a few weeks for the instructor to process regrade requests.

Intellectual property

Course materials provided on Quercus, including lecture slides, assessments, videos, and solutions, are the intellectual property of your instructor and are intended solely for the use of students currently enrolled in this course. **Sharing these materials with any person or organization outside of the course constitutes unauthorized use and violates copyright**.

Acceptable Uses of Generative Artificial Intelligence

ChatGPT and other generative AI are freely available tools that can perform a variety of functions for us. However, it's important to understand how such tools are allowed to be used in this course. Acceptable uses of generative AI in this course include:

- Editing or rephrasing written work that has already been written by the student to improve the syntax, grammar and overall readability of the work.
- Synthesizing or explaining course concepts while learning and studying to contribute to their understanding of the course material.
- Looking up appropriate syntax of individual R functions for use in a data analysis or for understanding errors that may arise when running R code.

However, the work turned in by students must ultimately be their own and students will therefore be accountable for the work they turn in. Unacceptable uses of generative AI in this course include:

- Copying from any generative artificial intelligence applications, including ChatGPT and other AI writing and coding assistants, for the purpose of completing assignments in this course.
- Producing an entire data analysis, or any other piece of work meant for grades.

In summary, generative AI like ChatGPT can be really helpful in your learning process and to improve skills valued in the workplace. However, it cannot be used as a substitute for learning and material produced from these tools should not be passed off as your own. This would be considered academic misconduct (see below). The instructor therefore reserves the right to ask students to explain their work and their process for creating their assignment.

Academic Integrity

The University treats cases of plagiarism and cheating very seriously. It is the students' responsibility for knowing the content of the University of Toronto's Code of Behaviour on Academic Matters. All suspected cases of academic dishonesty will be investigated following procedures outlined in the above document. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources (see http://academicintegrity.utoronto.ca/). Here are a few guidelines regarding academic integrity:

- Using ChatGPT and other generative AI for any purpose not outlined above.
- Being dishonest when reporting an illness or personal emergency to get an extension or accommodation is an academic offence.
- You may consult class notes/lecture slides during take-home assessments, however sharing or discussing questions or answers with other students is an academic offence.
- Students must complete all assessments individually. Working together is not allowed unless otherwise specified.
- Paying anyone else to complete your assessments for you is academic misconduct.
- Completing assessments for another student is academic misconduct.
- Sharing your answers/work/code with others is academic misconduct.
- All work that you submit must be your own! You must not copy mathematical derivations, computer output and input, or written answers, etc. from anyone or anywhere else. Unacknowledged copying or unauthorised collaboration will lead to severe disciplinary action, beginning with an automatic grade of zero for all involved and escalating from there. Please read the UofT Policy on Cheating and Plagiarism, and don't plagiarise.

Accomodations

The University of Toronto offers academic accommodations for students with disabilities. If you require accommodations, 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.

Tentative Schedule of Topics

Below is a tentative schedule of topics to be covered in class. The schedule is subject to change and modification.

Week (Dates)	Topics
1 (Jan. 6-10)	Introduction to Observational Studies and Designed Studies/Experiments. Review of mathematical statistics
2 (Jan. 13-17)	Comparing two groups via the randomization distribution
3 (Jan. 20-24)	Power and sample size for testing hypotheses on means and proportions
4 (Jan. 27-31)	Power via simulation, via randomization distribution (nonparametric procedures). Introduction to causal inference in randomized experiments
5 (Feb. 3-7)	Design of observational studies and propensity scores
6 (Feb. 10-14)	Review class and MIDTERM TEST
(Feb. 17-21)	READING WEEK.
7 (Feb. 24-28)	ANOVA - Comparing more than two groups, multiple comparisons
8 (Mar. 3-7)	Factorial designs at two levels
9 (Mar. 10-14)	Randomized block designs, Latin Squares, Balanced incomplete Block Designs, Square lattices, Rectangular lattices
10 (Mar. 17-21)	Blocking in factorial designs, fractional factorial designs
11 (Mar. 24-28)	Factorial Designs with Random Factors
12 (Mar. 31 - Apr. 4)	Restricted randomization and split-plot designs
Apr. 9-30	Final assessment period