

STAT 430/830: EXPERIMENTAL DESIGN SPRING 2022

COURSE INFORMATION

Lectures: MW 1:00pm – 2:20pm J.R. Coutts Engineering Lecture Hall (RCH) 101

Tutorials: F 1:30pm – 2:20pm J.R. Coutts Engineering Lecture Hall (RCH) 101

Office Hours: MF 11:30am – 12:30pm (Mondays in-person, Fridays virtual)

INSTRUCTOR INFORMATION

Instructor: Nathaniel T. Stevens

Office: Mathematics 3 (M3) 3143

Email: nstevens@uwaterloo.ca

COURSE DESCRIPTION

This course introduces students to the design and analysis of experiments with emphasis on practical application. Students will become familiar with the fundamental design principles of replication, blocking, randomization, and sequential problem solving. Technical topics include the design and analysis single factor experiments, multi-factor experiments such as full-factorial, 2^k factorial and 2^{k-p} fractional factorial experiments, randomized block designs, and response surface methodology. Students will use the statistical software R throughout the course to appreciate the importance and utility of automating both the design and analysis of experiments.

COURSE OBJECTIVES

Any student who successfully completes this course should be able to:

- Accurately define a problem statement and think critically and methodically about the design of an experiment that can help solve said problem.
- Acknowledge that an experiment is not the most appropriate solution to every problem and understand the limitations of experimentation.
- Describe the advantages of randomization, replication, and blocking in an experimental context.
- Design and analyze single factor, multi-factor, factorial, fractional factorial, randomized block and response surface experiments.
- Demonstrate competence with devising computational solutions to the design and analysis of experiments using R.
- Communicate the results of an experiment in a clear and coherent manner.
- Appreciate the relevance of experimentation in a variety of fields including applied statistics, data science, engineering, physical sciences, social sciences and healthcare.

COURSE TOPICS

1. Experimentation fundamentals
 - PPDAC
 - Replication, randomization, blocking
2. Single factor experiments
 - Two-level experiments (A/B testing)
 - Multi-level experiments (A/B/n testing) + multiple comparison problem
3. Randomized block designs
 - Complete blocks designs and Latin squares
4. Multi-factor experiments
 - Factorial experiments (multivariate tests)
5. Screening Designs
 - Two-level factorial experiments
 - Two-level fractional factorial experiments
6. Response surface methodology
 - Sequential experimentation + method of steepest ascent/descent
 - Response optimization + second order models and designs
7. Use of R (as it pertains to the content listed above)

LECTURES & TUTORIALS

Course content will be delivered via in-person lectures on Mondays and Wednesdays from 1:00-2:20pm (in RCH 101) and via in-person tutorials on Fridays from 1:30-2:20pm (in RCH 101). These sessions will consist of me talking while annotating typeset notes and performing analysis demonstrations in R. All relevant notes, datasets and R files for a given week will be posted on LEARN on Monday of that week. Note that these sessions *will not* be recorded, but annotated versions of the lecture notes *will* be made available.

OFFICE HOURS

On Mondays and Fridays from 11:30am – 12:30pm, I will hold office hours that provide an opportunity for extended discussion about course topics with myself and amongst each other. To respect varying levels of comfort with close, in-person contact, Monday office hours will be held in-person in my office (M3 3143) and Friday office hours will be held virtually via Gather Town. The Gather Town space devoted to office hours may be accessed by clicking the link below.

[CLICK HERE TO ACCESS GATHER TOWN OFFICE HOURS](#)

COURSE HOMEPAGE

The course homepage is on LEARN (<https://learn.uwaterloo.ca>). All course material will be posted here. It is my expectation that you regularly visit this webpage to download course material and receive important announcements.

COURSE COMMUNICATION

Although you may email me (please ensure these come from your “uwaterloo” email address) the primary mode of communication between you, myself, and the TAs will be with Slack, a workplace instant-messaging app. All discussions will take place within the stat430spring2022.slack.com workspace. To join the workspace, click the invite link below, and log in using your “uwaterloo” email address.

[CLICK HERE TO JOIN SLACK FOR STAT 430/830](#)

TEXTBOOK

There is no required textbook for this course. Instead, I will provide written course notes that blend material from the sources listed below. Each of these books is excellent, but it is my opinion that none on their own is sufficient for this course.

You will be assigned weekly readings from my course notes, but if you would like to supplement these readings, feel free to consult these books. Note that the books are ordered on a spectrum from more statistical to more applied.

- *Experiments: Planning, Analysis, and Optimization*, 2nd edition
C.F.J. Wu and M. Hamada, Wiley.
- *Design and Analysis of Experiments*, 10th edition (available for 3hr loan in DC)
D.C. Montgomery, Wiley.
- *Response Surface Methodology: Product and Process Optimization Using Designed Experiments*, 4th edition
R.H. Myers, D.C. Montgomery and C.M. Anderson-Cook, Wiley.
- *Design of Comparative Experiments*
R.A. Bailey, Cambridge
- *Statistical Methods in Online A/B Testing*
G.Z. Georgiev
- *Trustworthy Online Controlled Experiments*
R. Kohavi, D. Tang and Y. Xu, Cambridge.
- *Experiment! Website conversion rate optimization with A/B and multivariate testing*
C. McFarland, New Riders
- *A/B Testing: The Most Powerful way to Turn Clicks into Customers*
D. Siroker and P. Koomen, Wiley.
- *Experimentation Works*
S. Thomke, Harvard Business Review Press

ASSESSMENT

1. Assignments (30%)

- There will be four (4) assignments, each worth 7.5% of your final grade. Assignments will consist of hand calculations, proofs, definitional questions, short answer responses, open-ended communication questions, and analyses in R.
- You will have two weeks to complete each assignment – their release dates and due dates are shown in the table below. Assignments will be submitted electronically via Crowdmark by 11:59pm ET on their due dates.

Assignment	Release Date	Due Date
1	Friday May 6	Friday May 20
2	Friday May 27	Friday June 10
3	Monday June 20	Monday July 4
4	Monday July 11	Monday July 25

- You are expected to complete these assignments **independently** and submit your own work. Cheating is a serious offence and will be treated as such. Please refer to the Academic Integrity section below.
- If you fail to submit an assignment and have a **valid** reason with supporting documentation, the weight from that assignment will be shifted to the final exam.
- If your reason for incompleteness is not deemed valid, or you do not have supporting documentation, you will receive a zero. Note that for your circumstance to be deemed valid, you must have been incapacitated for the *majority* of the two-week timeframe between the assignment's release date and due date.
- Assignments up to 24 hours late will receive a 50% late penalty (i.e., your point total will be divided by 2). Assignments more than 24 hours late will not be graded, and you will receive a zero.
- If you submit your assignment to Crowdmark on time, but you do so incorrectly in any way (e.g., you upload your Question 3 solution in the Question 1 box), you will receive a 5% deduction (i.e., 5% of the assignment's point total will be deducted from your point total).

2. Midterm (30%)

- There will be one in-class, closed book, midterm exam on **Wednesday June 15**. This exam will last the duration of the lecture time.
- The midterm will evaluate your comprehension of the course material and may consist of a series of short answer calculations, short answer written responses, multiple choice questions, proofs and R output interpretation.
- If the midterm is missed for a **valid** reason, and you have supporting documentation, its weight will be shifted to the final exam. If the reason is not deemed valid or you do not have supporting documentation, you will receive a zero.
- **I will not offer a “make up” midterm for any reason.**

3. Final Exam (40%)

- There will be a 2.5-hour, closed book, cumulative final exam during the Spring 2019 Final Examination Period: **July 29 – August 13** scheduled by the Registrar's Office. Please refrain from booking Summer travel before the actual exam date is scheduled.
- The format of the final exam will mimic that of the midterm. Specifically, short answer calculations, written responses, multiple choice questions, proofs and R output interpretation can all be expected.
- If the final exam is missed for a **valid** reason, and you have supporting documentation, you will receive an "incomplete" (INC) grade as long as you have at least 70% in the course going into the final exam. Otherwise, you will receive a "did not write" (DNW). Documentation must be provided to me within 2 business days of the final exam.

Other Comments:

- STAT 430 and STAT 830 students will have different versions of their assignments, midterm, and final exam.
- If you have a dispute with your grade on an assignment or the midterm, it may be submitted to be remarked within 1 week of the assignment/ midterm being returned to you. Bear in mind that the entire assignment/ midterm is then subject to be remarked.
- For all accommodations due to illness, a [University of Waterloo Verification of Illness Form](#) (VIF) is the documentation I require.
- **In order to pass the course:** you must score *at least 50% on the final exam and also achieve an overall final grade of at least 50%* according to the above grading scheme. You cannot pass the course without passing the final exam.

INSTITUTIONAL REQUIRED STATEMENTS

Academic integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [See the [Office of Academic Integrity](#) for more information.]

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read [Policy 70, Student Petitions and Grievances, Section 4](#). When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for his/her actions. [See the [Office of Academic Integrity](#) for more information.] A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g.,

plagiarism, cheating) or about “rules” for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate associate dean. For information on categories of offences and types of penalties, students should refer to [Policy 71, Student Discipline](#). For typical penalties, check [Guidelines for the Assessment of Penalties](#).

Appeals: A decision made or penalty imposed under [Policy 70, Student Petitions and Grievances](#) (other than a petition) or [Policy 71, Student Discipline](#) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to [Policy 72, Student Appeals](#).

Note for students with disabilities: [AccessAbility Services](#), located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

Turnitin.com: Text matching software (Turnitin®) may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.

It is the responsibility of the student to notify the instructor if they, in the first week of term or at the time assignment details are provided, wish to submit alternate assignment.

Mental Health Support: The Faculty of Math encourages students to seek out mental health support if needed.

On-campus Resources:

- Campus Wellness: <https://uwaterloo.ca/campus-wellness/>
- Counselling Services: counselling.services@uwaterloo.ca 519-888-4567 ext 32655
- MATES: one-to-one peer support program offered by Federation of Students (FEDS) and Counselling Services: mates@uwaterloo.ca
- Health Services: located across the creek from the Student Life Centre, 519-888-4096.

Off-campus Resources:

- Good2Talk (24/7): Free confidential help line for post-secondary students. Phone: 1-866-925-5454
- Here 24/7: Mental Health and Crisis Service Team. Phone: 1-844-437-3247
- OK2BME: set of support services for lesbian, gay, bisexual, transgender or questioning teens in Waterloo. Phone: 519-884-0000 extension 213

Diversity: It is my intent that students from all diverse backgrounds and perspectives be well served by this course, and that students' learning needs be addressed both in and out of class. I recognize the immense value of the diversity in identities, perspectives, and contributions that students bring, and the benefit it has on our educational environment. Your suggestions are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In particular:

- I will gladly honour your request to address you by an alternate/preferred name or gender pronoun. Please advise me of this preference early in the semester so I may make appropriate changes to my records.
- I will honour your religious holidays and celebrations. Please inform of me these at the start of the course.
- I will follow AccessAbility Services guidelines and protocols on how to best support students with different learning needs.