STA261: Probability and Statistics II (Summer 2020)

Instructor:	Rob Zimmerman	**Lectures:**	M,W 14:00 - 17:00
Email:	robert.zimmerman@mail.utoronto.ca	**Tutorials:**	M,W 13:00 - 14:00
Course Website:	https://q.utoronto.ca/courses/155113	**Location:**	Online

Course Description: This course is a mathematically-rigorous introduction to statistical inference using the theory built up in STA257, roughly split into three parts. In the first part, we will focus on point estimators and learn about key properties such as unbiasedness and sufficiency (and how these properties relate to each other). In the second part, we will switch our attention to the the dual concepts of hypothesis testing and interval estimators, putting familiar concepts such as confidence intervals and p-values on a rigorous footing. In the final part, we will learn about the properties of consistency and efficiency for sequences of estimators, and use them to derive some asymptotic extensions of earlier concepts.

Learning Outcomes: After finishing STA261, you should be able to understand and explain the use of point estimation in the statistical literature, assess the quality and meaning of statistical hypothesis tests and decide which kinds of tests are appropriate in various situations, and explain the purpose and use of various asymptotic approximations.

Prerequisites: The official prerequisites are STA257H1/STAB52H3/STA256H5, which will be strictly enforced. Please don't email me about waiving prerequisites – such matters are outside of my jurisdiction and can be addressed by contacting the department at ug.statistics@utstat.utoronto.ca. Unofficially, you should have a strong calculus background, and you should come into the course with a good amount of *mathematical maturity*, since you will be expected to write and understand coherent mathematical proofs.

Head TA: TBD (TBD). TBD is the first point of contact for all administrative requests (missed tests, etc.). If you're not sure about who to contact, start with TBD, who will forward to me if necessary.

Lectures: Lectures will be used to go through theory and examples. They will be three hours long except for July 20 and August 5, where they'll be truncated to 2.5 hours to allow time for the quizzes. There will be no lectures on August 3, which is the Civic Holiday. Lectures will be held online via Bb Collaborate.

Tutorials: Tutorials will be used to solve selected problems from the assignments. Additionally, we'll also use them to cover any material missed in the prior lecture (only if necessary). There will be no tutorials on July 6 (the first day of lectures), August 3 (the Civic Holiday) or on the dates of Quizzes #1, #2, and #3 below. Tutorials will also be held online via Bb Collaborate.

Assignments: There will be five *optional* assignments, which you can think of as problem sets. Each will correspond to one of the five main subjects we'll be going through in the course (which roughly works out to one assignment per week). Most of the problems on these assignments will come from the course textbook. Solutions will not be provided, except for those presented in tutorials. You are encouraged to work on the problems with your fellow students, and *highly* encouraged to attempt the tutorial problems before tutorials.

Office Hours: Both instructor and TA office hours will take place online using Bb Collaborate; the exact weekly schedule will be posted on Quercus. The Bb Collaborate session for these will be "open" throughout the term, which means that you can enter at any time and discuss the course with your fellow students, regardless of whether there is a TA/instructor present.

Piazza: We have a Piazza page for the course at http://piazza.com/utoronto.ca/summer2020/sta261h1s. While the TAs and I will try to monitor the page, it's no substitute for office hours and there's no guarantee that we'll be able to answer every question that gets posted. You are highly encouraged to participate and answer the questions of your fellow students (good answers will be endorsed).

Marking Scheme: Final grades will be calculated as the best out of the following two schemes:

Scheme 1
- Quiz #1 (15%) ..... July 13, 14:00 - 15:15
- Quiz #2 (15%) ..... July 27, 14:00 - 15:15
- Quiz #3 (15%) ..... August 10, 14:00 - 15:15
- Quiz #4 (30%) ..... August 24, 14:00 - 16:30
- Term Project (20%) ..... Due August 17, 23:59
- Participation (5%) ..... In lecture

or

Scheme 2
- Quiz #1 (15%) ..... July 13, 14:00 - 15:15
- Quiz #2 (15%) ..... July 27, 14:00 - 15:15
- Quiz #3 (15%) ..... August 10, 14:00 - 15:15
- Quiz #4 (30%) ..... August 24, 14:00 - 16:30
- Term Project (25%) ..... Due August 17, 23:59

- The Quizzes will be open-book and consist of problems similar to those on the assignments (Quizzes will be cumulative, although the focus will be on material not covered in prior tests). The tests will be conducted through Crowdmark. The questions for each one will be released at the starting time listed above, and you'll be required to submit *clear, legible* photos of your answers by the ending time using the Crowdmark app. You'll be able to re-submit each answer as many times as you like prior to the ending time, but you will still need to plan your time carefully – it might be best to think of these as 65-minute tests, with an additional 10-minute allowance to upload your answers.
- The Term Project will require you to submit a paper demonstrating several course concepts in R; you will be permitted to work in groups of (up to) three. Details and a rubric will be provided in a separate document.
- The Participation mark will involve answering in-lecture poll questions within Quercus, as well as participating in a short mock Crowdmark exam held towards the beginning of the term (you are highly encouraged to participate in this anyway, in order to familiarize yourself with the test protocol and ensure that everything is working on your end).

Course Textbook: You don't need to purchase this if you don't want to (although I personally believe that it belongs on every statistician's bookshelf!). I'm working with the library to provide online access to the chapters we'll be going through.

- George Casella and Roger L. Berger. *Statistical Inference*. Brooks/Cole Cengage, 2nd ed., 2002. (Chapters 6-10)

Additional References: These are mainly textbooks used by several previous STA261 offerings; you might find them useful as a source of additional practice problems (although we'll have plenty from Casella/Berger already!). Buyer beware: there's no guarantee that what you find in these will be perfectly consistent with our presentation of the course, and you should not expect myself or the TAs to be completely familiar with their contents. Note that the first textbook is (officially) available for free on Mike Evans' website.

- Michael J. Evans and Jeffrey S. Rosenthal. *Probability and Statistics: the Science of Uncertainty*. Freeman, 2010.
- John A. Rice. *Mathematical Statistics and Data Analysis*. Duxbury Press, 3rd ed., 2006.
- Dennis Wackerly, William Mendenhall, et al. *Mathematical Statistics with Applications*. Duxbury Press, 7th ed., 2007.
- Richard J. Larson, Morris L. Marx. *An Introduction to Mathematical Statistics and Its Applications*. Pearson, 6th ed., 2017.

Tentative Lecture Schedule:

Subject	Lecture	Date	Topics
Data Reduction	1	July 6	• Sufficient Statistics • Minimal Sufficient Statistics
	2	July 8	• Ancillary Statistics • Sufficient, Ancillary, and Complete Statistics
Point Estimation	3	July 13	• Method of Moments • Maximum Likelihood Estimation
	4	July 15	• Mean Squared Error • Minimum-Variance Unbiased Estimation • Sufficiency and Unbiasedness
Hypothesis Testing	5	July 20	• Likelihood Ratio Tests • Error Probabilities and the Power Function
	6	July 22	• Most Powerful Tests • p-values
Interval Estimation	7	July 27	• Inverting a Test Statistic • Pivotal Quantities • Pivoting the CDF
	8	July 29	• Size and Coverage Probabilities • Test-Related Optimality
Asymptotic Evaluations	9	August 5	• Consistency • Efficiency • Calculations and Comparisons
	10	August 10	• Asymptotic Distribution of LRTs • Other Large-Sample Tests
	11	August 12	• Approximate Maximum Likelihood Intervals • Other Large Sample Intervals
Spillover/Exam Review	12	August 17	• (TBD)

Class Policy: Regular attendance in lectures and tutorials is essential and expected.

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. You must email TBD with any marking requests; do *not email me with these*. Requests must include a detailed reason for the change that references *objective fact*, and must be made for *legitimate perceived errors only*. The following are examples of unacceptable reasons for requesting a remark:

- "I feel my mark was unfair" (the TA felt otherwise, and they know more than you)
- "My friend got a better mark but they put the same thing as me" (so should I lower your friend's mark then?)
- "I need a bump to get my GPA over some threshold" (final grades will already be adjusted in accordance with recommendations outlined in the FAS Academic Handbook for Instructors)

If you legitimately find an error, then I'll happily change your mark. However, in the case of any ambiguity over the legitimacy of an error, I'll side with the TAs over you. Make sure you understand this:

By submitting a remark request, you are agreeing to have me (the instructor) remark your entire work, change the grade up, down, or not at all, and that the result of this represents your final mark on the work and will not be contested further.

Missed Quizzes: Student who miss quizzes should reach out to the Head TA as soon as possible, and no later than one week after the missed test. The remaining assessments will be reweighted; however, missing at least 50% of the assessments will result in an automatic fail. This means, for example, that if you miss both Quiz #1 and Quiz #2, then you will fail the course. If you are taking another course which requires your attendance during one of our quizzes, you will have to arrange alternative accommodations for the other course. Our quizzes are scheduled during the tutorial slots specifically to avoid this kind of overlap, and they will not be deferred.

Course Communication: I receive a lot of email, so it is important to abide by this email policy in order to ensure you receive a prompt and efficient response. You shouldn't email me about course concepts you're having trouble with – use office hours and Piazza for this. If you feel the need to contact the course team, first email the Head TA. This isn't because I don't want to talk to you, but rather because the Head TA is *paid* as part of their assigned hours to respond quickly to student emails. I am extremely busy and can't guarantee quick response times with hundreds of students enrolled in the course; this is why we have a whole course team here to assist you. It's like if you're in a store buying shoes: first you ask the sales associate, and if they can't answer your question, they'll go get the manager (I'm the manager). If you are following up on a conversation we have had in lecture or office hours, or if the matter is confidential and you don't want to share with the TA, then go ahead and email me directly. But when in doubt over who to email first, email TBD. They'll just forward it to me if they can't answer you.

Etiquette: When communicating with *anyone* in any way – but especially via email – make sure you courteous and respectful. This means using full sentences, not slang like "yo prof, I wanna get the lecture notes" (a real quote received by a fellow instructor), etc. This is good practice for your eventual transition into industry or grad school. Make us *want* to reply to you. Importantly, *we reserve the right to simply ignore any emails that don't follow these guidelines.* If you need to email us, follow these steps:

- Put "STA261: Student Communication" in the subject line.
- Start the email with "Hi Rob, ...", followed by your full name and UofT Student Number.
- State the purpose of your email.
- End the email with a "Thank you", "Sincerely", or something that indicates that the email is over.

This policy may seem rigid, but it is not meant to discourage student communication; rather, it is designed to encourage *productive* student communication, by forcing you to communicate professionally. It's hard to overstate how much this will help you in your future career. Here's an example of a good email to me:

> Hi Rob,
>
> My name is Bob Knobb (Student # 1005551234), and I'm a student in your STA261 class. I would like to follow up on our conversation after yesterday's lecture. Since then, I've come to the conclusion that sheafification is actually a left adjoint of the inclusion functor: $Mor_{PSh(X)}(\mathcal{F}, i(\mathcal{G})) = Mor_{Sh(X)}(\mathcal{F}^{\#}, \mathcal{G})$. Does this seem reasonable?
>
> Thank you,
> Bob

Technology Requirements: A set of recommended technology requirements for online learning can be found on the Office of the Vice-Provost's website. For our course, the most important of these requirements are a *fast, reliable internet connection* and access to a scanner or camera for the Term Tests. It is *your responsibility* to ensure your ability to satisfy these requirements (participating in the mock Crowdmark exam is a great way to do this). Shoddy internet connections or dead phone batteries are not valid excuses for missing a test. If you anticipate technology problems that could jeopardize your ability to write a test, you should reach out to to Accessibility Services (see below) as soon as possible.

Accessibility Services: Students with diverse learning styles and needs are welcome in this course. If you have a disability/health consideration that may require accommodations, please contact Accessibility Services at (416) 978-8060 or http://studentlife.utoronto.ca/as.

Academic Integrity: The University of Toronto's Code of Behaviour on Academic Matters outlines the behaviours that constitute academic misconduct, the processes for addressing academic offences, and the penalties that may be imposed. You are expected to be familiar with the contents of this document. Potential offences on tests include – but are not limited to – the following:

- Using unauthorized aids (internet resources, etc.)
- Contacting fellow students
- Misrepresenting your identity and/or using any kind of exam writing service
- Submitting altered tests for regrading
- Sending or receiving aid to/from anyone else

Course staff will be inspecting all submitted coursework for evidence of cheating, and will investigate any student suspected of an academic offense (which may include an interview with the student). If you refuse to participate in this investigation, or if we remain convinced that you have committed an academic offence, we will not hesitate to escalate the matter to the Department Chair.