BME1479H1F
Statistical discovery techniques for biomedical researchers
version Sept 4, 2024

Instructor: Prof. Julie Audet (julie.audet@utoronto.ca).
Communications with students are restricted to *utoronto.ca* email accounts.

Instructor-led case studies:

- Tuesday 10:10am-11:00am (SK548, Factor-Inwentash Faculty of Social Work Building, address: 246 Bloor St West i.e. Bloor & Bedford)
- Thursday 10:10am-11:00am (MY330, Myhal Building, address: 55 St. George Street)

In-person optional after-class student hours:

- Tuesday 11:00am to 11:30am (SK548)
- Thursday 11:00am to 11:30am (MY330)

Student hours can be very busy the week leading to an assignment deadline and they might last until 12pm. However, it tends to be quiet when there is no imminent deadline. When it is not busy, I might leave the classroom around 11:15am if there are no one present to meet with me.

Teaching Assistant: Oreoluwa Kolade (ore.kolade@mail.utoronto.ca). The TA will take students questions related to the JMP Pro software (glitches and technical issues). Questions related to the assignments should be posted on the Quercus discussion board.

How to access the Quercus course web site? Instructions can be found here.

Classroom sessions will not be recorded but, once inside the course Quercus page, it is possible to access MyMedia links to view recorded lectures many years ago. This is a last resort measure, in case you have to miss class due to illness, for instance. If you have to rely on those recorded lectures, please be careful when it comes to the assessment details, dates and deadlines mentioned as they will be different this year, as well as some aspects of the software functionality.

Besides the time reserved on Tuesday and Thursday in class for student hours, you can contact me by email to organize additional short meetings, either in-person or by Zoom or Teams. Students can request a U of T Zoom Pro account. Note that Zoom sessions require authentication. Visit the UofT Zoom Portal to create your account.

BME1479 is intended to provide students interested in biomedical research with an introduction to core statistical concepts and methods, including experimental design. The course also provides a good foundation in the use of discovery tools provided by a data analysis and visualization software. The topics covered will include: i) Importance of being uncertain; ii) Error bars; iii) Significance, p-values and t-tests; iv) Power and sample size; v) Visualizing samples with box plots; vi) Comparing samples; vii) Non parametric tests; viii) Designing comparative experiments; ix) Analysis of variance and blocking; x) Replication; xi) Two-factor designs; xii) Association, correlation and causation; xvi) Simple and multiple linear regression; xvii) Regression diagnostics. The concepts will be illustrated with realistic examples that

are commonly encountered by biomedical researchers. The statistical software package used in this course is JMP (installed on your laptop).

Note that this course is a core course choice for MASc, PhD students in BME. Students in these programs can choose to take other core courses to meet their program requirements (such as BME1477 and BME1478) as long as they take two core courses. BME1479 might not necessarily be the best course selection for those who have already taken more advanced course in statistics or who have no use for classical statistical approaches in their research. Also, in other to minimize overlap with another core course (BME1478), this course will not cover or use coding per se (although I might provide some codes lines occasionally for Python).

Learning objectives:

Effectively plot data to get insights into factor effects, biological variance and distribution. Understand and apply basic statistical methods for the design and analysis of biomedical experiments. Understand and verify the assumptions underlying the application of the statistical methods covered in the course. Use and interpret of the results from specialized computer software. Identify common misuses of statistical methods and tests in the scientific literature and propose alternative approaches.

Tentative class schedule:

Expected Date (subject to revision)	**Materials covered in-class (usually in the form of case studies)**	**Materials to cover on your own**
	Figard: Biostats Textbook JMP Interactive module: Help -> Sample Data -> Teaching Scripts	POS: Points of Significance articles Additional JMP Case Studies: see Quercus modules
Thursday, Sept 5	MODULE A: Introduction Syllabus Schedule Evaluations Required textbook Required software Required Quercus modules	
Preparation for next class: New JMP license distribution system for this year: download the software JMP Pro (Win or Mac/OS), valid for 12 months, here https://www.jmp.com/en_ca/academic/jmp-student-edition.html There won't be any drop-in student hour on Sept 5 at 11:00am.		

Tuesday, Sept 10	MODULE B Figard Chap 1: Some JMP Basics	
Thursday, Sept 12	MODULE C Figard Chap 2: Thinking Statistically JMP Interactive Teaching Module: "Distribution Generator" JMP Interactive Teaching Module: "Distribution Calculator" JMP Interactive Teaching Module: "Sampling Distribution of Sample Means"	POS: Importance of being uncertain
Tuesday, Sept 17	MODULE D Figard Chap 3: Statistical Topics in Experimental Design	POS: Power and sample size POS: Replication
Thursday, Sept 19	MODULE E Figard Chap 4: Describing Populations	POS: Visualizing samples
Tuesday, Sept 24	MODULE E Figard Chap 4: Describing Populations	JMP Case Study: Medical Malpractice JMP Case Study: Baggage Complains JMP Case Study: Performance of Food Manufacturing Process - Part 1
Thursday, Sept 26	MODULE F Figard Chap 5: Inferring and Estimating JMP Interactive Teaching Module: "Confidence Interval for the Population Mean" JMP Interactive Teaching Module: "Distribution Calculator" Assignment #1 (10%) due at 11:00pm	POS: Error bars JMP Case Study: Siblings

Tuesday, Oct 1	MODULE G Figard Chap 6: Null Hypothesis Significance Testing JMP Interactive Teaching Module: "Sampling Distribution of Sample Means" JMP Interactive Teaching Module: "Hypothesis Test for Mean" Figard Chap 9: Tests of Differences Between Two Groups	POS: Significance, P values and t-test JMP Case Study: Defect Sampling JMP Case Study: Price Quotes JMP Case Study: Performance of Food Manufacturing Process - Part 2
Thursday, Oct 3	MODULE H Figard Chap 9: Tests of Differences Between Two Groups JMP Interactive Teaching Module: "Demonstrate ANOVA" which also covers t tests (only t-test for now)	POS: Comparing samples part I POS: Designing Comparative Experiments POS: Non Parametric tests JMP Case Study: Treatment Facility JMP Case Study: Subliminal Messages
Tuesday, Oct 8	MODULE I Figard Chap 10: Tests of Differences Between More than Two Groups JMP Interactive Teaching Module: "Demonstrate ANOVA"	POS: Analysis of variance and blocking POS: Comparing samples part II JMP Case Study: Priority Assessment
Thursday, Oct 10	MODULE I Figard Chap 10: Tests of Differences Between More than Two Groups	POS: Analysis of variance and blocking POS: Comparing samples part II JMP Case Study: Per Capita Income JMP Case Study: Backgammon JMP Case Study: Detergent Cleaning Effectiveness

Tuesday Oct 15	MODULE J Figard Chap 11: Tests of Association: Regression JMP Interactive Teaching Module: "Demonstrate Regression"	POS: Regression diagnostics JMP Case Study: Archosaurs
Thursday Oct 17	MODULE J Figard Chap 11: Tests of Association: Regression Assignment #2 (20%) due at 11:00pm	POS: Regression diagnostics
Tuesday Oct 22	MODULE K Figard Chap 12: Tests of Association: Correlation	POS: Association, correlation, causation JMP Case Study: Endangered
Thursday Oct 24	MODULE L Figard Chap 13: Modeling Trends: Multiple Regression	POS: Multiple linear regression JMP Case Study: Cell Phone Service
Monday Oct 28	Deadline to drop the course without penalty	
Tuesday Oct 29	Reading week / No Class	
Thursday Oct 31	Reading week / No Class	

Tuesday Nov 5	MODULE L Figard Chap 13: Modeling Trends: Multiple Regression	POS: Multiple linear regression
Thursday Nov 7	MODULE M Figard Chap 16: Design of Experiments (DOE)	POS: Two-factor designs
Tuesday Nov 12	MODULE M Figard Chap 16: Design of Experiments (DOE)	POS: Two-factor designs

	Assignment #3 (35%) due at 11:00pm	
Thursday Nov 14	MODULE M Figard Chap 16: Design of Experiments (DOE)	POS: Two-factor designs Additional problem set
Tuesday Nov 19	MODULE M Figard Chap 16: Design of Experiments (DOE)	
Thursday Nov 21	MODULE N Figard Chap 18: Hindrances to Data Analysis	POS: Sources of variation POS: Analysing outliers: influential or nuisance?
Tuesday Nov 26	Additional case studies for review	
Thursday Nov 28	Additional case studies for review	
Tuesday Dec 3	Office hours only (last scheduled meeting)	
Thursday Dec 5	No class	
Monday Dec 9	Final assignment (#4): (35%) due Dec 9 at 5pm.	

Course Materials:

1) Required textbook: **Introduction to Biostatistics with JMP® by Steve Figard, 2019**:

ISBNs 9781642954562, 9781635267181, 9781629606330

Text can be viewed online from the U of T Library (check the *Library Reading List* tab in Quercus) with a limit of 3 users simultaneously and also from the Toronto Public Library if you get a library card. The Toronto Public Library does not seem to impose a limit on the number of users so that might be a good option if you are not planning to purchase a book.

Text available to purchase as an eBook at the U of T Bookstore, Amazon.ca, among many other places.

2) Required Software: **JMP installed on your computer (JMP 18)**

Mac/OS or PC/windows licenses for JMP are available here to download https://www.jmp.com/en_ca/academic/jmp-student-edition.html

This year, the software company has put in place a new license distribution system and I hope it this work as well as in previous years. This is a student license and it is only for teaching and research (no commercial or industrial use allowed). The software will expire in 12 months. At that time, it appears that it will be possible to download a new license as long as you are still a student at an eligible academic institution.

Note that earlier versions of JMP will work as well, as long as they are compatible with your computer operating system. You can check here the system requirements for the latest JMP versions, including the most recent. I cannot provide earlier versions this year unfortunately as I do not have access to license extensions for those versions.

3) Required: **Quercus Modules Contents** with Lecture slides, POS articles, Instructions for JMP Interactive Teaching Modules, exercises (JMP Case Studies), data sets will be posted.

4) **Optional Textbook** (for those who would like additional mathematical development and additional problem sets not covered in this course): *Engineering Statistics*, Montgomery, Runger, Hubele. 4th or 5th ed. Wiley. This is available at the U of T Libraries (Math) and U of T Bookstore. There is a more advanced text by the same authors: *Design and Analysis of Experiments*, Wiley which I used in BME1480 when it was offered. Then, of course, there is a classic textbook by Box, Hunter and Hunter, *Statistics for Experimenters,* Wiley.

5) **Optional Additional JMP Software instructions** (Optional, see Help tab in JMP where you find various manuals and step-by-step tutorials, as well as sample data sets)

JMP online documents (optional)

https://www.jmp.com/en_us/support/jmp-documentation.html

https://www.jmp.com/en_us/statistics-knowledge-portal.html

https://www.jmp.com/en_us/support.html

Assessments, penalties for late submissions and possibility of a make-up 2-hour exam in lieu of an assignment submitted too late:

By default, assessment for the course is based on 4 assignments (A1:10% + A2:20% + A3:35% + A4:35%). However, this course has a strict policy about missed deadlines but it will be enforced only when students go beyond a specific extension threshold of 72 hours (3 days) in total.

Each student is entitled to a maximum of a total of 3 days (72 hours) of deadline extensions for the entire course (and this covers the 4 assignments) with no justification or explanation required. You have the

option to take the whole 3 days (72 hours) for just one of the assignment or you can spread the hours over multiple assignments. Use this wisely as once you have used a total of 3 days (72 hours) of extensions for the course, it will not be possible to request additional extensions without penalty. At that point, there will be a penalty of 5 points per day (or 24 hours) deducted from your final mark (out of 100 points) for the course, until you reach a penalty of 15 points (or 3 additional days). After 3 additional days of extension (an additional 72 hours), it will not be possible for me to accept your assignment (as this delay would start impacting all the other students as I need to post the solutions before the next assignment is due). Then, the penalty for this assignment will be cancelled and, for you, this particular assignment will be replaced by a conventional, in-person 2-hour written exam, of equivalent weight, which should be scheduled before the end of the term. See table on next page for more detailed information.

Course policy for missed assignment deadlines and extension requests
(some of these scenarios are far-fetched but useful to illustrate how the policy described above would be applied)

Examples	A1 ext. (h)	A2 ext. (h)	A3 ext. (h)	A4 ext. (h)	Total ext. (h)	Penalty (mark deduction on final course mark)	Exam in lieu of late assignment	Which assignment submission would not be accepted ?
Scenario #1	0	0	48	24	72	n/a	No	n/a
Scenario #2	0	0	0	72	72	n/a	No	n/a
Scenario #3	0	0	0	96	96	5 pts	No	n/a
Scenario #4	0	24	24	96	144	15 pts	No	n/a
Scenario #5	2	24	24	96	146	n/a	Yes	A4
Scenario #6	24	24	97	0	145	n/a	Yes	A3
Scenario #7	72	12	12	12	108	7.5 pts	No	n/a
Scenario #8	84	12	24	24	144	15 pts	No	n/a
Scenario #9	72	84	0	0	156	n/a	Yes	A2
Scenario #10	72	84	24	0	180	5 pts (for A3)	Yes (for A2)	A2

n/a: not applicable, ext.: extension

Reminder: Deadline to drop graduate courses without penalty is October 28, 2024.

Requests for mark re-check and mark revisions:

Mark revisions or verification requests should be sent to me up to two weeks after the grades have been released for a given assignment. Marks will not be revised and assignment re-graded after this two-week period. Student should not wait until they see their final grade for the course to request mark revisions for assignments #1 to #3.

Final marks:

Students can request mark revisions for up to two weeks after the marks for a given assignment have been posted.

For graduate students, the final grades in courses are letters (A+, A, A-, B+, B, B-, FZ) and are not numerical. Therefore, only a letter will appear on your transcripts for this course. As Quercus does not convert numerical grades into letters properly for graduate students, this will be done manually by the instructor according to UofT policy for grading graduate students. You will be able to find your final letter grade on **ACORN from January 15, 2025**. Your final grade will not be posted on Quercus. If you feel that your final letter grade is lower than expected, you can request that we re-grade or check your assignment #4. Grading re-check can result in either no change in your final mark, a higher final mark or lower final mark depending on the nature of the marking errors found. A graded copy of your final assignment can be provided upon request if you feel that the outcome of the exam re-check is not satisfactory.

1.2.2. Graduate:

i. a truncated refined letter grade scale A+, A, A-, B+, B, B-, FZ (replacing C,D, and F);
ii. the numerical scale of marks, consisting of all integers from 0 to 100 (that is, 0,1...99, 100).

Graduate

Truncated Refined Letter Grade Scale	Numerical Scale of Marks
A+	90 - 100%
A	85 - 89%
A-	80 - 84%
B+	77 - 79%
B	73 - 76%
B-	70 - 72%
FZ**	0 - 69%

**FZ = Fail

Academic integrity:

It is not permitted to let anyone else use your Quercus account and submit work for you. It is not permitted to share your work (assignments) with other classmates, before or after it has been marked, until the final grades have been released on January 15, 2025. When you share your, work, you run the risk that someone else will misuse it (e.g. plagiarism or use on unauthorized aid) but until an investigation has been completed, it might not be clear what role you played. This could result in an alleged academic offence for you and the other student. Suspected cases of academic dishonesty will be investigated by SGS following procedures outlined in the *Code of Behaviour on Academic Matters*. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, please reach out to me. Note that you are expected to seek out additional information on academic integrity from me or from other institutional resources (for example, the University of Toronto website on Academic Integrity).

Notice of video recording and sharing (download if possible is permissible; re-use always prohibited):

Students might be provided access to recorded materials from many years ago. These videos will be available to students in the course for viewing remotely and not for download.

Course videos and materials belong to your instructor, the University, and/or other sources depending on the specific facts of each situation and are protected by copyright. In this course, you are permitted to view the materials for your own academic use, but you should not copy, share, or use them for any other purpose without the explicit permission of the instructor.

For questions about the recording and use of videos, please contact me.

Academic accommodations:

The University provides academic accommodations for students with disabilities in accordance with the terms of the Ontario Human Rights Code. This occurs through a collaborative process that acknowledges a collective obligation to develop an accessible learning environment that both meets the needs of students and preserves the essential academic requirements of the University's courses and programs. Note that, unless students are unable to hand in their assignment(s) on time, there are no conventional exams in this course and assessment is based on assignments.

Students with diverse learning styles and needs are welcome in this course. If you have a disability that may require accommodations, please feel free to approach me and/or the Accessibility Services office.

- Accessibility Services on the St. George campus

Equity, diversity and inclusion:

The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. U of T does not condone discrimination or harassment against any persons or communities.

If you are experiencing harassment, discrimination or harmful unprofessionalism, the Faculty of Applied Science and Engineering has a process for making confidential disclosures of incidents of that nature.

Graduate student wellness Portal and other resources:

As a graduate student, you may experience a range of wellness, financial, academic and supervision issues that may result in significant barriers to achieving your personal and academic goals. The University of

Toronto offers a wide range of free and confidential services and programs that may be able to assist you. We encourage you to seek out these resources early and often.

https://gradstudies.engineering.utoronto.ca/

http://www.sgs.utoronto.ca/currentstudents/Pages/wellness-portal.aspx

https://www.sgs.utoronto.ca/resources-supports/campus-life-resources/

If, at some point during the year, you find yourself feeling distressed and in need of more immediate support, visit the **Support when you feel distressed**

Webpage: http://www.studentlife.utoronto.ca/feeling-distressed, for more campus resources.