UNIVERSITY OF CALGARY
FACULTY OF SCIENCE

Department of Mathematics & Statistics
MS 476
403 220-5210
math@ucalgary.ca

COURSE OUTLINE

1. **Course:** STAT 421, Mathematical Statistics - Fall 2023

   Lecture 01 : MWF 10:00 - 10:50 in TRB 101

Instructor	Email	Phone	Office	Hours
Dr Alexander De Leon	adeleon@ucalgary.ca	403 220-6782	MS 588	MWF, 11am-12nn, 1-2pm

   To account for any necessary transition to remote learning for the current semester, courses with in-person lectures, labs, or tutorials may be shifted to remote delivery for a certain period of time. In addition, adjustments may be made to the modality and format of assessments and deadlines, as well as to other course components and/or requirements, so that all coursework tasks are in line with the necessary and evolving health precautions for all involved (students and staff).

   In Person Delivery Details:

   This course shall be delivered entirely in-person.

   Course Site:

   D2L: STAT 421 L01-(Fall 2023)-Mathematical Statistics

   Note: Students must use their U of C account for all course correspondence.

   Equity Diversity & Inclusion:

   The University of Calgary is committed to creating an equitable, diverse and inclusive campus, and condemns harm and discrimination of any form. We value all persons regardless of their race, gender, ethnicity, age, LGBTQIA2S+ identity and expression, disability, religion, spirituality, and socioeconomic status. The Faculty of Science strives to extend these values in every aspect of our courses, research, and teachings to better promote academic excellence and foster belonging for all.

2. **Requisites:**

   See section 3.5.C in the Faculty of Science section of the online Calendar.

   Prerequisite(s):
   Statistics 323.

3. **Grading:**

   The University policy on grading and related matters is described in F.1 and F.2 of the online University Calendar.

   In determining the overall grade in the course the following weights will be used:

Course Component	Weight	Due Date (duration for exams)	Modality for exams	Location for exams
Problem Sets[1]	45%	Ongoing		
Midterm Exam	35%	Nov 01 2023 at 10:00 am (50 Minutes)	in-person	TRB 101
Project[2]	20%	Dec 15 2023		

[1] A total of 8 Problem Sets will be assigned, each covering 1 of the 9 topics listed in the Lecture 1 slides (Note: Problem Set 1 will cover Topics 1 and 2). Problem Set 1 is due on Monday, September 18, 2023, while Problem Set 2 is due on Friday, September 29, 2023. The due dates for the rest of the Problem Sets will be determined as we progress through the Course Topics. Problem sets will be done individually. Students will prepare their complete solutions to Problems Sets using LaTeX – I will provide a template – or Microsoft Word. Handwritten work is perfectly acceptable, provided a PDF copy is created using, for example, a free-to-download document scanner app (e.g., iScanner). Each student will need to upload her solutions as a single PDF file to the corresponding Dropbox folder on D2L by the due dates (see Course Outline). No paper copies of solutions will be accepted in class.

[2] The project will be done individually or in pairs. Each project will involve carrying out a Monte Carlo simulation study to explore, for example, the impact of the parent distribution (e.g., symmetry, skewness, discreteness) and sample size on the (finite-sample) properties of estimators (e.g., exact/asymptotic sampling distribution, efficiency, asymptotic normality/non-normality) or of large-sample tests (e.g., asymptotic distribution of test statistic, asymptotic power, asymptotic sizes of Type I and Type II errors). A short list of possible studies that students can work on for their project will be provided. I will provide a list of projects from which you will select one to work on. The list will include specific questions that you will need to address in your project instructions, in particular, on what numerical work you and how to implement it in R. A written report is required, prepared using LaTeX – I will provide a template – or Microsoft Word. Guidelines on writing the report will be provided.

Each piece of work (reports, assignments, quizzes, midterm exam(s) or final examination) submitted by the student will be assigned a grade. The student's grade for each component listed above will be combined with the indicated weights to produce an overall percentage for the course, which will be used to determine the course letter grade.

The conversion between a percentage grade and letter grade is as follows.

	A+	A	A-	B+	B	B-	C+	C	C-	D+	D
Minimum % Required	95 %	88 %	84 %	80%	76%	72 %	68 %	64%	60%	55 %	50 %

A t the end of the term, a summary score will be computed from raw marks on midterm test, problem sets, and project as basis for assigning letter grades. Students' marks in each of the grading components will be posted on the D2L gradebook, so students can keep track of their course standing at any time during the term.

The University of Calgary offers a flexible grade option, Credit Granted (CG) to support student's breadth of learning and student wellness. Faculty units may have additional requirements or restrictions for the use of the CG grade at the faculty, degree or program level. To see the full list of Faculty of Science courses where CG is not eligible, please visit the following website: https://science.ucalgary.ca/current-students/undergraduate/program-advising/flexible-grading-option-cg-grade

4. **Missed Components Of Term Work:**

In the event that a student legitimately fails to submit any online or in-person assessment on time (e.g. due to illness, domestic affliction, etc...), please contact the course coordinator, or the course instructor if this course does not have a coordinator to arrange for a re-adjustment of a submission date, or possible exemption and reweighing of components. Absences not reported within 48 hours will not be accommodated. Students may be asked to provide supporting documentation (Section M.1) for an excused absence, SeeFAQ.

If an excused absence is approved, options for how the missed assessment is dealt with is at the discretion of the coordinator or course instructor. Some options such as an exemption and pro-rating among the components of the course may not be a viable option based on the design of this course.

5. **Scheduled Out-of-Class Activities:**

There are no scheduled out of class activities for this course.

6. **Course Materials:**

Recommended Textbook(s):

R. V. Hogg, J. W. McKean, & A. T. Craig,*Introduction to Mathematical Statistics, 8th ed.*: Pearson.

In order to successfully engage in their learning experiences at the University of Calgary, students taking online, remote and blended courses are required to have reliable access to the following technology:

- A computer with a supported operating system, as well as the latest security, and malware updates;
- A current and updated web browser;
- Webcam/Camera (built-in or external);
- Microphone and speaker (built-in or external), or headset with microphone;
- Current antivirus and/or firewall software enabled;
- Stable internet connection.

For more information please refer to the UofC ELearning online website.

7. **Examination Policy:**

   The Midterm Exam is a closed-book-no-notes 50-minute sit-down test. You will be provided a blue test booklet for your answers and solutions to the exam problems. You may bring a calculator for your use; any make (programmable, graphing, scientific, etc.) is OK. Internet access is not permitted, and use of your phone as calculator is not allowed.

   Students should also read the Calendar, Section G, on Examinations.

8. **Approved Mandatory And Optional Course Supplemental Fees:**

   There are no mandatory or optional course supplemental fees for this course.

9. **Writing Across The Curriculum Statement:**

   For all components of the course, in any written work, the quality of the student's writing (language, spelling, grammar, presentation etc.) can be a factor in the evaluation of the work. See also Section E.2 of the University Calendar.

   On Problem Sets. The world does not need solutions to problems in your Problem Sets. The point of the problem sets is to improve both your skills in solving problems and in communicating your solutions to others.

   Every solution that you submit is original work with your name on it. You should avoid handing in a shoddily written Problem Set as it reflects poorly on you and your work ethic. After you have solved a problem, write it up and put it aside for a day or so. Go back and re-read it, and re-write it. Fix up confusing passages and logical gaps.

   Each solution should be written up in grammatical English that is readable and understandable to anyone in the class (including me) and with its every step explained in detail using appropriate notations used in our lectures. Grammar and spelling are very important.

   Your Problem Sets must be neat (no coffee stains please!), detailed but mathematically concise, and written in grammatical English. Merely giving the correct answer without adequate explanation will not suffice.

   On the Project. You and your partner in the Project will carry out a simulation study to address a specific problem from the list I will post on D2L. You will then submit a (typed-up) report describing the purpose of your project, the approach you used, the empirical results, and your conclusions. You will need to do this in no more than 10 pages, including any appendices and computer output.

   The project is your opportunity to practice and hone your technical writing skills, for which clear exposition and and grammatical correctness are very important. The Writing Support program, occasional Writing Workshops, and other helpful writing resources are available at the Student Success Centre (SSC).

10. **Human Studies Statement:**

    Students will not participate as subjects or researchers in human studies.

    See also Section E.5 of the University Calendar.

11. **Reappraisal Of Grades:**

    A student wishing a reappraisal, should first attempt to review the graded work with the Course coordinator/instructor or department offering the course. Students with sufficient academic grounds may request a reappraisal. Non-academic grounds are not relevant for grade reappraisals. Students should be aware that the grade being reappraised may be raised, lowered or remain the same. See Section I.3 of the University Calendar.

    a. **Term Work:** The student should present their rationale as effectively and as fully as possible to the Course coordinator/instructor within **ten business days** of either being notified about the mark, or of the item's return to the class. If the student is not satisfied with the outcome, the student shall submit the Reappraisal of Graded Term work form to the department in which the course is offered within 2 business days of receiving the decision from the instructor. The Department will arrange for a reappraisal of the work within

the next ten business days. The reappraisal will only be considered if the student provides a detailed rationale that outlines where and for what reason an error is suspected. See sections I.1 and I.2 of the University Calendar

b. **Final Exam:** The student shall submit the request to Enrolment Services. See Section I.3 of the University Calendar.

12. **Other Important Information For Students:**

a. **Mental Health** The University of Calgary recognizes the pivotal role that student mental health plays in physical health, social connectedness and academic success, and aspires to create a caring and supportive campus community where individuals can freely talk about mental health and receive supports when needed. We encourage you to explore the mental health resources available throughout the university community, such as counselling, self-help resources, peer support or skills-building available through the SU Wellness Centre (Room 370, MacEwan Student Centre, Mental Health Services Website) and the Campus Mental Health Strategy website (Mental Health).

b. **SU Wellness Services:** For more information, see their website or call 403-210-9355.

c. **Sexual Violence:** The Sexual Violence Support Advocate, Carla Bertsch, can provide confidential support and information regarding sexual violence to all members of the university community. Carla can be reached by email (svsa@ucalgary.ca) or phone at 403-220-2208. The complete University of Calgary policy on sexual violence can be viewed here.

d. **Student Ombuds Office:** A safe place for all students of the University of Calgary to discuss student related issues, interpersonal conflict, academic and non-academic concerns, and many other problems.

e. **Student Union Information:** SU contact, Email your SU Science Reps: science1@su.ucalgary.ca, science2@su.ucalgary.ca, science3@su.ucalgary.ca,

f. **Academic Accommodation Policy:**

It is the student's responsibility to request academic accommodations according to the University policies and procedures listed below. The student accommodation policy can be found at: https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Student-Accommodation-Policy.pdf

Students needing an accommodation because of a disability or medical condition should communicate this need to Student Accessibility Services in accordance with the Procedure for Accommodations for Students with Disabilities: https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Accommodation-for-Students-with-Disabilities-Procedure.pdf.

Students needing an accommodation in relation to their coursework or to fulfil requirements for a graduate degree, based on a Protected Ground other than Disability, should communicate this need, by filling out the Request for Academic Accommodation Form and sending it to Jerrod Smith by email jerrod.smith@ucalgary.ca preferably 10 business days before the due date of an assessment or scheduled absence.

g. **Misconduct:** Academic integrity is the foundation of the development and acquisition of knowledge and is based on values of honesty, trust, responsibility, and respect. We expect members of our community to act with integrity. Research integrity, ethics, and principles of conduct are key to academic integrity. Members of our campus community are required to abide by our institutional Code of Conduct and promote academic integrity in upholding the University of Calgary's reputation of excellence. Some examples of academic misconduct include but are not limited to: posting course material to online platforms or file sharing without the course instructor's consent; submitting or presenting work as if it were the student's own work; submitting or presenting work in one course which has also been submitted in another course without the instructor's permission; borrowing experimental values from others without the instructor's approval; falsification/fabrication of experimental values in a report. Please read the following to inform yourself more on academic integrity:

Student Handbook on Academic Integrity
Student Academic Misconduct Policy and Procedure
Faculty of Science Academic Misconduct Process
Research Integrity Policy

Additional information is available on the Student Success Centre Academic Integrity page

h. **Copyright of Course Materials:** All course materials (including those posted on the course D2L site, a course website, or used in any teaching activity such as (but not limited to) examinations, quizzes,

assignments, laboratory manuals, lecture slides or lecture materials and other course notes) are protected by law. These materials are for the sole use of students registered in this course and must not be redistributed. Sharing these materials with anyone else would be a breach of the terms and conditions governing student access to D2L, as well as a violation of the copyright in these materials, and may be pursued as a case of student academic or non-academic misconduct, in addition to any other remedies available at law.

i. **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). Students should identify themselves on all written work by placing their name on the front page and their ID number on each subsequent page. For more information, see Legal Services website.

j. **Surveys:** At the University of Calgary, feedback through the Universal Student Ratings of Instruction (USRI) survey and the Faculty of Science Teaching Feedback form provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses. Your responses make a difference - please participate in these surveys.

Course topics

1. **Preliminaries.** Nature of (statistical) data, parametric, semi- and non-parametric statistical models, parametrizations and parameters, model and parameter identifiability.

2. **Parametric families.** Location and scale families, single- and multi-parameter regular exponential classes (RECs), multivariate normal (MVN) distributions (definition and characterizations, marginalization and conditionalization properties), Student's Theorem.

3. **Distribution theory for statistics.** Definition of statistic and its sampling distribution, CDF and MGF techniques for univariate/multivariate discrete and continuous cases, transformation method for univariate/multivariate continuous cases.

4. **Sufficiency, completeness, & ancillarity.** Sufficient statistics, minimal sufficient statistics, Factorization Theorem, ancillary statistic, completeness, Basu's Theorem.

5. **Decision theoretic framework.** Components of decision problems (i.e., decision space, loss and risk functions, decision rules/procedures, comparison of decision rules, Rao-Blackwell Theorem.

6. **Optimality criteria for estimation.** Unbiased estimation, minimum variance unbiased estimator (MVUE), Fisher information number/matrix, information and sufficiency, information recovery & ancillarity, Information Inequality, efficiency in regular exponential class, Lehmann-Scheffe Theorem, non-decision theoretic criteria.

7. **Maximum likelihood (ML) estimation.** Likelihood function, likelihood equation, ML estimator (MLE), ML estimation in regular exponential class, numerical calculation of MLEs, Newton-Raphson and EM algorithms, MVUE vs. MLE.

8. **Hypothesis testing.** Basic set-up (null H_0, alternative H_1, test statistic, (significance) level, size, Type I error, Type II error, power function, critical/rejection and acceptance regions, p-value, most powerful (MP) test, Neyman-Pearson Lemma, uniformly most powerful (UMP) test, monotone likelihood ratio (MLR), Karlin-Rubin Theorem, likelihood ratio tests (LRTs).

9. **Asymptotics.** Meaning and uses of asymptotics, modes of convergence (i.e, "in probability", "in distribution", "in MSE"), Weak Law of Large Numbers (WLLN), Central Limit Theorem (CLT), Slutsky's Theorem, delta method, consistency, asymptotic normality and efficiency of MLEs, large-sample tests (e.g., Wald, Rao's score, LRT).

Course Outcomes:

- derive distributions of functions of random variables by applying the change of variable technique, the cumulative distribution function technique, and the moment generating function technique;
- define a random sample and statistics (including estimators and order statistics) and obtain their sampling distributions
- define the multivariate normal distribution and explain some of its applications;
- use different modes of convergence (i.e., convergence in probability, convergence in distributions) and well-known asymptotic results (e.g., Weak Law of Large Numbers, Central Limit Theorem) to study large-sample properties of estimators (e.g., limiting and asymptotic distributions;
- apply the concepts of sufficiency and completeness to derive minimum variance unbiased estimators;
- define most powerful (MP), uniformly most powerful (UMP), and likelihood ratio tests and obtain them via, e.g., the Neyman-Pearson Theorem;

- obtain and apply chi-square goodness-of-fit tests, analysis of variance, regression analysis, the chi-square test of independence, the sign test and some nonparametric tests;
- define the prior and posterior distributions, a conjugate prior, and predictive distributions;
- apply the statistical software R for carrying out probability and statistical calculations.

Electronically Approved - Sep 05 2023 21:04

Department Approval