UNIVERSITY of GUELPH

STAT*4350 Multivariate Statistical Methods
STAT*6821 Multivariate Analysis

Fall 2023

College of Engineering and Physical Sciences

Version 1.02 – September 4, 2023

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1.1 Calendar Description

This course introduces the multivariate normal, Wishart and Hotelling's T-square distributions. Topics covered include: statistical inference on the mean vector, canonical correlation, multivariate analysis of variance and covariance, multivariate regression, principal components analysis, and factor analysis. Topics will be illustrated using examples from various disciplines. For graduate students, topics that are more current to the field will also be discussed such as: multivariate adaptive regression splines; projection pursuit regression; and wavelets.

Pre-requisites: (1 of MATH*1160, MATH*2150 or MATH*2160), STAT*3110, STAT*3240
Credit Weight: 0.5   **Academic Department**: Mathematics & Statistics

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2 Instructional Support

2.1 Instructor

Department of Mathematics & Statistics
Email:
Office:
Times:
Start Date: September 7, 2023; End Date: December 1, 2023.
Delivery Mode: Face-to-face; In-person attendance is required.
Office Hour: TBD and provided on Courselink once set. Office hours may change.

Due to the Fall Study Break, lecture for Monday, October 9 is rescheduled for Friday, December 1.

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3 Learning Resources

3.1 Text

Required Texts:

1. Applied Multivariate Statistical Analysis, 6th Ed., Johnson and Wichern, Preston Hall, 2007.
2. Applied Multivariate Statistics with R, D. Zelterman, Springer, 2015. (online in library)

Recommended Texts: Methods of Multivariate Analysis, 3rd Ed., Renchner and Christensen, Wiley, 2012. (online in library)

3.2 CourseLink

Course information and material (such as assignments, data sets, etc.) will be available on CourseLink. Students are responsible to check the website regularly for updated information and announcements. We mostly put materials on CourseLink for this course, but emergencies and big changes may get to you first via the university e-mail. It is equally important to check your e-mail regularly.

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4 Learning Outcomes

We will begin with a brief review of matrix algebra and random vectors. We will then move on to the multivariate normal distribution and making inferences about one or more means. Relevant distributions also include the Hotelling's T-squared distribution and the Wishart distribution. Statistical methods of analysis include multivariate analysis of variance and covariance (MANOVA, MANCOVA), multivariate regression, and dimension reduction methods including principal components analysis, factor analysis and canonical correlation analysis. Other important multivariate techniques are discrimination, classification and clustering methods, or through projects/presentations. Time permitting, we will look at advanced topics such as multivariate adaptive regression splines, projection pursuit regression, graphical Markov models, and methods for discrete multivariate data.

4.1 Key Objectives

The objective of this course is to acquaint students with the concepts, applicability, and methods of multivariate data analysis. Students who have successfully completed this course will be expected to:

1. Have a general knowledge and understanding of many of the key concepts, theoretical approaches and assumptions needed for dealing with multivariate problems;
2. Derive some fundamental classical results of multivariate analysis;
3. Recognize types of problems (e.g., classification versus clustering) and the appropriate method(s) of analysis;

4. Analyze multivariate data using statistical software (e.g. using R and related R packages);
5. Develop independent and critical thinking skills regarding multivariate data and data reduction;
6. Describe statistical methods and analysis results for multivariate data to a non- statistician in a written report with appropriate tables and figures.

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5 Teaching and Learning Activities

5.1 Lecture

Topics:

Week	Topic
Week 1	Overview of multivariate analysis tasks; Review of matrix algebra
Week 2-3	Random vectors and matrices
Weeks 3-4	Multivariate normal distribution
Weeks 5-6	Inference for means; simultaneous confidence intervals
Week 7	MANOVA/MANCOVA
Weeks 8-9	Principal Component Analysis, Factor Analysis
Week 10-11	Discrimination, Classification and Clustering
Week 12	Class Presentations

Note: The final coverage may not include all these topics depending on time and other factors.
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6 Assessments

6.1 Marking Schemes & Distributions

Assignment	Due Date	Weighting	
		ST4350	**ST6821**
Participation		5%	5%
Assignment 1	Fri. Sep. 29	7%	7%
Assignment 2	Fri. Oct. 13	7%	7%
Assignment 3	Fri. Oct. 27	7%	7%
Midterm Exam*	Wed. Nov. 1	25%	15%
Presentation Article Selection	Mon. Nov. 6	--	--
Assignment 4	Fri. Nov. 10	7%	7%
Project – Proposal	Wed. Nov. 15	5%	5%
Assignment 5	Fri. Nov. 24	7%	7%
Final Presentation			15%
Project – Final project submission	Fri. Dec. 1 (ST4350)	30%	--
	Mon. Dec. 4 (ST6821)	--	25%

* In-class: 10:00AM - 11:20AM

6.2 Assessment Policies

Participation: Students are expected to participate in class discussion. Every week, some class time will be dedicated to a data set or problem and we will discuss aspects of analyzing such data or addressing the problem. Some data sets/problems may be related to assignment questions.

Assignments: Assignments will be posted on Courselink and due at 11:59pm on the due date as outlined above. Students are encouraged to discuss assignment questions with each other, but you are expected to complete the assignments yourself and to submit your own work. See below for the University of Guelph policies on Academic Misconduct.

Presentation: (Graduate students only). The presentation will involve finding a recent article or book chapter that covers an advanced topic in multivariate analysis. You will have to read the article/chapter, understand it, and present it to the class in a twenty to twenty-five minute talk. You are strongly encouraged to select a method that will be used in your final project. In other words, you present the article (NOT your project) for your presentation, and then apply that method to a data set for your final project. The dates and order of presentations will be determined later in the semester. BEFORE you start working on the presentation, inform the instructor of your choice article by Nov. 6. The instructor may deem the article not suitable for this presentation and/or suggest an alternate article. However, you are encouraged to select the paper yourself. Final slides used will need to be submitted by the last day of classes.

Final Project: The project will consist of a written statistical report of a particular application of a multivariate technique to analyse a data set. You are responsible for proposing your own project topic and finding suitable data. You will have to submit a project proposal to the instructor approximately two weeks before the project due date. Graduate students are expected to use advanced multivariate methods that have not been covered in class, preferably one that can be presented to the class for the Presentation component of the course grade.

Usually, a project will require data exploration and a clear understanding of the materials presented in class or any reading assignments. The project is an extremely important tool, not only to help you understand the course subject matter, but also to help you develop a critical view of data analysis and refine your written communication skills. Your report must document the procedures used in your project and relevant findings. **Raw computer output is not acceptable**. Further details for the project will be given out later in the semester.

6.3 Course Grading

Passing grade: In order to pass the course, STAT*4350 students must obtain a 50% or higher while STAT*6821 students must obtain a grade of 65% or higher on the total mark of all assessments.

Group Work: Students are encouraged to work together but must each write up individually the material they turn in. Work on the final project may be done in consultation with other students or with faculty but the final project must be completely written and executed by the student.

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the graduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations: [https://calendar.uoguelph.ca/graduate-calendar/general-regulations/academic-accommodation-religious-obligations/]

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7 College of Engineering and Physical Sciences Statements

7.1 Wellness

If you are struggling with personal or health issues:

- Counselling Services offers individualized appointments to help students work through personal struggles that may be impacting their academic performance.
- Student Health Services is located on campus and is available to provide medical attention.
- For support related to stress and anxiety, besides Health Services and Counselling Services, Kathy Somers runs training workshops and one-on-one sessions related to stress management and high performance situations. http://www.selfregulationskills.ca/

7.2 Personal information

Personal information is collected under the authority of the University of Guelph Act (1964), and in accordance with Ontario's Freedom of Information and Protection of Privacy Act (FIPPA) http://www.e-laws.gov.on.ca/index.html. This information is used by University officials in order to carry out their authorized academic and administrative responsibilities and also to establish a relationship for alumni and development purposes.

For more information regarding the Collection, Use and Disclosure of Personal Information policies please see the Undergraduate Calendar. (https://www.uoguelph.ca/registrar/calendars/undergraduate/current/intro/index.shtml)

7.3 Course Offering Information Disclaimer

Please note that course delivery format (face-to-face vs online) is subject to change up to the first-class day depending on requirements placed on the University and its employees by public health bodies, and local, provincial and federal governments. Any changes to course format prior to the first class will be posted on WebAdvisor/Student Planning as they become available.

8 University Statements

8.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

8.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml
Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml
Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

8.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

8.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

8.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

8.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08- amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

8.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

8.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars https://www.uoguelph.ca/academics/calendars

8.9 Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, changes in classroom protocols, and academic schedules. Any such changes will be announced via CourseLink and/or class email.

This includes on-campus scheduling during the semester, mid-terms and final examination schedules. All University-wide decisions will be posted on the COVID-19 website (https://news.uoguelph.ca/2019-novel-coronavirus-information/) and circulated by email.

8.10 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g., final exam or major assignment).

8.11 Covid-19 Safety Protocols

For information on current safety protocols, follow these links:

· https://news.uoguelph.ca/return-to-campuses/how-u-of-g-is-preparing-for-your- safe-return/
· https://news.uoguelph.ca/return-to-campuses/spaces/#ClassroomSpaces

Please note, these guidelines may be updated as required in response to evolving University, Public Health or government directives.