

The University of Manitoba
STAT 7140 – Linear Models
Winter Term 2024
Course Outline

- Course Number & Title:** STAT 7140, Linear Models.
- Time, Location & CRN:** Tuesdays & Thursdays 10:00 a.m. – 11:15 a.m., 415 Machray Hall.
CRN: 60147.
- Instructor:** Dr. Saumen Mandal
Office: 328 Machray Hall, Department of Statistics.
E-mail: saumen.mandal@umanitoba.ca
Phone: 204-474-9661
- Office Hours:** Tuesdays and Thursdays: 1:00 p.m. – 2:00 p.m.
If the above time is not convenient for you, please email me to arrange an alternate time to meet. You can also stop me anytime if you have questions during lectures.
- Web Pages:** UM Learn: <http://umanitoba.ca/umlearn>
Statistics: <https://www.sci.umanitoba.ca/statistics>
Crowdmark: <https://crowdmark.com>
SAS software: <https://welcome.oda.sas.com>

Territory Acknowledgment

The University of Manitoba campuses are located on original lands of Anishinaabeg, Cree, Oji-Cree, Dakota and Dene peoples, and on the homeland of the Métis Nation. We respect the Treaties that were made on these territories, we acknowledge the harms and mistakes of the past, and we dedicate ourselves to move forward in partnership with Indigenous communities in a spirit of reconciliation and collaboration.

Calendar Description

Theory of linear models, regression analysis, and analysis of variance. Prerequisite: Consent of instructor.

Textbook and Course Materials

A First Course in the Theory of Linear Statistical Models by R.H. Myers and J.S. Milton, PWS-KENT Publishing Company, Boston. ISBN: 0-534-91645-7.

The textbook is required. This book is available both in physical (hard) copy and electronic form (e-Book). This book can be purchased in our Fort Garry Bookstore. The price for the electronic version (e-Book) is cheaper than the hardcopy. If you would like to order the book online, you can go to the Bookstore webpage: <http://www.umanitoba.ca/bookstore>, shop for textbooks and then search by course. You can also try this link: <http://bookstore.umanitoba.ca/SelectTermDept>, then Select Term, Department and Course. If you have difficulty, let me know. You can also go to the bookstore and purchase the physical (hard) copy directly from there. Before you go, give them a call to make sure they have the physical (hard) copy in stock.

Detailed Lecture Notes and other materials (e.g. SAS code, data sets) will be posted in UM Learn. I expect you to attend all the lectures so that you do not miss any information and you have a solid understanding of the course materials.

Supplementary References: Searle, S.R. *Linear Models*. Wiley, New York.
Rencher, A.C. and Schaalje, G.B. *Linear Models in Statistics*. 2nd Edition, Wiley-Interscience.

Statistical Software

SAS statistical software will be used to perform the statistical analysis throughout the course. You can have free access to SAS Studio with SAS OnDemand for Academics. This is a free cloud-based software for teaching and learning. No installation is required. After registering, you can start using SAS Studio in a web browser. Homepage of SAS OnDemand for Academics: https://www.sas.com/en_us/software/on-demand-for-academics.html
Frequently Asked Questions can be found at: https://support.sas.com/ondemand/caq_new.html

Instructions for Getting Started are given in the SAS web site. Here are the steps:

Step 1: Create and verify a SAS profile (use this link: <https://www.sas.com/profile/ui/#!/create>) if you don't have one. If you do have one, just log in.

Step 2: Register (use this link: <https://welcome.oda.sas.com/login>) for SAS OnDemand for Academics using your SAS profile credentials.

Step 3: Once you receive a confirmation email, click the link to go to SAS OnDemand for Academics.

Step 4: Log in to access SAS Studio.

After all the steps, for your convenience, make a bookmark at: <https://welcome.oda.sas.com/login>

Please watch this YouTube video on Getting Started with SAS OnDemand:
<https://www.youtube.com/watch?v=tmL8fdOd-pl>

I will give a demo in the class. Instructions will be given in the class. Data sets and SAS code will be posted in UM Learn.

Assignments, Midterm Test and Final Exam

Assignments: The assignments will be conducted using the **Crowdmark** software, an online grading tool. You need to create a Crowdmark account (if you don't have one) at the web site: <https://crowdmark.com/> using your U of M email. This email must be the same as you have in UM Learn. All assignments will be written by you on paper and then scanned (or taken a photo of your paper) and uploaded through a link you will be provided over email. You can also write your answers on iPad or tablet. Please make sure your scanned/photo pages are sharp and readable. I will provide the detailed information and instructions throughout the course.

There will be two assignments, each counting equally (10% each) toward your final grade. Please find below the tentative dates for the assignments. Assignments will include some theoretical problems and computing problems. The computing problems will involve some data analysis using SAS software. Whenever you answer a question using SAS, you must attach the output (highlight the appropriate sections and answer the questions using the output). Assignments are to be submitted to the Crowdmark link provided in your email by the due date and time. No late assignments will be accepted.

Approximate Due Dates:

Assignment 1: February 29. Assignment 2: March 28.

Midterm Test: There will be one in-class midterm test. The date for the test is March 14. If there is a change on this date, I will notify you well in advance. The syllabus for the midterm test will be the materials covered until March 7. There will be no make-up midterm test. Students who miss a test with legitimate reasons and notify me within 48 hours will have the midterm weight added to the final exam. Detailed instructions will be provided before the test.

Final Exam: The final exam will be of three hours in duration and will be scheduled by the Student Records Office. The final exam will cover the whole syllabus. Detailed instructions will be provided before the exam.

Both the midterm test and final exam are closed book. For both the test and exam, please note the following: (i) nonprogrammable handheld calculators are permitted (graphing calculators are not permitted), (ii) electronic devices, such as cell phones or headphones, are prohibited, (iii) statistical tables will be provided, if required.

Inappropriate collaboration, plagiarism, or contract cheating of any kind will be dealt with severely and forwarded to the appropriate disciplinary committee.

Course Evaluation and Grading Scheme

The final mark for the course will be obtained from the following rule:

Assignments (2): 20% (10% each)

Midterm Test: 30%

Final Exam: 50%

Work should normally be graded and returned promptly. It is expected to return the graded materials within two weeks of submission. Marks for the assignments and midterm test will be posted on UM Learn gradebook. I will give you feedback after each assignment and midterm test.

The following are the minimum percentage grades required to receive the final grades:
A+ (90%), A (80%), B+ (75%), B (70%), C+ (65%), C (60%), D (50%), F (below 50%).

Goals and Course Contents

The following is a non-exhaustive list of topics to be covered in the course. In the beginning, you will notice that we will be revisiting some topics in Linear/Matrix Algebra and Multivariate Statistics. Then we will start advanced topics. Our primary goal/objective will be to reinforce the **fundamental concepts**, and to have a **solid understanding of Linear Models**.

1. Introduction - Matrix Algebra (Chapter 1)

- Matrix Operations
- Eigenvalues, Eigenvectors, Rank and Trace
- Linear Dependence of Vectors
- Idempotent Matrices and Properties
- Orthogonal Matrices and Properties

2. Quadratic Forms and Their Distributions (Chapter 2)

- Quadratic Forms
- Differentiation of Quadratic Forms
- Expectation and Variance of Vectors and Matrices
- Distribution of Quadratic Forms
- Independence of Quadratic Forms

3. Estimation in the Full Rank Model (Chapter 3)

- Least Squares Estimation, Gauss-Markoff Theorem
- Maximum Likelihood Estimation
- Interval Estimation
- Joint Confidence Region on the Regression Coefficients
- Generalized Least Squares

4. Hypothesis Testing in the Full Rank Model (Chapter 4)

- Testing for Model Adequacy
- Testing for a sub-vector of the regression coefficients
- Partial and Sequential Tests
- The General Linear Hypothesis
- Likelihood Ratio Tests

5. Estimation in the Less Than Full Rank Model (Chapter 5)

- Model and Reparameterization
- Generalized Inverse and Properties
- Estimability of Parametric Functions, Gauss-Markoff Theorem
- Interval Estimation

6. Hypothesis Testing in the Less Than Full Rank Model (Chapter 6)

- Hypothesis Testing in a General Setting
- Reparameterization: One-Way Classification
- Testing for a Treatment Contrast
- Two-Way Analysis of Variance
- Randomized Complete Block Designs

If time permits, the following topic will be considered.

7. Analysis of Covariance (ANOCOVA) (Chapter 7)

I will provide **Detailed Lecture Notes** on all topics.

Approximate Durations

Introduction, matrix algebra: 1.5 weeks.

Distributions of quadratic forms: 1.5 weeks.

Estimation in full rank model: 2.5 weeks.

Testing in full rank model: 2 weeks.

Estimation in less than full rank model: 2.5 weeks.

Testing in less than full rank model: 2 weeks.

Other topics: 0.5 weeks.

Important Dates

The following dates are important to how the course will progress throughout the term. The dates are tentative and subject to change at my discretion and/or based on the learning needs of the students.

Jan. 9: First lecture - course overview.

Jan. 19: Last date to drop Winter term courses.

Mar. 14: Midterm test.

Feb. 19 – 23: Winter term break (no classes).

Mar. 20: Voluntary withdrawal (VW) deadline.

Apr. 9: Last lecture.

Apr. 12 – 26: Final exam period.

Check out a complete list of important dates at: <https://umanitoba.ca/registrar/important-dates-deadlines>

Academic Integrity

I expect students to hold themselves to the highest standards of academic integrity. It is important that you understand what constitutes academic dishonesty and that you are familiar with the very serious consequences. Links to resources that describe academic dishonesty (including plagiarism, cheating, inappropriate collaboration, examination impersonation and typical penalties) can be found at:

<https://umanitoba.ca/student-supports/academic-supports/academic-integrity>

Academic Integrity Message from Associate Dean Krystyna Koczanski:

<https://www.youtube.com/watch?v=unjmw4Eztqc>

I expect you to be honest, conduct yourself with integrity, actively encourage your peers to conduct themselves with integrity, and uphold the value of what a degree from the University of Manitoba means. When you are in doubt, always consult with me. My door is always open for discussions. Bear in mind that what is considered a violation of academic integrity can vary from course to course so it is always important to ask and clarify.

ChatGPT

The use of generative artificial intelligence (genAI) tools and apps is strictly prohibited for all assessments (including assignments) in this course. This includes ChatGPT and other AI writing and coding assistants. Use of genAI in this course constitutes an act of academic dishonesty.

Copyrighted Material

Please respect copyright. We may use copyrighted content in this course and ensure that the contents are appropriately acknowledged according to copyright laws and university guidelines. The course notes, assignments, tests and exams are the intellectual property of your instructor or the Department of Statistics. Reproduction or distribution of these materials is strictly forbidden without their consent. You do not have permission to upload any course notes, tests, assignments, or handouts to any note sharing websites. See the university's copyright website at <http://umanitoba.ca/copyright>.

Recording of Class Lectures

Your instructor and the University of Manitoba hold copyright over the course materials, presentations and lectures which form part of this course. No audio or video recording of lectures or presentations is allowed in any format, openly or surreptitiously, in whole or in part without permission from your instructor.

Respectful Behaviour and Use of Electronics in the Classroom

It is expected that you conduct yourself professionally and do not distract your fellow students with unnecessary or inappropriate chat messages, sounds, or images while in the classroom. It is the general University of Manitoba policy that all technology resources are to be used in a responsible, efficient, ethical and legal manner. A student may use technology in the classroom setting only for educational purposes approved by the instructor and/or the University of Manitoba Accessibility Services. Students should not engage in electronic messaging/posting activities (e-mail, texting, video or voice chat, social networking (e.g. Facebook) or electronic gaming during scheduled class time.

Class Communication

The University requires all students to activate an official University email account. Please note that all communication between your instructor and you as a student must comply with the Electronic Communication with Students Policy. For more information, please see:

http://umanitoba.ca/admin/governance/governing_documents/community/electronic_communication_with_students_policy.html

You are required to obtain and use your U of M email account for all communication between yourself and the university.

Student Accessibility Services

If you are a student with a disability, please contact Student Accessibility Services (SAS) for academic accommodation supports and services such as note-taking, interpreting, assistive technology and exam accommodations. Students who have, or think they may have, a disability (e.g. mental illness, learning, medical, hearing, injury-related, visual) are invited to contact SAS to arrange a confidential consultation. For more information, please see: <https://umanitoba.ca/student-supports/accessibility>.

Schedule A

Schedule A of the Faculty of Science and the University of Manitoba lists resources and policies for students. It is important that you familiarize yourself with these resources and policies. Schedule A will be posted in UM Learn. Please review the information in Schedule A.

Finally, I would like to repeat that our primary goal/objective will be to reinforce the fundamental concepts, and to have a solid understanding of Linear Models by the end of the course. Please feel free to ask me whenever you have problem understanding any of the materials. You can stop me anytime if you have questions during lectures. When you are in doubt on anything, please feel free to consult with me. Let us together make this course successful.