

**The University of Manitoba**  
**STAT 7140 – Linear Models**  
**Fall Term 2018**  
**Course Outline**

**Course Number & Title:** STAT 7140, Linear Models.

**Time, Location & CRN:** Tuesdays & Thursdays 11:30 a.m. – 12:45 p.m., 316 Machray Hall.  
CRN: 10760.

**Instructor:** Dr. Saumen Mandal

Office: 328 Machray Hall, Department of Statistics.  
E-mail: saumen.mandal@umanitoba.ca  
Phone: (204) 474-9661

**Office Hours:** Tuesdays & Thursdays 9:45 a.m. – 11:15 a.m., or by appointment.

If the above times are not convenient for you, please phone, email or speak to me to arrange an alternate time to meet.

**Web Pages:** UM Learn: <http://umanitoba.ca/umlearn>  
Statistics: <http://umanitoba.ca/statistics>  
Gradebook: <http://www.stats.umanitoba.ca/gradebook>

**Calendar Description**

Theory of linear models, regression analysis, and analysis of variance.

Prerequisite: Consent of instructor.

**Textbook**

Myers, R. H. and Milton, J. S. (1991). *A First Course in the Theory of Linear Statistical Models*. PWS-KENT Publishing Company, Boston.  
ISBN: 0-534-91645-7.

Note that this book is out of print. With the copyright permission from the publisher, our bookstore has made copies of this text for you. You can buy it from the bookstore for \$69.95 (plus applicable taxes).

Lecture notes and other materials will be posted in UM Learn.

**Supplementary References:**

Searle, S. R. (1971). *Linear Models*. Wiley, New York.

Rencher, A. C. and Schaalje, G. B. (2008). *Linear Models in Statistics*. 2nd Edition, Wiley-Interscience.

## Statistical Software

If needed, you may use any software of your choice. Some software output from the textbook will be used. I have some SAS code for this course. We will use this software in the class. Instructions will be given in the class. You can install a copy of the SAS University Edition in your computer for free:

[http://www.sas.com/en\\_us/software/university-edition.html#for-students-learners](http://www.sas.com/en_us/software/university-edition.html#for-students-learners)

Documentation, including installation guides: <http://support.sas.com/software/products/university-edition/#s1=3>

There are many computers on campus that can be used for running SAS. In particular, you can practice this software in the Stats Lab at 311 Machray Hall.

## Assignments, Midterm Tests and Final Exam

There will be no formal assignments for this course. There will be two in-class midterm tests. The tentative dates are October 18 and November 22. If there is a change on these dates, I will notify you well in advance. The syllabus for the first midterm test will be the materials covered until October 11. The syllabus for the second midterm test will be the materials covered until November 8. Fall Term Break is November 13 to 16. There will be no make-up midterm tests. Students who miss a test with legitimate reasons and notify me within 48 hours will have the midterm weight added to the final exam. The final exam will be scheduled by the Student Records Office. The final exam will cover the whole syllabus.

For the midterm tests and the final examination: (i) nonprogrammable handheld calculators are permitted (graphing calculators are not permitted), (ii) electronic devices, such as cell phones or headphones, are prohibited, and (iii) statistical tables will be provided, if required. There will be no formula sheet for the midterm tests and final exam. The midterm tests and final exam are closed book.

## Course Evaluation and Grading Scheme

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

Midterm Test 1: 25%

Midterm Test 2: 25%

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 midterm tests will be posted on our Statistics Gradebook: <http://www.stats.umanitoba.ca/gradebook>

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%).

## 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. Changes are subject to Section 2.8 of the ROASS Procedure.

Sept. 6: First lecture - course overview.

Sept. 18: Course drop date - the last date to drop a course with a refund.

Sept. 19: Course add date - the last date to add a course in the revision period.

Oct. 18: Midterm test 1.

Nov. 13 – 16: Fall Term break.

Nov. 19: Voluntary withdrawal (VW) deadline.

Nov. 22: Midterm test 2.

Dec. 6: Last lecture.

Dec. 10 – 21: Final exam period.

## General 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 will be to reinforce the fundamental concepts, and to have a solid understanding of Linear Models.

### 1. Introduction - Matrix Algebra (Chapter 1)

- Matrix Operations
- Matrix Inverse and Orthogonality
- Eigen values, Rank and Trace
- Idempotent Matrices and Properties
- Row and Column spaces

### 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)

## **Academic Dishonesty**

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: <http://umanitoba.ca/science/undergrad/resources/webdisciplinedocuments.html>.

## **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. For more information, see the university's copyright office 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.

## **Use of Electronics 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](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.

## **ROASS Schedule A**

Schedule A of the Responsibilities of Academic Staff with regards to Students (ROASS) policies of 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. This document is also available from the Department of Statistics web page: <http://umanitoba.ca/statistics>.