FOUNDATION FOR ADVANCED EDUCATION IN THE SCIENCES

MATH 215 – Linear algebra with applications in statistics – Fall 2019

Instructor:	Caetano Souto Maior	**Time:**	W 18:00 – 21:00
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Course Pages:

1. http://faesmath.github.io/math215 - general course information and login to online classroom
2. https://faes.instructure.com/courses/200 – direct login to Canvas course page
3. https://my.faes.org/secure/student/student.aspx - FAES student portal

Office Hours: Friday, 15:30, usual classroom (tentative)

Textbooks:

- Gilbert Strang. Introduction to Linear Algebra, Fifth Edition (2016). Wellesley-Cambridge Press (http://math.mit.edu/~gs/linearalgebra/) **[main text, recommended]**
- Jim Hefferon. Linear Algebra, Third Edition (2017). Orthogonal Publishing (http://joshua.smcvt.edu/linearalgebra/) **[alternative text, free]**

Course Description:

Introduction to linear algebra and statistics: systems of linear equations, matrix algebra, linear independence, vector spaces and subspaces, bases and dimension, determinants, eigenvalues and eigenvectors, diagonalization, multiple linear regression, singular value decomposition, principle components analysis. This course provides a comprehensive introduction to linear algebra with the intention of developing intuition into contemporary statistical and mathematical modeling techniques. Most commonly used statistical tests are either implicitly or explicitly related to some underlying linear model. For example, two-sample t-tests correspond to simple linear regression, while ANOVA and ANCOVA correspond to multiple regression and mixed effects models, respectively. In addition, many non-model-based data exploration techniques, such as principle components analysis, are based on concepts in linear algebra. The specification and analysis of differential equations of multiple variables also requires knowledge of linear algebra techniques.

This course provides the mathematical foundations linking together all of these techniques. In addition, it will have a lab component using Python and R.

Objectives: Analyze and solve systems of linear equations. Become proficient in matrix manipulation and arithmetic. Learn the concept of vector spaces, subspaces, and linear dependence. Learn spectral methods for analyzing matrices. Understand statistical methods based on linear models and their analyses. Learn basic techniques for differential equations rooted in linear algebra.

Structure of the course: This course will be divided into three units. The first unit will include a short review of vectors and linear equations, and the remaining of it will cover matrix operations in the context of vector spaces, independence of vectors and other important matrix properties and operations. The second unit will cover concepts slightly more advanced and less intuitive of matrices, like determinants and eigen values, and begin to place these and previous concepts in the context of applications and statistical methods like least squares regression. The third and final unit will emphasize applications of linear algebra in statistics, taking into account the uses and interests of the class.

The Learning Process: The math courses will take into account the diversity of backgrounds and stage of career of students taking the courses, who may be less or more comfortable with a hard math class; therefore, the course will start with a comprehensive introduction to the essential principles, both to assess the general level of the class as well as to make sure everyone is up to speed within a few lectures. Because of this focus on the core principles of algebra and the need to include applications in statistics, more esoteric details and proofs may not be explored in-depth; nevertheless, homework, office hours, and online lecture notes will be provided for any students who wish to gain deeper understanding of any topic. With this approach I expect to be able to be able to cover most or all of the syllabus of a standard linear algebra textbook, include modern applications in statistics that are also relevant to the students, and make sure that no one is left behind.

Prerequisites: One semester of differential calculus.

Important Dates: Exam dates are subject to change:

Class begins ..... September 11, 2019
Last day to drop ..... September 27, 2019
Midterm I ..... Oct 2, 2019
Midterm II ..... Nov 6, 2019
Last day to change status ..... November 15, 2019
Thanksgiving week (no class) ..... Nov 27, 2019
Final Exam/Presentations ..... Dec 11, 2019

Grading Policy:
Midterm 1 (25%), Midterm 2 (25%), Final (30%), Quizzes (20%). Quizzes and exams are cumulative. Extra credit can be obtained up to 10 points. 100 points is the highest grande in this course.

Grading Scale: The grading scale will be the following:

A	A-	B+	B	B-	C+	C	C-	D+	D
93+	$90-92$	$87-89$	$83-86$	$80-82$	$77-79$	$72-76$	$70-72$	$67-69$	$60-66$

Quiz Policy:
Approximately 10 quizzes will be administered in this course. The higher 50% quantile of scores will make up the final grande contribution. There are no make-up quizzes.

Homework Policy: Homework does not count directly to the final grade, but is strongly recommended as practice for both quizzes and exams.

Extra Credit: The students can earn extra credit in several ways:

1. Pointing out errors in any of the texts or presentations used in the course;

2. Writing 1-2 paragraphs about concepts they find difficult or think require clearer explanation/helping with supplementary lecture notes;
3. Replying to lecture-related questions in online classroom;
4. Creating an account in the Stack Exchange Math forum and inform the instructor of their user name, and;
    - posting questions about exercises or definitions, sending the link to the instructor, and getting replies;
    - or replying to questions from others.

Extra credit is limited to one point per week.

Class Policy:

- Attendance in every class is strongly encouraged. Although the course is modeled after typical introduction to linear algebra, it will at times deviate from that, and some topics may not be completely covered by the textbook and notes;
- Quiz and exam problems are not simple repetitions of textbook exercises – attendance is likely to increase familiarity with different styles of problems;
- Computers and regular-sized tablets are allowed in class for note-taking and occasional online consultations, please refrain from using any other resources, and especially social media. Cell phones are not allowed, please silence and put away your phones during class.

Communication Policy:

- Any questions about lecture content should be asked using the Canvas online classroom platform;
- Preferred (and likely fastest) communication method for other matters is e-mail, replies will normally be sent within 2 workdays;
- Calls and text should be used only in urgent cases via Slack channel/direct contact during business hours (request to be added if you would like to be able to use this platform)

Policy on Academic Integrity from FAES:

Academic Policies: This course adheres to all FAES policies described in the academic catalog and student handbook, including the Academic Integrity policy listed on page 11 of the academic catalog and student handbook. Be certain that you are knowledgeable about all of the policies listed in this syllabus, in the academic catalog and student handbook, and on the FAES website. As a student in this program, you are bound by those policies.

Copyright: All course materials are the property of FAES and are to be used for the studentâĂŹs individual academic purpose only. Any dissemination, copying, reproducing, modification, displaying, or transmitting of any course material for any other purpose is prohibited, will be considered misconduct, and may be cause for disciplinary action. In addition, encouraging academic dishonesty by distributing information about course materials or assignments which would give an unfair advantage to others may violate the FAES Academic Integrity policy. Course materials may not be exchanged or distributed for commercial purposes, for compensation, or for any purpose other than use by students enrolled in the course. Distributions of course materials may be subject to disciplinary action.

Guidelines for Disability Accommodations: FAES is committed to providing reasonable and appropriate accommodations to students with disabilities. Students with documented disabilities should contact Dr. Mindy Maris, Assistant Dean of Academic Programs.

Dropping the Course: Students are responsible for understanding FAES policies, procedures, and deadlines regarding dropping or withdrawing from the course or switching to audit status.

Academic misconduct: Cheating, fabrication or plagiarism by students is not acceptable in any form. If a student is found to be in violation of acceptable conduct by any of the practices below, they will be stripped from the grade of that assignment and potentially others

Cheating is defined as an attempt to give or obtain inappropriate/unauthorized assistance during any academic exercise, such as during examination, homework assignment, class presentation.

Fabrication is defined as the falsification of data, information or citations in any academic materials.

Plagiarism is defined as using the ideas, methods, or written words of another, without proper acknowledgment and with the intention that they be taken as the work of the deceiver. These include, but are not limited to, the use of published articles, paraphrasing, copying someone else's homework and turning it in as one's own and failing to reference footnotes. Procuring information from online sources without proper attribution also constitutes plagiarism.

Tentative Course Schedule: Recommended reading may not align perfectly with lecture content. Importance of each section will be emphasized during lectures depending on profile/background of enrolled students, overall progress, and interest in specific applications (the latter applies to the statistical applications unit – the last third of course).

Date	Topic(s)	Reading (Strang)
Sep 11	**Lecture 1:** Introduction, Vectors, Systems of linear equations	1, 2.1-2.3
Sep 18	**Lecture 2:** Matrices, Inverses, Factorization, Transposes	2.4-2.7
Sep 25	**Lecture 3:** Vector spaces and subspaces	3.1-3.3
Oct 2	**Lecture 4:** Dependence, basis, and dimension	3.4-3.5
Oct 9	**Lecture 5:** Orthogonality, projections, orthonormal bases **(Midterm I)**	4.1,4.2,4.4
Oct 16	**Lecture 6:** Least-squares	4.3, *notes*
Oct 23	**Lecture 7:** Determinants	5.1-5.3
Oct 30	**Lecture 8:** Eigenvalues and Eigenvectors	6.1-6.2
Nov 6	**Lecture 9:** Symmetric matrices **(Midterm II)**	6.3-6.5
Nov 13	**Lecture 10:** Singular value decomposition and PCA	7.1-7.4
Nov 20	**Lecture 11:** Linear transformations	8.1-8.3

Dec 4	**Lecture 12:** Statistical applications, complex numbers	9,10, *notes*
Dec 11	**Final presentations**	

Additional learning resources:

Khan Academy https://www.khanacademy.org/math/linear-algebra

MIT OpenCourseWare https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/