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

Instructor:	Caetano Souto Maior	**Time:**	W 18:00 – 21:00
Email:	caetano.soutomaior@nih.gov	**Place:**	NIH Building 10, 4-3330

Course Pages:

1. http://faesmath.github.io/math215.html - general course information and login to online classroom
2. 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.

Prerequisites: One semester of differential calculus.

Important Dates: Exam dates are subject to change:

Class begins	September 11, 2019
Midterm I	Oct 2, 2019
Midterm II	Nov 6, 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;
3. Creating an account in the Stack Exchange Math forum and inform the instructor of their user name, and;
   - post questions about exercises or definitions, sending the link to the instructor, and getting replies;
   - or reply to question from others.

Extra credit is limited to one point per week.

Course Policy:

- We strongly recommend that you sign up with FAES; the course may be cancelled in the event of low registration.

Class Policy:

- Attendance in every class is strongly encouraged. Although it is modeled after typical introduction to linear algebra courses and will cover a standard text book material, it will deviate from that by glossing over more arcane details in favor of statistical applications and practical implementations, which are not entirely included in the textbooks.
- 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.

Policy on Academic Integrity from FAES: The FAES Graduate School at NIH prides itself on providing quality educational experiences and upholds the highest level of honesty, integrity, and mutual respect. It is our policy that cheating, fabrication or plagiarism by students is not acceptable in any form. If a student is found to be in violation of any, or all of the below, his/her credits will be forfeited, and he/she will not be allowed to enroll in future courses or education programs administered by FAES.

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 and overall progress, and interest in specific applications (the latter applies to the statistical applications unit – the last third of course).

Date	Topic(s)	Reading
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 and projections **(Midterm I)**	4.1,4.2,4.4
Oct 16	**Lecture 6:** Least-squares, orthonormal bases	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 Open Courseware https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/