MAS 4115: Linear Algebra for Data Science Spring 2023

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Office Hours:	MW 1:55–2:45pm (per. 7), or appointment
Class Meetings:	MWF 12:50–1:40pm (period 6), LIT 0235
Prerequisites:	MAS3114, MAS4105 or equivalent

Course Description and Objectives: Second course in linear algebra, focusing on topics that are the most essential for data science. Introduces theory and numerical methods required for linear problems associated with large data-sets and machine learning. Topics include LU, QR, and singular-value decompositions of matrices; conditioning and stability; complex vector spaces; the DFT and linear filters; deep learning; fully connected and convolutional nets; and gradient descent.

Course Goals and Objectives: A student who successfully completes this course will be able to:

- Perform basic linear algebra computations by hand and in Python.
- Prove the existence of the various standard matrix decompositions and use their numerical implementation for data analysis and solving linear problems.
- Construct routines which avoid the common sources of error based on an appreciation of conditioning and stability in numerical linear algebra computations.
- Derive the basic properties and write Python code implementations of the Discrete Fourier Transform, convolution, and filtering
- Construct simple feedforward neural networks using learning functions, loss functions and stochastic gradient descent

Resources: Most of the course will be based on lecture notes. The following are useful resources

- Linear Algebra and Learning from Data, by Gilbert Strang, Wellesley-Cambridge Press; First edition (2019).
- Numerical Linear Algebra, Lloyd Trefethen and David Bau, SIAM Press, 1997
- Neural Networks and Deep Learning by Michael Nielsen http://neuralnetworksanddeeplearning.com/index.html
- Deep Learning by Ian Goodfellow and Yoshua Bengio and Aaron Courville http://www.deeplearningbook.org/

Programming Prerequisite: Class demos will use Python. Class assignments will require Python or comparable platform, such as R, Matlab or Julia. So you don't know how to program in one of these you will need to have enough experience with a programming language to pick up Python reasonably quickly.

Homework: Homework will be assigned every other week on Fridays and due the in two weeks with occasional breaks. It will be posted as a File in Canvas. The homework will foster mastery over the material covered in class in the previous weeks. It will include hand computations, proofs and computer computations. The lowest homework score will be dropped.

Honor Code and Collaboration: In this course authorized aid on projects and hw consists of talking to me, other students, reading the documentation for your computational platform, and looking at the notes for this course. This means that you are not allowed to look on-line, in other books for solutions to the hw or projects, or at the written solutions of other students. You can collaborate with fellow students but must write up and code individually.

Weekly Schedule (subject to change):

- Week 1: Review of basic Linear Algebra: linear independence, basis, dimension,
- Week 2: Matrices, linear transformations, associated subspaces
- Week 3: Systems of equations, LU decomposition
- Week 4: Eigenvalues, eigenvectors, linear differential equations
- Week 5: Inner products, orthogonality, QR decomposition, orthogonal projection
- Week 6: Spectral theorem, norms, positive definite matrices
- Week 7: Gradient, Hessian, introduction to least squares
- Week 7: Singular value decomposition, principal component analysis, best low rank approximation
- Week 8: Basic numerical linear algebra, conditioning, stability,
- Week 9: Deep learning, layers, learning and loss functions
- Week 10: Fully connected and convolutional nets
- Week 11: Back propagation and chain rule, gradient descent

- Week 12: Complex vector spaces, orthonormal basis, best least squares approximation
- Week 13: Fourier Series and Discrete Fourier Transform, convolution
- Week 14 Toeplitz matrices and shift invariant linear filters
- Week 15: Overflow of previous
- Finals week

Grading: Homework problems will be assigned and due every other week. There will be no exams or quizzes. All homework grades will be posted to canvas. Please notify me as soon as possible if you anticipate being unable to submit a homework assignment. Any issues or questions about the grading of homework or exams must be brought to my attention within one week after the exams or homework are returned to the class.
Semester letter grade assignments will be no stricter than the following: 93-100 A, 90-92 A-, 87-89 B+, 83-86 B, 80-82 B-, 77-79 C+, 73-76 C, 70-72 C-, 67-69 D+, 63-66 D, 60-62 D-, 0-59 E. We will adhere to the university grading policies that can be found here: `https://catalog.ufl.edu/UGRD/academic-regulations/grades-grading-policies/`

Announcements: You are responsible for all announcements made in Canvas and via email which could include changes in exam dates and material covered.

Diversity Statement: I am committed to diversity and inclusion of all students in this course. I acknowledge, respect, and value the diverse nature, background and perspective of students and believe that it furthers academic achievements. It is my intent to present materials and activities that are respectful of diversity: race, color, creed, gender, gender identity, sexual orientation, age, religious status, national origin, ethnicity, disability, socioeconomic status, and any other distinguishing qualities.

Attendance: Attendance is required. We will adhere to the university attendance policies that can be found here: `https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/`.

Student Evaluations: Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at `https://gatorevals.aa.ufl.edu/students/`. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via `https://ufl.bluera.com/ufl/`. Summaries of course evaluation results are available to students at `https://gatorevals.aa.ufl.edu/public-results/`.

Disabilities statement: Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the Disability Resource Center by visiting `https://disability.ufl.edu/`. It is important for students to share their accommodation letter with their instructor and discuss their access needs as early as possible in the semester.

Academic Integrity: UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code." On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Conduct Code specifies a number of behaviors that are in violation of this code and the possible sanctions. See `https://sccr.dso.ufl.edu/process/student-conduct-code/` to read the Conduct Code. If you have any questions or concerns, please consult with the instructor or TA in this class.