University of Florida

Philip Boyland
Department of Mathematics

College *of* Liberal Arts *and* Sciences

MAS 4115: Linear Algebra for Data Science, F21

Note: The class format and conduct may change based on University Guidelines and recommendations.

Course Number: MAS 4115

Time and Location: Little Hall, 219, period 5

Office Hours : Monday 3:00 – 3:50 (office, Little 338), Tuesday and Thursday, zoom address on canvas

Course Description: A 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 Matlab.
- 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 Matlab code implementations of the Discrete Fourier
  Transform, convolution, and filtering
- Construct simple feedforward neural networks using learning functions, loss functions and

stochastic gradient descent

Prerequisites: A course in linear algebra (MAS 3114, MAS4105 or equivalent course) is required.

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 Matlab. Class assignments will require Matlab or comparable platform, such as R, Python 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 Matlab reasonably quickly.

Homework: Homework will be assigned week on a Friday and due the next Friday (with breaks for exams), so there will be about 12 total assignments. It will be posted as a File in Canvas. The homework will foster mastery over the material covered in class in the previous week. It will include hand computations, proofs and computer computations. All problems will be graded and the graded homework will be returned by the following Friday. You may turn in the homework by the next Monday for 2/3 credit. No submissions will be accepted after that. 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.

Exams: There will be three 50 minute exams. They will take place on Wednesday, September 16, Wednesday October 30, and Wednesday, December 15 (during the classes final exam period). All exams take place in the regular classroom.

Grades: The three exams are weighted equally and are not cumulative. The three exams constitute 75% of the grade and the homework is 25%. The grade ranges for the total scores are 93-100% A, 90-92% A-, 88-89% B+,83-87% B, 80-82% B-, 78-79% C+,73-77% C, 70-72% C-, 60-69% D, <60% F.

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

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

Excused Absences: In certain circumstances a student will be able to make up a missed exam. These circumstances could include medical situations, family emergencies, travel for University activities (eg. band, debating club, etc), and religious observances. In these cases the student must inform me before or within one week after the missed work and **provide written documentation**.

Grading Disputes: Any issues or questions about the grading of exams must be brought to my attention within one week after the exams or homework are returned to the class.

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.

Additional Information:

Grades: Grading will be in accord with the UF policy stated at https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx.

Honor Code: "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 Honor Code specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class."

Class Attendance: "Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies that can be found at: https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx."

Accommodations for Students with Disabilities: "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/students/get-started/. 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."

Online 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/."

Contact information for the Counseling and Wellness Center: https://counseling.ufl.edu/, 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

U Matter, We Care: If you or someone you know is in distress, please contact umatter@ufl.edu, 352-392-1575, or visit umatter.ufl.edu/ to refer or report a concern and a team member will reach out to the student in distress.