New Course Fall 2021: Math 464/664
Linear Algebra with Data Applications

- **Prerequisites:** CS112 and MATH322 or permission of the instructor. The course assumes a solid background of basic linear algebra (vector spaces, bases, matrices, eigenvalues) and ability to write basic mathematical proofs. Projects will require basic programming/computational experience.
- **Instructor:** Tyrus Berry, tberry@gmu.edu, http://math.gmu.edu/˜berry/
- **Book:** Linear Algebra in Action (Second Edition) by Harry Dym

Overview

The course covers Linear Algebra from an abstract viewpoint and shows how it motivates many advanced topics in theoretical math. We then connect these abstract concepts to practical applications with an emphasis on data-driven applications such as clustering, dimensionality reduction, feature identification, data assimilation, and control theory. The course is project and homework based with short blackboard quizzes (unlimited attempts) to help check that you understand the concepts as we go. This course is designed for advanced undergraduates, especially students that may be considering graduate school in mathematics or related fields.

Key abstract concepts include fundamental subspaces, duality, invariants, and the operator algebra. These are grounded in their respective linear algebra instances, namely, bases, adjoints, eigenspaces, and matrix decompositions including the Jordan decomposition and SVD. Topics are presented at a level of abstraction that allows natural generalization. Computational projects connect the abstract concepts to foundational methods and techniques in data science such as dimensionality reduction, graph embeddings, and regularized regression.

Optional topics: Restricted conjugacy and algebra of orbits; linear mappings on normed linear spaces; dual extremal problems; introduction to numerical linear algebra; introduction to linear programming; dual spaces of derivatives and forms in multivariable calculus; spectral radius; algebra of resolvents; matrices over other fields.

Optional applications: Kernel methods, sparsity and compression, FFT, dynamics, linear stability analysis, Markov processes, state estimation, optimal control, graph/network analysis, dimensionality reduction, clustering, regularized regression, data visualization, feature identification.

Some example applications: