# COURSE SYLLABUS

**Course Title:** **Honors Computational Linear Algebra for Data Science**

Abbreviated Title As Appears on Transcript: `Honors Linear Algebra Data Sci`

Course Number: DMAT 337

Credit Hours: 5 credits [semester credit hours]

Course Description: An honors-level first course in matrix algebra and linear spaces with emphasis on computational software techniques and geometrical analysis, with applications applicable to data science. Topics include matrices, solutions of systems of linear equations, determinants, linear spaces and transformations, inner products, higher dimensional spaces, inverses and pseudoinverses, rank, Singular Value Decomposition, change of basis, Eigenvalues and Eigenvectors, matrix decomposition and diagonalization, Principal Component Analysis, image and data compression, and an introduction to numerical analysis issues in the subject. Honors courses will include greater breadth and depth of topics, and develop technical writing skills, culminating in a mathematical term paper on an approved topic.

Prerequisite: Successful completion with grade B or higher in Calculus II or equivalent, or consent of instructor.

Course Workload: 5 semester credit hours • 3 student work hours per credit hour • 14 week Carnegie semester = 210 hours student course workload average

Examination Requirements: Proctored written final examination must be passed at 60% or higher to earn passing grade in course. "B" and "A" grade paths have additional examinations.
See https://www.distancecalculus.com/grades/ for more information.

Course Professor: Robert R. Curtis, Ph.D.<rcurtis@rwu.edu>, <robert@distancecalculus.com>

University Information: Roger Williams University, University College, 1 Empire Plaza, Providence, RI, USA 02903. Roger Williams University, 1 Old Ferry Road, Bristol, RI 02809. Accredited by New England Commission of Higher Education (NECHE).
See https://www.rwu.edu/academics/accreditation/ for more information.

E-Textbook: *Matrices, Geometry & Mathematica* by Davis/Porta/Uhl

Mathematical Software: Mathematica™ Computer Algebra & Graphing System

## ADA ACCOMMODATIONS

Roger Williams University has a continuing commitment to providing reasonable accommodations for students with documented disabilities. Students with disabilities who need accommodations in order to fully participate in this class are urged to contact Student Accessibility Services, as soon as possible, to explore the arrangements needed to be made to assure access. Student Accessibility Services is open Monday through Friday from 8:00AM to 5:00PM Eastern Time; Email: sas@rwu.edu or Voice: 401-254-3841. For more information about SAS, visit https://www.rwu.edu/undergraduate/academics/student-academic-success/student-accessibility-services-sas

**Learning Outcomes for DMAT 337 - Honors Computational Linear Algebra for Data Science**

1. To understand the core connection between matrix algebra and a study of systems of linear equations
2. To understand and compute measurements of vectors and their geometry
3. To understand and compute core matrix algebra operations and their geometrical interpretations
4. To understand and compute the fundamental properties of determinants and inverses of matrices, both for square and non-square generalizations
5. To understand and compute Singular Value Decomposition
6. To understand and compute the core concept of rank and its variations
7. To understand and compute Gaussian elimination and other strategies for finding solutions or approximate solutions to systems of linear equations
7. To understand and compute bases, change of bases, spanning and linear independence, kernel and image sets
8. To understand and compute the diagonalization of a matrix, both with Singular Value Decomposition, and Eigenvalue - Eigenvector constructions.

Honors Topics:

9.* To understand and compute interpolating polynomials and Fourier fitting and analysis
10.*To understand and compute the Gram-Schmidt process in relation to Singular Value Decomposition
11.*To understand and compute the diagonalization of a matrix when Eigenvalues are repeated and/or complex.
12.*To understand and compute the relationship of matrix diagonalization and dynamical systems of differential equations
13.*To understand and compute the Spectral Theorem
14.*To understand Principal Component Analysis and additional concepts in data fitting
15.*To understand issues concerned with image compression and round-off error
16.*To develop mathematical technical writing skills, culminating in a term paper on an approved topic

Syllabus Topics Outline for DMAT 337 - Honors Computational Linear Algebra for Data Science

1. Getting Started
   - 1.1 Email and Chat
   - 1.2 Learning About the Course
   - 1.3 Required Hardware
   - 1.4 Software Fundamentals

2. Vectors
   - 2.1. Geometry of Vectors
   - 2.2. Perpendicular Frames
   - 2.3. Curves in 2D: Change of Frames/Basis
   - 2.4. Dot Products
   - 2.5. Cross Products
   - 2.6. Ellipses and Ellipsoids
   - 2.7. Area and Volume

3. Matrices
   - 3.1 Basics
   - 3.2 Transforming Curves
   - 3.3 Matrix Arithmetic
   - 3.4 Translations and Rotations
   - 3.5 Shears
   - 3.6 Linear Transformations
   - 3.7 Inverses
   - 3.8 Determinants
   - 3.9 Transposes
   - 3.10 Matrix Decomposition: Singular Value Decomposition
   - 3.11 Rank
   - 3.12 Projections
   - 3.13 Higher Dimensions

4. Linear Systems
   - 4.1 Conversion to Matrix Notation
   - 4.2 Gaussian Elimination
   - 4.3 Vector Spaces and Subspaces
   - 4.4 Numerical Considerations
   - 4.5 Applications: Least Square Fit
   - 4.6 Spanning Sets; Basis
   - 4.7 Linear Independence
   - 4.8 Pseudo Inverses
   - 4.9 Approximate Solutions
   - 4.10 Null Space and Image Space
   - 4.11* Interpolating Polynomials and Trigonometric Functions: Fourier Fit
   - 4.11* Undetermined Coefficients in Differential Equations Systems

5. Eigenvalues and Eigenvectors
   - 5.1 Diagonalization of a Matrix
   - 5.2 Eigenvalues
   - 5.3 Eigenvectors
   - 5.4 Exponential of a Matrix

6. Principal Data Component Analysis
   - 6.1 Image and Data Compression
   - 6.2 Round-off Error
   - 6.3 Principal Data Component Analysis with SVD

7.* Honors Topics
   - 7.1* Gram-Schmidt Process and Singular Value Decomposition
   - 7.2* 4D Projections
   - 7.3* Non-Real Eigenvalue and Eigenvectors
   - 7.4* Applications to Dynamical Systems
   - 7.5* Spectral Theorem

8.* Mathematical Writing
   - 8.1* Cogent writing
   - 8.2* Mathematical Presentation
   - 8.3* Term Paper Topic and Research