DISTANCE CALCULUS @ RWU ROGER WILLIAMS UNIVERSITY

COURSE SYLLABUS

Course Title: **Differential Equations & Linear Algebra**

Abbreviated Title As Appears on Transcript: `Differential Eqns and Lin Alg`

Course Number: DMAT 346

Credit Hours: 5 credits [semester credit hours]

Course Description: A combined course in differential equations and matrix algebra and linear spaces with emphasis on computational software techniques and geometrical analysis. 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, bases, rank, Eigenvalues and Eigenvectors, matrix decomposition and diagonalization; First, Second, and higher-order ordinary differential equations, analysis of forcing functions, Laplace Transforms, convolution integral techniques, Fast Fourier Transforms and data approximations, systems of differential equations, classical algebraic solution methods, power series solutions.

Prerequisite: Successful completion (C- or higher) of 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 and oral final examination must be passed at 70% or higher to earn passing grade in course. "B" and "A" grade paths have additional examinations and assignments. See https://www.distancecalculus.com/grades/ for more information.

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Accredited by New England Commission of Higher Education (NECHE).
See https://www.rwu.edu/academics/accreditation/ for more information.

E-Textbook:

Differential Equations & LiveMath and *Matrices, Geometry & LiveMath* by Robert R. Curtis, Ph.D., adapted from Davis/Porta/Uhl *Calculus&Mathematica* courseware series

Mathematical Software: LiveMath and Mathematica Computer Algebra & Graphing Systems

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

COURSE RULES

Academic Honesty

Academic Dishonesty in a Distance course includes copying or relying upon another person's work. Working with other students is good and encouraged, but the work you submit for this course must be genuinely your own work. Private tutors are allowed, but you must notify the instructor that you have obtained a private tutor to aid in your studies. Any documented instance of Academic Dishonesty will be grounds for immediate failure in this course.

Final (and Other) Examinations

A written and oral proctored final exam will occur at the student's location over video with the course professor; The student must score 70% or higher on this final exam to be eligible to earn a passing grade in the course.

Communication

Communication is the key to success in a Distance course. It is the student's responsibility to keep good communication channels with the instructors during the course; failure to participate in the course does not constitute "dropping" the course (Withdrawal from the course must be requested in writing to the instructors before the completion date deadline)

Roger Williams University Policies & Procedures

Roger Williams University has Policies & Procedures that all students must follow, including the Roger Williams University Student Handbook. Student must agree to follow all stated rules governing student conduct listed on the Roger Williams University website, and at the Roger Williams University Course Catalog

Course Completion 1 Year Rule

All Distance Calculus students are afforded 1 Year to finish their course from the Date of Enrollment. Students will be placed in the Academic Semester based upon their Date of Enrollment for academic records purposes. If a student does not finish the course, and does not request a Course Withdrawal for a W, then an "F" grade will be issued.

No Chatbots / AI

Students must pledge to **not** use any Chatbot/AI at all - **period**. Student must pledge to **limit** use of search engines (Google, Bing, etc) to a minimal level. Student must pledge to not engage in dishonest disguise of any Chatbot/AI/Search Engine source of information as student's own honest academic work. Verified chatbot usage will result in an "F" course grade, and will be referred to the Roger Williams

Learning Outcomes for DMAT 346 - Differential Equations & Linear Algebra

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.
9. To understand orthogonalization and the Gram-Schmidt process.
10. To understand the core construction of the differential equation, and its classification parts
11. To understand the role of the forcing function in differential equations
12. To understand, observe, and compute the steady state solutions for a differential equation
13. To understand, observe, and compute solutions of differential equations with a variety of forcing functions, including DiracDelta, step, oscillatory, and others
14. To understand, observe, and compute solutions of differential equations with a variety of forcing functions, including DiracDelta impulses, step, oscillatory, et al.
15. To understand and compute solutions of second order differential equations oscillators and how forcing functions affect their solutions
16. To understand and compute manual solutions of first and second order differential equations using classical techiques
17. To understand and compute with the Laplace Transform method
18. To understand and compute graphical and numerical solution methods of differential equations
19. To understand and compute solutions of linear systems of differential equations
20. To understand and compute polynomial approximations to solutions of differential equations

Syllabus Topics Outline for DMAT 346 - Differential Equations & Linear Algebra

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, Rotations, Shears, Rigid Motions
   - 3.5 Linear Transformations
   - 3.6 Inverses
   - 3.7 Determinants
   - 3.8 Transposes
   - 3.9 Singular Value Decomposition & Geometry
   - 3.10 Rank and Nullity
   - 3.11 Projections
   - 3.12 Higher Dimensions: 2D, 3D, 4D

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 Orthonormal Bases & Gram-Schmidt Process

5. Eigenvalues and Eigenvectors
   - 5.1 Diagonalization of a Matrix
   - 5.2 Eigenvalues
   - 5.3 Eigenvectors
   - 5.4 Exponential of a Matrix
   - 5.5 Dynamical Systems
   - 5.6 Trace, Determinant
   - 5.7 SVD Analysis & Eigenvalue Decomposition Connection via Transposes

6. Exponential Differential Equations

- 6.1 Unforced DEs
- 6.2 Forced DEs
- 6.3 Steady State
- 6.4 Personal Finance
- 6.5 Step Function and Dirac Delta Function
- 6.6 Tangent Vectors
- 6.7 Initial Conditions
- 6.8 Integration Factors

7. Second-Order Differential Equations
- 7.1 Overdamped and Underdamped Oscillators
- 7.2 Linear Forced and Unforced Oscillators
- 7.3 Homogeneous and Inhomogeneous Equations
- 7.4 Convolution Method
- 7.5 Characteristic Equations
- 7.6 Euler's Formula
- 7.7 Impulse Forcing
- 7.8 Dirac Delta Convolutions
- 7.9 Springs and Electrical Charges
- 7.10 Higher Order Equations

8. Laplace Transforms
- 8.1 Laplace Transforms of First and Second Order Equations
- 8.2 Fourier Analysis and Fourier Fit Approximations

9. Graphical Analysis of Differential Equations
- 9.1 Euler's Method
- 9.2 Flow Plots and Trajectories
- 9.3 Preditor-Prey Model
- 9.4 Logistic Harvesting

10. First-Order Differential Equations
- 10.1 Autonomous Equations
- 10.2 Non-Autonomous Equations
- 10.3 Separation of Variables Solving Method

11. Systems of Differential Equations
- 11.1 Flows and Trajectories
- 11.2 Conversion Between Higher Order ODEs and Systems
- 11.3 Relationship to Eigenvalues and Eigenvectors

12. Power Series Solutions of Differential Equations
- 12.1 Recursion Relations
- 12.2 Comparing Series Solution to Numerical Solution
- 12.3 Barriers