COURSE SYLLABUS

Course Title: **Honors Computational Differential Equations**

Abbreviated Title As Appears on Transcript: `Honors Comp Differential Eqns`

Course Number: DMAT 322

Credit Hours: 4 credits [semester credit hours]

Course Description: A first course in the study of differential equations with emphasis on modern software computational techniques with geometrical and qualitative interpretations. Topics include 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. 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: 4 semester credit hours • 3 student work hours per credit hour • 14 week Carnegie semester = 168 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>

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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 & 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 322 - Honors Computational Differential Equations

1. To understand the core construction of the differential equation, and its classification parts
2. To understand the role of the forcing function in differential equations
3. To understand, observe, and compute the steady state solutions for a differential equation
4. To understand, observe, and compute solutions of differential equations with a variety of forcing functions, including DiracDelta, step, oscillatory, and others
5. To understand, observe, and compute solutions of differential equations with a variety of forcing functions, including DiracDelta impulses, step, oscillatory, et al.
6. To understand and compute solutions of second order differential equations oscillators and how forcing functions affect their solutions
7. To understand and compute manual solutions of first and second order differential equations using classical techiques
8. To understand and compute with the Laplace Transform method
9. To understand and compute graphical and numerical solution methods of differential equations
10. To understand and compute solutions of linear systems of differential equations
11. To understand and compute polynomial approximations to solutions of differential equations

Honors Topics:

12. *To understand and compute the linearization and equilibrium point solution methods
13. *To understand and compute the classic examples of Van der Pol, Lorenz, Hamiltonian Systems
14. *To understand an introduction to partial differential equations
15. *To understand and compute solutions to the Heat and Wave Equations.
16. *To develop mathematical technical writing skills, culminating in a term paper on an approved topic

Syllabus Topics Outline for DMAT 322 - Honors Computational Differential Equations

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

2. Exponential Differential Equations
   - 2.1. Unforced DEs
   - 2.2. Forced DEs
   - 2.3. Steady State
   - 2.4. Personal Finance

- 2.5. Step Function and Dirac Delta Function
- 2.6. Tangent Vectors
- 2.7. Initial Conditions
- 2.8. Integration Factors

3. Second-Order Differential Equations
   - 3.1. Overdamped and Underdamped Oscillators
   - 3.2. Linear Forced and Unforced Oscillators
   - 3.3. Homogeneous and Inhomogeneous Equations
   - 3.4. Convolution Method
   - 3.5. Characteristic Equations
   - 3.6. Euler's Formula
   - 3.7 Impulse Forcing
   - 3.8 Dirac Delta Convolutions
   - 3.9 Springs and Electrical Charges
   - 3.10 Higher Order Equations

4. Laplace Transforms
   - 4.1 Laplace Transforms of First and Second Order Equations
   - 4.2 Fourier Analysis and Fourier Fit Approximations

5. Graphical Analysis of Differential Equations
   - 5.1 Euler's Method
   - 5.2 Flow Plots and Trajectories
   - 5.3 Preditor-Prey Model
   - 5.4 Logistic Harvesting

6. First-Order Differential Equations
   - 6.1 Autonomous Equations
   - 6.2 Non-Autonomous Equations
   - 6.3 Separation of Variables Solving Method

7. Systems of Differential Equations
   - 7.1 Flows and Trajectories
   - 7.2 Conversion Between Higher Order ODEs and Systems
   - 7.3 Relationship to Eigenvalues and Eigenvectors

8. Power Series Solutions of Differential Equations
   - 8.1 Recursion Relations
   - 8.2 Comparing Series Solution to Numerical Solution
   - 8.3 Barriers

9.* Linearization of Nonlinear Differential Equations
   - 9.1* Equilibrium Points
   - 9.2* Lyapunov's Rules

- 9.3* Pendulum Oscillator
- 9.4* Linearizations and Gradients
- 9.5* Van der Pol Oscillator
- 9.6* Hamiltonian Systems
- 9.7* Chaos and the Lorenz Attractor

10.* Heat and Wave Equations
- 10.1* Examples and Calculations of the Heat and Wave Equations
- 10.2* Introduction to Partial Differential Equations
- 10.3* Fourier Analysis and Fourier Fit Approximations

11.* Mathematical Writing
- 11.1* Cogent writing
- 11.2* Mathematical Presentation
- 11.3* Term Paper Topic and Research