COURSE SYLLABUS

Course Title: **Honors STEM Calculus I**

Abbreviated Title As Appears on Transcript: `Honors STEM Calculus I`

Course Number: DMAT 254

Credit Hours: 5 credits [semester credit hours]

Course Description: An honors-level first course introduction to differential and integral calculus for engineering and science students, with emphasis on a modern, empirical exposition of the classical subject. Topics include a study of the algebraic, numerical, and graphical aspects of polynomial, exponential, logarithmic, and trigonometric functions, limits, function growth, derivative analysis and optimization, introduction to differential equations, methods and applications of integration, numerical computations of integrals including the Monte-Carlo method, and the Fundamental Theorem of Calculus. 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 Precalculus with Trigonometry 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: "Calculus & LiveMath" by Robert R. Curtis, Ph.D., adapted from Davis/Porta/Uhl "Calculus&Mathematica" courseware series

Mathematical Software: LiveMath™ 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 254 - Honors STEM Calculus I

1. To identify, manipulate, and understand the algebraic, numerical, and graphical fundamentals of linear, polynomial, exponential, logarithmic, rational polynomial, and trigonometric functions;
2. To understand and compute algebraic, numerical, and graphical limits at finite and infinite values;
3. To understand and compute the fundamental concept of the derivative;
4. To understand and compute various measurements of growth of a function
5. To algebraically compute derivatives of common functions using summation, product, quotient, and chain rules for derivatives;
6. To formulate and understand introductory analytical proofs in application to the concepts of limits and the derivative;
7. To understand and compute optimization of functions using derivatives, finding critical values;
8. To understand and compute the second derivative;
9. To understand and compute the Mean Value Theorem and related concepts;
10. To understand and compute first order differential equations;
11. To understand and compute implicit differentiation and related rates;
12. To understand and compute parametric equations, including projectile motion;
13. To understand and calculate numerically and graphically the core concepts of the integral for applications to signed area measurements;
14. To compute numerically, algebraically, and graphically integrals of a variety of functions;
15. To algebraically compute integrals of basic polynomial, exponential, and trigonometric functions, with an introduction to the algebraic substitution technique;
16. To use of tools of differential and integral calculus in various applications
17. To understand and compute the Fundamental Theorem of Calculus
18. To understand and compute an integral functions, including inverse trigonometric and logarithmic integrals that do not algebraically resolve;
19. To utilize computer algebra and graphing software to amplify traditional manual computation techniques.

Honors Additional Topics:

20. *To investigate data interpolation and algebraic modeling of data sets using polynomial and trigonometric functions
21. *To investigate Preditor-Prey differential equations modeling
22. *To investigate numerical limits error analysis, the need for Lagrange, Newton, L'Hopital, Extrapolation methods
23. *To understand and compute integrals with the Monte-Carlo method
24. *To understand the concept of algebraic integration in Finite Terms

25.*To develop mathematical technical writing skills, culminating in a term paper on an approved topic.

* = Additional topics for Honors course

Syllabus Topics Outline for DMAT 254 - Honors STEM Calculus I

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

2. Growth: Preparing for the Derivative
   - 2.1 Growth of Linear Functions
   - 2.2 Growth of Power Functions
   - 2.3 Growth of Exponential Functions
   - 2.4 Dominance of Growth of Functions
   - 2.5 Percentage Growth of Functions
   - 2.6 Global Scale: Infinite Limits
   - 2.7 Data Functions and Interpolation
   - 2.8 Approximation of Functions by Linear Functions

3. Continuity
   - 3.1 Limits
   - 3.2 Continuous Functions
   - 3.3 Jump Discontinuities
   - 3.4 Piecewise Functions and Continuity
   - 3.5 Limit Rules

4. Exponential Functions and Natural Logarithms
   - 4.1 e = Euler's Number
   - 4.2 Natural Logarithm
   - 4.3 Growth Analysis
   - 4.4 Applications: Carbon Dating
   - 4.5 Percentage Growth and Steady Growth of Exponential Functions
   - 4.6 Data Functions and Logarithmic Analysis
   - 4.7 Inverse Functions
   - 4.8 Applications: Compound Growth Rates
   - 4.9 Applications: World Population

5. The Derivative of Polynomial, Exponential, Logarithmic, and Fractional Powers
   - 5.1 Instantaneous Growth Rates
   - 5.2 Definition of the Derivative
   - 5.3 Computing the Derivative Graphically
   - 5.4 Computing the Derivative Algebraically
   - 5.5 Computing the Derivative Numerically

- 5.6 Average Growth Rate vs. Instantaneous Growth Rate
- 5.7 Applications of the Derivative: Spread of Disease
- 5.8 Finding Maxima and Minima of Functions
- 5.9 Relating a Function and Its Derivative

6. Computing Derivatives
   - 6.1 Sum, Difference, Product, Quotient Rule
   - 6.2 Chain Rule
   - 6.3 Instantaneous Percentage Growth
   - 6.4 Growth Dominance

7. Using Derivatives
   - 7.1 Finding Maxima and Minima
   - 7.2 Finding Good Representative Plots
   - 7.3 Applications: Maximizing Volume
   - 7.4 The Second Derivative
   - 7.5 Applications: The Space Shuttle Challenger

8. Differential Equations
   - 8.1 Linear Differential Equations
   - 8.2 Logistic Equations
   - 8.3 Rate Track Principal
   - 8.4 Approximations - Introduction to Taylor's Theorem

9. Integration
   - 8.1 Measuring Area Under a Curve
   - 8.2 Definition of the Integral
   - 8.3 Properties of Integrals, Symmetry
   - 8.4 Integrals of Data Functions
   - 8.5 Numerical Methods: Rectangles, Trapezoids
   - 8.6 Undefined Integrals
   - 8.7 Numerical Calculation of Integrals
   - 8.8* Monte-Carlo Method of Integration

9. Fundamental Theorem of Calculus
   - 9.1 Derivative of an Integral
   - 9.2 Integral of a Derivative
   - 9.3 Fundamental Formula
   - 9.4 Distance, Velocity, and Acceleration
   - 9.5 Improper Integrals
   - 9.6 More Properties of Integrals
   - 9.7 Applications: Measure Accumulation Totals
   - 9.8 Indefinite Integrals and Antiderivatives
   - 9.9 u-Substitution
   - 9.10 Inverse Circular and Hyperbolic Trigonometric Functions

10.* Limits Revisited
- 10.1* Limitations of Numerics with Limits
- 10.2* Lagrange, Newton, Extrapolation Numerical Methods
- 10.3* L'Hopital's Rule for Limits
- 10.4* Introduction to Polynomial and Rational Polynomial Approximation

11.* Preditor-Prey Systems
- 11.1* Parametric Solutions of Differential Equations
- 11.2* Preditor-Prey Models
- 11.3* Applications

12.* Data Interpolation
- 12.1* Linear and Quadratic Approximations
- 12.2* Polynomial Approximations and Interpolation
- 12.3* Trigonometric Function Interpolation
- 12.4* Taylor's Theorem

13.* Integration in Finite Terms
- 13.1* Machine Integration Engines
- 13.2* Finite Terms
- 13.3* Quadrature and Limitations

14.* Mathematical Writing
- 14.1* Cogent writing
- 14.2* Mathematical Presentation
- 14.3* Term Paper Topic and Research