COURSE SYLLABUS

Course Title: **Honors Calculus I+II for Data Science**

Abbreviated Title As Appears on Transcript: `Honors Calc BC for Data Sci`

Course Number: DMAT 255

Credit Hours: 5 credits [semester credit hours]

Course Description: An honors-level single course introduction to differential and integral calculus for data science students, with emphasis on a modern, empirical exposition of the classical subject, condensing the essential topics from first year calculus. 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, the Fundamental Theorem of Calculus, calculus of data sets, numerical issues of derivative and integral computations, Monte-Carlo method, Taylor's Theorem and spline approximations, and methods of integration. Honors courses will include greater breadth and depth of topics, and develop technical writing skills, culminating in a combination programming project and mathematical term paper on an approved topic.

Prerequisite: Successful completion with B grade or higher in Precalculus with Trigonometry or equivalent, or consent of instructor; experience with a computer programming language.

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:

Calculus&LiveMath by Davis/Porta/Uhl

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

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 University Academic Integrity Committee.

Learning Outcomes for DMAT 255 - Honors Calculus I+II for Data Science

1. To understand and compute algebraic, numerical, and graphical limits at finite and infinite values;
2. To understand and compute the fundamental concept of the derivative;
3. To understand and compute various measurements of growth of a function
4. To algebraically compute derivatives of common functions using summation, product, quotient, and chain rules for derivatives;
5. To understand and compute optimization of functions using derivatives, finding critical values;
6. To understand and compute the second derivative;
7. To understand and compute first order differential equations;
8. To understand and compute parametric equations, including projectile motion;
9. To understand and calculate numerically and graphically the core concepts of the integral for applications to signed area measurements;
10. To compute numerically, algebraically, and graphically integrals of a variety of functions;
11. To algebraically compute integrals of basic polynomial, exponential, and trigonometric functions, with an introduction to the algebraic substitution technique;
12. To use of tools of differential and integral calculus in various applications
13. To understand and compute the Fundamental Theorem of Calculus
14. To understand and compute an integral functions, including inverse trigonometric and logarithmic integrals that do not algebraically resolve;
15. To utilize computer algebra and graphing software to amplify traditional manual computation techniques.
16. To understand spline interpolation with polynomial functions; points of contact
17. To understand Taylor's Theorem, error analysis
18. To understand convergences and divergence concepts of sequences, series, polynomial approximations
19. To understand and compute double integrals
20. To understand and compute 3D vector analysis, dot product, planes, and cross products
21. To understand and compute partial derivatives and tangent planes to a surface

Honors Additional Topics:

22. *To investigate data interpolation and algebraic modeling of data sets using polynomial and trigonometric functions
23. *To investigate numerical limits error analysis, the need for Lagrange, Newton, L'Hopital, Extrapolation, more advanced polynomial and rational polynomial approximation methods.
24. *To understand the concept of algebraic integration in Finite Terms
25. *To understand and compute integrals using complex integration techniques
26. *To understand and compute numerical integration techniques of Newton, Midpoint, and Runge-Kutta, and higher RK approximations.

27. *To understand and explore higher integral functions, such as those defined by elliptical and hyperbolic integrals
28. *To explore and analyze Preditor-Prey systems of differential equations
29. *To develop mathematical technical writing skills, culminating in a term paper on an approved topic
30. *To utilize programming-based computer algebra software to make investigations for a programming term project in application to data science

* = Additional topics for Honors course

Syllabus Topics Outline for DMAT 255 - Honors Calculus I+II 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. 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. 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

10. Integral Functions & Computation

- 10.1 u-Substitution
- 10.2 Integral Functions and Monoticity
- 10.3 Integral Functions as Numerical Tabulations with Interpolation
- 10.4 Computing the Inverse Function Numerically
- 10.5 Inverse Circular and Hyperbolic Trigonometric Functions & Integrals

11.* Limits Revisited
- 11.1* Limitations of Numerics with Limits
- 11.2* Lagrange, Newton, Extrapolation Numerical Methods
- 11.3* L'Hopital's Rule for Limits

12.* Preditor-Prey Systems
- 12.1* Parametric Solutions of Differential Equations
- 12.2* Preditor-Prey Models
- 12.3* Applications

13.* Data Interpolation
- 13.1* Linear and Quadratic Approximations
- 13.2* Polynomial Approximations and Interpolation
- 13.3* Trigonometric Function Interpolation

14.* Algebraic Integration Theory
- 14.1* Machine Integration Engines
- 14.2* Integration in Finite Terms
- 14.3* Integratability and Limitations
- 14.4* Defining advanced special functions using integrals or series

15. Taylor's Expansion of a Function
- 15.1 Splines and Smooth Splines
- 15.2 Points of Contact
- 15.3 Application: Landing an Airplane
- 15.4 Taylor Expansion
- 15.5 Recognizing Familiar Expansions
- 15,6 Using Expansions for Approximations
- 15.7 Derivatives and Integrals of Expansions
- 15.8 Expansions At Other Points
- 15.9 Newton's Method
- 15.10 Convergence Intervals and Barriers
- 15.11 Calculating Limits: L'Hopital's Rule
- 15.12* Expansions and Solving Differential Equations
- 15.13* Complex Exponentials
- 15.14* Euler, Midpoint, Runge-Kutta Integral Estimates

16.* Differential Equations

16.1* Types of Differential Equations
16.2* Linkage to Algebraic and Numerical Integration Theory
16.3* Power Series Solutions to Differential Equations
16.4* Elliptical and Hyperbolic Integration Functions
16.5* Exploring Special Named Functions

17. Polar Coordinates
17.1 Basic Graphing
17.2 Recognizable Curves
17.3 Differentiation and Integration in Polar Coordinates

18. Vector Analysis
18.1 Vector Arithmetic
18.2 Dot Product, Cross Product
18.3 Planes
18.4 Partial Derivatives
18.5 Tangent Planes

19.* Mathematical Writing
19.1* Cogent writing
19.2* Mathematical Presentation