COURSE SYLLABUS

Course Title: **Honors Multivariable Calculus and Vector Analysis**

Abbreviated Title As Appears on Transcript: `Honors Multivar Calculus IV`

Course Number: DMAT 356

Credit Hours: 5 credits [semester credit hours]

Course Description: An honors-level first course in multivariable differential and integral calculus, with emphasis on computational techniques, vector field analysis, and the generalized Fundamental Theorem of Calculus giving insight to the classical theorems of Green, Gauss, and Stokes. Topics include geometric analysis of multivariable functions, partial derivatives, level curves and surfaces, optimization, properties of vector fields, gradients, potential functions, path integrals and independence, field singularities, divergence and rotation, multiple integration, integral coordinate Jacobian transforms. 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 both Calculus I and Calculus II or equivalent, or consent of instructor; experience with programming languages.

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: *Vector Calculus & 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 356 - Honors Multivariable Calculus and Vector Analysis

1. To understand the core geometrical elements of Euclidean space
2. To understand and compute vector operations and their geometrical interpretations
3. To understand and compute partial derivatives and gradient functions
4. To understand and compute curves, level curves, surfaces, and level surfaces to multidimensional functions
5. To understand and compute vector-valued functions and their geometric representations
6. To understand and compute the classical optimization procedure of Lagrange Multipliers
7. To understand, compute, and graph vector fields and their associated metrics
7. To understand and compute path integrals of vector fields
8. To understand, compute, and graph sources, sinks, and singularities of vector fields
9. To understand and compute the divergence of a vector field, and its associated computations
10. To understand and compute the rotation and curl of a vector field, and its associated computations.
11. To understand and compute path integrals in the presence of singularities
12. To understand and compute multiple integrals, and their associated geometrical interpretations
13. To understand and utilize Fubini's Theorem for reordering integrations
14. To understand and compute Jacobian transformations of multiple integrals
15. To understand and compute cylindrical, spherical, and other coordinate systems, and their associated measurments with derivatives and integrals
16. To understand an introduction to the Generalized Fundamental Theorem of Calculus, and its variations in the Divergence Theorem, and the Theorems of Gauss, Green, and Stokes.

Honors Topics:

17.*To understand and compute curves with dictated curvature
18.*To understand and compute examples in data fitting by polynomials and trigonometric functions
19.*To understand and compute higher dimensional optimizations using multivariable derivatives
20.*To understand and compute potential functions as antiderivatives of gradient functions
21.*To understand an introduction to Electric and Hamiltonian Fields
22.*To understand and compute 3D path integrals and surface integrals, both directly and using the reductions afforded by the Generalized Fundamental Theorem of Calculus
23.*To develop mathematical technical writing skills, culminating in a term paper on an approved topic

Syllabus Topics Outline for DMAT 356 - Honors Multivariable Calculus and Vector Analysis

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 Tangent Vectors; Velocity Vectors, Acceleration Vectors
   2.3 Vector Length
   2.4 Dot Products
   2.5 Vector Projection
   2.6 Perpendicularity
   2.7 Lines
   2.8 Normal Vectors
   2.9 Cross Product
   2.10 Planes in 3D
   2.11 Normal, Binormals, Curvature, Torque
   2.12* Curvature Dictating Curves

3. The Derivative
   3.1 Partial Derivatives
   3.2 Gradient
   3.3 Level Curves and Surfaces
   3.4 Linearization
   3.5 Total Differential
   3.6 Lagrange Multipliers
   3.7* Data Fitting
   3.8* Higher Dimensional Optimizations

4. Vector Fields
   4.1 Plotting and Trajectories
   4.2 Flow-Along and Flow-Across Curves
   4.3 Differential Equations and Vector Fields
   4.4 Path Integrals
   4.5 Gradient Fields
   4.6 Sources, Sinks
   4.7 Divergence Theorem
   4.8 Singularities
   4.9 Rotation and Curl
   4.10*Potential Functions
   4.11*Electrical Fields
   4.12*Hamiltonian Fields
   4.13*Implicitly Defined Functions
   4.14*Work
   4.15*Laplacians and the Heat Equation

5. Multiple Integrals
   - 5.1 Basic Computation
   - 5.2 u-v Transformations; Jacobians
   - 5.3 Measurement of Volume, Mass, Density
   - 5.4 3D Integrals
   - 5.5 Average Value
   - 5.6 Fubini's Theorem
   - 5.7* Ribbons of Constant Width
   - 5.8* Eigenvalues and Eigenvectors
   - 5.9* Hypervolume

6. Other Coordinate Systems
   - 6.1 Cylindrical Coordinates
   - 6.2 Spherical Coordinates
   - 6.3 Integration in Other Coordinate Systems
   - 6.4* Tubes, Horns
   - 6.5* Average Values, Centers of Mass
   - 6.6* Mobius Strips

7. Gauss, Green, Stokes Theorems
   - 7.1 Green's Theorem
   - 7.2 Stokes' Theorem
   - 7.3 Divergence Theorem
   - 7.4 Generalized Fundamental Theorem of Calculus
   - 7.5 Sources, Sinks, and 3D Gauss's Formula
   - 7.6 Surface Integrals
   - 7.7* Gradient Test in 3D
   - 7.8* Work in 3D
   - 7.9* Parallel Flow and Irrotational Flow
   - 7.10* curlField and rotField Connections
   - 7.11* Laplacians
   - 7.12* Flux and Electric Fields

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