COURSE SYLLABUS

Course Title: **Computational Differential Geometry**

Abbreviated Title As Appears on Transcript: `Comp Differential Geometry`

Course Number: DMAT 451

Credit Hours: 4 credits [semester credit hours]

Course Description: A first course in differential geometry from a computational and graphical standpoint. Topics include a comprehensive study of curves and surfaces with emphasis on exploring a catalog of named geometrical objects, curvature and other metrics, orientable, non-orientable, ruled, and minimal surface, culminating with an introduction to the Gauss-Bonnet Theorem.

Prerequisite: Successful completion (C- or higher) of Multivariable Calculus 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>

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: *Differential Geometry of Curves and Surfaces using Mathematica*, 3rd Edition, by Gray et al.

Mathematical Software: Mathematica™ & LiveMath™ 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

Learning Outcomes for DMAT 451 - Computational Differential Geometry

1. To use computer graphing tools to visualize 2D and 3D curves and surfaces
2. To understand and compute various metrics about parametric and non-parametric curves and surfaces
3. To understand and compute the key concept of curvature, and understand its relationship to derivatives and differential equations
4. To understand the role of motions in geometry
5. To understand and compute the Frenet frames for curves
6. To understand and compute the concept of the derivative for vector fields
7. To understand and compute the local Gauss map for surfaces
8. To understand and compute the concept of orientability of surfaces
9. To understand and compute Gaussian and Mean curvature
10. To understand and compute Ruled and Minimal Surfaces
11. To be introduced to the Gauss-Bonnet theorem

Syllabus Topics Outline for DMAT 451 - Computational Differential Geometry

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

2. Curves
2.1 Euclidean Spaces
2.2 2D and 3D Parametric Curves
2.3 Arclength
2.4 Curvature vs. Derivative
2.5 Angles
2.6 Catalog of Famous Curves

3. Alternative Ways of Plotting Curves
3.1 Implicit Curves
3.2 Contour Plots
3.3 Polar Coordinates
3.4 New Curves from Old

4. Solving Curvature Equations
4.1 Euclidean Motions
4.2 Intrinsic Equations

4.3 Assigned Curvature

5. Global Properties of Plane Curves
5.1 Total Signed Curvature
5.2 Turning Numbers
5.3 Rotation Index
5.4 Convexity
5.5 Constant Width
5.6 Support Functions

6. Space Curves
6.1 Tangent, Normal, Binormal Frames
6.2 Curvature and Torsion
6.3 Frenet Formulas
6.4 Arbitrary Speed Curves
6.5 Tubes and Tori

7. Fundamental Theorem of Space Curves
7.1 Assigned Curvature and Torsion
7.2 Contact
7.3 Curves That Lie on a Sphere
7.4 Curves of Constant Slope

8. Calculus of Euclidean Space
8.1 Tangent Vectors and Directional Derivatives
8.2 Tangential Maps
8.3 Vector Fields
8.4 Derivatives of Vector Fields

9. Surfaces in Euclidean Space
9.1 Patches
9.2 Local Gauss Map
9.3 Regular Surfaces
9.4 Level Surfaces
9.5 Catalog of Famous Surfaces

10. Non-Orientable Surfaces
10.1 Orientability
10.2 Mobius Strip and Klein Bottle
10.3 Projective Planes

11. Surface Metrics
11.1 Distance
11.2 Isometries
11.3 Conformal Maps

11.4 Gaussian and Mean Curvature
11.5 Non-Parametrically-Defined Surfaces

12. Ruled and Other Surfaces
12.1 Examples
12.2 Curvature
12.3 Surfaces of Revolution
12.4 Examples of Minimal Surfaces