

COURSE SYLLABUS

Course Title: Introduction to Numerical Analysis

Abbreviated Title Intro Numerical Analysis
As Appears on Transcript

Course Number: DMAT 462

Credit Hours: 4 credits [semester credit hours]

Course Description: An introductory course on Numerical Analysis with emphasis on the computational and visual aspects of the subject. Topics include approximation and errors, numerical differentiation, non-linear equations, numerical linear algebra, interpolation, regression, numerical integration, numerical solutions of differential equations, and numerical optimization techniques.

Prerequisite: Successful completion with grade B or higher in Linear Algebra and 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 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.

Course Professor: Robert R. Curtis, Ph.D. <rcurtis@rwu.edu>, <robert@distancecalculus.com>
Roger Williams University, Extension School, 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:

Numerical Methods with Applications by Kaw et al. and Elements of Numerical Analysis with Mathematica by Loustau

Mathematical Software: LiveMath and Mathematica 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>

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 462 - Introduction to Numerical Analysis

1. To understand the initial topics of Numerical Analysis as a springboard into Data Science and other related fields.
2. To understand the concept of approximation and error analysis.
3. To understand the techniques and necessities of numerical differentiation
4. To understand the solution techniques for non-linear equations
5. To understand the numerical issues of large-scale matrix algebra
6. To understand the concepts of interpolation
7. To understand the numerical issues involved with statistical regression
8. To understand the numerical approach to integration
9. To understand the numerical solution techniques for differential equations
10. To understand the numerical approaches to optimization
11. To understand and utilize software tools to investigate visualization and computational aspects of the subject.

Syllabus Topics Outline for DMAT 462 - Introduction to Numerical Analysis

1. Getting Started
 - 1.1 Email and Chat
 - 1.2 Learning About the Course
 - 1.3 Required Hardware
 - 1.4 Software Fundamentals
2. Approximations and Errors
 - 2.1 Introduction to Scientific Computing
 - 2.2 Measuring Errors
 - 2.3 Sources of Error
 - 2.4 Binary Representation of Numbers
 - 2.5 Floating Point Representation
 - 2.6 Propagation of Errors
 - 2.7 Taylor Series Revisited
3. Numerical Differentiation
 - 3.1 Primer on Differential Calculus
 - 3.2 Differentiation of Continuous Functions
 - 3.3 Differentiation of Discrete Functions
 - 3.4 Finite Differences and Vector Fields
 - 3.5 Finite Difference Explicit Method
 - 3.6 Neumann Stability Analysis
 - 3.7 Finite Difference Implicit Method & Crank Nicolson
4. Nonlinear Equations
 - 4.1 Solving Quadratic Equations Exactly
 - 4.2 Solving Cubic Equations Exactly
 - 4.3 Bisection Method
 - 4.4 Newton-Raphson Method

- 4.5 Secant Method
- 4.6 False Position Method

- 5. Simultaneous Linear Equations
 - 5.1 Vectors
 - 5.2 Binary Matrix Operations
 - 5.3 Unary Matrix Operations
 - 5.4 System of Equations
 - 5.5 Gaussian Elimination Method
 - 5.6 LU Decomposition Method
 - 5.7 How does Gauss-Seidel method work?
 - 5.8 Adequacy of Solutions
 - 5.9 Eigenvalues and Eigenvectors
 - 5.10 Cholesky and LDLT Method

- 6. Interpolation
 - 6.1 History of Interpolation
 - 6.2 Direct Method
 - 6.3 Newton's Divided Difference Method
 - 6.4 Lagrange Method
 - 6.5 Spline Method
 - 6.6 The lurking dangers of extrapolation!
 - 6.7 Why is higher order interpolation a bad idea?
 - 6.8 Why do we need spline interpolation
 - 6.9 How choice of points of interpolation affects approximations!
 - 6.10 How splines can help in developing a shorter path for a robot!

- 7. Regression
 - 7.1 Primer on statistical terminology
 - 7.2 Introduction to Regression
 - 7.3 Linear Regression
 - 7.4 Nonlinear Regression
 - 7.5 Adequacy of Regression Models

- 8. Integration
 - 8.1 Primer on Integral Calculus
 - 8.2 Trapezoidal Rule
 - 8.3 Simpson's 1/3 Rule
 - 8.4 Romberg Rule
 - 8.5 Gauss-Quadrature Rule
 - 8.6 Discrete Data Integration
 - 8.7 Improper Integration
 - 8.8 Simpson's 3/8 rule
 - 8.9 Monte-Carlo Integration

- 9. Ordinary Differential Equations

- 9.1 Primer on Ordinary Differential Equations
- 9.2 Euler's method
- 9.3 Runge-Kutta 2nd order method
- 9.4 Runge-Kutta 4th order method
- 9.5 On solving higher order & coupled ordinary differential equations
- 9.6 Shooting Method
- 9.7 Finite Difference

- 10. Optimization
 - 10.1 Golden Section Search Method
 - 10.2 Newton's Method
 - 10.3 Multidimensional Direct Search Method
 - 10.4 Multidimensional Gradient Method
 - 10.5 Simplex Method