



## § I: MATH 3338 Numerical Analysis Syllabus

### Catalog Description

Prerequisites: MATH 2203 and a standard programming language. Topics include: solutions of algebraic and transcendental equations by iterative methods; system of linear equations (matrix inversion, etc.); interpolation, numerical differentiation and integration; solution of ordinary differential equations. Scientific and engineering applications. 3 credits.

### Required Textbook

*Numerical Methods Using Matlab*, by John H. Mathews and Kurtis D. Fink. Pearson, 4e, ISBN **9780130652485** (2004). All students are encouraged to become familiar with the use of a variety of software tools that augment the teaching of this course.

### Course Objectives

The course, MATH 3338, provides a foundation in some fundamental numerical methods for problem solving in a scientific computing environment. The emphasis is on connecting mathematical concepts with practical computer based applications that can be applied to solving problems that arise in engineering and the applied sciences. Underlying all of this is the need to develop an understanding of the role of error and convergence in the application of numerical methods. Numerical methods provide approximate solutions to some mathematical problems. Learning to quantifying the quality of these approximations is an important part of this course, as is developing insight into the difficulties that can arise with implementing numerical methods to solve a variety of computational problems in the applied sciences and engineering.

### Student Learning Outcomes

After successfully completing this course the student is able to:

1. Account for numerical error in computational analysis, rates of convergence of algorithms, and recognize known difficulties associated with classical computational algorithms.
2. Approximate and interpolate data and functions and work with fundamental concepts in approximation.
3. Solve systems of linear equations numerically and solve nonlinear systems.
4. Appreciate the difference between iterative and direct methods of solution for linear and nonlinear equations.
5. Solve problems involving numerical integration and differentiation. Solve basic differential equations numerically.
6. Work with computer software to construct numerical solutions to problems and analyze the results.

### Required Curriculum Content

Key topics covered include:

1. Numerical error: Developing an understanding of numerical errors due to finite precision arithmetic.
2. Solution of non-linear equations: Bisection algorithm; fixed point iteration and its convergence; solution of linear equations using Gaussian elimination, including pivoting strategies; error and residual of an approximation; and, matrix inversion.
3. Interpolation of discrete 2d data: Polynomial approximation; direct matrix methods; polynomial interpolation using the Lagrange and Newton forms; error in the interpolating polynomial; and constructing splines.

4. Numerical differentiation and integration: Use of finite differences for approximating the derivative of a function; Integration using polynomials (Trapezoidal rule, Simpson's rule, and others); Richardson extrapolation and Romberg's rule; Gaussian quadrature; and computing multiple integrals.
5. Numerical solution of differential equations: finite difference approximation of initial value problems, including Euler's method and its convergence; Runge-Kutta methods; Higher order equations; and, boundary value problems, including shooting methods and finite difference methods.

The MATH 3338 Numerical Analysis will cover, as a minimum, the material from *Numerical Methods Using Matlab*, by John H. Mathews and Kurtis D. Fink. Pearson, 4e, ISBN **9780130652485** (2004), as listed:

Sec	Textbook Topic
	<b>Chapter 1 - Linear Equations in Linear Algebra</b>
1.1	Systems of Linear Equations
1.1	Review of Calculus
1.2	Binary Numbers
1.3	Error Analysis
	<b>Chapter 2 - The Solution of Nonlinear Equations</b>
2.1	Iteration for Solving $x = g(x)$
2.2	Bracketing methods for locating Roots
2.3	Initial Approximations and Convergence Criteria
2.4	Newton Rapheson and Secant Methods
2.5	Aitken's Process and Steffensen's and Muller's Methods
	<b>Chapter 3 - The Solution of Linear Systems</b>
3.1	Introduction to Vectors and Matrices
3.2	Properties of Vectors and Matrices
3.3	Upper Triangular Linear Systems
3.4	Gaussian Elimination and Pivoting
3.5	Triangular Factorization
3.6	Iterative Methods for Linear Systems
3.7	Iteration for Nonlinear Systems: Seidel and Newton's Methods
	<b>Chapter 4 - Interpolation and Polynomial Approximation</b>
4.1	Taylor Series and Calculation of Functions
4.2	Introduction to Interpolation
4.3	Lagrange Interpolation
4.4	Newton Polynomials
4.5	Chebyshev Polynomials
	<b>Chapter 5 - Curve Fitting</b>
5.1	Least-squares Line
5.2	Curve Fitting
5.3	Interpolation by Spline Functions
5.4	Fourier Series and Trigonometric Polynomials
	<b>Chapter 6 - Numerical Differentiation</b>
6.1	Approximating the Derivative
6.2	Numerical Differentiation Formula
	<b>Chapter 7 - Numerical Integration</b>
7.1	Introduction to Quadrature
7.2	Composite Trapezoidal and Simpson's Rule
7.4	Gauss-Legendr Integration
	<b>Chapter 9 - Solution of Differential Equations</b>

<b>Sec</b>	<b>Textbook Topic</b>
9.1	Introduction to Differential Equations
9.2	Euler's Method
9.3	Heun's Method
9.4	Taylor Series
9.5	Runge-Kutta Methods
9.5	Predictor-Corrector Methods
9.8	Boundary Value Problems
9.9	Finite Difference Methods

### **Common Department Requirements for MATH 3338**

While students in each section of MATH 3338 are assessed by the course instructor, there are general guidelines that apply to all sections of MATH 3338. These include:

- Calculators and other electronic devices are not allowed on any exams.

## Department, College and University Expectations and Policies

It is important that students familiarize themselves with a range of policies and guidelines that have been established by the Department of Mathematics and Physics, the College of Arts and Sciences, and the University of New Haven. These are an integral part of the syllabus for this course.

### Adding/Dropping a Class

The final day to drop this course without it appearing on your transcript is discussed on the **Academic Schedules and Registration** web page. After the first week of class, self-service registration will not be enabled for students to directly add or drop classes. Students should contact the Registrar's office directly or the Academic Success Center for assistance with adding and dropping courses during this time.

### Attendance Regulations

University attendance policy guidelines require that:

Students are expected to attend regularly and promptly all their classes, appointments, and exercises. While the university recognizes that some absences may occasionally be necessary, these should be held to a minimum. A maximum of two weeks of absences will be permitted for illness and emergencies. The instructor has the right to dismiss from class any student who has been absent more than the maximum allowed. A dismissed student will receive a withdrawal (**W**) from the course if they are still eligible for a withdrawal per the university Withdrawal from a Course policy, or a failure (**F**), if not. A student who is not officially registered in the course is not permitted to attend classes or take part in any other course activities. Students absent from any class meeting are responsible for making up missed assignments and examinations at the discretion of the instructor.

Students are to adhere to the policy attendance policy guidelines outlined in the University Catalog under the heading, *Attendance Regulations*, found online in the **Undergraduate Catalog** or alternatively found in the **Student Handbook** on pp. 48–49.

### Religious Observance Policy for Students

The University of New Haven respects the right of its students to observe religious holidays that may necessitate their absence from class or from other required university-sponsored activities. Students who wish to observe such holidays should not be penalized for their absence, although in academic courses they are responsible for making up missed work. The College provides that,

Instructors should try to avoid scheduling exams or quizzes on religious holidays, but where such conflicts occur should provide reasonable accommodations for missed assignment deadlines or exams. If a class, an assignment due date, or exam interferes with the observance of such a religious holiday, it is the student's responsibility to notify their instructor, preferably at the beginning of the term, but otherwise at least two weeks before the holiday.

More information about religious observance policies can be found in the Student Handbook on pp. 48–49 under the heading, *Attendance Policies: Religious Observance Policy for Students*.

### Withdrawal from a Course

Students wishing to withdraw must submit a request for an official course withdrawal in writing using the online **Course Withdrawal Form**, or alternatively complete and hand in the pdf based **Course Withdrawal Form**. The final date to request a withdrawal is listed in the **Academic Calendar**. This request must be submitted to the Registrar's Office and signed by the International Office if you are an international student. The grade of **W** will be recorded, but the course will not affect the GPA.<sup>1</sup>

### Incomplete Grade Policy

A grade of Incomplete (**INC**) is given only in special circumstances and indicates that the student has been given permission by the instructor to complete required course work (with the same instructor) after the end

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<sup>1</sup>Please note that it is the responsibility of the student to assure that the required paperwork and documentation is completed by the deadline.

of the term. In the absence of the instructor a student should contact the Department Chair. Students need to examine carefully the **changed guidelines** pertaining to **INC** grades, specifically:

To remove the **INC** grade, the student must complete all required course work in timely fashion as stipulated by the instructor but no later than the end of the following term. Fall and intersession course incomplete grades must be completed no later than the last day of the spring term. Spring and summer course incomplete grades must be completed no later than the last day of the fall term.

If the course work is not submitted within the allotted time, the **INC** grade will be changed to an **F** shortly after the deadline by the Office of the University Registrar. Students will be notified via campus email at least two weeks prior to the change of grade process.

The University policy on incomplete grades is discussed in the **Academic Catalog** under the heading, *Incomplete (INC) Grade Policy*.

### **Academic Integrity Policy and Procedures**

The University of New Haven expects its students to maintain the highest standards of academic conduct. Academic dishonesty is not tolerated at the University. To know what it is expected, students are responsible for reading and understanding the statement regarding academic honesty in the Student Handbook. Specifically, students are required to adhere to the Academic Integrity Policies specified in the **Student Handbook**, i.e., on **pp. 66–73**.

Please ask your instructor about their expectations regarding permissible or encouraged forms of student collaboration if there is any confusion about this topic. The Department of Mathematics and Physics fully adheres to the Academic Integrity Policy:

Academic integrity is a core university value that ensures respect for the academic reputation of the University, its students, faculty and staff, and the degrees it confers. The University expects that students will conduct themselves in an honest and ethical manner and respect the intellectual work of others. Please be familiar with the University's policy on Academic Integrity. Please ask about expectations regarding permissible or encouraged forms of student collaboration if they are unclear.

### **Coursework Expectations**

This course will require significant in-class and out-of-class commitment from each student. The University estimates that a student should expect to spend two hours outside of class for each hour they are in a class. For example, a three credit course would average six [6] hours of additional work outside of class.<sup>2</sup> Coursework expectations are detailed in the **Academic Catalog** under the heading, *Course Work Expectations*.

Please note, that MATH 3338 is a 3-credit course, and as such requires a total of 9 hours per week invested in study and homework for the average student.

### **Commitment to Positive Learning Environment**

The University adheres to the philosophy that all community members should enjoy an environment free of any form of harassment, sexual misconduct, discrimination, or intimate partner violence. If you have been the victim of sexual misconduct we encourage you to report this. If you report this to a faculty/staff member, they must notify our college's Title IX coordinator about the basic facts of the incident (you may choose to request confidentiality from the University). If you encounter sexual harassment, sexual misconduct, sexual assault, or discrimination based on race, color, religion, age, national origin, ancestry, sex, sexual orientation, gender identity, or disability please contact the Title IX Coordinator, Caroline Koziatek at (203)-932-7479 or **CKoziatek@newhaven.edu**. Further online information about is available at **Title IX**.

### **Reporting Bias Incidents**

At the University of New Haven, there is an expectation that all community members are committed to creating and supporting a climate which promotes civility, mutual respect, and open-mindedness. There also exists an understanding that with the freedom of expression comes the responsibility to support community

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<sup>2</sup>Please note that study guidelines are important, i.e., there is substantial evidence that shows that the pass rates for students in math courses decrease dramatically as the time spent on outside study falls below 2 hours of homework per credit per week.

members' right to live and work in an environment free from harassment and fear. It is expected that all members of the University community will engage in anti-bias behavior and refrain from actions that intimidate, humiliate, or demean persons or groups or that undermine their security or self-esteem.

If you have witnessed or are the target of a bias-motivated incident, please contact the Office of the Dean of Students at 203-932-7432 or Campus Police at 203-932-7014. Further information about this and other reporting options may be found at **Report It**.

## University Support Services

The University recognizes students often can use some help outside of class and offers academic assistance through several offices. In addition to discussing any academic issues you may have with your instructor, advisor, or with the the courses or department coordinator or chair, the University provides these additional resources for students:

### The Center for Academic Success and Advising (CASA)

The **Academic Success Center** is located in Maxcy 208 for help with your academic studies, or call 203-932-7234 to set up an appointment.

### University Writing Center

The mission of the Writing Center (an expansion of the **Writer to Writer** peer-tutoring program) is to provide high-quality tutoring to undergraduate and graduate students as they write for a wide range of purposes and audiences. Tutors are undergraduate and graduate students and they work with students at any stage in the writing process; Bring in your assignment, your ideas, and any writing done so far. To make an appointment, register for an account at <https://newhaven.mywconline.com>.

### The Math Zone

Please contact the **Math Zone** if you wish to challenge your Math Placement by taking a Math Challenge Exam or by taking a Math Post Placement Exam. These are discussed more extensively at [http://math.newhaven.edu/mathphysics/placement\\_html](http://math.newhaven.edu/mathphysics/placement_html). The Math Zone also provides a range of tutoring and classroom support service for students taking development math classes.

### The Center for Learning Resources (CLR)

The **Center for Learning Resources** located in Peterson Library, provides academic content support to the students of the University of New Haven using metacognitive strategies that help students become aware of and learn to apply optimal learning processes in the pursuit of creating independent learners CLR tutors focus sessions on discussions of concepts and processes and typically use external examples to help students grasp and apply the material.

### Accessibility Resources Center

Students with disabilities are encouraged to share, in confidence, information about needed specific course accommodations. The **Accessibility Resources Center** (ARC) provides comprehensive services and support that serve to promote educational equity and ensure that students are able to participate in the opportunities available at the University of New Haven. Accommodations cannot be made without written documentation from the ARC. The ARC is located on the ground floor in the rear of Sheffield Hall. Sheffield Hall is located in the Residential Quad area, and can be contacted at 203-932-7332. The ADA/Section 504 Compliance Officer is Rebecca Johnson, [RJohnson@newhaven.edu](mailto:RJohnson@newhaven.edu), and can be reached by phone at 203-932-7238. Information on the ARC can be found at

### **Counseling and Psychological Services**

The Counseling Center offers a variety of services aimed at helping students resolve personal difficulties and acquire the balance, skills, and knowledge that will enable them to take full advantage of their experience at the University of New Haven. Information about the, **Counseling and Psychological Services**, is available online.