

**Syllabus, MTH 537LEC (17451)**  
**Introduction to Numerical Analysis 1**  
**Fall 2019**

**Meeting Times:** MWF 1:00PM – 1:50PM, Room 122 Mathematics Building

**Delivery Mode:** traditional

**Credit Hours:** 3.0

**Instructor Information:**

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Office Hours: MW 2:00PM – 3:00PM

**Course Description:** bisection method, Newton's method, numerical solution of linear systems, polynomial approximation, spline, least squares approximation on a finite point set, computation of eigenvalues and eigenvectors, numerical differentiation, numerical integration, numerical solution of systems of nonlinear equations, local optimization [This list is not exhaustive. See Academic Content for more.]

**Prerequisites:** Prerequisite: MTH 145, MTH 241 and MTH 306

**Course Materials:** Primary textbook (this is formally a required textbook) is: A. S. Achleh, E. D. Allen, R. B. Kearfott, P. Seshaiyer. Classical and Modern Numerical Analysis. CRC Press (2010). We will use UBLearns to manage homework as soon as it is ready. Till then, we will use a tentative course website:

<http://www.nsm.buffalo.edu/~naokimas/>

**Academic Content**

The scope of the course will mostly overlap with the content of Chapters 1-6, Chapter 8, and Section 9.1 of the primary textbook. Topics I plan to cover are

Chapter 1: Mathematical review and computer arithmetic (0.5 week)

- Mathematical review (Section 1.1)
- Computer Arithmetic (Section 1.2)

Chapter 2: Numerical solution of nonlinear equations of one variable (1.5 weeks)

- Bisection method (Section 2.2)
- Fixed point method (Section 2.3)
- Newton's method (Section 2.4)
- Secant and Müller's methods (Section 2.6)
- Roots of polynomials (Section 2.8)

Chapter 3: Numerical linear algebra (3.5 weeks)

- Basic results from linear algebra (Section 3.1)
- Normed linear spaces (Section 3.2)
- Direct methods for solving linear systems (Section 3.3)
- Iterative methods for solving linear systems (Section 3.4)
- Singular value decomposition (Section 3.5)

#### Chapter 4: Approximation theory (3.5 weeks)

- Norms, projections, inner product spaces, and orthogonalization in function spaces (Section 4.2)
- Polynomial approximation (Section 4.3)
- Piecewise polynomial approximation (Section 4.4)
- Trigonometric approximation (Section 4.5)
- Least Squares Approximation on a finite point set (Section 4.8)

#### Chapter 5: Eigenvalue-eigenvector computation (1 week)

- Basic results from linear algebra (Section 5.1)
- Power method (Section 5.2)
- Inverse power method (Section 5.3)
- Deflation (Section 5.4)

#### Chapter 6: Numerical differentiation and integration (2 week)

- Numerical differentiation (Section 6.1)
- Automatic differentiation (Section 6.2)
- Numerical integration (Section 6.3)

#### Chapter 8: Numerical solution of systems of nonlinear equations (1.5 week)

- Introduction to Fréchet derivatives (Section 8.1)
- Successive approximation and the contraction mapping theorem (Section 8.2)
- Newton's method and variations (Section 8.3)
- Quasi-newton methods (Section 8.5)

#### Chapter 9: Optimization (0.5 week)

- Local optimization (Section 9.1)

This leaves 1 week for midterm exams or a more leisurely pace.

I will skip Aitken acceleration and Steffensen's method (Section 2.7), rational approximation (Section 4.6), wavelet bases (Section 4.7), most of the QR method (Section 5.5), Jacobi diagonalization (Section 5.6), Simultaneous iteration (Section 5.7), Methods for finding all solutions (Section 8.6), and anything on interval arithmetic (Section 1.3, 2.5, 3.3.7, 3.4.5, 4.3.9, 6.3.8, 8.4).

### **Learning Outcomes**

(1) Demonstrate an understanding of algorithms of numerical analysis methods and underlying mathematical underpinnings.

Methods of Assessment: homework, midterm exams, final exam

(2) To be able to code several of the algorithms in Python, and interpret and explain the obtained numerical results.

Methods of Assessment: homework

### **Course Requirements:**

#### *Homework:*

- Assigned Friday every week (except the final week and the weeks just before the midterm weeks).
- Due Wednesday 1pm in the following week.
- Late submission not accepted.
- They all count (2% each).

*Midterm Exams:* You will have three midterm exams during the semester. They are planned to be in the meeting time on September 16, October 11, 2019, and November 6, 2019. Each midterm exam covers the materials taught till then (e.g., the second midterm exam does not cover the materials covered by the first midterm exam). They all do count to the final grade.

*Final Exam:* You will have the final exam in the exam period. It covers the materials that are not covered by the midterm exams.

### **Grading Policy:**

Homework 22% (2% each)

Midterm exams 48% (16% each)

Final exam 30%

### **Academic Integrity**

Students must be familiar with and abide by the university's policies and procedures on Academic Integrity, available at the following link: *Academic Integrity:* <https://catalog.buffalo.edu/policies/integrity.html>

### **Accessibility Resources**

If you have any disability which requires reasonable accommodations to enable you to participate in this course, please contact the Office of Accessibility Resources in 60 Capen Hall, 716-645-2608 and also the instructor of this course during the first week of class. The office will provide you with information and review appropriate arrangements for reasonable accommodations, which can be found on the web at: <http://www.buffalo.edu/studentlife/who-we-are/departments/accessibility.html>.

## **Attendance Policy**

### **Classroom Decorum**

Full attendance at class is expected. Respectful discussion of class material is encouraged. During class, the use of cell phones, and the use of laptops for non-class purposes, are not permitted.

### **Critical Campus Resources**

#### Sexual Violence

UB is committed to providing a safe learning environment free of all forms of discrimination and sexual harassment, including sexual assault, domestic and dating violence and stalking. If you have experienced gender-based violence (intimate partner violence, attempted or completed sexual assault, harassment, coercion, stalking, etc.), UB has resources to help. This includes academic accommodations, health and counseling services, housing accommodations, helping with legal protective orders, and assistance with reporting the incident to police or other UB officials if you so choose. Please contact UB's Title IX Coordinator at 716-645-2266 for more information. For confidential assistance, you may also contact a Crisis Services Campus Advocate at 716-796-4399.

#### Mental Health

As a student you may experience a range of issues that can cause barriers to learning or reduce your ability to participate in daily activities. These might include strained relationships, anxiety, high levels of stress, alcohol/drug problems, feeling down, health concerns, or unwanted sexual experiences. Counseling, Health Services, and Health Promotion are here to help with these or other issues you may experience. You can learn more about these programs and services by contacting:

#### *Counseling Services:*

- 120 Richmond Quad (North Campus), 716-645-2720
- 202 Michael Hall (South Campus), 716-829-5800

#### *Health Services:*

- Michael Hall (South Campus), 716-829-3316

#### *Health Promotion:*

- 114 Student Union (North Campus), 716-645-2837