CS/MATH 3414 – Numerical Methods

Virginia Tech Department of Computer Science, Fall 2026

1 Basic information

Instructor: Sumeet Khatri

- Office: 2160H Torgersen Hall
- Email: skhatri@vt.edu
- Course website (also accessible on Canvas)

Description: This course introduces computational methods for solving mathematical problems that arise in computer science, engineering, data analysis, and scientific computing. Topics include floating-point arithmetic and error analysis, solutions of nonlinear equations and linear systems, interpolation and approximation, Monte Carlo simulation of random processes, and optimization. Students will apply these techniques to real-world problems such as fitting models to noisy data, simulating physical systems, and machine learning. Students will develop and evaluate numerical algorithms for these problems using a modern programming language.

Course prerequisites: A grade of C or better required in CS prerequisite 1044 or 1705. A student can earn credit for at most one of 3414 and MATH 4404.

Learning objectives: Upon successful completion of this course, a student will be able to do the following.

- Explain how floating-point representation, rounding, and truncation affect numerical computations.
- Analyze numerical algorithms for accuracy, convergence, stability, and computational cost.
- Design computational experiments to test and compare numerical algorithms.
- Describe various methods for numerically solving single- and multi-variable equations.
- Explain how to use the least-squares method to fit (non-)linear models to noisy data using a pseudocode description.
- Explain how optimization problems can be solved numerically using gradient descent and other methods using a pseudocode description.

Timing and location: Tuesday and Thursday from 11:00am to 12:15pm in 316 McBryde Hall.

Teaching assistant: Abdullah Al Noman

Office hours:

- Sumeet: Tuesdays from 4pm–5pm via Zoom. (Zoom link shared on Canvas.) Also in person by appointment; please send an email.

- Noman: Mondays, Wednesdays, Fridays from 3pm–5pm in Torgersen 1120.

2 Outline of topics

1. **Representation of real numbers on computers:** floating-point numbers; significant digits; accuracy and precision; error analysis.
2. **Numerical solutions to single-variable (non-)linear equations:** Newton's method, secant method; convergence analysis and guarantees.
3. **Computational linear algebra:** matrix multiplication, singular-value decomposition, linear systems, Gaussian elimination; least-squares optimization (data fitting/linear regression) and polynomial interpolation.
4. **Simulating random processes:** random numbers, sampling from probability distributions; Monte Carlo simulations.
5. **Optimization:** gradient descent, application to neural networks and machine learning; linear programming, application to Markov decision processes and reinforcement learning.

We will integrate these topics with numerical implementations in the Python programming language, primarily using the NumPy and SciPy packages.

3 Reading Materials

The following two sources will be followed closely. Lecture notes will be provided, so it is not required to buy any of these books.

- Numerical Mathematics and Computing, 7th edition, by Ward Cheney and David Kincaid (Cengage Learning, 2012).
- Numerical Analysis, 10th edition, by Richard L. Burden, J. Douglas Faires, and Annette M. Burden (Cengage Learning, 2016).

4 Grading

The grading will consist of *six in-class assignments*, a *final exam*, and *in-class participation*.

About in-class assignments: you will have the full 75-minute class time to complete them. The assignment must be completed and submitted by the end of the class in order to be eligible for credit. You may work with your peers and consult the instructor while completing the assignment. **Use of AI tools is prohibited for completing the in-class assignments.** See Section 5 for more information about the AI-use policy for this class.

Practice problems will be posted to help prepare for the in-class assignments. Some of the problems will be incorporated into the lectures as well.

About the final exam: it will be cumulative, written, and conducted during the final day of class, which is December 8, 2026.

Grading schemes

Your final grade will be based on whichever among the four schemes below gives you the highest grade percentage out of 100%. Note: you do not have to choose one of these schemes — the instructor will simply take the one that gives you the highest percentage out of 100%.

Final grade component	**Scheme 1**	**Scheme 2**	**Scheme 3**	**Scheme 4**
In-class assignments (top five)	60%	50%	30%	0%
Final exam	30%	50%	60%	100%
Participation*	10%	0%	10%	0%

(*Note that participation requires attendance!)

In-class assignment schedule

Assignment 1	September 10, 2026
Assignment 2	September 24, 2026
Assignment 3	October 8, 2026
Assignment 4	October 22, 2026
Assignment 5	November 5, 2026
Assignment 6	November 19, 2026

Number to letter grade conversion

Percentage	93–100	90–93	87–90	83–87	80–83	77–80
Letter grade	A	A−	B+	B	B−	C+

Percentage	73–77	70–73	67–70	63–67	60–63	0–60
Letter grade	C	C−	D+	D	D−	F

5 AI-Use Policy: Learning Support Only

Students may use university-approved generative AI tools as a learning aid in this course. Acceptable uses include asking conceptual questions (“Explain the relationship between an object and a class.”), requesting explanations of course topics, obtaining high-level debugging hints (“Why would I get a null-pointer exception?”), brainstorming approaches, or reviewing examples for study.

Students may not use AI tools to generate final solutions, code, written responses, or other work for submission. Also, students must not submit their programs to an AI tool for review or correction.

Students are responsible for verifying the accuracy of any AI-generated explanation or suggestion they consult. Students are also responsible for verifying with the instructor whether their use of generative AI complies with this policy. Ultimately, all submitted work must reflect the student’s own reasoning, writing, and implementation.

6 Academic Accommodations

Virginia Tech welcomes students with disabilities into the University's educational programs. The University promotes efforts to provide equal access and a culture of inclusion without altering the essential elements of coursework. If you anticipate or experience academic barriers that may be due to disability, including but not limited to ADHD, chronic or temporary medical conditions, deaf or hard of hearing, learning disability, mental health, or vision impairment, please contact the Services for Students with Disabilities (SSD) office (540-231-3788, ssd@vt.edu, or visit ssd.vt.edu). If you have an SSD accommodation letter, please meet with me privately during office hours as early in the semester as possible to deliver your letter and discuss your accommodations. You must give me reasonable notice to implement your accommodations, which is generally 5 business days and 10 business days for final exams.

7 Academic Integrity

The Graduate Honor Code pledge that each member of the university community agrees to abide by states: "As a Hokie, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do." Students enrolled in this course are responsible for abiding by the Honor Code. A student who has doubts about how the Honor Code applies to any assignment is responsible for obtaining specific guidance from the course instructor before submitting the assignment for evaluation. Ignorance of the rules does not exclude any member of the University community from requirements and expectations of the Honor Code. Specifically, the Honor Code applies in this class as follows.

You can consult the Reading Materials for the course. The instructor is available to provide any assistance that you may need. No other person or resource may give you answers to the assignment questions. You are allowed to work in small groups for assignments, but you must write the final solutions independently from your group.

8 Student Well-Being

Supporting your mental health and well-being is of high priority to me and Virginia Tech. If you are feeling overwhelmed academically, having trouble functioning, or are worried about a friend, please reach out to:

- **Cook Counseling**
  - 540-231-6557 to schedule an appointment and/or 24/7 crisis support
  - ucc.vt.edu for more information
- **Dean of Students Office**
  - 540 231-3787 for general advice
  - 540-231-6411 for after hours crisis
  - Refer a Student of Concern
  - dos.vt.edu for more information

- **Hokie Wellness**
  - hokiewellness.vt.edu for well-being education and prevention opportunities including financial wellness
- **Services for Students with Disabilities (SSD)**
  - 540-231-3788 or ssd.vt.edu for more information about accommodations and other disability-related supports
- **TimelyCare**
  - 12 free scheduled counseling sessions per academic year, unlimited on-demand mental health support 24/7, unlimited access to health coaching
  - Register for TimelyCare

For a full listing of campus resources, check out well-being.vt.edu.

Please also feel free to speak with me. I will make an effort to work with you; I care about you.