# MATH 453: High-Performance Numerical Computing
## *Spring 2025 Course Syllabus*

**NJIT Academic Integrity Code**: All Students should be aware that the Department of Mathematical Sciences takes the University Code on Academic Integrity at NJIT very seriously and enforces it strictly. This means that there must not be any forms of plagiarism, i.e., copying of homework, class projects, or lab assignments, or any form of cheating in quizzes and exams. Under the University Code on Academic Integrity, students are obligated to report any such activities to the Instructor.

## COURSE INFORMATION

**Course Description**: This course covers state-of-the-art numerical algorithms for solving large scale problems accurately and efficiently. Topics include iterative methods for linear systems and eigenvalue computations, introduction to parallel programs and parallel numerical algorithms, and spectral methods. An instructor selected advanced topics will be included in the course.

**Number of Credits**: 3

**Prerequisites**: MATH 340 with a grade of C or better and MATH 391 with a grade of C or better.

**Course-Section and Instructors:**

| Course-Section | Instructor |
|---|---|
| Math 453-002 | Professor S. Afkhami |

**Office Hours for All Math Instructors**: Spring 2025 Office Hours and Emails

**Required Textbook**:

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|---|---|
| **Title** | *Introduction to High Performance Scientific Computing* |
| **Author** | David L. Chopp |
| **Edition** | First Edition, 2019 |
| **Publisher** | SIAM |
| **ISBN #** | 978-1-611975-63-5 |

**Additional Text:** Introduction to Parallel Computing, Second Edition, 2003 by Ananth Grama, Anshul Gupta,

George Karypis, Vipin Kumar, ISBN: 0-201-64865-2 (freely available online)

**University-wide Withdrawal Date**: The last day to withdraw with a **W** is **Monday, April 7, 2025**. It will be strictly enforced.

## POLICIES

**DMS Course Policies**: All DMS students must familiarize themselves with, and adhere to, the Department of Mathematical Sciences Course Policies, in addition to official university-wide policies. DMS takes these policies very seriously and enforces them strictly.

**Grading Policy**: The final grade in this course will be determined as follows:

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|---|---|
| **Homework** | 50% |
| **Midterm** | 20% |
| **Final Project** | 30% |

**Attendance Policy**: Attendance at all classes will be recorded and is **mandatory**. Please make sure you read and fully understand the Math Department's Attendance Policy. This policy will be strictly enforced.

**Religious Observance**: NJIT is committed to supporting students observing religious holidays. Students must notify their instructors in writing of any conflicts between course requirements and religious observances, ideally by the end of the second week of classes and no later than two weeks before the anticipated absence.

**Exams**: Final project presentation will be during the final exam week:

| | |
|---|---|
| Final Exam Period | May 10 - May 16, 2025 |

**Makeup Exam Policy**: There will be **NO MAKE-UP QUIZZES OR EXAMS** during the semester. In the event an exam is not taken under rare circumstances where the student has a legitimate reason for missing the exam, the student should contact the Dean of Students office and present written verifiable proof of the reason for missing the exam, e.g., a doctor's note, police report, court notice, etc. clearly stating the date AND time of the mitigating problem. The student must also notify the Math Department Office/Instructor that the exam will be missed.

**Cellular Phones**: All cellular phones and other electronic devices must be switched off during all class times.

## ADDITIONAL RESOURCES

**Math Tutoring Center**: Located in the Central King Building, Lower Level, Rm. G11 (See: Spring 2025 Hours)

**Further Assistance**: For further questions, students should contact their instructor. All instructors have regular office hours during the week. These office hours are listed on the Math Department's webpage for Instructor Office Hours and Emails.

**Accommodation of Disabilities**: The Office of Accessibility Resources and Services (OARS) offers long term and temporary accommodations for undergraduate, graduate and visiting students at NJIT.

If you are in need of accommodations due to a disability please If you need an accommodation due to a disability please contact the Office of Accessibility Resources and Services at oars@njit.edu. The office is located in Kupfrian Hall, Room 201. A Letter of Accommodation Eligibility from the Office of Accessibility Resources and Services office authorizing your accommodations will be required.

For further information regarding self identification, the submission of medical documentation and additional support services provided please visit the Office of Accessibility Resources and Services (OARS) website at:

https://www.njit.edu/accessibility/

**Important Dates** (See: Spring 2025 Academic Calendar, Registrar)

| Date | Day | Event |
|---|---|---|
| January 21, 2025 | Tuesday | First Day of Classes |
| January 27, 2025 | Monday | Last Day to Add/Drop Classes |
| March 16, 2025 | Sunday | Spring Recess Begins |
| March 22, 2025 | Saturday | Spring Recess Ends |
| April 3, 2025 | Thursday | Wellness day |
| April 7, 2025 | Monday | Last Day to Withdraw |
| April 18, 2025 | Friday | Good Friday - No Classes |
| April 20, 2025 | Sunday | Easter Sunday - No Classes Scheduled |
| May 6, 2025 | Tuesday | Thursday Classes Meet |
| May 7, 2025 | Wednesday | Friday Classes Meet |
| May 7, 2025 | Wednesday | Last Day of Classes |
| May 8, 2025 | Thursday | Reading Day 1 |
| May 9, 2025 | Friday | Reading Day 2 |
| May 10 - May 16, 2025 | Friday to Thursday | Final Exam Period |

# Course Outline

| Week # | Subject Topic |
|---|---|

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|---|---|
| Week 1 | *Finite difference numerical methods; Iterative methods, Jacobi, Gauss-Seidel.* |
| Week 2 | *Introduction to parallel computing.* |
| Week 3 | *Introduction to OpenMP; Parallel matrix and vector operations.* |
| Week 4 | *OpenMP; Parallelizing iterative methods with OpenMP.* |
| Week 5 | *OpenMP; Performance metrics.* |
| Week 6 | *Finite difference numerical methods - 2D Poisson equation; Multigrid methods.* |
| Week 7 - 8 | *High performance linear algebra: Conjugate Gradient method. Iterative method for eigenvalues. Solving non-linear system of equations.* |
| Week 9 - 10 | *Introduction to MPI; Parallelizing iterative methods with MPI.* |
| Week 11 | *Introduction to Fast Fourier Transform.* |
| Week 12 | *GPU programming using CUDA.* |
| Week 13 | *Spectral methods.* |
| Week 14 | *Introduction to Machine Learning, Stochastic Gradient Descent.* |

## Generative AI

*Student use of artificial intelligence (AI) tools is permitted in this course but you must indicate where and how you have used these tools. Additionally, if and when students use AI in this course, the AI must be cited as is shown within the NJIT Library AI citation page for AI. If you have any questions or concerns about AI technology use in this class, please reach out to your instructor prior to submitting any assignments. Note that students are ultimately responsible for developing skills in the course content area and therefore assignments that have errors and incorrect results will be graded accordingly regardless of whether or not AI tools are used. If you use AI in your coursework, you are encouraged to attempt to understand generated materials.*

*Updated by Professor S. Afkhami - 2025*
*Department of Mathematical Sciences Course Syllabus, Spring 2025*