NYU COURANT INSTITUTE OF MATHEMATICAL SCIENCES

Numerical Methods II
MATH-GA 2020 / CSCI-GA 2421
3 Units
Spring 2026

Course Syllabus

Lecture	Mon & Wed 11:00AM - 12:15PM CIWW 1302
Instructor	Mike O'Neil cims.nyu.edu/~oneil oneil@cims.nyu.edu 212-998-3125 CIWW 1119
Office hours	Mon 2:30PM – 3:30PM Tue 2:00PM – 3:00PM Or by appointment
Course website	cims.nyu.edu/~oneil/nmii26

Prerequisites

- Graduate student standing or permission of instructor.
- Proficiency with material covered in MATH-GA 2010 Numerical Methods I.
- Advanced undergraduate-level familiarity with linear algebra, ODEs, and PDEs.
- Programming experience *highly recommended*.

Description

This course is focused on numerical methods for solving ordinary and partial differential equations, and will include topics such as: numerical approximation theory, orthogonal polynomials, the Fast Fourier Transform, finite differences, spectral methods, 2-point boundary value problems, elliptic, parabolic, and hyperbolic PDEs and integral equations in higher dimensions, high-order quadrature techniques, and some fast structured matrix computations. Computer programming assignments will form an essential part of the course.

Materials

Much of the material for the course will be drawn from the two following texts:

- L. N. Trefethen, Spectral Methods in MATLAB, SIAM, 2000
  https://epubs.siam.org/doi/book/10.1137/1.9780898719598
- R. Leveque, Finite Difference Methods for Ordinary and Partial Differential Equations, SIAM, 2007
  https://epubs.siam.org/doi/book/10.1137/1.9780898717839

Additional and more advanced material may be drawn from various journal publications. Additional reference textbooks that may prove helpful include:

- D. Gottlieb and S. Orszag, Numerical Analysis of Spectral Methods, SIAM, 1977
  https://epubs.siam.org/doi/book/10.1137/1.9781611970425
- J. P. Boyd, Chebyshev and Fourier Spectral Methods, Springer, 1989
  https://store.doverpublications.com/products/9780486411835
- L. N. Trefethen, Approximation Theory and Approximation Practice, SIAM, 2019
  https://epubs.siam.org/doi/10.1137/1.9781611975949
- W. L. Briggs and V. E. Henson, The DFT: An Owner's Manual for the Discrete Fourier Transform, SIAM, 1995
  https://epubs.siam.org/doi/book/10.1137/1.9781611971514
- R. B. Guenther and J. W. Lee, Partial Differential Equations of Mathematical Physics and Integral Equations, Prentice Hall, 1987
  https://store.doverpublications.com/products/9780486137629

Assignments

There will be a mix of homework assignments and a take-home final/final project. The homework assignments during the semester will be released, submitted, and graded on Gradescope. Details regarding submission of coding projects will be given at the time of assignment. A link to the course on Gradescope can be found on Brightspace. Assignments will be released roughly every other week. More details regarding homework and exams will be provided in-class and/or via Brightspace.

Grading

The overall course grade will be determined from a final numerical weighted average. The following breakdown will be used to compute an overall numerical grade:

60%	Homework, each contributes equal weight regardless of length (Lowest grade dropped)
40%	Take home final or Final project

There is no extra credit. Late submission of assignments is *not allowed* unless permission from instructor has been obtained in advance of the due date. Discussion with your classmates is encouraged, but everyone must prepare their own assignments and *write every line of their own code.*

Note: The option of a final project will only be available to those students who have a strong track record on homework assignments and submit a convincing pre-proposal. This is at the discretion of the instructor. More details will be provided mid-way through the course.

The overall numerical grade will be converted to a letter grade with equivalencies:

```
93% <= A
88% <= A- <   93%
83% <= B+ <   88%
78% <= B  <   83%
73% <= B- <   78%
68% <= C+ <   73%
60% <= C  <   68%
50% <= D  <   60%
       F  <   50%
```

The final letter grade may be curved depending on the overall distribution of grades in the course, but only as to increase the corresponding letter grade.

Policies

- There will not be makeup homework assignments or exams without *prior approval* of the instructor. Late homework is not accepted without prior approval of the instructor. Exceptions will be only made in extraordinary circumstances (e.g. illness, emergencies, etc.). Official documentation may be required for some absences.
- While attendance/participation does not factor into the overall grade in the course, attendance and class discussions will likely be crucial to the success of students in the course. It is often the case that students who attend class and contribute to class discussions do very well in the course.
- Collaboration and discussion are strongly encouraged on homework assignments, but each student must write-up and turn in their own work.
- Use of Artificial Intelligence: Use of AI or AI-assisted coding tools such as opencode or claude *is allowed* only insofar as they are a *resource* you use to help with your homework or project. These tools often generate incorrect code, and many of the homework problems will be sufficiently specific where you will need to understand mathematics as well as write a code. You also **must cite what tool you used, and how you used it, along with prompts** if you decide to use them.

Weekly schedule

Each week, there will be two lectures. The lectures will cover various theorical concepts, and applications of these ideas, and may contain code demonstrations. More details of specific references for each topic (e.g. sections from a textbook) will be posted to the course webpage or to Brightspace.

Below is a rough week-by-week schedule of topics:

1. Introduction, overview, numerical computing environment
2. Fourier analysis, Discrete Fourier Transform, basic sampling theory
3. Spectral methods for periodic ODEs, Fast Fourier Transform
4. Chebyshev spectral methods for 2-point BVPs, integral equation formulation
5. Finite differences for 2-point BVPs
6. Spectral, finite difference, and integral methods for elliptic equations in 2D and 3D
7. Finite element methods
8. Krylov methods, preconditioners
9. Nested dissection, fast solvers
10. Initial value problems in 1 dimension: implicit, explicit, stability
11. Runge-Kutta methods and spectral deferred correction
12. Parabolic problems
13. Parabolic problems
14. Hyperbolic problems
15. Hyperbolic problems

Disability Disclosure Statement
Academic accommodations are available for students with disabilities. The Moses Center website is www.nyu.edu/csd. Please contact the Moses Center for Student Accessibility (212-998-4980 or mosescsd@nyu.edu) for further information. Students who are requesting academic accommodations are advised to reach out to the Moses Center as early as possible in the semester for assistance.

Academic Integrity, Plagiarism, and Cheating
Academic integrity means that the work you submit is original. Obviously, bringing answers into an examination or copying all or part of a paper straight from a book, the Internet, or a fellow student is a violation of this principle. But there are other forms of cheating or plagiarizing which are just as serious — for example, presenting an oral report drawn without attribution from other sources (oral or written); writing a sentence or paragraph which, despite being in different words, expresses someone else's idea(s) without a reference to the source of the idea(s); or submitting essentially the same paper in two different courses (unless both instructors have given their permission in advance). Receiving or giving help on a take-home paper, examination, or quiz is also cheating, unless expressly permitted by the instructor (as in collaborative projects).
(Above is adapted from the website of the College of Arts & Science: https://cas.nyu.edu/content/nyu-as/cas/academic-integrity.html)

Student Wellness
In a large, complex community like NYU, it is vital to reach out to others, particularly those who are isolated or engaged in self-destructive activities. Student wellness is the responsibility of all of us.
https://cas.nyu.edu/content/nyu-as/cas/academic-programs/student-wellness.html
The NYU Wellness Exchange is the constellation of NYU's programs and services designed to address the overall health and mental health needs of its students. Students can access this service 24 hours a day, seven days a week by emailing wellness.exchange@nyu.edu or calling (212) 443-9999. Students can call the Wellness Exchange hotline (212-443-9999) or the NYU Counseling Service (212-998-4780) to make an appointment for Single Session, Short-term, or Group counseling sessions.
https://www.nyu.edu/students/health-and-wellness/wellness-exchange.html