CE 31500 Computational Methods in Civil Engineering

Spring 2024

TuTh, 10:00-12:15

106 Baskerville Hall (Thursdays); 207 Steinman Hall (Tuesday)

Instructor: **Nir Krakauer** nkrakauer@ccny.cuny.edu

Office hours: Th 2-3 PM (or by appointment) (180 Steinman Hall)

Credits/Contact Hours: 3 Cr.; 2 hr lecture and 3 hr lab per week

Zero Textbook Cost Course

Textbooks:

1) Qingkai Kong, Timmy Siauw, Alexandre Bayen, *Python Programming and Numerical Methods: A Guide for Engineers and Scientists* (available online at https://pythonnumericalmethods.berkeley.edu/)

2) Autar Kaw, *Numerical Methods with Applications* (available online at https://nm.mathforcollege.com/textbook-numerical-methods-with-applications/)

The course lecture notes are also a useful reference: https://nirkrakauer.net/classes/ce315/notes_lec.pdf

Catalog description: Algorithmic formulation of the solution to civil engineering problems. Flowcharts. Solutions to algebraic and differential equations common to civil engineering. Matrix problems. Differentiation and integration. Optimization problems. Students will primarily use microcomputers and a programming language, spreadsheets and "macros" and symbolic calculations software.

Prerequisites: CSc 10200, CE 26400, CE 23100 (min. C grade); Coreqs: Math 39100, Math 34600 or 39200.

Required Course

Course Learning Objectives and associated ABET Outcomes

	By the end of the course, the student should be able to:	**ABET Outcome**
1.	Know when a numerical method is likely to be appropriate for solving common engineering problems, and decide among available methods based on accuracy, reliability, and computational cost.	1, 6
2.	Use built-in programming-language commands and write functions and scripts to solve numerical problems.	1, 3, 6
3.	Apply numerical methods to find roots of equations	1, 6
4.	Use numerical procedures to carry out differentiation and integration	1, 6
5.	Use polynomial interpolation, cubic splines, and least-squares method for curve fitting	1, 6
6.	Numerically solve systems of linear equations	1, 6
7.	Numerically integrate systems of ordinary differential equations	1, 6
8.	Assess the accuracy of a numerical solution	1, 4
9.	Deliver technical reports and oral presentations of computing projects	1, 3, 4, 6

Topics:

1. Introduction and overview: Computation in the engineering problem-solving process. Common properties and examples of numerical methods.

2. Numerical errors: Floating-point numbers and roundoff. Ill-conditioned problems. Ways of estimating and preventing error.

3. Linear algebra: Matrix notation and operations. Special matrix types. Systems of linear equations: Gauss elimination. Row pivoting. LU decomposition.

4. Eigenvalues and eigenvectors: Properties. Computation. Application to systems of oscillators.

5. Numerical differentiation: Finite difference formulas. Richardson extrapolation.

6. Numerical integration: Trapezoid, midpoint, Simpson's rules. Accuracy of composite rules. Achieving higher-order accuracy.

7. Ordinary differential equation initial value problems: Euler method. Higher-order Runge-Kutta method. Adaptive stepsize solvers.

8. Ordinary differential equation boundary value problems: Finite difference approximation.

9. Interpolation: Polynomial, linear, cubic spline.

10. Regression: Least-squares criterion. Design matrix and normal equations for linear problems. Model selection. Nonlinear least squares.

11. Root-finding: Newton's method, secant method, bisection. Algorithm implementations and error estimates.

12. Optimization: Golden section search. Newton's method. Using programmed optimization routines.

COURSE POLICIES

Academic Integrity Policy: Students are encouraged to collaborate on homework and exam preparation. However, the work submitted must be their own and in their own words. Any work that appears to not be original will be questioned for academic misconduct and reported to Student Judicial Affairs. Violations of academic integrity will result in an "F" on the assignment, and may also result in suspension or expulsion.

CE Department: www.ccny.cuny.edu/civileng/ce-policy

CUNY: cuny.edu/about/administration/offices/legal-affairs/policies-procedures/academic-integrity-policy/

Attendance Policy: Students are expected to attend class. Attendance will be monitored.

Late assignments (includes homework and project components): 10% deduction if submitted up to 24 hours late. Otherwise not accepted.

Missed exams: No make-up exam will be given without a legitimate excuse and prior notification. The student must provide documentation of the emergency and a support letter from the Chair of the Civil Engineering Department.

Other College-wide policies and useful resources are listed at
ourtlc.commons.gc.cuny.edu/syllabus-statements/

Grading Policy: Grades will not be curved and so your grade will not depend on the grades of your classmates. The following general types of assignments are required for CE 31500:

- Written assignment
- Computer programming assignment
- Data analysis assignment
- Computer assignment
- Oral presentation

Your overall course grade will be calculated using the following weighting:

1.	Homework	18%
2.	Project	20%
3.	In-class quizzes and assignments	5%
4.	Exam 1	14%
5.	Exam 2	19%
6.	Final	24%

SCHEDULE (approximate – any major adjustments will be announced in class or over e-mail)
Topic numbers follow the section headings in the lecture and lab notes, on the course website.

Class	*Date*	*Topics (with related textbook readings) and Exams*
#1	1/25	Topic 1 – KSB chapters 1-5, 12, 18; K section 01.01,01.07
#2	1/30	Lab 1
#3	2/1	Topic 2 – KSB chapters 9-10; K section 01.02-01.06
#4	2/6	Lab 2; HW 1 due
#5	2/8	Topic 3 – KSB chapters 14, 8; K sections 04.01-04.09, 04.11
#6	2/13	Lab 3; HW 2 due
#7	2/15	Topic 4 – KSB chapter 15, 11; K section 04.10
#8	2/20	Lab 4; HW 3 due
#9	2/27	Topic 5 – KSB chapter 20; K sections 02.01-02.03
#10	2/29	Lab 5; HW 4 due
#11	3/5	Exam 1 (topics 1-4)
#12	3/7	Topic 6 – KSB chapter 21; K sections 07.01-07.08
#13	3/12	Lab 6; project proposal due; HW 5 due
#14	3/14	Topic 7 – KSB chapter 22; K sections 08.01-08.05
#15	3/19	Lab 7; HW 6 due
#16	3/21	Topic 8 – KSB chapter 23; K section 08.07
#17	3/26	Lab 8
#18	3/28	Topic 9 – KSB chapter 17; K sections 05.01-05.10
#19	4/2	Lab 9; HW 7 due
#20	4/4	Topic 10 – KSB chapter 16, 25.1, 25.3; K sections 06.01-06.05
#21	4/9	Exam 2 (topics 5-8)
#22	4/11	Lab 10
#23	4/16	Topic 11 – KSB chapter 19; K sections 03.03-03.06; project first draft due
#24	4/18	Lab 11; HW 8 due
#25	5/2	Topic 12 – K sections 09.01-09.02
#26	5/7	Lab 12
#27	5/9	Project presentations
#28	5/14	Project presentations; Summary and review; Project report due; HW 9 due

Final exam (topics 1-12): time TBA by registrar

Additional Information

Blackboard and email
Make sure you can access the class Blackboard site (under bbhosted.cuny.edu). You will submit many of the assignments there. Messages to the class, which may announce changes in schedule or other important information, will be sent to the email address you have on Blackboard, so check it regularly.

Supplemental Material
Notes, slides, and supplemental reading and learning material are posted on the class website:

https://nirkrakauer.net/classes/ce315/

Homework submissions
Depending on their format, some homework problems will be submitted on Blackboard, while others will be submitted through the class website, and yet others through the class WeBWorK site https://webwork.ccny.cuny.edu/webwork2/24Sp_CE315/

Computing Tools
In this course, we will employ Python (https://www.python.org/) for numerical computation. You should install a Python distribution on your laptop or desktop so that you can easily program with it. One possibility is Anaconda (https://www.anaconda.com/products/individual). There is also a department server at https://jupyterce.levich.net/ where you can enter and run Python programs in a browser; let me know if you need an account.

Evaluation

In-class assignments and homework
Quizzes will periodically be held during class on the assigned readings and on recently covered material, and problems will also be given as in-class assignments.
Homework assignments will be posted on Blackboard and due weekly. Each homework set will typically include a combination of problems to submit on Blackboard, problems to be solved on the WeBWorK site online, and programs to be submitted on the class website. You may cooperate with other students on homework. Allow plenty of time to do each homework, and start early. To allow for any unexpected problems, it's strongly recommended to plan to submit homework before the due date.

Exams
The two midterm exams will cover topics 1-4 and 5-8 respectively. The final exam will be cumulative (1-12). The exam problems will be similar to the shorter homework problems. To do well on exams (and in the course), take careful notes, work through the examples and homework problems, and get help when you don't understand something. More details about the exam format will be provided during the class.

Project
The term project will involve solving a computational engineering problem of your choice by doing some additional reading and programming. Your results should be written in engineering lab report format. You will also give a 5-minute presentation of your topic and main findings to

the class. The term project must be only your own work. More details are given in a document on the course website.

Extra Credit

If you're the first to email me about any mistake in the lecture notes, slides, homework, or practice problems, you'll have 0.5% added to your course grade. If you attend a department seminar and submit by e-mail, within two weeks, a well-written, approximately 2 page summary of the talk and how the work described uses computation and relates to something discussed in the class (if that isn't clear from the talk, try asking the speaker), you can also have up to 0.5% added to your course grade. If you're not sure whether a talk would be eligible , email me ahead of time to get approval. The maximum amount of extra credit per student is 5%.

Course Grade

After combining the grade components using the weighting given above and adding any extra credit, a letter grade will be assigned based on the following grading scale. Depending on how challenging the problems given turn out to be (relative to the class objectives), this scale may end up being adjusted a few percentage points in your favor.

A+	[97 – 100]
A	[93 – 97)
A-	[90 – 93)
B+	[87 – 90)
B	[83 – 87)
B-	[80 – 83)
C+	[77 – 80)
C	[73 – 77)
C-	[70 – 73)
D	[60 – 70)
F	[0 – 60)

Online class contingencies

Class sessions are planned to be primarily in person. However, some (or even, under unexpected circumstances, many) may be online.

If classes are online, we will have lectures/labs at the class times using Blackboard Collaborate (within the class Blackboard site). They will be recorded so that you can listen to them after.

Recording: The instructor may record class sessions and share them with the class to aid review. Students will also be asked to make in-class or recorded presentations that will be shared with the class. Students may also be required to share audio and video of their workspace and use proctoring software during examinations. By continuing enrollment in the class, students are deemed to agree to being recorded under those circumstances.

Office hours may be by phone/teleconferencing. If so, the time, number, and how to sign up for an appointment will be shared via e-mail.