Spring, 2026

Optimization and AI
Saturday mornings, 11:45 am – 1:15 pm ET

An Online Group Class
Offered by Eric Anthony Comstock, M.S. Aerospace Engineering '24
Georgia Tech PhD Candidate,
and Davidson Young Scholar alumnus

About the instructor

I have a BS in aerospace engineering (*magna cum laude*) with engineering honors and minors in math and chemistry from Texas A&M University in College Station. I recently graduated with an M.S. in Aerospace Engineering in December of 2024 from Georgia Tech. I am currently a PhD candidate at Georgia Tech in aerospace engineering. I created this class for Davidson Young Scholars, and have been teaching Davidson scholars for the past 3 years. I can be reached at: **eric.comstock@gatech.edu**

Course Overview

Artifical intelligence is an increasingly large part of both daily life and the economy, and is fundamentally built on the even more widely applicable field of optimization. If you are intellectually curious about the subject, and if you have the background of algebra, differential calculus, and Python knowledge, the ability to catch on to concepts quickly, and the willingness to participate in class and complete homework, then this class is for you!

From these building block prerequisites, we will cover most major optimization methods in detail, to ensure you have a solid understanding of how and where they can be used, and why selecting the right method is critical in the field of AI. The class will be very fundamentals-oriented, and is designed to teach you how to build AI tools from scratch and using pre-existing libraries, not how to use AI tools efficiently. We will spend most of our time covering optimization techniques, as these form the backbone of AI technology.

There is no age requirement for this class. Having grown up as an academically accelerated Davidson student, I realize that age has no bearing on intellectual merit.

I. Topics covered

I expect to cover one to three of these topics per hour and a half long lecture, organized into blocks.

1. Introduction
    a. Need for numerical optimization in engineering design
    b. Optimization is the backbone of AI – almost all AI are built on optimization methods
    c. Review of multivariate calculus fundamentals
2. Unconstrained Optimization
    a. Necessary conditions for optimality
    b. Line search algorithms
        i. Zeroth order (Powell's method, univariate search)
        ii. First order (steepest descent, Fletcher-Reeves conjugate gradient, BFGS, etc.)
        iii. Second order (Newton's method)
    c. Direct search algorithms (grid search, random walk, coordinate pattern search, etc.)
    d. Normalization approaches and convergence criteria
3. Constrained Optimization
    a. Challenges of constraints; activity, feasibility
    b. KKT necessary conditions for optimality
    c. Indirect methods and penalty functions (interior, exterior, augmented Lagrangian, etc.)
    d. Linear programming and the simplex method
    e. Direct methods (SLP, MoFD, generalized reduced gradient method, SQP, etc.)
4. Metaheuristic Optimization
    a. Metropolis algorithm and simulated annealing
    b. Binary representation (decimal/binary conversion, Hamming distance, Gray codes)
    c. Genetic operators and algorithms (selection, crossover, mutation, replacement)
    d. Particle swarm algorithms
5. Multi-Objective Optimization
    a. Partial ordering and Pareto dominance
    b. Aggregate objective function (AOF) approach
    c. epsilon-constraint method
    d. Normal boundary intersection (NBI) and related methods
    e. Multi-objective genetic algorithms (NSGA-II, etc.)
6. Designs of Experiments and Surrogate Models
    a. Full and fractional factorial designs
    b. Space filling designs (Latin Hypercube, minimax and maximin, maximum entropy, uniform)
    c. Multiple linear regression models: polynomials and radial basis functions (RBFs)
    d. Nonlinear regression models: artificial neural networks (ANN) and Gaussian processes
    e. Assessing fit quality: error measures, validation sets, cross-validation, overfitting

7. AI, neural networks, and applications
    a. Gradient descent vs metaheuristic optimization
    b. Necessary network size
    c. Developing your own AI agent from scratch in Python
    d. Applications
        i. Classification
        ii. Regression
        iii. Generation
8. AI tools in Python
    a. SciPy optimization
    b. SciKit-learn

II. Homework and Grading

Homework will be present in half to two thirds of the weeks, and will be assigned one class and generally due at 11:59 PM ET on Mondays, 9 days after the class occurs. Homeworks will typically consist of 1-4 questions per homework. Every week that the homework is late will deduct from the student's grade, as follows:

0 to 1 days late	-3% reduction
1 day to 1 week late	-15% reduction
1 week to 2 weeks late	-30% reduction
2 weeks to 3 weeks late	-45% reduction
Greater than 3 weeks late	-60% reduction

Homeworks that are incomplete may be submitted, and questions that are answered later will have their grades deducted individually based on the above rubric. My fundamental goal is helping these students learn and not punishing them for turning in homework late. While some standards are necessary for any learning environment, I want my learning environment to be sensitive to the needs of young learners in order to encourage and foster a love of math and science.

I generally expect to give short but thought-provoking homeworks, designed to test understanding of as much of the material as possible as quickly as possible. Students are thus highly encouraged to come to office hours or reach out to me via email to ask questions about the homework – I will be happy to help them through the solution to a similar problem. Extra credit will be available on some homeworks, but its inclusion is up to my discretion. If included, it will usually involve some kind of proof or generalization.

The student's total grade will be determined as follows:

Homework weighted average	90%
Attendance	10%

III. Prerequisites

Students are recommended to enter the course with knowledge of differential calculus, the Python programming language, and algebra. Enthusiasm for learning, as well as the ability to pick up math concepts quickly, will also enhance the experience significantly, since much of the course is designed to be driven by individual curiosity.

Experience in integral calculus or differential equations will be useful, but is not required.

IV. Schedule

Classes will be held on Saturday mornings from 11:45 – 1:15 pm ET, beginning Saturday, Janurary 10th according to the schedule below. My office hours will be on weekday evenings (TBD – updates on my website's mentoring page) for questions related to the homework, a resource which students are strongly encouraged to use.

How fast the class goes depends upon how well the class goes. If most students are having trouble then I will likely slow down so that they are better able to understand the material. And, if the class is doing well, then I will likely speed up to present them a challenge. For these reasons, I do not have a specific end date, but I expect the class to last on the order of a school semester.

Preliminary Schedule (First three blocks)	
Date	***Class number***
First Block: $150	
Janurary 10	1
Janurary 17	2
Second Block: $375	
Janurary 24	3
Janurary 31	4
Feburary 7	5
Feburary 14	6
Feburary 21	7
Third Block: $375	
Feburary 28	8
March 7	9
March 14	10
March 21	11
March 28	12

Blocks are how tuition is billed. Please see the tuition section below for more information. Note that a fourth block is almost certain, but its length will depend on class progress during the third block, likely between 3 and 6 sessions.

V. Tuition

Tuition will be $75 per 1.5 hour class, or $50 per hour, once per week. Two weeks tuition will be due up front to secure your spot in the class with no ongoing obligation. Upon payment receipt, a link will be sent to join the online class.

Tuition may be paid via Zelle to
Eric Comstock, eric.comstock@gatech.edu.

After the first two weeks, if you decide to continue in the class, five weeks tuition will be due by 11:59 pm the day before the third class. An updated link for the third through eighth classes will be sent out the day of class upon tuition receipt. Since it is not yet known how many classes we will have, tuition payment will be managed in this manner until the end of the course.

That is, if we begin Saturday, Janurary 10, 2026

$150 is due immediately to secure your spot in the class
$375 due by 11:59 pm on Janurary 23, 2026 (just prior to third class)
$375 due by 11:59 pm on February 27, 2026 (just prior to eighth class) – this would take us through the class on March 28, 2026.

One additional block of around 3 to 6 classes is likely, but due to lack of information on the preferred learning speed of the students, the exact number of classes cannot be determined.

VI. Textbook

There will be no textbook. Lectures will be based on my lecture notes which will be provided.

VII. Online meeting platform

We will be using an application that I have access to that does not require any software for the student. It is very easy to use. All the student needs is an internet connection, a browser, microphone and camera. The student will merely click on a link sent via email and allow access to their microphone and camera, then they will join the meeting. Most browsers work with this platform.

VIII. General Expectations

Given that this class is open to all ages, I must emphasize that students must behave in a manner that is appropriate to all ages during the class. That is, older students must refrain from speaking about any topics that are inappropriate for younger students. This rule will be strictly enforced.

I will not wait for tardy students, and will always start exactly on time. Please try to come to class on time.

I do take attendance, and while it is not a large component of your grade, it can make the difference between an A and a B. I will deduct points if you are not in class and do not have an excuse. Please let me know beforehand if you cannot make class.