Course Information

Course Title: Mathematical Foundations of Analytics
Course Number and Section: CS 660 CRN 40729
Term: Summer 2023
Class Meeting time: Monday 6:10pm – 9:00pm
Class delivery format/location: **On-campus**: 1 Pace Plaza W603
In person attendance is required, there will be no Zoom access to class.

Contact Information

Instructor(s) Name(s): Analee Miranda
Email: amiranda2@pace.edu
Phone: (212) 346-1772
Preferred Contact Method: Email
Office location: 41 Park Row, Room 708
New York, NY 10038
Office hours: Mon 4:00pm – 6:00pm (In-Person, no appointment needed)
Fri Virtual (By appointment only – email for available times)

Face Coverings and Social Distancing in Indoor and Outdoor Spaces

Under current guidance from the Centers for Diseases Control and Prevention, face coverings are recommended.

Vaccines are required for everyone in our community coming to campus. If you have not yet uploaded your vaccine record, please do so immediately via the confidential Patient Portal.

More information is available on the Return to Campus website.

Course description

This course covers the fundamental mathematics needed for further study in data science, machine learning and artificial intelligence. Students will learn the theory and application of linear algebra, analytic geometry, matrix decompositions, vector calculus, probability theory and optimization. Building upon these mathematical foundations, the course culminates with an overview of some key machine learning concepts: linear regression; principal components analysis; density estimation; and support vector machines. The emphasis of this course is on the theory underlying data science methods and machine learning.

https://csis.pace.edu/~fparisi/pages/CS660.html

Prerequisites

Multivariate calculus and linear algebra.

I assume you know the fundamental concepts in multivariate calculus, and linear algebra, and this course we build on these topics. If you do not know the pre-requisite material this course will be difficult for you.

See the Additional Resources provided on the course web page.

Course learning objectives

After taking this course, the students will be able to

1. Understand and apply the concepts of linear algebra including solving systems of linear equations, matrices, vector spaces and groups
2. Understand and compute inner products, derive orthogonal bases, and orthogonal projections
3. Understand and find determinants, inverses, and singular value decompositions of matrices
4. Differentiate vector valued functions and calculate gradients
5. Understand and apply probability theory and probability distributions, including Bayesian analysis
6. Understand the formulation of optimization problems and how to solve them
7. Recognize the distributions most relevant to modeling and data science
8. Understand the theory of linear regression, principal components analysis, density estimation, and support vector machines
9. Continue further study in machine learning, artificial intelligence, optimization, and related areas, building upon the mathematical background learned in this course

Instructional Materials

Required

Mathematics for Machine Learning, M. P. Deisenroth, A. A. Faisal, and C. S. Ong. Cambridge University Press (2020), ISBN: 9781108455145 (Print)

Most current eBook version available free from the publisher at https://mml-book.com

Grading Policy

Final Grade Breakdown:

Assignment	**Weight**
Homework Assignments (six total)	100 points
Midterm	100 points
Final Exam	100 points
Total	**300 points**

Summing up points earned and dividing by 300 to get a final grade percentage and rounded up to the next whole number determines the final grade. The table below shows the correspondence between the percentages and the final letter grades.

The grading scale (%) is as follows:

Percentage	Letter Grade
93% and higher	A
90% – 92%	A-
87% – 89%	B+
83% – 86%	B
80% – 82%	B-
77% – 79%	C+
70% – 76%	C
Less than 70%	F

Assignments & Homework

A student's performance on the homework assignments, the midterm exam, and the final exam determines the course grade. There will be **no make-ups for missed homework or exams, and missing assignments and exams receive a grade of zero**. **Moreover, I do not offer extra credit assignments. Please do not ask.**

Rubric

Evaluations reflect how well you understand the theory and concepts, and your ability to apply these concepts to solve problems.

Course Policies

Attendance and Participation

I expect in-class participation from students throughout the semester. While participation is not explicitly graded, it may earn you a boost in your grade.

Penalty on Late Work

Late assignments earn a zero; there will be **no make-ups for missed homework or exams.**

Plagiarism

All work submitted must be original. *Copying from others or the internet is not acceptable*. Students must adhere to the University's Academic Integrity Code. **I will fail any student caught cheating.**

Classroom Climate

Our Pace community benefits from the richly unique experiences and individual diversity each of us bring. Intellectual growth and development happen when we engage in free and open discourse that challenges our own assumptions and beliefs. Together we all have the responsibility to create and maintain an environment where differences are respected and valued. To that end, we will challenge all manifestations of bias and discrimination to maintain a climate of mutual respect and civility.

Whether you are learning in an online or on campus environment, the same expectations of courtesy and conduct apply. All classroom interactions should remain civil, respectful, and supportive. If you disagree with someone, aim to acknowledge your disagreement in a respectful way. Try responding with a question to open up further discussion (e.g., I'm not sure that I understand your point of view. Can you say more?). When working online, choose your words carefully. It's easy for someone to misinterpret your meaning when they can't see your expressions or hear the tone of your voice. Be careful when using sarcasm and humor. Without face-to-face communication, your comments may be misinterpreted.

Course Schedule (Timing is approximate)

Monday	Week	Topic	Reading	Assignments Due HW is due by 11:59pm
June 5	1	Linear algebra ● Systems of linear equations, Matrices, Solving SLEs, Vector Spaces ● Linear Independence, Basis and Rank, Linear Mappings, Affine Spaces	Chapter 2	
June 12	2	Analytic geometry	Chapter 3	HW#1 – Linear Algebra
June 19	3	Matrix Decomposition ● Determinants and trace, Eigenvalues and eigenvectors, Cholesky Decomposition, Eigendecomposition and diagonalization ● SVD, Matrix approximation	Chapter 4	HW#2 – Analytic Geometry
June 26	4	Vector calculus ● Differentiation and gradients ● Gradients of Vector-Valued Functions and Matrices, Backpropagation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series	Chapter 5	HW#3 – Matrices
July 3	5	Probability and distributions ● Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem	Chapter 6	HW#4 – Vector Calculus
July 10	6	**Midterm Exam Ch. 2-5**		
July 17	7	Probability and distributions ● Summary Statistics and Independence, Gaussian Distribution, Bayesian Analysis	Chapter 6	
July 24	8	Probability and distributions ● Conjugacy and the Exponential Family, Change of Variables/Inverse Transform	Chapter 6	
July 31	9	Optimization	Chapter 7	HW#5 – Probability
August 7	10	Data and machine learning modeling concepts	Chapter 8	
August 14	11	Four Pillars of Machine Learning ● Linear regression, Principal Components Analysis Density estimation, Support vector machines	Chapter 9, 10, 11, 12	HW#6 – Optimization
August 21	12	**Final Exam Ch. 6 -12**		

University Policies and Resources

Academic Integrity

Students in this course are required to adhere to Pace University's Academic Integrity Code. The Academic Integrity Code supports honesty and ethical conduct in the educational process. It educates students about what constitutes academic misconduct, helps to deter cheating and plagiarism, and provides a procedure for handling cases of academic misconduct. Students are expected to be familiar with the Code, which can be found under "University Policies" in the Student Handbook. Individual schools and programs may have additional standards of academic integrity. Students are responsible for familiarizing themselves with the policies of the schools, programs, and courses in which they are enrolled. Before the second class meeting read the Academic Integrity Code and answer the attestation on the Classes home page for this course.

Learning Centers

The Learning Center uses an array of programs and a holistic approach to assist students with academic skills and content knowledge. We are dedicated to developing independent learners by creating purposeful interactions with trained, well-qualified peer and professional staff.

Procedure for Students Who Wish to Obtain Reasonable Accommodations for a Course:

The University's commitment to equal educational opportunities for students with disabilities includes providing reasonable accommodations for the needs of students with disabilities. To request a reasonable accommodation for a qualified disability a student with a disability must self-identify and register with Student Accessibility Services for his or her campus. No one, including faculty, is authorized to evaluate the need for or grant a request for an accommodation except Student Accessibility Services. Moreover, no one, including faculty, is authorized to contact Student Accessibility Services on behalf of a student. For further information, please see Resources for Students with Disabilities page.

Technological Resources:

- List of all Pace Information Technology Services.
- For assistance with a technological concern (Blackboard, Internet, Computer, etc.), contact the Pace Helpdesk at 914-773-3648 or create a help desk ticket.
- Visit the Learning Remotely website

Appropriate Use Policy for Information Technology*:*

Pace endorses the following statement on software and intellectual rights distributed by EDUCAUSE, the non-profit consortium of colleges and universities, committed to the use and management of information technology in higher education. The statement reads:

> *Respect for intellectual labor and creativity is vital to academic discourse and enterprise. This principle applies to work of all authors and publishers in all media. It encompasses respect for the right to acknowledgment, right to privacy and right to determine the form, manner and terms of publication and distribution.*
>
> *Because electronic information is volatile and easily reproduced, respect for the work and personal expression of others is especially critical in computer environments. Violations of authorial integrity, including plagiarism, invasion of privacy, unauthorized access and trade secret and copyright violations, may be grounds for sanctions against members of the academic community.*

Pace's appropriate use policy applies to recordings of classroom instruction and digital artifacts created by faculty and students.

Career Services Office

Career Services is here to assist you with all your professional goals! Through a simple, step-by-step program, our team of experts will help you:

- Build a resume that gets results.
- Utilize Handshake to find jobs and internships.
- Deliver a great pitch and interview like a pro.
- Establish an "all-star" LinkedIn profile.
- Learn how to create professional correspondence.
- Attend career fairs, employer spotlights, and road trips.
- Find a mentor and expand your network.

To schedule a remote appointment or attend a virtual workshop, log into Handshake (pace.joinhandshake.com) with your Pace credentials. Call us at (212) 346-1950 in NYC or (914) 773-3415 in PLV or email us at career@pace.edu. Visit our website: https://www.pace.edu/career-services/

Sex-Based Misconduct Policy and Procedure:

Pace University is committed to providing a safe environment for every member of its community and to ensuring that no student, faculty or staff member is excluded from participation in or denied the benefits of any University program or activity on the basis of sex. Accordingly, the University prohibits the following forms of Sex-Based Misconduct: sexual assault, sexual harassment, gender-based harassment, dating violence, domestic violence, sexual exploitation, and stalking.

Instructors are a **non-confidential** resource and have an obligation to report any information about sexual assault with the Executive Director of Institutional Equity and Title IX Coordinator (Bernard Dufresne, bdufresne@pace.edu, 163 Williams Street, Room 1017, 212-346-1310). The Title IX/Affirmative Action Office is responsible for investigating violations of the sexual misconduct policy. For more information about the Pace University sexual misconduct policy, see the Sex-Based Misconduct Policy and Procedure (PDF).

Members of the University community who believe that they have been subjected to Sex-Based Misconduct are encouraged to report such incidents to the University and, where applicable, to local law enforcement. **Confidential** resources include the **University Counseling Centers, Offices of Sexual and Interpersonal Wellness** and **University Healthcare**. Contact information for those offices may be found in the self-care section below.

Self-Care:

Your academic success in this course and throughout your college career depends heavily on your personal health and well-being. Stress is a common part of the college experience, and it often can be compounded by unexpected life changes outside the classroom. The Pace Community strongly encourages you to take care of yourself throughout the term before the demands of midterms and finals reach their peak. Please feel free to talk with me about any difficulty you may be having that may impact your performance in this course as soon as it occurs and before it becomes unmanageable. Please know there are several other support services on campus that stand ready to assist you. I strongly encourage you to contact them when needed.

Just In Case App:

The Counseling Center's *Just In Case* App supplies potentially life-saving mental health information to Pace University students, staff, and faculty. This smart phone App puts vital information and support options at your fingertips. Scan and open the App today, just in case you or a friend needs help. Download

the Counseling Center *Just In Case* App or go to "Counseling Center: Just In Case" on the MyPace Mobile App.

Department	**Pleasantville**	**New York City**
Counseling Center	914-773-3710	212-346-1526
Dean for Students Office	914-773-3351	212-346-1306
Health Care Unit	914-773-3760	212-346-1600
Residential Life	914-923-2791	212-346-1295
Student Development and Campus Activities	914-773-3861	212-346-1590
Office of Multicultural Affairs & Diversity Programs	914-773-3775	212-346-1563
Sexual Assault Prevention & Education	914-597-8783	212-346-1931
Academic Advisement		
Advising Center for Exploring Majors	914-773-3847	212-346-1798
College of Health Professions	914-773-3961	914-773-3552
Dyson College	914-773-3781	212-346-1518
International Student / Scholars	914-773-3425	212-346-1368
Lubin School of Business	914-773-3531	212-618-6550
Pforzheimer Honors College	914-773-3941	212-346-1697
Seidenberg School	914-773-3254	212-346-1864
Study Abroad	914-773-3447	212-346-1368