MSDS 400: Math for Modelers

Instructor Contact Information

	Instructor: Philip M. Goldfeder, PhD Email: philip.goldfeder@northwestern.edu (preferred) Office Hours: By appointment Response Time: I will usually respond to emails within moments and postings within hours. Optional Synchronous Meetings (Sync Sessions): TBA

Biography

Dr. Goldfeder has undergraduate degrees in Physics and Philosophy from Lafayette College in Easton, PA (go Leopards!) and graduate degrees in Applied Mathematics from some school in Evanston whose name is probably familiar to you if you are reading this. His prior work was as a management consultant with Booz & Company (formerly Booz Allen and Hamilton), specializing in mergers and acquisitions. He has been published in *Journal of Phys. Chemistry B, Mathematical Problems in Engineering, Journal of Engineering Mathematics*, and *Graziadio Business Review*, as well as several chapters in the *Macmillan Science Library*. He has taught many subjects and disciplines over many levels, ranging from middle school through doctoral level, in both traditional and online settings, here in the states and internationally. He lives in the Chicagoland area with his wife and sons. Phil's favorite pastimes are Crossfit, travel, and family time, in varying order depending on the day.

Teaching Assistant Contact Information

Teaching Assistant: Barry Chiu

Email: barryc@northwestern.edu

Weekly Office Hours: Mondays at 7:30 PM CDT

Email via Canvas is the best way to reach Barry. He will respond to queries within 24 – 48 hours.

Biography

Barry finished received his MSDS degree at Northwestern SPS in 2022 and MSIT degree in 2016. He works as a system administrator team lead with over 20 years of experience. Barry has produced monthly reports for service delivery and capacity management used by upper management. In 2020, he joined a High-Performance Computing team that administers servers for researchers and uses metrics to track the performance of the compute cluster.

Course Description

Students learn techniques for building and interpreting mathematical models of real-world phenomena in and across multiple disciplines, including linear algebra, discrete mathematics, probability, and calculus, with an emphasis on applications in data science and data engineering. Provides students with a firm understanding orreview of these fields of mathematics prior to enrolling in courses that assume understanding of mathematical concepts.

Course Objectives

By the end of this course, you will be able to:
- Explore concepts in linear algebra.
- Apply linear programming methods to real-world models.
- Analyze and interpret mathematical models.

- Calculate and analyze derivatives and integrals of real-world models.
- Solve applications involving multivariate calculus.
- Optimize outcomes modeled by graphs and trees.

Prerequisites

There are no prerequisites for this course.

Diversity Statement

I truly believe that we are all unique individuals and each of us adds value to the world around us. We all deserve respect and equity regardless of our backgrounds or identities. I embrace the knowledge that I have gained from my students over the years and look forward to learning more from you. Your opinions, approaches, knowledge, and experiences are important to me and I welcome broadening my experiences and knowledge by working with you. I teach with the approach that I am more than simply a subject matter expert. I am here to not only guide you, but to work alongside you as you take this journey through this course.

Required and Optional Readings and Resources

Required Readings

- Arnold, D. *Elementary Algebra*. LibreTexts.
- Hartman, G. *Fundamentals of Matrix Algebra*. LibreTexts.
- Sekhon, R., Bloom R. *Applied Finite Mathematics*. LibreTexts. Strang, G., Herman, E. *Calculus (OpenStax)*. LibreTexts.
- Rosen, K. *Discrete Mathematics and its Applications, 7th ed (pdf version)*. [ISBN-13: 978-0-07-338309-5].

Optional Readings

- Downey, A. B. (2012). *Think Python.* Sebastopaol, Calif.: O'Reilly. [ISBN-13: 9781449330729] (No purchase necessary. Available as a free electronic download at Think Python or at Amazon for purchase as either an eBook or traditional text.)

Additional required readings and media are posted on Canvas, including timely news articles,

academic research, and videos that you will review in order to complete some assignments and participate in discussion forums.

Assignment Overview and Grading Breakdown

Grading and feedback turnaround will be no more than one week from the due date. You will be notified if turnaround will be longer than one week.

The discussion forums will be graded based on specific criteria or a rubric. The criteria or rubric for each discussion will be available in the course. To view the discussion forum rubric, click the gear icon in the upper right corner of the page and choose Show Rubric.

Assignment	Description	Value
Class Participation	Weekly class participation is determined by posting to discussion forums. You will be expected to provide quality insights in class discussion forums in a timely fashion and interact with others in a manner that provides depth and insight into the discussion. Initial discussion posts based on the prompt provided will be due by 11:55pm CT on Thursday of each week and at least two additional posts to peers will be due by 11:55pm CT on Sunday of each week. Each discussion is worth 10 points.	20%
Weekly Problem Sets	Weekly assignments of problems will be completed in MyOpenMath (MOM). The problems will be based on the weekly readings and the point values will vary. These assignments will be completed in weeks 1 through 9 and will be due by 11:55pm CT on Sunday of each week.	30%
Midterm Exam	This exam will cover the material from weeks 1-4 of the course. It will be posted at 12:01 AM CST the Monday of week five and will be due at 11:55pm CST on Sunday of that same week. You will download the exam at the beginning of the week and upload your completed exam on or before the due date. There will be ten	25%

	questions, mostly short answer. You will be permitted, but not required, to use Python to solve any/all of the problems and must show all of your work on all problems in order to received full credit.	
Final Exam	A self-proctored, timed final exam will be assigned in week 10 based on the readings and material from weeks 1 through 9. The exam will consist of 10 questions and will become available to the students no later than 12am CT on the fifth day of week 10. The exam will have a two-hour time limit and completion of the exam will be based on a time that is convenient for the student within the last three days of class. This assignment will be due at 11:59pm CT on the last day of class.	25%
	Total	100%

Grading Scale

Grade	Points
A	93-100
A-	90-92
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-72
F	Below 70

Late Work Policy

Unless otherwise noted, all assignments due by 11:59 PM (Central Time, GMT-5) on Sunday of the week in which they are assigned. This includes exams and participation in the discussions. Late work is not accepted unless prior arrangements have been made with the instructor. Discussion posts after the week has ended will not be accepted.

AI Policy

You are prohibited from using GenAI to complete any portion of the discussions, problem sets, quizzes, or final exam. Improper, undisclosed, or unauthorized use of GenAI tools constitutes a violation of [Northwestern's Principles of Academic Integrity](#).

Online Communication and Interaction Expectations

Discussion Forums

The purpose of the Weekly Discussion in general is to allow students to freely exchange ideas. It is imperative to remain respectful of all viewpoints and positions and, when necessary, agree to respectfully disagree. While active and frequent participation is encouraged, cluttering a Weekly Discussion with inappropriate, irrelevant, or insignificant material will not earn dditional points and may result in receiving less than full credit. Frequency is not unimportant, but content of the message is paramount. Please remember to cite all sources (when relevant) in order to avoid plagiarism.

Attendance and participation are a critical part in forming a dynamic learning experience, in school as well as on the job. As a result, you are expected to participate in activities and discussions within the Weekly Discussion group. The discussion questions will be addressed each week in threaded topics accessible through the weekly modules. You are expected to log on and participate actively at least four days each week. This strategy is found to be most effective in promoting success: a little every day gets the job done. It also happens to be the exact methodology required of managers—continual, lifelong, everyday learning. Except for the last session/week, you are expected to respond to the discussion prompt each week. The prompt is directly related to the week's topics. The expectation is several quality posts per week per person. I expect these to be polished, well-structured and APA-compliant posts. Even though they are only discussions, you still must include references and check for spelling and grammar. Since you have a spell-checker built in, this should not be an onerous task.

I will be the observer/facilitator of this process and will be assessing your contributions to the topic-related discussions. I am looking for insightful analysis, probing questions, and *constructive* suggestions to each other. Keep thinking from the perspective—how can I *add*

something useful? It may be an experience you have had professionally or a quote from an article/web site you come across. If it is the latter, please do not forget to cite it properly.

The quality of your posts and how others view and respond to them are the most valued. A single statement mostly implying "I agree" or "I do not agree" is not counted as a post. Explain, clarify, politely ask for details, provide details, persuade, and enrich communications for a great discussion experience. Please note, there is a requirement to respond to at least two fellow class members posts.

All initial posts addressing the prompt are due by 11:59 CT on Thursdays each week – though earlier is always better -- and there is a requirement to respond to at least two fellow class members' posts.

Online Communication Etiquette

Beyond interacting with your instructor and peers in discussions, you will be expected to communicate by Canvas message, email, and sync session. Your instructor may also make themselves available by phone or text. In all contexts, keep your communication professionaland respect the instructor's posted availability. To learn more about professional communication, please review the Communicating Effectively with Faculty guide.

Just as you expect a response when you send a message to your instructor, please respond promptly when your instructor contacts you. Your instructor will expect a response within two business days. This will require that you log into the course site regularly and set up your notifications to inform you when the instructor posts an announcement, provides feedback on work, or sends you a Canvas message. For guidance on setting your notifications, please review How do I set my Canvas notification settings as a student? It is also recommended thatyou check your u.northwestern e-mail account regularly, or forward your u.northwestern e-mailto an account you check frequently.

Participation and Attendance

This course will not meet at a particular time each week. All course goals, session learning objectives, and assessments are supported through classroom elements that can be accessed at any time. To measure class participation (or attendance), your participation in threaded discussion boards is required, graded, and paramount to your success in this course. Please note that any scheduled synchronous meetings are optional. While your attendance is highly encouraged, it is not required and you will not be graded on your attendance or participation.

Student Support Services

AccessibleNU

This course is designed to be welcoming to, accessible to, and usable by everyone, including students who are English-language learners, have a variety of learning styles, have disabilities, or are new to online learning. Be sure to let me know immediately if you encounter a required element or resource in the course that is not accessible to you. Also, let me know of changes I can make to the course so that it is more welcoming to, accessible to, or usable by students who take this course in the future.

Northwestern University and AccessibleNU are committed to providing a supportive and challenging environment for all undergraduate, graduate, professional school, and professional studies students with disabilities who attend the University. Additionally, the University and AccessibleNU work to provide students with disabilities and other conditions requiring accommodation a learning and community environment that affords them full participation, equal access, and reasonable accommodation. The majority of accommodations, services, and auxiliary aids provided to eligible students are coordinated by AccessibleNU, which is part of the Dean of Students Office.

SPS Student Services

The Department of Student Services supports the academic and professional growth of SPS students. The Student Services team guides students through academic planning, policies, and administrative procedures, and promotes a supportive environment to foster student success. Students are encouraged to actively make use of the resources and staff available to assist them: Academic and Career Advisers, Counseling and Health Services, Student Affairs, Legal Services, Financial Aid and Student Accounts, among other services.

For a comprehensive overview of course and program processes and policies and helpful student resources, please refer to your SPS Student Handbook.

Academic Accommodations for Religious Holidays

Although Northwestern University does not as an institution observe religious holidays, the academic calendar is designed to avoid conflicts with observed holidays, such as July 4, Memorial Day, Thanksgiving, New Year's Day, and Christmas. As the diversity of our community has increased, additional religious holidays now affect a significant number of students and faculty. Consistent with our commitment to creating an academic community that is respectful of and welcoming to persons of all backgrounds, we believe that every reasonable effort should be made to allow members of the university community to observe their religious holidays without jeopardizing the fulfillment of their academic obligations.

In support of this commitment to inclusion, the University provides [guidance](#) for faculty and students regarding any academic accommodations. Students wishing to request a reasonable accommodation must notify the faculty member of conflicts due to religious holidays within the first two weeks of the term. If asked, the student should provide accurate information about the obligations entailed in the observance of that particular holiday.

Academic Support Services

Northwestern University Library

As one of the leading private research libraries in the United States, Northwestern University Library serves the educational and information needs of its students and faculty as well as scholars around the world. Visit the [Library About](#) page for more information or contact Distance Learning Librarian Tracy Coyne at 312-503-6617 or tracy-coyne@northwestern.edu.

Program-Specific Library Guides

- [Data Science](#)
- [Statistics](#)

Additional Library Resources

- [Connectivity: Campus Wireless and Off-Campus Access to Electronic Resources](#)
- [Getting Available Items: Delivery to Long-Distance Patrons](#)
- [Quick Access to Major Newspapers](#)
- [Reserve a Library Study Room](#)
- [Resources for Data Analysis](#)
- [Schaffner Library Top Resources](#)
- [Sign up for an in-person or online Research Consultation Appointment](#)
- [Social Science Data Resources](#)

The Writing Place

The Writing Place is Northwestern's center for peer writing consultations. Consultations are free and available to anyone in the Northwestern community: undergraduates, graduate students, faculty, or staff. To book an appointment, go to [The Writing Place](#) website.

The Math Place

The Math Place is a free tutorial service provided to students currently enrolled in any Northwestern University courses. Students of all levels can benefit from the individual tutoring

provided from this service, whether they are taking undergraduate or graduate level courses. To book an appointment, go to [The Math Place](#) website.

SPS Learning Studios

Learning studios are available to students who would like additional support in commonly used tools and topics, including: statistics, Excel, and coding in R. An instructor is available to answer your questions as you work through self-paced content and exercises. Students can self-enroll for free by visiting the SPS [Academic Services](#) page.

Read&Write Gold

Read&Write Gold is an optional text reading and writing program with numerous beneficial features. Originally developed to assist users with print disabilities, such as visual impairments, dyslexia, ADHD, etc., this program provides a wide array of tools to assist with reading, writing, and notetaking. One of the most useful tools is the text-to-speech function, which students may use to convert digital text into an audio format.

Read&Write Gold is available for free to all Northwestern students, faculty, and staff. Visit the [Northwestern IT site on Read&Write Gold](#) for more information about the software, as well as instructions on how to download it.

Academic Integrity at Northwestern

Students are required to comply with University regulations regarding academic integrity. If you are in doubt about what constitutes academic dishonesty, speak with your instructor or graduate coordinator before the assignment is due and/or examine the University Web site. Academic dishonesty includes, but is not limited to, cheating on an exam, obtaining an unfair advantage, and plagiarism (e.g., using material from readings without citing or copying another student's paper). Failure to maintain academic integrity will result in a grade sanction, possibly as severe as failing and being required to retake the course, and could lead to a suspension or expulsion from the program. Further penalties may apply. For more information, visit [The Office of the Provost's Academic Integrity page](#).

Some assignments in SPS courses may be required to be submitted through Turnitin, a plagiarism detection and education tool. You can find [an explanation of the tool here](#).

Self-Proctored Final Exam Requirements

To meet accreditation requirements, this course requires that students verify their identity before taking the final exam. Before you take your final exam, you will complete a registration survey while on video to practice. In the survey, you will verify your identity, acknowledge the final exam rules, and demonstrate to your instructor that you meet the technical requirements for

creating a self-proctored exam video. In addition, you will be required to record yourself and your computer screen for the duration of the final exam. Additional details on these activities can be found in Canvas.

Course Technology

This course will involve a number of different types of interactions. These interactions will take place primarily through the Canvas system. Please take the time to navigate through the course and become familiar with the course syllabus, structure, and content and review the list of resources below.

Systems Requirements for Distance Learning

Students and faculty enrolled in SPS online classes should have access to a computer with the [Minimum System Requirements](#).

Canvas

The [Canvas Student Center](#) includes information on communicating in Canvas, navigating a Canvas course, grades, additional help, and more. The [Canvas at Northwestern](#) website provides information of getting to know Canvas at Northwestern and getting Canvas support. The [Canvas Student Guide](#) provides tutorials on all the features of Canvas. For additional Canvas help and support, you can always click the Help icon in the lower left corner to begin a live chat with Canvas support or contact the Canvas Support Hotline.

The [Canvas Accessibility Statement](#) and [Canvas Privacy Policy](#) are also available.

My Open Math

All assignments for this course, including the final exam will be completed using [My Open Math](#) (MOM). MOM is an open source platform for completing assignments involving math. Detailed information on registering and accessing MOM is provided in Canvas.

Zoom

We will use Zoom for optional synchronous meetings. The [Zoom support page](#) provides additional guidance for using Zoom.

The [Zoom Privacy Policy](#) and the [Accessibility Features on Zoom](#) are also available.

Please note that any scheduled synchronous meetings are optional. While your attendance is highly encouraged, it is not required and you will not be graded on your attendance or

participation. These synchronous sessions will be recorded, so you will be able to review the session afterward.

Panopto

Videos in this course may be hosted in Panopto and the self-proctored final exam will require the use of Panopto. If you have not used Panopto in the past, you may be prompted to login to Panopto for the first time and authorize Panopto to access your Canvas account. You can learn more about using Panopto and login to Panopto directly by visiting the Panopto guide on the [Northwestern IT Resource Hub](#). Because the final exam registration and the final exam in this course each require a video, you will be asked to create each video using Panopto in addition to viewing content that your instructor has provided through Panopto.

The [Panopto Privacy Policy](#) and the [Accessibility Features on Panopto](#) are also available.

Python

Students in this course have the option to use the programming language Python to complete assignments. Python can be downloaded at [Anaconda](#). Download and install the most recent Python 3.x version of Anaconda. Additional documentation on downloading and installing Anaconda can be found at [Anaconda Documentation](#). After installation, you should be able to access the Anaconda Navigator. It is recommended you use Jupyter Notebook for any work in Python. This can be accessed via Anaconda.

Completed problems for select questions from each Problem Set will be published each week after the due date of each assignment. Python is the primary supplemental programming language in this course.

Minimum Required Technical Skills

Students in an online program should be able to do the following:
- Communicate via email and Canvas discussion forums.
- Use web browsers and navigate the World Wide Web.
- Use the learning management system Canvas.
- Use integrated Canvas tools (e.g., Zoom, MOM, and Course Reserves).
- Use software applications for math calculations (Python)

Required Digital Literacy Skills

In order to be successful in an online course, students should be able to locate, evaluate, apply, create, and communicate information using technology.

Students in this online course should be able to do the following:
- Create, name, compose, upload, and attach documents.

- Download, modify, upload, attach document templates.
- Record and upload video taken with a webcam via Panapto.
- Access and download Course Reserve readings; read and review PDF documents.
- Access and use a digital textbook.
- Participate in threaded discussions by contributing text responses, uploading images, sharing links.
- Use a video player to review content, including pausing and restarting video.

MSDS — Minimum Hardware Specifications

To successfully complete the assignments and activities in the Master of Science in Data Science Program, you must use a laptop or desktop computer that meets the following specifications:

- Processor: 8th Generation Intel® CoreTM i7-8700 Processor (3.20GHz, up to 4.60GHz with Turbo Boost, 12MB Cache)
- Operating System: Windows 10 Pro 64
- Memory: 16.0GB DDR4 2666 MHz
- Hard Drive: 500 GB 7200 RPM + 256GB SSD
- Graphics: NVIDIA GeForce GTX 1050Ti 4GB
- Keyboard: Wireless English Keyboard
- Pointing Device: Wireless Mouse
- Network: 802.11 AC adapter or Gigabit Ethernet
- Webcam
- Capable of installing Docker Desktop. Refer to installation requirements for Mac and Windows.

NOTE: SPS IT does not recommend using Apple Mac computers because they do not support all software used by MSDS classes.

Technical Help and Support

The SPS Help Desk is available for Faculty, Students and Staff to support their daily IT needs. For additional technical support, contact the Northwestern IT Support Center.

Permissions

Instructional Materials

This course was developed in partnership with Distance Learning staff in the School of Professional Studies at Northwestern University. Every effort has been made to responsibly acquire instructional materials for this class, by adhering to copyright law, obtaining permission

from copyright holders, selecting Open Educational Resources (OERs) and Creative Commons (CC) materials, and using citations to credit the work of others.

The same is expected of students in this course. Please review the Academic Integrity statement for more information.

Sharing Course Content

Content within this course--including assignment descriptions, exam questions, and other course components--may not be distributed outside of the course, either to other students or on the Internet more broadly.

Student Ownership of Content

Students retain ownership of all content developed while completing this course, as dictated by the university Copyright Policy ("copyright ownership resides with the Creator(s) of copyrightable works").
Per the Family Educational Rights and Privacy Act (FERPA), if your instructor wishes to share your work with future students, your permission must be obtained in writing.
Your instructor may limit access to the course after a cutoff date. When you complete the course, please ensure that you have saved all work. You may not be able to return to the course to download your submissions.

Course Schedule

Module 1
Learning Objectives

- Create and interpret models involving linear function.
- Interpret the meaning of the slope of a line.
- Set up and solve systems of linear questions.
- Recognize the role of matrices in systems of linear equations.

Readings & Media

Required Readings

- *Elementary Algebra*: [Chapters 3 & 4](#)
- *Fundamentals of Matrix Algebra*: [Sections 1.1 – 1.2](#)

Assignments

- Introductions Discussion (not graded)
- Module 1 Discussion
- Module 1 Problem Set

Module 2
Learning Objectives

- Solve systems of linear equations using the Echelon method, Gauss-Jordan Method and inverse matrices.
- Manipulate matrices using addition, subtraction, and multiplication.
- Apply Cramer's Rule to solve systems of linear equations.
- Calculate eigenvalues and eigenvectors of matrices.

Readings & Media

Required Readings

- *Fundamentals of Matrix Algebra*: Sections 1.3 – 1.5; Chapters 2 – 4

Assignments

- Module 2 Discussion
- Module 2 Problem Set

Module 3
Learning Objectives

- Set up and solve linear programming models involving real-world scenarios.
- Apply the Simplex method to linear programming models.
- Create and solve the dual of linear programming models.

Readings & Media

Required Readings

- *Applied Finite Mathematics*: Chapters 3 & 4

Assignments

- Module 3 Discussion
- Module 3 Problem Set

Module 4
Learning Objectives

- Calculate average and instantaneous rates of change.
- Calculate and interpret the derivative of various types of functions.
- Apply the chain rule to composite functions.

Readings & Media

Required Readings

- *Calculus (OpenStax)*: Sections 2.1 – 2.4, 3.1 – 3.6, 3.9

Assignments

- Module 4 Discussion
- Module 4 Problem Set

Module 5
Learning Objectives

- Determine relative and absolute extrema.
- Identify intervals of increase and decrease using derivatives.

- Analyze the shape of a graph using derivatives.
- Solve applications involving differentiation.

Readings & Media

Required Readings

- *Calculus (OpenStax)*: Sections 4.3 – 4.9

Assignments

- Module 5 Discussion
- Module 5 Problem Set
- Midterm Exam

Module 6
Learning Objectives

- Calculate integrals of various types of functions.
- Apply the Fundamental Theorem of Calculus to real-world problems.
- Explore integration by parts and partial fraction decomposition.
- Evaluate improper integrals.

Readings & Media

Required Readings

- *Calculus (OpenStax)*: Sections 5.1 – 5.6, 6.1, 7.1, 7.4, 7.6 – 7.7

Assignments

- Module 6 Discussion
- Module 6 Problem Set

Module 7
Learning Objectives

- Solve applications involving partial derivatives.
- Identify relative extrema and saddle points.
- Determine tangent planes to surfaces.
- Use Lagrange multipliers to optimize functions subject to constraints.

Readings & Media

Required Readings

- *Calculus (OpenStax)*: [Chapter 14 (exclude Section 14.6)](#)

Assignments

- Module 7 Discussion
- Module 7 Problem Set

Module 8
Learning Objectives

- Explore various types of graphs and graph terminology.
- Create graphs to model real-world networks.
- Construct Euler and Hamilton paths and circuits.
- Execute algorithms for determining the shortest path.

Readings & Media

Required Readings

- *Discrete Mathematics*: Sections 10.1 – 10.6 (Available via Course Reserves in Canvas)

Assignments

- Module 8 Discussion
- Module 8 Problem Set
- Final Exam Registration (Step 1)

Module 9
Learning Objectives

- Determine when graphs are planar.
- Calculate the chromatic number of a graph.
- Explore characteristics of trees and tree applications.
- Solve applications involving minimum spanning trees.

Readings & Media

- *Discrete Mathematics*: Sections 10.7 – 10.8; Chapter 11 (Available via Course Reserves in Canvas)

Assignments

- Module 9 Discussion
- Module 9 Problem Set

Module 10
Learning Objectives

- None

Assignments

- Module 10 Discussion
- Final Exam Access Code (Step 2)
- Final Exam and Final Exam Video Submission (Step 3)