MARYLAND APPLIED GRADUATE ENGINEERING

COURSE TITLE: ENAI601 Numerical Methods for Engineering AI
Sections 0101 and AEC1

Term: Fall 2025

Professor: Richard J. La
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Office Hours: Monday 2 – 3 PM (in person), Thursday 7:30 – 8:30 PM (virtual on Zoom)
Credit: 3
Course Dates: September 2, 2025 – December 12, 2025
Course Times: Friday 1 – 3:40 PM
Classroom: JMP 2216

Canvas/ELMS: https://umd.instructure.com/courses/1383636

Course Description

ENAI 601 covers the fundamentals of optimization, from formulating a mathematical optimization problem from a problem description, to solving a mathematical optimization problem using numerical algorithms in optimization software, with an emphasis on convex optimization. The main topics include: linear algebra overview; convex sets and convex functions; convex optimization; duality theory and optimality criteria, Karush-Kuhn-Tucker conditions; reinforcement learning; unconstrained optimization algorithms: gradient method, Newton's method, quasi-Newton methods; constrained optimization algorithms: conditional gradient method, gradient projection method, alternating direction method of multipliers, interior point method, primal-dual method; stochastic gradient descent; distributed optimization; global search algorithms. Students will acquire not only theoretical knowledge of optimization, but also hands-on experience with optimization methods and software through assignments and a project.

Prerequisites

Undergraduate courses in calculus and linear algebra.

Learning Outcomes

After successfully completing this course you will be able to:

- Explain the role of optimization in artificial intelligence (AI)/machine learning (ML) and engineering disciplines
- Given a description of an engineering problem, formulate a suitable mathematical optimization problem and solve it using a numerical method
- Determine whether or not a given optimization problem is a convex optimization problem
- For a given optimization problem, formulate a Lagrange dual problem and determine the optimality gap
- Use the Karush-Kuhn-Tucker conditions to determine or verify an optimal point for optimization problems for which strong duality holds
- Understand the key ideas behind numerical methods for solving unconstrained and constrained optimization problems and their advantages and limitations

Course Materials

Required Resources

- Mathematical/scientific software (e.g., Matlab or Python) for solving optimization problems. Matlab is available to the students from terpware.umd.edu
- Total Estimated costs of required course materials: $0.00

Supplemental Resources (no purchase required)

- "Optimization Methods" Giuseppe Calafiore and Laurent El Ghaoui
- "Convex Optimization", Stephen Boyd and Lieven Vanderberghe
- "Convex Optimization Algorithms", Dimitri Bertsekas
- "Algorithms for Optimization", Mykel Kochenderfer and Tim Wheeler
- "Linear Algebra and Its Applications", David Lay, Steven Lay and Judi McDonald
- "Linear Algebra", Stephen Friedberg, Arnold Insel and Lawrence Spence
- Hardware/Software: None

Course Structure

This course includes both on-campus and online sections. To attend synchronously online, log into ELMS-Canvas at the time of the Section 0101 class (Friday, 1 – 3:40 PM) and select "Video Conference" from the left side menu. This will open a Zoom link to the live classroom.

For asynchronous online students, all lectures will be recorded and made available on ELMS-Canvas under "Panopto Recordings/Video Lectures" within 24 hours of the class time. Be sure to review the recorded lecture in a timely manner.

On-campus students should come to class prepared to engage with the lecture and materials. Online students, be sure to log into Canvas regularly and participate in discussions and activities. Regardless of the section you are enrolled in, participation is expected.

Please note that students enrolled in the on-campus section are required to attend in person. If you have a conflict on a particular day, please reach out to me in advance to discuss.

Communication Guidelines

Communicating with the Instructor

My goal is to be readily available to you throughout the semester. I can be reached by email at hyongla@umd.edu. Please DO NOT email me with questions that are easily found in the syllabus or on ELMS-Canvas (e.g., When is this assignment due? How much is it worth? etc.), but please DO reach out about personal, academic, and intellectual concerns/questions.

While I will do my best to respond to emails within 24 hours, you will more likely receive email responses from me on weekdays from 8 AM to 4:45 PM EST.

When constructing an email to me please put “ENAI 601: Your Topic” in the subject line. This will draw my attention to your email and enable me to respond to you more quickly.

Additionally, please review These tips for 'How to email a Professor'. By following these guidelines, you will be ensured to receive a timely and courteous response.

Finally, if you need to discuss issues not appropriate for the classroom and/or an email, we can arrange to talk over Zoom or in person. Send me an email asking for a meeting and we can set something up.

Announcements

I will send IMPORTANT messages, announcements, and updates through ELMS-Canvas. To ensure you receive this information in a timely fashion, make sure your email and announcement notifications (including changes in assignments and/or due dates) are enabled in ELMS-Canvas (How to change notification settings in CANVAS).

Log into our ELMs-Canvas course site at least once every 24-hour period to check your inbox and the Announcements page.

Communicating with your Peers

With a diversity of perspectives and experience, we may find ourselves in disagreement and/or debate with one another. As such, it is important that we agree to conduct ourselves in a professional manner and that we work together to foster and preserve a virtual classroom environment in which we can respectfully discuss and deliberate controversial questions. Keep in mind, that free speech has its limit and this course is NOT the space for hate speech, harassment, and derogatory language. I will make every reasonable attempt to create an atmosphere in which each student feels comfortable voicing their argument without fear of being personally attacked, mocked, demeaned, or devalued.

Any behavior (including harassment, sexual harassment, and racially and/or culturally derogatory language) that threatens this atmosphere will not be tolerated. Please alert me immediately if you feel threatened, dismissed, or silenced at any point during our semester together and/or if your engagement in discussion has been in some way hindered by the learning environment.

Netiquette Policy

Netiquette is the social code of online classes. Students share a responsibility for the course’s learning environment. Creating a cohesive online learning community requires learners to support and assist each other. To craft an open and interactive online learning environment, communication has to be conducted in a professional and courteous manner at all times, guided by common sense, collegiality and basic rules of etiquette.

Grading

Grade Breakdown

Assignment	Percentage %
Homework	**15%**
Midterm Exam	**25%**

Participation/Engagement	**5%**
Team Project/Paper/Presentation	**20%**
Final Exam	**35%**
Total	**100%**

Course Assignments

Homework Assignments

- There will be (almost) weekly homework assignments on the materials covered during each lecture. The problems will test student's understanding of basic concepts covered during the lectures

Participation & Engagement

- Students will be graded based on their participation during lectures. The instructor will ask questions throughout the lectures to engage the students.

Project

- There will be a project in the course. Students are expected to identify a problem for which a suitable non-trivial optimization problem can be formulated. Each student will be asked to submit a report at the end of the semester and give an oral presentation in the last week.

Midterm and Final Exams

- There will be a midterm exam in week 8 and a final exam at the end of the semester. The midterm will cover the materials in the first 7 weeks. The final exam will be comprehensive and cover all the materials discussed in the course.

Grading of Assignments

All assignments will be graded according to a predetermined set of criteria (i.e., rubric) which will be communicated to students before the assignment is submitted.

To progress satisfactorily in this class, students need to receive timely feedback. To that end, it is my intention to grade all assignments within **two weeks** of their due date. If an assignment is taking longer than expected to grade, students will be informed of when they can expect to see their grade.

Grade Computation

All assessment scores will be posted on ELMS/Canvas page. If you would like to review any of your grades (including the exams), or have questions about how something was scored, please email me to schedule a time for us to meet and discuss. However, the average will be computed according to the grading policy on the syllabus (and the average shown on ELMS/Canvas may be different.)

It is expected that you will submit work by the deadline listed in the syllabus and/or on ELMS-Canvas. No late work will be accepted as stated in the **Course Policies and Procedures** section below.

Grade Disputes: I am happy to discuss any of your grades with you, and if I have made a mistake, I will immediately correct it. Any formal grade disputes must be submitted in writing and within one week of receiving the grade.

Final letter grades are assigned based on the percentage of total assessment points earned. To be fair to everyone I have to establish clear standards and apply them consistently, so please understand that being close to a cutoff is not the same as making the cut (79.99 ≠ 80.00). It would be unethical to make exceptions for some and not others.

Final Grade Cutoffs									
+	95.00%	+	75.00%	+	60.00%	+	45.00%	+	
A	85.00%	B	70.00%	C	55.00%	D	40.00%	F	<35.0%
-	80.00 %	-	65.00%	-	50.00%	-	35.00%	-	

Course Schedule

Week #	Topic	Deliverable
1 (9/5/25)	Introduction to optimization and examples in artificial intelligence (AI)/machine learning (ML) and engineering Linear algebra review: vectors, vector spaces, linear independence, spanning set, dimension, basis, inner product and inner product space, norm, subspace, orthogonality, projection	**Homework Assignment 1**
2 (9/12/25)	Linear algebra review (cont'd): orthogonality, projection, Gram-Schmidt process, matrices, range, null-space, determinant, rank, invertible matrices, eigen-values and eigen-vectors, symmetric matrices, singular values and vectors, matrix decompositions, matrix similarity	**Homework Assignment 2**
3 (9/19/25)	Examples of simple optimization problems in AI/ML and engineering Affine and convex sets, hyperplanes, halfspaces, operations that preserve convexity, supporting hyperplanes Convex functions and examples	**Homework Assignment 3**
4 (9/26/25)	Establishing convexity of functions, first-order and second-order conditions for convex functions, sublevel sets, operations that preserve convexity of functions Basic optimization, connection to AI/ML and engineering, mathematical optimization	**Homework Assignment 4**
5 (10/3/25)	Convex optimization, optimality criteria, linear programs, quadratic programs, geometric programs	**Homework Assignment 5**

6 (10/10/25)	Lagrangian, Lagrange dual function, dual problem, weak duality and duality gap, strong duality, Slater's condition, complementary slackness	**Homework Assignment 6**
7 (10/17/25)	Karush-Kuhn-Tucker (KKT) conditions, application of KKT conditions to AI/ML and engineering problems	**Homework Assignment 7**
8 (10/24/25)	**Midterm Exam**	
9 (10/31/25)	Reinforcement learning, Q-learning, deep-Q learning	**Homework Assignment 8**
10 (11/7/25)	Unconstrained optimization algorithms: gradient-descent method, conjugate-gradient method, Newton's method, quasi-Newton method, subgradient method	**Homework Assignment 9**
11 (11/14/25)	Constrained optimization algorithms: conditional gradient method, gradient projection method, dual ascent method, alternating direction method of multipliers, primal-dual algorithm	**Homework Assignment 10**
12 (11/21/25)	Constrained optimization algorithms (cont'd): interior point method, polyhedral approximation, outer linearization, inner linearization Stochastic gradient descent, backpropagation	**Homework Assignment 11**
13 (12/5/25)	Distributed optimization Global search algorithms: simulated annealing, genetic algorithms, particle swarm optimization, firefly algorithm	**Homework Assignment 12**
14 (12/12/25)	Multi-objective optimization Oral Presentation of Project	**Final Project Report**

Note: This is a tentative schedule, and subject to change as necessary – monitor ELMS-Canvas for current deadlines. In the unlikely event of a prolonged university closing, or an extended absence from the university, adjustments to the course schedule, deadlines, and assignments will be made based on the duration of the closing and the specific dates missed.

Course Policies and Procedures

The University of Maryland's conduct policy indicates that course syllabi should refer to a webpage of course-related policies and procedures. For a complete list of graduate course related policies, visit the Graduate School website. Below are course-specific policies and procedures which explain how these Graduate School policies will be implemented in this class.

Satisfactory Performance

The Graduate School expects students to take full responsibility for their academic work and academic progress. The student, to progress satisfactorily, must meet all the academic requirements of this course. Additionally, each student is expected to complete all readings and any preparatory work before each class session, come to class prepared to

make substantive contributions to the learning experience, and to proactively communicate with the instructor when challenges or issues arise.

Questions about Assignments

Please ask all questions you may have about an assignment by 12 PM the day before the assignment is due. Any questions asked after that time may not be answered in time for you to make changes to your work.

Late Work Policy

Assignments should be completed by the due date and time listed with the assignment, on the syllabus, and/or in the course calendar. If you are unable to complete an assignment by the stated due date, it is your responsibility to contact your instructor to discuss an extension, at least 48 hours BEFORE the assignment is due. Extensions will be granted at the instructor's discretion for legitimate reasons (e.g., medical emergency, family emergency, university sponsored activity).

No late homework assignment will be accepted without prior permission from the instructor. However, the lowest homework assignment score will be dropped at the end of the semester.

Religious Observance

It is the student's responsibility to inform the instructor of any intended absences for religious observances in advance. Notice should be provided as soon as possible but no later than the end of the schedule adjustment period.

Academic Integrity

The University's Code of Academic Integrity is designed to ensure that the principles of academic honesty and integrity are upheld. In accordance with this code, the University of Maryland does not tolerate academic dishonesty. Please ensure that you fully understand this code and its implications because all acts of academic dishonesty will be dealt with in accordance with the provisions of this code. All students are expected to adhere to this Code. It is your responsibility to read it and know what it says, so you can start your professional life on the right path. **As future professionals, your commitment to high ethical standards and honesty begins with your time at the University of Maryland.**

It is important to note that course assistance websites, such as CourseHero, or AI generated content are not permitted sources, unless the instructor explicitly gives permission. Material taken or copied from these sites can be deemed unauthorized material and a violation of academic integrity. These sites offer information that might be inaccurate or biased and most importantly, relying on restricted sources will hamper your learning process, particularly the critical thinking steps necessary for college-level assignments.

Additionally, students may naturally choose to use online forums for course-wide discussions (e.g., Group lists or chats) to discuss concepts in the course. However**, collaboration on graded assignments is strictly prohibited unless otherwise stated**. Examples of prohibited collaboration include: asking classmates for answers on quizzes or exams, asking for access codes to clicker polls, etc. Please visit the **Office of Graduate Studies' full list of campus-wide policies** and reach out if you have questions.

Finally, on each exam or assignment you must write out and sign the following pledge: ***"I pledge on my honor that I have not given or received any unauthorized assistance on this exam/assignment."***

If you ever feel pressured to comply with someone else's academic integrity violation, please reach out to me straight away. Also, ***if you are ever unclear*** about acceptable levels of collaboration, ***please ask***!

To help you avoid unintentional violations, ***the following table*** lists levels of collaboration that are acceptable for each graded exercise. Each assignment may contain more specific information regarding acceptable levels of collaboration.

						
Homework Assignments	✔	✔	✔	---	---	---
Midterm Exam	---	---	---	---	---	---
Project	✔	✔	✔	✔	✔	✔
Final Exam	---	---	---	---	---	---

Course Evaluation

Please submit a course evaluation through Student Feedback on Course Experiences in order to help faculty and administrators improve teaching and learning at Maryland. All information submitted to Course Experiences is confidential. Campus will notify you when Student Feedback on Course Experiences is open for you to complete your evaluations at the end of the semester. Please go directly to the **Student Feedback on Course Experiences** to complete your evaluations. By completing all of your evaluations each semester, you will have the privilege of accessing through Testudo the evaluation reports for the thousands of courses for which 70% or more students submitted their evaluations.

Copyright Notice

Course materials are copyrighted and may not be reproduced for anything other than personal use without written permission.

Tips for Succeeding in this Course

1. **Participate.** I invite you to engage deeply, ask questions, and talk about the course content with your classmates. You can learn a great deal from discussing ideas and perspectives with your peers and the professor. Participation can also help you articulate your thoughts and develop critical thinking skills.
2. **Manage your time.** Students are often very busy, and I understand that you have obligations outside of this class. However, students do best when they plan adequate time that is devoted to course work. Block your schedule and set aside plenty of time to complete assignments including extra time to handle any technology related problems.
3. **Login regularly.** I recommend that you log in to ELMS-Canvas several times a week to view announcements, discussion posts and replies to your posts. You may need to log in multiple times a day when group submissions are due.

4. **Do not fall behind.** This class moves at a quick pace and each week builds on the previous content. If you feel you are starting to fall behind, check in with the instructor as soon as possible so we can troubleshoot together. It will be hard to keep up with the course content if you fall behind in the pre-work or post-work.
5. **Use ELMS-Canvas notification settings.** Pro tip! Canvas ELMS-Canvas can ensure you receive timely notifications in your email or via text. Be sure to enable announcements to be sent instantly or daily.
6. **Ask for help if needed.** If you need help with ELMS-Canvas or other technology, please contact IT Support. If you are struggling with a course concept, reach out to me and your classmates for support.

Student Resources and Services

Taking personal responsibility for your learning means acknowledging when your performance does not match your goals and doing something about it. I hope you will come talk to me so that I can help you find the right approach to success in this course, and I encourage you to visit the Counseling Center's Academic Resources to learn more about the wide range of resources available to you. Below are some additional resources and services commonly used by graduate students. For a more comprehensive list, please visit the Graduate School's Campus Resources Page.

Accessibility and Disability Services

The University of Maryland is committed to creating and maintaining a welcoming and inclusive educational, working, and living environment for people of all abilities. The University of Maryland is also committed to the principle that no qualified individual with a disability shall, on the basis of disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of the University, or be subjected to discrimination. The Accessibility & Disability Service (ADS) provides reasonable accommodations to qualified individuals to provide equal access to services, programs and activities. ADS cannot assist retroactively, so it is generally best to request accommodations several weeks before the semester begins or as soon as a disability becomes known. Any student who needs accommodations should contact me as soon as possible so that I have sufficient time to make arrangements.

For assistance in obtaining an accommodation, contact Accessibility and Disability Service at 301-314-7682, or email them at adsfrontdesk@umd.edu. Information about sharing your accommodations with instructors, note taking assistance and more is available from the Counseling Center.

Writing Center

Everyone can use some help sharpening their communication skills (and improving their grade) by visiting The Graduate School's Writing Center and schedule an appointment with them. Additionally, international graduate students may want to take advantage of the Graduate School's free English Editing for International Graduate Students (EEIGS) program.

Health Services

The University offers a variety of physical and mental health services to students. If you are feeling ill or need non-emergency medical attention, please visit the University Health Center.

If you feel it would be helpful to have someone to talk to, visit UMD's Counseling Center or one of the many other mental health resources on campus.

Notice of Mandatory Reporting

Notice of mandatory reporting of sexual assault, sexual harassment, interpersonal violence, and stalking: As a faculty member, I am designated as a "Responsible University Employee," and I must report all disclosures of sexual assault, sexual harassment, interpersonal violence, and stalking to UMD's Title IX Coordinator per University Policy on Sexual Harassment and Other Sexual Misconduct.

If you wish to speak with someone confidentially, please contact one of UMD's confidential resources, such as CARE to Stop Violence (located on the Ground Floor of the Health Center) at 301-741-3442 or the Counseling Center (located at the Shoemaker Building) at 301-314-7651.

You may also seek assistance or supportive measures from UMD's Title IX Coordinator, Angela Nastase, by calling 301-405-1142, or emailing titleIXcoordinator@umd.edu.
To view further information on the above, please visit the Office of Civil Rights and Sexual Misconduct's website at ocrsm.umd.edu.

Basic Needs Security

If you have difficulty affording groceries or accessing sufficient food to eat every day, or lack a safe and stable place to live, please visit UMD's Division of Student Affairs website for information about resources the campus offers you and let me know if I can help in any way.

Veteran Resources

UMD provides some additional supports to our student veterans. You can access those resources at the office of Veteran Student life and the Counseling Center. Veterans and active duty military personnel with special circumstances (e.g., upcoming deployments, drill requirements, disabilities) are welcome and encouraged to communicate these, in advance if possible, to the instructor.