MARYLAND APPLIED GRADUATE ENGINEERING

DRAFT SYLLABUS

GENERATIVE ENGINEERING AI (ENAI 605)
Sections XXXX and XXXX

Term: *Spring 2026*
Professor: Harry Dankowicz (*he/him*)
Office Phone: 301-405-3031
Email: danko@umd.edu

Office Hours: TBD (6 hours total)

Credits: 3
Course Dates: From January 2026 - May 2026
Course Times: ###
Classroom: ###

Canvas/ELMS: https://umd.instructure.com/courses/1385148

Course Description
ENAI605 Generative Engineering AI develops the student's analytical and practical familiarity with and understanding of key generative engineering AI techniques and their application across select engineering disciplines. Students will develop proficiency in the mathematical foundations underlying current and future digital twin technologies, including variational filters for inference, generative models for prediction, and reinforcement learning for decision making, and will explore the potential for digital twins to drive innovation and solve complex engineering problems. Through lectures, hands-on assignments, and projects students will develop the knowledge and skills to harness the power of generative AI in advancing engineering research and practice.

Prerequisites
- ENAI600 and ENAI601

Learning Outcomes
After successfully completing this course, students will be able to:

- **Explain the use of digital twin technologies for engineering systems and processes:** Learn to identify the components of digital twins, describe theoretical concepts that characterize their function, and discuss practical opportunities and challenges that may benefit from generative solutions.
- **Apply principles of probability theory to model simulation, inference, prediction, and generation:** Learn to construct data-driven simulation models, employ deep neural networks for model regression, and use generative architectures to build surrogate models.
- **Solve dynamic engineering decision problems using reinforcement learning:** Learn to recognize and apply the foundational algorithms that enable machines to learn how to make optimal decisions in dynamic and unpredictable environments, including training methods, architecture designs, and optimization techniques.

- **Implement generative AI models using appropriate programming frameworks:** Gain hands-on experience in implementing computational techniques and generative AI architectures using Python-based frameworks, such as PyTorch or TensorFlow.
- **Identify use cases for generative AI-based solutions for digital-twin technologies:** Learn to analyze candidate generative AI solutions in terms of sample efficiency, training paradigms, communication architectures, and real-time autonomy.

Course Materials

Required Resources

- Application/Software: Python
    - In special circumstances, alternative programming languages, such as MATLAB and R, can be used; however, support will only be offered for Python. Several packages and data sets will be used in this course that might not be available to other programming languages.
    - Instruction will rely on the use of Google Colab (https://colab.google/). This is a browser-based interface for running Python. All UMD students have access to this free resource, and no local installation or setup is required. If you wish to install Python locally, you are welcome to do so.
- Total Estimated costs of required course materials: $0

Supplemental Resources (no purchase required)

- *A Toolbox for Digital Twins: From Model-Based to Data-Driven* by M. Asch. Society for Industrial and Applied Mathematics, 2022, ISBN: 9781611976960. Sample code and supplementary material available at https://markasch.github.io/DT-tbx-v1/
- The Engineering of Digital Twins edited by J. Fitzgerald, C. Gomes, P. G. Larsen. Springer Nature Switzerland, 2024, ISBN: 9783031667190. Sample code and supplementary material available at https://digital-twin-book.org/
- *Probabilistic Machine Learning: An Introduction* by K.P. Murphy. The MIT press, 2022, ISBN: 9780262046824. Sample code and supplementary material available at https://probml.github.io/pml-book/book1.html
- Probabilistic Machine Learning: Advanced Topics by K.P. Murphy. The MIT press, 2023, ISBN: 9780262375993. Sample code and supplementary material available at https://probml.github.io/pml-book/book2.html
- *Mathematical Foundations of Reinforcement Learning* by S. Zhao. Tsinghua University Press, 2025, ISBN: 9789819739448k. Sample code and supplementary material available at https://github.com/MathFoundationRL/Book-Mathematical-Foundation-of-Reinforcement-Learning
- *Mastering reinforcement learning with Python : build next-generation, self-learning models using reinforcement learning techniques and best practices* by E. Bilgin. Packt Publishing, 2020. ISBN : 978-1838648497. Online copy available through https://lib.umd.edu
- *Deep reinforcement learning with Python : master classic RL, deep RL, distributional RL, inverse RL, and more with OpenAI Gym and TensorFlow* by S. Ravichandiran, Packt Publishing, 2020. ISBN : 9781839215599. Online copy available through https://lib.umd.edu.
- Software Resources:
    - Beginner's Python Tutorial: (https://python.land/python-tutorial)

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 [include day/time] 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 F1 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

The instructor's goal is to be readily available to you throughout the semester. The best way to reach the instructor is through the discussion forum on ELMS-Canvas. For questions that are appropriate for the entire class, the discussion forum allows the instructor and your peers to view and respond quickly. The instructor will do their best to respond within 24 hours. Please DO NOT ask 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 academic and intellectual concerns/questions.

For more personal/private questions, please feel free to email the instructor at the emails provided at the top of this syllabus. Please include "ENAI 605" in the subject line. This will draw their attention to your email and enable them 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, please send an email asking for a meeting and one will be arranged to be held by phone, over Zoom, or in person.

Announcements

IMPORTANT messages, announcements, and updates will be sent 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.

Names/Pronouns and Self-Identifications

The University of Maryland recognizes the importance of a diverse student body. The instructor is committed to fostering inclusive and equitable classroom environments. You are invited, if you wish, to tell the instructor how you want to be referred to in this class, both in terms of your name and your pronouns (he/him, she/her, they/them, etc.). Keep in mind that the pronouns someone uses are not necessarily indicative of their gender identity. Visit https://lgbtq.umd.edu/ to learn more.

Additionally, it is your choice whether to disclose how you identify in terms of your gender, race, class, sexuality, religion, and dis/ability, among all aspects of your identity (e.g., should it come up in classroom conversation about our experiences and perspectives). Such a choice should not be presumed or imposed. The instructor will do their best to address and refer to all students accordingly, and ask you to do the same for all of your fellow Terps.

Communicating with your Peers

With a diversity of perspectives and experience, people may find themselves in disagreement and/or debate with one another. As such, it is important to agree to conduct ourselves in a professional manner and to work together to foster and preserve a virtual classroom environment in which controversial questions can be respectfully discussed and deliberated. You are encouraged to confidently exercise your right to free speech—bearing in mind, of course, that you may be expected to craft and defend arguments that support your position. Keep in mind, that free speech has its limit and this course is NOT the space for hate speech, harassment, and derogatory language. The instructor 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 the instructor 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 BreakdownCourse Assignments

Assignment	Percentage %
Homework	**15%**
Midterm Exam	**25%**
Project Presentations	**25%**
Final Exam	**35%**
Total	**100%**

Homework

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

Midterm Exam and Final Exam

- There will be a midterm exam halfway through the semester 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.
- The exams will be administered online using ELMS-Canvas. They will be open-note, open-book.

Project Presentations

- There will be a project in the course. Students are expected to identify a relevant digital twin technology and to give several presentations on the applicability of the course concepts to this technology.

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 the instructor's intention to grade all assignments within **one week** 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 the 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 the instructor to schedule a time to meet and discuss.

It is expected that you will submit work by the deadline listed in the syllabus and/or on ELMS-Canvas. Late work will be penalized according to the late work policy described in the **Course Policies and Procedures** section below.

Grade Disputes: The instructor is happy to discuss any of your grades with you, and if there has been a mistake, this will be immediately corrected. 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, clear standards will be established and applied consistently, so please understand that being close to a cutoff is not the same as making the cut (89.99 ≠ 90.00). It would be unethical to make exceptions for some and not others.

Final Grade Cutoffs

+	97.00%	+	87.00%	+	77.00%	+	67.00%	+	
A	93.00%	B	83.00%	C	34.00%	D	63.00%	F	<60.0%
-	90.00%	-	80.00%	-	70.00%	-	60.00%	-	

Course Schedule

Week #	Topic	Deliverable
1	*Digital Twins:* Foundational technology concepts, use cases, services, verification, autonomy	
2	*Digital Twins:* Models, data, simulation, calibration, controllability, observability, identifiability	**Homework Assignment 1**
3	*Probabilistic Inference:* Introduction to filtering and smoothing, Kalman filters, particle filters	**Homework Assignment 2**
4	*Probabilistic Inference:* Monte Carlo Methods, Markov Chain Monte Carlo	**Homework Assignment 3**
5	*Probabilistic Prediction:* Introduction to predictive models, regression, deep neural networks, Bayesian neural networks	**Homework Assignment 4**
6	*Probabilistic Prediction:* Gaussian processes, adversarial attacks	**Homework Assignment 5**
7	*Probabilistic Generation:* Introduction to generative models, variational autoencoders	**Homework Assignment 6**
8	**Midterm Exam**	
9	*Probabilistic Generation:* Generative adversarial networks	
10	*Reinforcement Learning:* Introduction to Markov decision processes, Bellman's equation, Bellman's optimality equation	**Homework Assignment 7**

11	*Reinforcement Learning:* Dynamic programming techniques, value iteration, policy iteration	**Homework Assignment 8**
12	*Reinforcement Learning:* Model-free learning, temporal difference methods, exploration vs exploitation	**Homework Assignment 9**
13	*Reinforcement Learning:* Value Function Methods, Policy Gradient Methods, Actor-Critic Methods	**Homework Assignment 10**
14	**Project Presentations**	

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 11:59 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 24 hours BEFORE the assignment is due. Extensions are not guaranteed, but may be granted at the instructor's discretion.

Assignments submitted late will receive a 10% deduction in total grade per each calendar day late up to a maximum of three days late (i.e., there is a maximum of a 30% grade reduction for assignments submitted late). Work submitted more than three days late will not receive feedback and will automatically earn a grade of zero.

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

For this course, some of your assignments may be collected via Turnitin on ELMS/Canvas. We have chosen to use this tool because it can help you improve your scholarly writing and help us verify the integrity of student work. For information about Turnitin, how it works, and the feedback reports you may have access to, visit Turnitin Originality Checker for Students

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 us 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 will contain more specific information regarding acceptable levels of collaboration.

						
Homework	✔	✔	---	---	---	---
Midterm Exam	✔	✔	---	---	---	---
Project Presentations	✔	✔	✔	✔	✔	---
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.** We 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 professor. Participation can also help you articulate your thoughts and develop critical thinking skills.
2. **Manage your time.** Students are often very busy, and we 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.** We 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 your 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, 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. We hope you will come talk to me so that we can help you find the right approach to success in this course, and we 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 we 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 us know if we 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.