MARYLAND APPLIED GRADUATE ENGINEERIN

Introduction to Robotic Modeling (ENPM 662) Sections 0101, 0201, 0301, and RO01

Professor: Dr. Reza Monfaredi
Pronouns: he/him
Office Phone: -
Email: rmonfare@umd.edu
Office Hours: TBD

Teaching Assistant: Saksham Verma | Shantanu Parab
Pronouns: he/him | he/him
Email: saksham1@umd.edu | sparab@umd.edu
Office Hours: TBD

Term: Fall 2023

Section(s)	Course Times	Course Location
Section 0101 and RO01	Tuesdays 1:00 – 3:40 PM	JMP 2222 and Online
Section 0201	Tuesdays 4:00 – 6:40 PM	JMP 2121
Section 0301	Tuesdays 7:00 – 9:40 PM	JMP 2116

CANVAS/ ElMs Links
Section 0101 and RO01:
Section 0201:
Section 0301:

Course Description

This course introduces basic principles for modeling a robot, including forward and inverse kinematics, velocity kinematics, Jacobians, dynamics, planning, and contact. It primarily considers serial open-chain robots, but also touches on parallel robots, closed-chain systems, aerial and mobile robots, hyper-redundant systems, and grasping. The concepts introduced in this course may be subsequently utilized in control and planning courses.

Prerequisites

A proficiency in linear algebra, and basics of programming in C++ / python

Learning Outcomes

After successfully completing this course you will be able to:

- Create reasonable mathematical models predicting the motion of most robot types. ●
  Use a mathematical model to determine a robot's capabilities and analyze its behavior. ●
  Design, control, and simulate simple robots in a virtual environment.
- Determine the kinematics and inverse kinematics models that will serve as the basis for the design of planners and controllers.

Required Course Textbooks

Robot Modeling and Control. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar. John Wiley & Sons (2006). ISBN-10 0-471-64990-2.

A Mathematical Introduction to Robotic Manipulation. Richard M. Murray, Zexiang Li, S. Shankar Sastry CRC Press (1994). ISBN 0-8493-7981-4. Note: The full text pdf is available online for free.

Course Structure
This course includes both on-campus and online sections.

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. If online students wish to attend synchronously online, you can do so by logging into ELMS-Canvas at the time of the Section 0101 class [Tuesday 1:00pm - 3:40pm] and selecting "Video Conference" from the left side menu. This will open a Zoom link to the live classroom.

On-campus students are expected to attend in-person class sessions and be prepared to engage with the lecture and materials. If you have a conflict on a particular day, please reach out to me in advance to discuss. 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.

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 rmonfare@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. I will do my best to respond to emails within 24 hours.

When constructing an email to me please put "ENPM XXXX (Section XXXX): 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 by phone, 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.

Names/Pronouns and Self-Identifications

The University of Maryland recognizes the importance of a diverse student body, and we are committed to fostering inclusive and equitable classroom environments. I invite you, if you wish, to tell us 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 trans.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) and should be self-identified, not presumed or imposed. I will do my best to address and refer to all students accordingly, and I ask you to do the same for all of your fellow Terps.

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. I encourage you to confidently exercise your right to free speech—bearing in mind, of course, that you will 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. 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	Points	Percentage % of Grade
5 Homework Assignments @ 50 points each	250	25%
Hardware implementation- for project 1 OR 2* (for teams of 3)	50	5%
Project 0 - Introduction to ROS/Gazebo/Rviz	50	5%
Project 1 *- Modeling a toy car and creating its URDF model	100	10%
Project 2 (Final): 3 tasks @ 100 points each: Proposal Final report- Final presentation	300	30%
Class activities (class participation, quizzes, etc)	50	5%
Final Exam submitted on ELMS; take home; open-book	200	20%
Total		100%

* For teams of 2, the project 1 total points will be considered as 150 and hardware implementation is not required.

Course Assignments

Homework Assignments

    ● The course will entail 5 homework assignments for students to work out individually. ● Their purpose is to build upon the concepts taught in the lectures and extend them to apply to the given problems. Evaluation will be focused on the methodology and approach shown to tackle the problem, with clear rubrics breaking down the marks and steps expected.

    ● Working together on homework is highly encouraged, but you must write up solutions yourself. Providing technical support to one another (e.g. how to use a simulation tool) is also encouraged.

    ● Enough time and resources will be given to attempt and submit the assignments, and the course office hours are an excellent place to discuss the problems or any difficulties in attempting them with the instructor and TAs

Hardware Implementation

    ● For project 1 and 2, there is an optional hardware implementation, for which the expectation is to apply the algorithms and concepts to a physical robot (e.g. The Turtlebot). You are encouraged to build your

hardware, work with a commercially available robot or get support from the Robotics Lab for your requirements.
- ● Students can work in teams of 3 for this, and additional marks will be provided for a successful demonstration. However, make sure all the project requirements are fulfilled as hardware execution often proves to be more challenging than a simulation implementation.

Project
- ● The course will have 3 projects (project 0, project 1, and project 2), to help the students get into actual execution of the concepts taught during the course. Projects 1 and 2 are expected to be undertaken in teams of 2 (or 3 if attempting a hardware implementation). Projects 0 and 1 will have a defined scope with respect to what the expected result should be, whereas project 2 will be more open-ended. All project teams must be formed and declared before the group projects start.
    - ● Project 0 will involve controlling the TurtleBot in ROS Gazebo using an open loop controller, and is an individual project. You will have to set up the environment, import the libraries and execute the decided trajectory. Detailed instructions and tutorials will be given in class as well as in the project description.
- ● Project 1 will revolve around controlling a mobile robot in using teleop / keyboard inputs with a closed-loop controller. Students will be expected to design, model, and import their own robots for this assignment. ● Project 2 is more open-ended, with the requirements being applying inverse kinematics to control a multi link robot. More instructions and guidelines will follow the project announcement. Students will need to submit a proposal regarding their goals, tools, software, and targets; and potentially a progress report during the course of the project. There will be a final presentation during class hours, and a report outlining your work will have to be submitted on ELMS.

Class Activities
- ● Students are expected to attend the lectures in person, and there will be periodic quizzes to evaluate the concepts taught.
- ● There will be at least 2 quizzes during the semester, and their time slots and scope will be communicated in advance. They will have to be attended to in person during regular class hours.

Final Exam
- ● The final exam will be a take-home test, for which at least 48 hours will be given for the students to attempt. It will be an individual assignment, but feel free to refer to the course material, textbooks, and online resources for reference (while maintaining academic integrity requirements)
- ● The submission will be on ELMS, with a rigid deadline as the final exam will be during the last week of the semester.
- ● Exams will be open-book / open note, but communication with other students or other external parties (e.g. posting on a message board) is strictly prohibited. Any use of AI tools is also restricted.

Grading 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 **2 weeks(s)** 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 the TAs and me to schedule a time for us 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: I am happy to discuss any of your grades with you, and if me or the TAs have made a mistake we 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 (89.99 ≠ 90.00). It would be unethical to make exceptions for some and not others.

To promote an atmosphere of collaboration as opposed to competition, I do not intend to curve grades, but set clear objective marks to be achieved for a given grade. Cutoffs have been determined based on last year's outcomes.

Final Grade Cutoffs		
+ 97.00% + 87.00% + 77.00% + 67.00% + A 94.00% B 84.00% C 74.00% D 64.00% F - 90.00% - 80.00% - 70.00% - 60.00% -		<60.0%

Course Schedule

NOTE: Assignments will not be accepted for credit after the solutions have been given.

Week #	Dates	Topic	Deliverable/Due Date
1	28-Aug - 01-Sep	Lecture #1: Chapter 1 - Introduction to course	
2	04-Sep - 08-Sep	Lecture #2: Chapter 1 - Introduction to course	
3	11-Sep - 15-Sep	Lecture #3: Chapter 2 - Kinematics	
4	18-Sep - 22-Sep	Lecture #4: Chapter 2 - Dynamics	**HW 1**
5	25-Sep - 29-Sep	Lecture #5: Chapter 2 - Control	
6	02-Oct - 06-Oct	Lecture #6: Chapter 3 - Kinematics (Position)	**Project 0**
7	09-Oct - 13-Oct	Lecture #7: Chapter 3 - Velocity Kinematics	**HW 2**
8	16-Oct - 20-Oct	Lecture #8: Chapter 3 - Inverse Kinematics	
9	23-Oct - 27-Oct	Lecture #9: Chapter 3 - Inverse Kinematics	**Project 2 Pre-Proposal, HW3**

10	30-Oct - 03-Nov	Lecture #10: Chapter 3 - Dynamics (Fwd and Inv)	**Project 1**
11	06-Nov - 10-Nov	Lecture #11: Chapter 3 - 2-legged robot/grasping	
12	13-Nov - 17-Nov	Lecture #12: Chapter 3 - Software and simulation	**HW 4**
13	20-Nov - 24-Nov	Lecture #13: Chapter 3 - Control	
14	27-Nov - 01-Dec	Project 2 Presentations	**HW 5**
15	04-Dec - 08-Dec	Project 2 Presentations	
16	11-Dec - 15-Dec	Final Report Due	**Project 2 Final 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 06:00 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.

Absolutely no assignments will be accepted after the solutions are posted.

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 will be collected via Turnitin on ELMS/Canvas. I have chosen to use this tool because it can help you improve your scholarly writing and help me 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 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 will contain more specific information regarding acceptable levels of collaboration.

	OPEN NOTES	USE BOOK	LEARN ONLINE	GATHER CONTENT With AI	ASK FRIENDS	WORK IN GROUPS
Homework Assignments	✔	✔	✔	---	---	---
Quizzes & Weekly Summaries	✔	✔	✔	---	---	---
Team 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

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 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, 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.