ECE4560 - Introduction to Automation and Robotics (4-3-3)

School of Electrical and Computer Engineering
Georgia Institute of Technology

Instructor:	Maegan Tucker	*T.A.:*	TBD
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Inquiry Room:	TSRB 442	*Inquiry Room:*	van Leer E265
Inquiry Hours:	Tuesday 3:00PM - 4:00PM	*Inquiry Hours:*	TBD
	Friday 10:00AM - 11:00AM		TBD

Laboratory: VL E265 or area outside TSRB 442 (for biped project)
Lab Hours: Open Lab from 8AM to 8PM (requires Card Access after)

Prerequisite: ECE 3085/3084 or ECE3550
Optional Course Books:
Craig, J.J. Introduction to Robotics: Mechanics and Control, 3rd Ed.
Murray, Li, and Sastry. A Mathematical Introduction to Robotic Manipulation.
Lynch, and Park. Modern Robotics: Mechanics, Planning, and Control.
Spong, Hutchinson, Vidyasagar. Robot Modeling and Control. 3rd Edition.
Additional eBooks to be noted elsewhere.
Purchase not required.

Catalogue Description: Fundamental disciplines of modern robotics: mechanics, control, and computing. Analysis, design, and control of mobile robots and manipulators. Course may contain team projects and hands-on labs.

Scope and Goals: The goal of the course is to provide you with the knowledge to analyze and understand robotic manipulators. Consequently the course will cover elements of theoretical and applied kinematics, which deal with the mathematical analysis and synthesis of mechanical manipulators.

At the termination of the class, you should be able to:

- analyze and mathematically describe a given manipulator,
- understand said manipulator's operational limits,
- create design proposals for a manipulator given its specifications,
- confidently read the kinematics and robotics literature, and possibly
- understand some of the programmatic issues related to serial manipulators.
- potentially pursue and demonstrate mastery in an area of robotics of your choosing.

Topic Outline: The course is broken up into two segments covering the following topics:

1. Mathematics and Modeling.
   - Coordinate representation of manipulators
   - Homogeneous coordinates and representation of orientation
   - Lie groups and Lie algebras, $\exp$ and $\ln$
   - Body versus spatial reference frames.
2. Kinematics
   - Forward kinematics
   - Workspace analysis
   - Inverse kinematics
   - Manipulator velocities and Jacobian
   - Task planning
3. Dynamics
   - A primer on Euler-Lagrange equations, Lagrangian mechanics
   - Position/Torque control

Course Mechanics and Grading: The course meets two times a week, TuTh 5:00-6:15PM in Scheller 203. Being a laboratory course, each student must identify a lab experience. This will be discussed in the following section.

The course grading criteria consist of the following components whose percentage of the total grade calculation is also given,

	Homework	Lab	Midterm	Final
Percent of Final Grade	40%	20%	20%	20%

where the contributions are based on total points per category (e.g., total points for homework).

Lab Projects. The lab project will culminate in a final presentation. The labs will be group-based with each group consisting of 2-4 students. Each group will choose which robotic platform to work with, with the options being:

1. Piktul planar manipulator project
2. Turtlebot mobile robot project
3. Bipedal robot project
4. SO-101 manipulator project (New for Fall 2025)

Each group will be formed and asked to select a lab project track within the first three weeks of the course.

Throughout the semester, 50% of the project grade (10% of the overall grade) will be based on the weekly homework submissions (3/15 points each week). While the weekly homework submissions are about your project progress as a group, each student must submit their own writeup. Late written submissions will be deducted according to the homework policy.

The remaining 50% of the project grade (additional 10% of the overall grade) will be based on the final presentation.

Homeworks. The homeworks are intended to reinforce the topics presented in class. I will typically make an effort to be available for a short period after class for any questions that may arise. You should also feel free to e-mail me if homework statements are unclear or to set up an alternative time to meet, however please be sure to include the string "ECE4560" in the subject heading.

Homework will be assigned approximately every week. These homework assignments will be due on Friday (11:59pm). All material should be submitted virtually on Gradescope via Canvas.

All students are automatically given three days for extensions. These days can be broken up in any way. For example, three assignments can be handed in one day late each, or one assignment can be handed in three days late, or any other combination. Once your three extension days have been used, homeworks can be submitted up to 72 hours late, without request, for a 20% penalty per 24 hours. After 72 hours, solutions for the homework will be posted. Once the solutions are posted, late homework will not be accepted. For any other extensions, or unusual circumstances please make sure to contact me prior to the solutions being posted.

While collaboration is encouraged regarding the homework material, all work to be turned in is expected to be individually completed. It is presumed that we are all operating under the Georgia Tech Honor Code.

Programming. The course will require programming the learned mathematics into Matlab and/or Python. If you are unfamiliar with either Matlab or Python, there are many sources of documentation and primers online.

For those choosing to work with the Piktul manipulator, Matlab will be the only option provided. Likewise, the bipedal robot project will involve Matlab plus some additional libraries that can be compiled to run on Windows, MacOS, and Linux. The Turtlebot Mobile Robot lab thread will involve the Robot Operating System (ROS) and python running on the Linux operating system. The new SO-101 manipulator project will involve Python.

Course Schedule (subject to change):

Course Schedule			
Week	**Date**	**Lecture**	**Assignment Due**
1	August 19	Syllabus + Introduction	
	August 21	1. Planar Kinematics	
2	August 26	2. Coordinates	
	August 28	3. Transformations	HW 1
3	September 2	4. Homogeneous Coordinates	
	September 4	5. Introduction to Velocity	HW 2
4	September 9	Guest Lecture on Robotics	
	September 11	6. Angular Velocity and Twists	HW 3
5	September 16	7. Vectors	
	September 18	8. Exponential Representation of Rotations	HW 4
6	September 23	9. Exponential Representation of Motion	
	September 25	10. Midterm Review	HW 5
7	September 30	– Midterm Exam –	
	October 2	11. Manipulators & Manipulator Analysis	
8	October 7	12. Forward Kinematics	
	October 9	13. Inverse Kinematics 1	HW 6
9	October 14	– Fall Break –	
	October 16	14. Inverse Kinematics 2	
10	October 21	15. Manipulator Jacobian 1	
	October 23	16. Manipulator Jacobian 2 (PRE RECORDED)	HW 7
11	October 28	17. Jacobians and Singularity Analysis	
	October 30	18. Trajectory Design 1	HW 8
12	November 4	19. Trajectory Design 2	
	November 6	20. Trajectory Design 3	HW 9
13	November 11	21. Trajectory Design 4	
	November 13	22. Wrenches and Forces	
14	November 18	23. Introduction to Control	
	November 20	Group Projects 1	Presentations Due
15	November 25	Group Projects 2	
	November 27	– November Break –	
16	December 2	Review	HW 10
	December 4	– Final Exam (6-8:50pm) –	