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

School of Electrical and Computer Engineering
Georgia Institute of Technology

Instructor:	Patricio A. Vela	*T.A.:*	Yi-Pu Zhao
Office:	van Leer E368	*Location:*	van Leer E265
Phone:	TBD	*Phone:*	TBD
e-mail:	pvela@gatech.edu	*e-mail:*	yipu.zhao@gatech.edu
Inquiry Room:	VL E265	*Inquiry Room:*	VL E265
Inquiry Hours:	Thu 5:00 - 7:00PM	*Inquiry Hours:*	Fri 5:00 - 7:00PM

Laboratory:	VL E265 (overflow: VL C257)
Lab Hours:	Open Lab with Card Access
Prerequisite:	ECE 3085/3084 or ECE3550
Course Book:	Craig, J.J. Introduction to Robotics: Mechanics and Control, 3rd Ed. Purchase not required
Optional Refs:	Murray, Li, and Sastry. A Mathematical Introduction to Robotic Manipulation. Spong, Hutchinson, Vidyasagar. Robot Modeling and Control. 3rd Edition. Additional eBooks to be noted elsewhere.

Catalogue Description: Concurrent engineering principles; robotic manipulator kinematics, dynamics, and control; applications of robots in industry, medicine, and other areas; team projects and hands-on laboratory experience.

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.

Course Mechanics and Grading: The course meets three times a week, MoWeFr 12:20PM-01:10PM in Whitaker 1103. Being a laboratory course, each student must identify a lab experience from a set of pre-existing ones, or identify a suitable custom project. For the pre-existing projects, working in pairs is acceptable, but each student must submit their own solution. The standard lab projects involve (1) interfacing and controlling small manipulators, (2) controlling a mobile robot, and (3) synthesizing a walking gait for a planar bipedal robot. The custom version may involve a group effort towards a project chosen by the group, and accepted by the instructor. It is up to the group to sub-divide their tasks and report the breakdown of effort.

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

	Robot Arm	Mobile Robot	Biped	Custom
Homework	40%	35%	35%	35%
Lab	20%	25%	30%	35%
Midterm	20%	20%	15%	15%
Final	20%	20%	20%	15%

Since the lab projects have differing difficulty levels, the grading will differ based on the track chosen. The difficulty has to do with the alignment of the project with the lecture material, the availability of actual solutions (in some cases, there are none), and the amount of external study necessary. Which lab track to elect will occur within the first three weeks of class. Students pursuing the custom project-based lab experience will be required to present their project to the class during the last week of class, as well as submit a final report describing their project and its goals, plus some of their efforts towards realizing the goals. It is anticipated that the project-based trajectory might be more challenging than the standard trajectory due to the exploratory nature of the project. There will be some guidance by a group advisor to mitigate the difficulty.

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. 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.

At minimum, there will be weekly homeworks due at 2AM on Tuesdays, preferably via t-square, however submission can also be put in the ECE4560 bin or under my door (VL E368). The bin can be found in the ECE mail room (small closet area to the left as you enter), which is across the hall from the Academic Office, closer to the water fountain. The door automatically locks at the close of day, so you may need to slide it under my door. If an extension is required for acceptable reasons, then please contact me. Make sure to turn it in whether I have responded or not when you have it done. Homeworks can be submitted up to 24 hours late, without request, for a 10% penalty. If there will be a delay beyond 24 hours, then please contact me to negotiate a submission time, otherwise there will be a sliding scale for each additional 24 hour period.

The course will require programming the learned mathematics into Matlab. For those choosing to work with the manipulator, Matlab will be the only option provided. Anyone wishing to utilize other platforms may do so and is more or less on their own; I am willing to provide help to a limited degree. If you are unfamiliar with Matlab, there are many sources of documentation and primers online. Also, students pursuing the project can decide what programming language and environment to use in support of the project goals.

Topical Outline: The course is broken up into three, segments which cover the following topics:

- 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.
- Kinematics
  - Forward kinematics.
  - Workspace analysis.
  - Inverse kinematics.
  - Manipulator velocities and Jacobian.
  - Task planning.
- Dynamics
  - Euler-Lagrange equations, Lagrangian mechanics.
  - Manipulator dynamics.
  - Position/Torque control.

Progress in the third section varies from year to year, but first two sections are always completely covered.