Syllabus
MEEG 671 – Introduction to Robotics

COURSE INFORMATION

Lecture:

TuTh 9:30–10:45, Memorial 126

Instructor: Bert Tanner

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Text: *Robot Modeling and Control*, by M. W. Spong, S. Hutchinson, and M. Vidyasagar. Wiley 2006.

Description: This is an introductory course in robotics for senior undergraduate and junior graduate students who have had little to no other introductory courses on the topic. The course focuses on topics in robotics that relate to modeling, dynamics, and control of robotic manipulators. Mathematical preliminaries include matrix and vector analysis, basic kinematics and kinetics, and classical (frequency-based) control theory. Some background on more advanced topics such as Lagrangian dynamics, and modern linear and non-linear dynamical system analysis definitely help.

Most, if not all, course-related communication and material sharing, including class note handouts and occasional videos, will be done through Canvas.

Material to be Covered: Very fast review of 3D kinematics; representation of kinematic chains, Denavit-Hartenberg frame assignment convention; forward and inverse kinematics; Jacobians, static force/torque relationships, and maneuverability; Independent joint control; Path and trajectory planning, and dynamics (time permiting).

Tentative topic sequence

- Preliminaries
- A glimpse on 2D planar position kinematics
- A glimpse on 2D planar velocity kinematics
- Relative position
- The rotation matrix
- The anatomy of a rotation matrix
- Composition of rotations
- Parameterizations of rotation
- The similarity transformation
- Switching rotation parameterizations
- Rigid body motions
- Denavit Hartenberg parameters
- DH-example
- Inverse kinematics – theory
- Inverse kinematics – examples
- Inverse kinematics – more examples
- Forward kinematics on the Puma
- Angular velocity

- Representation of angular velocity
- The Jacobian
- Jacobian examples
- Singularities
- Singularity examples
- Jacobian with forces & accelerations
- Newtonian Dynamics
- Newtonian dynamics example
- Lagrangian dynamics
- Lagrangian dynamics example
- Independent joint control
- Feedback linearization / computed torque control

Evaluation methods:

PROJECT (20%) which is to be completed at several stages (milestones) throughout the course of the semester, and puts into practice theoretical, computational, and some (relatively basic) coding concepts. The project will utilize a (free) robot simulation environment called Webots. It will be evaluated upon completion, and while collaboration is welcome, every student submits their own report that should clearly demonstrate independent work. Feedback on project work (and incremental grading) is provided after the submission of each project milestone.

QUIZES (10%) are assigned at the end of (sometimes a group of) modules and test basic understanding of key concepts introduced. A fifth of this portion of the grade requires completion of the student evaluation survey at the end of the course. Homework problems will be assigned on a weekly basis, but not graded. The purpose of these assignments is for the students to test their understanding of the material provided in classroom instruction and through the textbook, and the expectation is that students

will try them out on their own with the same commitment that they come to class, and they are considered a prerequisite for any exam preparation strategy. The final answers of the problems will typically be provided in advance so that students can know if they are on the right track, and are expected to seek help from the instructor in a timely fashion (so that comprehension problems to not worsen) if they cannot solve them.

MIDTERM EXAM (30%) which is to be scheduled close to (shortly before of after) the spring break. Exact date to be determined. It will be an in-class, open-book but closed notes exam. Students bring their own paper and calculators.

FINAL EXAM (40%) which is scheduled at the time and date specified by the University. No modifications on the time or date of the final exam can be made. Students bring their own paper and calculator.

Grades The rubric for partial grade for each component of assignments and exams is as follows:

Response assessment	credit
Correct response, clearly written and justified	1.00
Only grade-level derivation errors	0.75
Knows process but has trouble executing	0.50
Has some understanding of the thought process	0.25
Clueless	0.00

The standard Canvas assignment of (0-100) numerical grade to letter grade is being used.

Further reading:

- Siciliano, Sciavicco, Villani, and Oriolo*Robotics: Modeling, Planning and Control*, Springer
- Craig, *Introduction to Robotics*, Pearson Prentice Hall.
- Lynch and Park, *Modern Robotics: mechanics, planning and control*, Cambridge

POLICIES

Working Together: Collaboration is accepted on homework, but solutions should be given based on individual justification and reasoning, which needs to be clear on your paper. Collaboration on exams is of course is forbidden.

Absences: You are expected to attend every class. It is not acceptable to give priority to assignment completion over class attendance. The 20% penalty on assignments thus applies also to the case where you choose to miss class in order to finish your assignment.

Plagiarism: Definition: http://www.udel.edu/stuguide/06-07/code.html#honesty
In this context, students are expected to present their own interpretation of other people's ideas and work. Summarizing and paraphrasing without proper citation and documentation[1] is unacceptable. The same applies to copying assignment solutions from manuals available online. The University's *minimum penalty* for cheating or plagiarism is *a failure in the course*. For the first time the transgression is noted, the assignment will not receive a grade. Repeated offenses may result to dismissal from the University.

Intellectual Property: No student may distribute notes, audio-visual or other material from the class, whether or not for a fee. If any UD student, whether enrolled in the class or not, distributes such material in contradiction of this prohibition, (s)he will be in violation of the Student Code of Conduct.

Disclosures of Instances of Sexual Misconduct If, at any time during this course, I happen to be made aware that a student may have been the victim of sexual misconduct (including sexual harassment, sexual violence, domestic/dating violence, or stalking), I am obligated by federal law to inform the university?s Title IX Coordinator. The university needs to know information about such incidents to, not only offer resources, but to ensure a safe campus environment. The Title IX Coordinator will decide if the incident should be examined further. If such a situation is disclosed to me in class, in a paper assignment, or in office hours, I promise to protect your privacy—I will not disclose the incident to anyone but the Title IX Coordinator. For more information on Sexual Misconduct policies, where to get help, and reporting information please refer to www.udel.edu/sexualmisconduct. At UD, we provide 24 hour crisis assistance and victim advocacy and counseling. Contact 302-831-2226, Student Health Services, to get in touch with a sexual offense support advocate.

[1] *Defining and Avoiding Plagiarism: The WPA Statement on Best Practices*, 2003. Online: http://www.ilstu.edu/ ddhesse/wpa/positions/WPAplagiarism.pdf . Accessed August 29, 2006