COURSE OUTLINE – ECE 4550/6550
Fundamentals of Robot Manipulators
Summer II 2020 – Online Course
I.D. Walker
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Time: M-F (online)
Text: Robot Modeling and Control, M. Spong, S. Hutchinson, and M. Vidyasagar, Wiley (required)
Office Hours: Email will be the primary mode of contact. Technical questions should be communicated by email or Skype/Hangout. Skype/Hangout conversation appointments must be scheduled in advance by email.
TA: Michael Wooten
TA office: EIB 313, email: mbwoote@clemson.edu

Prerequisites: MATH 2080 and PHYS 1220 (each with a C or better) and senior standing, or consent of instructor. *NOTE: enrollment is restricted to students residing, during the time of the course, within the United States, and students MUST take the midterm exam and final exam from 12:00-2:30pm Eastern US time on Friday 7/10, and from 11:30am-2:00pm Eastern US time on Monday 8/3, respectively.*

Description: Analysis of robot manipulator systems. Emphasis is on rigid-link robot manipulator systems.

Topical Outline:
History of robotics technology
Kinematics: forward, inverse, and velocity (Jacobian)
Dynamics: Lagrangian
Control: Conventional and Inverse Dynamics

Attendance: This is an on-line course, so attendance is not applicable. However, students are responsible for all material covered in on-line lectures, reading assignments, and homework assignments.

Organization:
We will set up a class email list which will be used to communicate with the class. Important information (such as reading assignments to supplement the lectures and support the homework assignments) and reminders will be sent out this way.

Course Objectives and Learning Outcomes:
The emergence of robotics is significantly impacting the industrial and wider world. The objective of this course is to investigate challenges and the state of the art in modeling robot manipulators. By the completion of this course, students will develop an understanding of how robot manipulators are modeled, and how these models are used for their operation and control. Students will demonstrate an ability to apply the models to examples of classical and current robot manipulators.

Homeworks:
Homework assignments and solutions are posted online. Students are required to work out the problems, scan them into a pdf file, and submit their assignments at the end of the semester as a single pdf file. The pdf file should be emailed to the TA. Working the homework problems is *essential* to the learning of the material in this course: in fact, most of your learning will come from doing the homework. It is expected that your homework will represent your own work, although working in groups is allowed. *Late homework will not be accepted or graded.*

Exams:
There will be one midterm exam and one final exam. The exams MUST be taken online (see below), and will be closed book, with no electronic devices (laptop/phone, etc.) permitted. You will be allowed one piece of 8.5 by 11 sheet of paper for each exam, on which you can write (NOT copy or print) anything you wish before the exams. The midterm exam will be held Friday 7/10, from 12:00pm to 2:30pm, and the final exam will be held Monday 8/3 from 11:30am to 2:00pm, both in Eastern U.S. time.

Exam Administration:
Exams must be taken online, *and only within the United States*. Exams will be emailed to students at the beginning of the specified exam periods, and student solutions to the exams, including all work and the previously prepared 8.5 by 11 sheets, must be scanned and emailed back to the class TA (mbwoote@clemson.edu) before the end of the 2.5 hours allocated for taking the exam. No exceptions to this policy will be granted.

Exam Attendance:
If you cannot take an exam for any reason, we should be notified ahead of time if possible, otherwise at least on the day of the exam. Except under very exceptional circumstances, no make-up exams will be given.

Assessment of Student Performance and Grading Policies:
Overall student scores for the class will be calculated according to the following scale: homework assignments (10%), midterm exam (45%), final exam (45%), total: 100 points. Grading scale: 90-100: A, 80-90: B, 70-80: C, 60-70: D, 0-59: F. We reserve the right to adjust the grading scale depending on overall class performance, but only in your favor.

On-Line Procedures:
ECE 455/655 is an On-line summer course. All materials, except for the textbook, will be provided online. Homework due dates and procedures for submission, as well as exam procedures, will be sent to the class via email, in addition to being posted online.

Other Policies:
Please see appended ECE Common Course Syllabus.

Reading, Homework, Lecture Video, and Reading Pace:

The following is a list of topics covered in the course. You are expected to read the topics in the text and listen to the video lectures. The homework assignments are listed too and their solutions are also provided. Your guide here is the lectures. The material covered in the lectures and the homework assignments is the key to what you will be tested on.

Topic 1: Introduction
Brief history of robots
Overview of robot technology
Definitions and key concepts (joints, links, axes, etc.)

Lecture file: 455_Lecture_1
Reading: Text, Chapter 1 (sections 1.1, 1.2, pages 1-12)
Homework: none (but the material is important in setting up later homeworks!)
Suggested study pace: cover by Friday 6/26

Topic 2: Rotations
Common robot structural designs
Coordinate Frames
Rotations

Lecture file: 455_Lecture_2
Reading: Text, Chapter 1 (section 1.3, pages 12-27), Chapter 2 (sections 2.1-2.4, pages 35-53)
Homework: 455_hw1.pdf
Suggested study pace: cover by Wednesday 7/1

Topic 3: Forward Kinematics
Homogeneous Transformations
The Denavit-Hartenberg Algorithm

Lecture files: 455_Lecture_3, 455_Lecture_4
Reading: Text, Chapter 2 (sections 2.6-2.8 pages 60-65), Chapter 3 (sections 3.1, 3.2, pages 73-93)
Homework: 455_hw2.pdf, 455_hw3.pdf
Suggested study pace: cover (reading, lecture 3, lecture 4) by Tuesday 7/12, (homework 2, homework 3) by Wednesday 7/8

Midterm exam Friday 7/10, 12:00-2:30pm, Eastern U.S. time, covering topics 1-3

Topic 4: Inverse Kinematics
Geometric Techniques
Analytical Techniques

Lecture file: 455_Lecture_5
Reading: Text, Chapter 3 (sections 3.3, 3.4, pages 93-111)
Homework: 455_hw4.pdf
Suggested study pace: cover by Wednesday 7/15

Topic 5: Velocity Kinematics
Manipulator Jacobian
Application to inverse kinematics/singularity analysis
Jacobian computation
Statics

Lecture file: 455_Lecture_6
Reading: Text, Chapter 4 (sections 4.1-4.6, pages 119-137, sections 4.9, 4.10, pages 141-150)
Homework: 455_hw5.pdf
Suggested study pace: cover by Wednesday 7/22

Topic 6: Dynamics and Control
Kinetic, Potential energy
Lagrangian manipulator dynamic models
Inverse Dynamics controllers
Industrial set point PD control: why it works

Lecture file: 455_Lecture_7
Reading: Text, Chapter 7 (sections 7.1-7.4, pages 239--267), Chapter 8 (sections 8.1, 8.2, pages 289-299)
Homework: 455_hw6.pdf
Suggested study pace: cover by Wednesday 7/29

Final exam Monday 8/3, 11:30-2:00pm, Eastern U.S. time, covering topics 4-6

It is strongly suggested that students download and store the pdf and wmv files at the beginning of the semester. It is important that the files are always available to you on your laptop/computer when your internet connection is down and/or unavailable. The files and video lectures are meant to be listened to and read repeatedly for maximum benefit. This is an advantage over the traditional method of instruction. Be sure to make the most of it.