SYLLABUS
ME EN 5230/6230, CS 6330, ECE 6651
INTRODUCTION TO ROBOT CONTROL- SPRING 2023

Instructor: Stephen Mascaro, MEK 1151, smascaro@mech.utah.edu

Lecture: M/W 1:25-2:45 pm in M LI 1130. Given the nature of this course, attendance is required, and adjustments cannot be granted to allow non-attendance, except in cases of quarantining due to COVID-19 exposure, or for those who have an ADA accommodation. If you need to seek an ADA accommodation to request an exception to this attendance policy due to a disability, please contact the Center for Disability and Access (CDA). CDA will work with us to determine what, if any, ADA accommodations are reasonable and appropriate.

Labs: MEK 2333. Lab Fee: $40. Use card access to enter and complete labs at your convenience.

Web Page: A course webpage has been set up on Canvas at https://utah.instructure.com/
The web page will be updated regularly with assignments and solutions. Gradescope https://www.gradescope.com/ will be used for electronic submissions and grading.

Objectives: Control of serial manipulators is examined. Topics include control system fundamentals, sensors and actuators, joint level control, centralized control, operational space control, and force control. Projects provide hands on experience controlling a serial link manipulator.

Prerequisites: ME EN 5220/6220 or CS 5310/6310 or ECE 6650 (Intro to Robotics) or equivalent is absolutely required. ME EN 5200/6200 or equivalent (Classical Control Systems) is strongly recommended.

Text: Robotics: Modeling, Planning and Control, by Siciliano, Sciavicco, Villani and Oriolo, Springer, 2009. Marriott Library has link to E-book (Mostly just need chapters 8&9).

References: 1. *Intro to Robotics Course Notes* by Hollerbach (available online)
2. *Control System Engineering*, 8th Ed. by Norman S. Nise, 2019.

Software: MATLAB will be required. It is freely available to all students at osl.utah.edu

Grader: Nick Posselli <Nicholas.Posselli@utah.edu>

Problem Set and Lab Assignment Policies:

1. It is the students' responsibility to regularly check **Canvas** for assignments and solutions.
2. Assignments must be submitted electronically on **Gradescope** by midnight on the date due. Unless prior arrangements exist, late assignments will be marked down 10% per business day up to 2 days. Thereafter, no credit will be given. Solutions will generally be posted 2 days after due date.
3. Students may collaborate, but each student must complete each Problem Set individually (MATLAB files and figures CANNOT be shared). In the case of Lab Assignments, students are encouraged to work in teams to program controllers and collect data, but each student must turn in their own write-up (in this case MATLAB files and data may be shared, but plots may not). Use of old material from previous years is forbidden. Violation of these policies will result in a failing grade on the assignment.
4. For clarification on assignments and solutions, please contact the instructor. For grading issues, first contact the course grader.

Exam Policies:

1. Exams must be taken at the scheduled time unless prior arrangements are made at least two weeks before.
2. Accommodations will be arranged if a student has a special requirement due to a disability. It is the responsibility of the student to request these accommodations at least two weeks prior to the exam and provide documentation specifying the arrangements from the University of Utah Center for Disability Services (see College Guidelines below).
3. Any students cheating on an exam will receive a failing grade for the class.

Grade Weightings:

Problem Sets:	30%	Midterm Exam:	20%
Labs:	20%	Final Exam:	30%

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Academic Integrity:

Academic Integrity: Engineering is a profession demanding a high level of personal honesty, integrity and responsibility. Therefore, it is essential that engineering students, in fulfillment of their academic requirements and in preparation to enter the engineering profession, adhere to the Department of Mechanical Engineering Policy for Academic Misconduct. This policy is based upon the University of Utah's Policy 6-400: Code of Student Rights and Responsibilities[1] (student code) where academic misconduct *"...includes, but is not limited to, cheating, misrepresenting one's work, inappropriately collaborating, plagiarism, and fabrication or falsification of information. It also includes facilitating academic misconduct by intentionally helping or attempting to help another to commit an act of academic misconduct."*

As part of the ME policy, students must review and acknowledge the "ME Academic Misconduct Policy" and the "ME EN 5230/6230 Definition of Academic Misconduct" provided on the course Canvas page. Students must provide acknowledgment of these policies via the Canvas Academic Integrity Module for this course before the end of the second week of class or they will be asked to drop the class and will otherwise receive an EU grade.

University Policies:

1. ***The Americans with Disabilities Act***. The University of Utah seeks to provide equal access to its programs, services, and activities for people with disabilities. If you will need accommodations in this class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building, (801) 581-5020. CDS will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in an alternative format with prior notification to the Center for Disability Services.
2. ***University Safety Statement.*** The University of Utah values the safety of all campus community members. To report suspicious activity or to request a courtesy escort, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit https://safeu.utah.edu/ .
3. ***Addressing Sexual Misconduct***. Title IX makes it clear that violence and harassment based on sex and gender (which includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran's status or genetic information. If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or the Office of the Dean of Students, 270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to the police, contact the Department of Public Safety, 801-585-2677(COPS).

College Guidelines:

Policies regarding appeals procedures, disability accommodations, and adding/withdrawing/repeating courses can be found on the COE website: https://www.coe.utah.edu/semester-guidelines

Student Mental Health Resources: https://studentaffairs.utah.edu/mental-health-resources/index.php

Campus COVID-19 Response: https://coronavirus.utah.edu/

[1] Student Code: http://regulations.utah.edu/academics/6-400.php.

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TENTATIVE SCHEDULE

No	Date	LECTURE TOPIC	READING	PROBLEM SETS	LABS	ASSIGNMENT TOPIC
1	1/09	Introduction				
2	1/11	Manipulator Kinematics/Statics	Hollerbach Ch. 4,5,8,9			
	1/16	***Martin Luther King Day Holiday***				
3	1/18	Manipulator Dynamics	Hollerbach Ch. 10			
4	1/23	Drive Train Dynamics	Siciliano 5.1-5.2	PS #1 Due:		Kinematics & Statics
5	1/25	Motor and Amplifier Dynamics	Siciliano 5.1-5.2			
6	1/30	Feedback Control	Nise Ch. 4-7	PS #2 Due:		Manipulator Dynamics
7	2/01	Root Locus Control Design	Nise Ch. 8,9			
8	2/06	Lyapunov Stability	Arimoto 1983	PS #3 Due:		Drivetrain/Motor Dynamics
9	2/08	Decentralized Control	Siciliano 8.1-8.3			
10	2/13	Computed Torque Control	Siciliano 8.4	PS #4 Due:		1DOF Linear Control
11	2/15	Inverse Dynamics Control	Siciliano 8.5.1-2			
	2/20	***President's Day Holiday***				
12	2/22	Sensors and Control Hardware	Siciliano 5.3-5.4	PS #5 Due:		Coordinated Motion Control
13	2/27	Real-Time Control Demo	QUARC Tutorial			
14	3/01	**Midterm Exam**				
	3/06	***Spring Break***				
	3/08	***Spring Break***				
15	3/13	Robust Control	Siciliano 8.5.3		Lab #1 Due:	1 DOF Linear Control
16	3/15	Adaptive Control	Siciliano 8.5.4			
17	3/20	Operational Space Control	Siciliano 8.6		Lab #2 Due:	Coordinated Motion Control
18	3/22	Stiffness Control	Siciliano 9.1-9.2	PS #6 Due:		Robust/Adaptive Control
19	3/27	Impedance Control	Siciliano 9.3		Lab #3 Due:	Robust/Adaptive Control
20	3/29	Admittance Control	Siciliano 9.3	PS #7 Due:		Operational Space Control
21	4/03	Direct Force Control	Siciliano 9.4-9.5		Lab #4 Due:	Operational Space Control
22	4/05	Hybrid Position/Force Control	Siciliano 9.6-9.7	PS #8 Due:		Indirect Force Control
23	4/10	Multi-Arm Coordination	Uchiyama 1988		Lab #5 Due:	Indirect Force Control
24	4/12	Teleoperation	Niemeyer 1991	PS #9 Due:		Direct Force Control
25	4/17	Teleoperation	Niemeyer 1991		Lab #6 Due:	Direct Force Control
26	4/19	Visual Servoing	Siciliano 10	PS#10 Due:		Multi-Arm Coordination
27	4/24	Learning Control	Arimoto 1991		Lab #7 Due:	Teleoperation
	4/26	**Reading Day**			Lab #8 Due:	Visual Servoing
	5/01	**Final Exam 1:00-3:00pm**				

Note: All dates and assignments are subject to change. Additional problems may be assigned for 6000 level students. Students should monitor Canvas for updates.