ME (MFG) 584: Advanced Mechatronics for Manufacturing (Winter 2015)

Instructor: Prof. Chinedum Okwudire, 2162 GGB, okwudire@umich.edu

GSI: Mr. Deokkyun Yoon, 1100 DOW, yydkyoon@umich.edu

Lectures: Tu/Th 10:30-12, 2166 DOW

Office Hours: Thursdays, 1-3, 2162 GGB

Course Website: https://ctools.umich.edu/portal

Text Book(s): Relevant texts (mostly open-source) will be provided along with lecture notes.

Software: Solid Works (only basics), MATLAB/Simulink (high proficiency needed).

Labs: Course will have a total of four labs:

> **Lab 1:** NC programming and part cutting
>
> **Lab 2:** Time and frequency domain electro-mechanical system identification
>
> **Lab 3:** Controller design, tuning and analysis (basic and adv. controllers)
>
> **Lab 4:** Multi-axis command generation and contouring analysis

Each lab will entail some home work before the lab, on-machine time and a detailed individual report which will be graded. The on-machine portion of the lab will be performed in small groups, based on a flexible schedule that accommodates all group members and the schedule of the lab facilitator/equipment.

Reading Assignments and Quizzes: Reading assignments will be assigned in advance of some lectures. A short quiz based on the assigned reading material may be given during the lecture for which the reading was assigned.

Participation Bonus: Active participation in this course not required but is highly encouraged; everyone benefits from a very engaged class. Therefore, a bonus of up 5% will be applied to the final grades of students who demonstrate *above-average* participation in this course. The bonus grade will consist of three components.

(1) Instructor's Bonus (up to 1%): Assigned by the instructor (and GSI) to students who are particularly active in and out of class, for instance, by asking very good questions, making very insightful comments and/or pointing out important mistakes, etc.

(2) Homework (HW) Bonus (up to 1.5%): Assigned by the instructor to students based on their participation in preparing HW problems for the class. Students will be given three

opportunities during the semester to create *their own* HW problems and solutions which will be graded by the instructor/GSI based on criteria that will be announced in due time; bonus points will be assigned in proportion to the grades received. The HW problems created through this process will be shared with the rest of the class as optional (ungraded) HW assignments and would likely be integrated in some form or the other into exam problems.

(3) Classmates' Bonus (up to 2.5%): On April 14, in class, each student will have the chance to anonymously vote on whether or not they have benefited from the in-class or out-of-class participation of each of their fellow classmates. Students who garner more than the average number of votes from the class will each receive a bonus of up to 2.5%. Students are encouraged to use this opportunity to show their appreciation to their classmates who in one way or the other have helped them to better understand the course material. This peer evaluation should be treated as any other examination. Evidence of any malpractice (e.g., canvassing for votes, pre-arranged voting agreements, using coercion or favors to get votes, etc.) will be treated as a violation of the College of Engineering's Honor Code.

Note: The highest letter grade attainable in this course (without adding bonus points) is an A. To get an A+, a student must gather <u>at least</u> 2% extra in bonus points. It is not unusual for bonus points to bump students one grade up, e.g., from an A− to an A. Please work hard to earn them.

Individual Project vs. Final Exam (Default) Option: Students will be given the opportunity to choose between an individual project and a final exam option in this course. Students who choose the project option will only have to take Part A of the final exam (which will evaluate their basic understanding of the topics covered in the course). On the other hand, students who choose the final exam option will also have to take Part B of the final exam (which will evaluate their comprehensive understanding of the entire course content) in addition to Part A. More details about the individual project option will be announced in class and posted on the course web page.

Grading:

Quizzes/Reading Assignment	5%
Labs	50%
Midterm Exam	15%
Final Exam (Part A)	5%
Final Exam (Part B) or Project	25%
Participation Bonus	5%

Course-Specific Policies:

- You are allowed to discuss labs and your project with other students. However, your reports must be based on your own work. You are not allowed to share your computer codes or reports with other students. You are also not allowed to possess, look at, use or in anyway derive advantage from the existence of computer codes, lab reports or solutions prepared in prior years from former students' work. Violation of this policy will be treated as a breach of the College of Engineering's Honor Code and will be filed with the Honor's Council.
- Students are allowed to audit this course, in which case they may attend lectures but may not participate in any of the graded portions of the course. However, students who have enrolled in the course for credit may **not** revert to audit status after the add/drop deadline (January 27), except under extenuating circumstances.
- All lab rules must be obeyed during on-machine work.
- Lab reports and projects must be submitted on time otherwise a late penalty will be incurred.
- Other specific policies will be announced in class and on course website as the need arises.

Tentative Course Outline

Topic	Date(s)	Special Note(s)
Part 1: Introduction		
Course overview/introduction	1/8	RA1 assigned
Machining process flow, CNC programming, modules and general architecture	1/13	Quiz on RA1; RA2 assigned
Part 2: Electro-Mechanical System (Plant)		
Machine tool feed drives and their components (actuators, sensors, etc.)	1/15	Quiz on RA2; Lab 1 assigned
Sizing of drive components	1/20	RA3 assigned
Review of mechanical vibrations	1/22	Quiz on RA3
Modeling of electro-mechanical drive system	1/27	HW1 entries due
Identification of system parameters	1/29	RA4 & Lab 2 assigned
Part 3: Control System		
Review of SISO control concepts	2/3	Quiz on RA4
Analysis of open loop dynamics	2/5	
Cascaded P-PI controller	2/10	
Advanced controllers (ASMC, ZPETC, CCC, etc.)	2/12-2/26	HW2 entries due
Winter Recess	3/3-3/5	Lab 3 assigned
Advanced controllers (ASMC, ZPETC, CCC, etc.)	3/10-3/12	
Midterm Exam	3/17	
Advanced controllers (ASMC, ZPETC, CCC, etc.)	3/19-3/23	

Part 4: Software System (Command Generation)

Geometric interpolation	3/26	Lab 4 assigned
Trajectory generation	3/31-4/2	
Look-ahead functions	4/7	
Feed rate optimization	4/9	

Part 5: Special Topics/Project Presentations

Course review; voting for bonus assignment	4/14	HW3 entries due
Special topic/Project presentations	4/16	Attendance taken (RA5)
Special topic/Project presentations	4/21	Attendance taken (RA5)

Final Exam: Tuesday, April 28, 1:30 pm - 3:30 pm.

Note: RA = Reading Assignment