Course Syllabus

Description This is a project-based course in digital control. We will cover a variety of topics relevant and typical to real-world control implementations: sampling, filters, digital control design, non-linear dynamic effects (saturation, slew rates, friction, backlash, etc.), and a variety of advanced control techniques. Typical final projects include inverted pendulum swing up and stabilization, pendubot control, a chaotic bouncing ball, a maglev device, and a balancing seesaw. Additional student-designed options are certainly possible (and encouraged!), but you must demonstrate working hardware by the mid-term review to continue work on any project using equipment that is not already in the Control Lab (HFH 3120A).

Instructor Prof. Katie Byl (katiebyl@ece.ucsb.edu)
Room 5115, Harold Frank Hall (HFH)

Lecture Tuesday and Thursday, 2-3:50pm, **in HFH 3120A** (Controls Lab).
Please note the planned change of room, above. If our class enrollment is too large for everyone to fit comfortably in lab, we may also be split lectures into two groups.

Lab Open hours, by card access, in HFH 3120A. You may generally use lab during any hours EXCEPT 7-10 Tuesday and Thursday, as these times are pre-assigned for ECE 147A labs. Please stop by the ECE Electronics Shop (HFH 1160) to let them know you will need access to 3120A for ECE 238. If you do not already have an access card, you will need to purchase one, as well.

Prerequisites A good graduate course in *Controls*.

Office Hours Monday and Wednesday, 3-4pm, in 5115 HFH

Optional Text There is no required text for this course. If you want a reference, I suggest "Digital Control of Dynamic Systems" by Franklin, Powell and Workman (FPW) [3rd ed., Addison Wesley Longman, Inc., 1998]. This book is out of print but can be obtained here: http://www.powells.com (Then, type in the book title to search.)

Grading The goal of this course is to get hands-on experience at "making things work" via digital control, and this will require completion of a term project of your choice. The homework assignments should be helpful toward this goal, but are of secondary importance.
Your grade will be the higher of the following two options:

20% Homework, 80% Final Project
50% Homework, 50% Final Project

(Toward encouraging completion of the homework, I will note that grading on homework is likely to be more lenient.)

Homework Homework will consist of a combination of on-paper problems and in-lab assignments. Homework will either be turned in either electronically (email to katiebyl@ece.ucsb.edu) or in the homework drop box outside of HFH 3120A, as appropriate to each assignment.

Final Project Includes a mid-term project update, and an end-of-term presentation (10 minutes) and final report (5pp). More details will be given in class.

Topics

The list below will likely be modified, based on class interest and background, as we will only have time to cover a subset of the topics. You will be asked to give feedback (via returning the anonymous check list on the next page to Prof. Byl at the end of the first lecture) on which topics best fit your own interests and level.

Early topics in the course will focus on practical issues common to real-time control (e.g., review of digital control concepts, system ID, anti-aliasing, loop shaping, etc…) while later topics will generally focus on a variety of advanced control techniques (MPC, PFL, inner/outer loop design, etc.)

- Digital control / Sampled-data systems
- Quantization / Encoders
- Filtering
- System ID: empirical frequency response, via swept sine response
- Loop shaping: frequency response methods for controller design
- Aliasing: Anti-aliasing (analog) filters / simple op-amp controllers
- Estimator design
- Kalman filtering
- Sensor fusion
- Integrator anti-windup / saturation
- 4^{th}-order dynamics: collocated vs non-collocated control
- Magnetic bearing (maglev) modeling and control
- Linearization (of nonlinear dynamics)
- Partial feedback linearization (PFL)
- Feedforward
- Computed torque
- Switching control
- Model predictive control (MPC)
- Internal model control (IMC)
- Nonlinear PID
- Nested loops (inner / outer loop structure; cascade control)
- Backstepping

Please DETACH THIS PAGE and return it to Prof. Byl in class today.

At left, circle items you particularly wish to cover in the class ("Yes") or wish to skip ("No"). You don't need to answer on each topic, but it is in your own interest to give *some* feedback – as we will not have time to cover everything.

Interested in Topic?			List of possible topics in ECE 238
Yes	Maybe	No	Digital control / Sampled-data systems
Yes	Maybe	No	Quantization / Encoders
Yes	Maybe	No	Filtering
Yes	Maybe	No	System ID: empirical frequency response, via swept sine response
Yes	Maybe	No	Loop shaping: frequency response methods for controller design
Yes	Maybe	No	Aliasing: Anti-aliasing (analog) filters / simple op-amp controllers
Yes	Maybe	No	Estimator design
Yes	Maybe	No	Kalman filtering
Yes	Maybe	No	Sensor fusion
Yes	Maybe	No	Integrator anti-windup / saturation
Yes	Maybe	No	4^{th}-order dynamics: collocated vs non-collocated control
Yes	Maybe	No	Magnetic bearing (maglev) modeling and control
Yes	Maybe	No	Linearization (of nonlinear dynamics)
Yes	Maybe	No	Partial feedback linearization (PFL)
Yes	Maybe	No	Feedforward
Yes	Maybe	No	Computed torque
Yes	Maybe	No	Switching control
Yes	Maybe	No	Model predictive control (MPC)
Yes	Maybe	No	Internal model control (IMC)
Yes	Maybe	No	Nonlinear PID
Yes	Maybe	No	Nested loops (inner / outer loop structure; cascade control)
Yes	Maybe	No	Backstepping