Robot Dynamics and Control - Syllabus

Instructors:

Lecture:	Prof. Katie Byl (lecturer)	katiebyl+179d@gmail.com
Lab:	Brian Satzinger (TA)	bsatzinger+179d@gmail.com
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Corequisites: ECE 130A (or equivalent) or ME 155A (or equivalent).

Website: http://www.ece.ucsb.edu/courses/ECE179/179D_S12Byl/index.html
(Or, google "Katie Byl" to get to http://www.ece.ucsb.edu/~katiebyl/
Then click on appropriate link under "Teaching".)

Lecture: 2-3:15pm Tues. and Thurs., in Phelps 2516.

Lab: 3-hour session, once per week. **Lab section assignments TBA.**

Required Text: 1) *Robot Modeling and Control*, by Spong, Hutchinson and Vidyasagar.

Supplemental Texts: 2) *Autonomous Mobile Robots*, by Siegwart and Nourbakhsh.
3) *Introduction to Robotics: Mechanics and Control*, by Craig.
4) *System Dynamics*, by Ogata.
5) *Modeling, Analysis, and Control of Dynamic Systems*, by Palm.
6) *Mechatronics*, by Centinkunt.

Office Hours: Tues/Wed 3:30-4:30pm, or by email to: katiebyl+179d@gmail.com >.

Grading: This is a 4-unit course. Grade weighting is given below.

- Homework (24%). There will be approximately 5-6 homework assignments.
- Laboratory (28%). There will be 7 labs, all involving sensing and control of Lego NXT robots, built by the TA's and programmed by you via MATLAB's Simulink environment. Lab 1 introduces basic concepts and involves only a short pre-lab and write-up. The other 6 labs are broken down into three projects, each lasting two weeks. Each lab will include a short pre-lab assignment. Each project (i.e., after Labs 1,3,5, and 7) will also include a group report. The three laboratory projects are:
  - Beverage-cup pong robot arm control.
  - 3-wheeled omni-directional robot motion planning.
  - Balancing "Segway-style" inverted pendulum.
- Midterm (20%). The midterm will occur during the usual time and place for lectures. Tentatively, it is scheduled for **Tuesday, May 8**.
  You are allow one (1) single-sided sheet of notes for the midterm exam.
- Final Exam (28%). The final exam has been scheduled by the registrar for:
  - **Tuesday, June 12, 4-7pm**, in Phelps 2516.

  You are allowed two (2) single-sided sheets of notes for the final exam.

Video: Video of lectures from "Robot Dynamics and Control" in Spring 2011 will be available on the "Lecture Materials" page of the course website. Lectures will not

be identical this year and are intended only as a resource for rare times when you must miss lecture.

Topics and Schedule (subject to some revision throughout the quarter):

Week	Lab	Lecture Topic	Reading	Other
1	1 (Tuesday 4/3 – Monday 4/9)	L1. Introduction. Robot terminology and geometry. Kinematics and feasibility.	Spong: Ch.1-3 (skim only)	
		L2. Work: force and displacement (review). Mechanical impedance.	Spong: pp. 325-328	
2	2 (Tuesday 4/10 – Monday 4/16)	L3. Model elements: DC motors, nonlinearities (e.g., friction), transmissions, digital effects	Spong: 6.1-6.2, 6.5	
		L4. Single-input single-output (SISO) control, pt I: PD and PID, tuning controllers on real-world systems.	Spong: 6.3 Handout L4	
3	3 (etc…)	L5. SISO control, pt II: Feedforward. Brief overview of state space.	Spong: 6.4	
		L6. The Jacobian, pt I: Virtual work; Jacobians in the force domain.	Spong: 4.10 *Handout L6*	
4	4	L7. The Jacobian, pt. II: Matrix velocity kinematics.	Spong Ch. 4	
		L8. Wheeled-vehicle dynamics, pt I: Kinematic constraints; mobility, steerability, maneuverability; wheel types.	*Handout L8*	
5	-	L9. Wheeled-vehicle dynamics, pt II: Holonomic vs. Nonholonomic constraints.	Spong 7.1, 10.5	
		L10. Review for Midterm.	-	
6	5	[L11. No "Lecture 11". This is the Midterm.]	-	**Midterm (May 8)**
		L12. The Lagrangian, pt I: Kinetic co-energy and potential energy; deriving equations of motion (EOMs)	Spong 7.2-7.3	
7	6	L13. The Lagrangian, pt II: Relative vs absolute coordinates; generalized fores; loss terms.	Spong 7.1-7.3	
		L14. State space, pt I: "Segway" robot Lagrangian, EOMs.	Spong 6.6	
8	-	L15. State space, pt II: Controllability and LQR.	(Spong 6.6)	
		L16. Multi-input multi-output (MIMO) control: Controllability, Observability. MATLAB examples.	Spong 8.1-8.3 *Handout L16*	
9	7	L17. MIMO control, pt II: Inner/outer loop control; inverse dynamics (aka "computed torque")	Spong 9.1-9.3.2 *Handout L17*	
		L18. Task space (Cartesian) dynamics and control; force control; impedance control.	Spong 9.3.2-9.3.3 *Handout L18*	
10	-	L19. Hybrid position/force control. Feedback linearization.	Spong 10.2 *Handout L19*	
		L20. Underactuated systems; locomotion; partial feedback linearization (PFL).	*Handout L20*	
Finals Week				**Final Exam (June 12, 4-7pm)**

Note: Labs for "Week N" will occur on Thursday and/or Friday of Week N, plus Monday of "Week N+1".