Robot Dynamics and Control - Syllabus

Instructors:

Lecture:	Prof. Katie Byl (lecturer)	katiebyl+179d@gmail.com
Lab:	Chris Steward (TA)	steward@umail.ucsb.edu
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Corequisites: ECE 130A (or equivalent) or ME 155A (or equivalent).

Website: http://www.ece.ucsb.edu/courses/ECE179/179D_F12Byl/index.html

Lecture: 2-3:15pm Tues. and Thurs., in **Phelps 1260. (Note the change of room!!)**

Lab: 3-hour session, 6 times during term. **Lab section schedule 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.

Office Hours: Mon/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 (25%). There are expected to be 6 homework assignments. Only your top 5 of 6 homework grades will count. (Lowest homework grade is dropped.)
- Laboratory (25%). There are 6 labs, covering 3 project topics. Equal weight will be given to each of 3 prelabs (to be done individually) and 3 short lab reports (to be done in groups). Only your top 5 of 6 lab grades will count. (Lowest lab grade is dropped.)
  Note: Labs involve sensing and control of Lego NXT robots, built by the TA and programmed by you via MATLAB's Simulink environment. The three projects are:
  - "Beverage-cup pong" robot arm control (Labs 1 and 2)
  - 3-wheeled omni-directional robot motion planning (Labs 3 and 4)
  - Balancing "Segway-style" inverted pendulum (Labs 5 and 6)
- Midterm (20%). The midterm will occur during the usual time and place for lectures. Tentatively, it is scheduled for **Tuesday, November 6**.
  You are allow one (1) single-sided sheet of self-prepared notes for the midterm exam.
- Final Exam (30%). The final exam has been scheduled by the registrar for:
  - **Tuesday, December 11, 4-7pm**, in Girvetz 2120.

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

Video: We hope to video tape lecture and make links available. Video of lectures from the Spring 2011 will be available instead, if this is not practical to update video this term.

Lecture 4 and 5 Rescheduling. Prof. Byl will be traveling Oct. 6-11. Lectures for Oct. 9 and 11 will be rescheduled, tentatively for Oct. 12 (e.g., during the normal, weekly lab period).

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

Week	Lab	Lecture Topic	Reading	Other / Due dates
1	-	-		Lab to be scheduled first week of class.
		L1. (Sep. 27) Introduction. Robot terminology and geometry. Kinematics and feasibility.	Spong: Ch.1-3 (skim only)	
2	-	L2. (Oct. 2) Work: force and displacement (review). Mechanical impedance.	Spong: pp. 325-328	Prelab 1 due Oct. 5.
		L3. (Oct. 4) Model elements: DC motors, nonlinearities (e.g., friction), transmissions.	Spong: 6.1-6.2, 6.5	
3	1 (Oct. 8)	L4. (Oct. 12) Single-input single-output (SISO) control, pt I: PD and PID, tuning controllers on real-world systems.	Spong: 6.3 *Handout L4*	MAKE-UP DATE! Lect. 4 and 5 are Oct. 12, in 3120 HFH, time TBD. HW 1 due Oct. 10.
		L5. (Oct. 12) SISO control, pt II: Feedforward. Brief overview of state space.	Spong: 6.4	
4	-	L6. (Oct. 16) The Jacobian, pt I: Virtual work; Jacobians in the force domain.	Spong: 4.10 *Handout L6*	
		L7. (Oct. 18) The Jacobian, pt. II: Matrix velocity kinematics.	Spong Ch. 4	
5	2 (Oct. 22)	L8. (Oct. 23) Wheeled-vehicle dynamics, pt I: Kinematic constraints; mobility, steerability, maneuverability; wheel types.	*Handout L8*	HW 2 due Oct. 22. Prelab 3 due Oct. 26.
		L9. (Oct. 25) Wheeled-vehicle dynamics, pt II: Holonomic vs. Nonholonomic constraints.	Spong 7.1, 10.5	
6	3 (Oct. 29)	L10. (Oct. 30) The Lagrangian, pt I: Kinetic co-energy and potential energy; deriving equations of motion (EOMs)	Spong 7.2-7.3	Lab 2 due Oct. 29. HW 3 due Nov. 2.
		L11. (Nov. 1) The Lagrangian, pt II: Relative vs absolute coordinates; generalized forces; loss terms.	Spong 7.1-7.3	
7	4 (Nov. 5)	[No lecture: Nov. 6 is the Midterm, in class.]	-	**Midterm (Nov. 6)**
		L12. (Nov. 8) State space, pt I: "Segway" robot Lagrangian, EOMs.	Spong 6.6	
8	-	L13. (Nov. 13) State space, pt II: Controllability and LQR.	(Spong 6.6)	Lab 4 due Nov. 13. Prelab 5, Nov. 16.
		L14. (Nov. 15) Multi-input multi-output (MIMO) control: Controllability, Observability. MATLAB examples.	Spong 8.1-8.3 *Handout L14*	
9	5 (Nov. 19)	L15. (Nov. 20) MIMO control, pt II: Inner/outer loop control; inverse dyn. (aka "computed torque")	Spong 9.1-9.3.2 *Handout L15*	HW 4 due Nov. 19.
		NO CLASS (Thanksgiving)		
10	6 (Nov. 26)	L16. (Nov. 27) Task space (Cartesian) dynamics and control; force control; impedance control.	Spong 9.3.2-9.3.3 *Handout L16*	HW 5 due Nov. 28.
		L17. (Nov. 29) Hybrid position/force control. Feedback linearization.	Spong 10.2 *Handout L17*	
11	-	L18. Underactuated systems; locomotion; partial feedback linearization (PFL).	*Handout L18*	Lab 6 due Dec. 3. HW 6 due Dec. 6.
		L19. REVIEW		
Finals Week		**Final Exam (Dec. 11, 4-7pm)**		**Final Exam (Dec. 11, 4-7pm)**

Note: Dates for labs are Monday, but exact dates for each lab may change somewhat, compared with above.