AEM8423: Convex Optimization Methods in Control

Instructor:
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Office Hours: M 3:45-4:45pm, W 10:10-11am

Course Information:
Lectures: MW 2:30pm - 3:45pm in 13 Rapson (3 Credits)
Webpage: https://www.aem.umn.edu/courses/aem8423/fall2014/
University Policy Statements: http://www.aem.umn.edu/teaching/syllabi.shtml
Prerequisites: AEM5321, EE5231, or instructor consent

Course Description:
Convex optimization plays a central role in the numerical solution of many design and analysis problems in control theory. This course focuses on the practical aspects of using convex optimization methods to solve these problems. Convex optimization plays a central role in the numerical solution of many design and analysis problems in control theory. This course focuses on the practical aspects of using convex optimization methods to solve these problems.

Homework:
Homeworks will be assigned approximately once every two weeks. They will be due at the beginning of class. You are encouraged to collaborate with others in the course, but you should only hand in your own work, i.e. no direct copying. Extensions will be granted if requested at least several days in advance. Otherwise late homeworks without such prior approval will be assessed a 50% penalty.

Final Project:
A report (6 pages or less) is due on the final lecture. You should apply convex optimization methods to an analysis or synthesis problem for a physical system. Alternatively, you can tackle an open theoretical problem related to convex optimization and control theory. More details will be given later in the semester.

Scholastic Dishonesty:
Cheating, whether it is on your problem sets or exams, is absolutely unacceptable. Please refer to the Student Conduct Code at:
http://regents.umn.edu/sites/regents.umn.edu/files/policies/Student_Conduct_Code.pdf

Grading:
Letter grades for the course will be assigned using the following scale:

A	90.0 - 100
B	80.0 - 89.9
C	70.0 - 79.9
D	60.0 - 69.9
F	below 60.0

This is only a rough scale. This scale may be adjusted depending on the performance of the class. Any adjustments to the scale will only lower the cut-offs to achieve a specified grade; cut-offs will not be raised beyond those listed here. Grades will be weighted as follows: Homeworks 70% and Final Project 30%. There will be no exams in this course. Students can check their posted grades at: http://www.aem.umn.edu/srs

Course Outline:

1. **Essentials of Convex Optimization**: Linear algebra review, convex sets, convex functions, convex optimization, duality, unconstrained optimization, available software.
   Reference: Convex Optimization by Boyd and Vandenberghe
   (http://www.stanford.edu/~boyd/cvxbook/)

2. **Nominal Analysis and Synthesis:** Lyapunov inequality, Bounded Real Lemma, H_∞ synthesis, H_2 synthesis, Linear Parameter Varying Systems
   Reference: Linear Matrix Inequalities in System and Control Theory by Boyd, El Ghaoui, Feron, and Balakrishnan (http://www.stanford.edu/~boyd/lmibook/)

3. **Robust Analysis and Synthesis:** Quadratic stability, Multiplier methods, Integral Quadratic Constraints.
   Reference: Linear Matrix Inequalities in System and Control Theory by Boyd, El Ghaoui, Feron, and Balakrishnan (http://www.stanford.edu/~boyd/lmibook/)

4. **Nonlinear Analysis with Sums-of-Squares:** Gram Matrix Representation, Region of Attraction Analysis, Input/Output gain analysis.
   Reference: Structured Semidefinite Programs and Semialgebraic Geometry Methods in Robustness and Optimization by Parrilo (Ph.D. Thesis, California Institute of Technology May 2000).
   (http://www.mit.edu/~parrilo/pubs/index.html)

5. **Miscellaneous Topics:** Time Permitting

Disclosure Statement:
Prof. Peter Seiler is a consultant for MUSYN, a company that produces some of the design and analysis software for automatic control systems taught in this class.