Loyola University Chicago, Spring 2013

Special Topics in Mathematics

Nonlinear Systems and Elements of Control

General course information:

- lecture and discussion time and place: Monday, Wednesday, Friday 9:20 am - 10:10 am, Cuneo 003
- textbook: none, various texts will be on reserve at the library
- prerequisites: Math 212: Linear Algebra, Math 264: Ordinary Differential Equations
- webpage: *www.math.luc.edu/∼rgoebel1/Spring13Math388*
- final exam: Saturday, May 4th, 1:00 - 3:00 pm

Instructor information:

- name: Rafal Goebel
- contact: email rgoebel1@luc.edu (preferred) or office phone 773 508 7541
- office: Loyola Hall 202

- office hours: check the course webpage

Course description and content: A majority of systems encountered in biology, chemistry, economics, engineering, etc. evolve over time and can be described and then studied using differential equations. Some of such systems can be controlled, for example by eliminating a number of predators in a predator-prey system or by firing rocket engines in a mechanical system involving a satellite. While some arising differential equations and control systems are linear, which means, for example, that doubling the voltage in a simple electrical circuit may double the current, a great variety of systems leads to nonlinear differential equations and nonlinear control systems. The nonlinearity is displayed, for example, when doubling the initial investment does not double the eventual profit, or when your car accelerates only so much no matter how hard you press on the gas pedal.

This course will present the basic theory and several applications of nonlinear differential equations. Elements of control theory will be included. Linear differential equations, in 2 or more variables, will be studied to some extent and then used to approximate nonlinear differential equations. Asymptotic behavior of solutions to differential equations and control systems will be carefully analyzed, as motivated by the need to predict long-term behavior of economic systems or ensure stability of a mechanical system. To this end, Lyapunov functions, invariance principles, and other design tools used by control engineers, will be used. The lectures will be loosely based on the first several chapters of the textbook "Nonlinear Systems" by Hassan Khalil but other supplementary material will be used as well.

Grading scheme: The course grade will be based on the number of points. The maximum number of points is 100. The grade of A is guaranteed for 95 points or more. The grade of C- is guaranteed for 70 points or more. Points can be accumulated in the following way: homework 40 pts, midterms 30 pts, final exam 30 pts.

Homework: Regular homework assignments will be assigned and collected, with some variation between 388 and 488 students. The lowest homework score will be dropped.

Collaboration on homework is allowed, and in fact encouraged. Talk about homework to your classmates, work on the problems together, form study groups. However, your final solution and answer should be your own.

Midterms: There will be 2 midterms, the dates of which will be decided soon. Each midterm will be about 49 minutes long. Problems on the midterms will be similar to the sample midterm problems, which will be provided in the days before the midterms. Midterms are closed-book, but one letter-sized, one-sided sheet of handwritten (by you) notes is allowed. Collaboration is not allowed.

Final: There will be one final exam, on Saturday, May 4th, 1:00 - 3:00 pm. It will cover all of the course material. Problems on the final will be similar to the sample final problems solved in the review lectures before the final exam. Final is closed-book, but one letter-sized, double-sided sheet of handwritten (by you) notes is allowed. Collaboration is not allowed.

Missing quizzes or exams: Usually, only religious holidays, official Loyola athletic activities, and well-documented emergencies are basis for a make-up exam or late turn-in of homework. In general, the sooner you notify the instructor about a conflict with an exam, the better. Missing an exam without prior notification and without a well-documented emergency or other extenuating circumstances will result in a score of 0.

Academic integrity: All work performed during quizzes and final exam must be your own work. Cheating may result in a grade of "F" and notification of the appropriate dean. Cheating during quizzes, midterms, and the final includes, but is not limited to: copying another person's work, allowing another person to copy your work, collaborating with another person, using unauthorized references, etc. Remember though: collaboration on homework assignments is OK, and in fact is encouraged.