Math 150 Nonlinear Dynamics and Chaos Fall 2009
Course Information

BLOCK: C (TuWF 9:30–10:20)
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PREREQUISITES: Math 38 or consent.

TEXT: Steven H. Strogatz, Nonlinear Dynamics and Chaos, Westview Press

COURSE DESCRIPTION: Math 150 is primarily a course on ordinary differential equations, with emphasis on qualitative, geometric aspects of the subject; however, there is also some material on iterated maps — that is, on dynamical systems in which time ticks discretely instead of flowing continuously. Applications in physics, biology, chemistry, and engineering will be discussed in detail.

We will discuss coupled systems of n differential equations describing n quantities $x_i(t)$, $i = 1, ..., n$. (Here t is time and $x_i(t)$ is a real number.) Following the book, the course has three parts: $n = 1$, $n = 2$, and $n > 2$.

Even the case $n = 1$ has very interesting aspects. We will discuss bifurcations in a single differential equation for a single time-dependent unknown quantity, with applications to lasers, the motion of a bead on a rotating hoop immersed in molasses (we have to immerse it in molasses in part 1, otherwise $n = 2$ for this problem), insect outbreaks, and the simplest mathematical caricature of excitable (nerve and muscle) cells.

Systems with $n = 2$ allow oscillatory behavior. (Systems with $n = 1$ do not.) We will study the classification of fixed points, phase portraits, limit cycles (that is, persistent oscillations), and bifurcations in two dimensions. There is an abundance of applications of these subjects: the pendulum (first without drive, then the driven pendulum), predator and prey populations, oscillating chemical reactions, nerve cells, and the bead on the hoop without the molasses.

Systems with $n > 2$ allow "chaos". We will study the famous Lorenz equations (one of the first systems of differential equations in which chaotic behavior was discovered), chaos in iterated one-dimensional maps, fractals, and strange attractors.

This course is suitable for upper level undergraduate and beginning graduate students from Mathematics, Engineering, Biology, Chemistry, and Physics.