Delay Differential Equations in Life Sciences

APM 598 # 92820 Fall, 2018 3 credits
Time: 12:00-1:15pm, TTH Location: Tempe STAUF A317

Instructor: Yang Kuang (5-6915) WXLR A 429, Office hours: T, W, Th, 1:30-2:30pm
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Textbook:
1. Y. Kuang, 1993. Delay Differential Equations with Applications in population Dynamics, Academic Press.
2. H. L. Smith, 2011. An introduction to delay differential equations with applications to the life sciences. Texts in Applied Mathematics. Springer.

Grade: Based on i) 4 assignments, or ii) 2 assignments plus one project that involves model formulation, mathematical analysis and computer simulation.
Prerequisites: A basic understanding of ODEs, or the consent of the instructor.

Topics: Ordinary and partial differential equations models have played dominant roles in the modeling of natural and life science problems. However, they are only the first approximations of the real systems. Realistic models often include some of the past states of the systems. In other words, real systems should be modeled by differential systems with time delays.

Does small delay matter? The following simple example shows it does. We all know that the trivial solution of the following ODE is asymptotically stable.
$x'(t)+2x'(t)=-x(t)$
However, we will see in the first lecture of this course that the trivial solution of
$x'(t)+2x'(t-T)=-x(t)$
is unstable for any (no matter how small) positive delay T.

In this course, we will systematically study the qualitative (through mathematical analysis) and quantitative (through MATLAB simulations) theories of delay differential equations (DDEs) that are important and essential in applications. We will cover the first three chapters in detail, and time permitting, we will also touch chapter 4, 5, 6. Our focus will be on chapter 2, basic theory of DDEs, and chapter 3, the analysis of characteristic equations in various situations and a couple of case studies in life sciences. Additional material from current literature will be presented. To illustrate the theories, we will discuss various applications to medical (cell, cancer and diabetes models) and population biology models.

An important objective of this applied DDE course is to empower students with the tools to formulate, simulate, validate and perform critical mathematical analysis on appropriate linear and nonlinear delay differential equation models.