Delay Differential Equations in Life Sciences

APM 598 # 91923 Fall, 2021 3 credits
Time: 3:00-4:15pm, MW Location: WXLR A111

Instructor: Yang Kuang (5-6915) WXLR A 429, Office hours: M, 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. ISBN 0124276105.

2. H. L. Smith, 2011. An introduction to delay differential equations with applications to the life sciences. Texts in Applied Mathematics. Springer. ISBN 978-1-4419-7646-8.

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 (DDEs).

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 week 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 DDEs that are important and essential in applications. We will cover the first three chapters of textbook 1 in detail, and time permitting, we will also touch chapter 4, 5, 6 of the textbook 1. Our focus will be on chapter 2, basic theory of DDEs, and chapter 3, the analysis of characteristic equations in various situations. **Many exercises will be selected from textbook 2**. Additional material from literature will be presented. To illustrate the theories, various applications to medical (cell, cancer and diabetes models) and population models (too many to list) will be covered in details.

An important objective of this applied DDE course is to have students familiar with the use of popular programs such as MATLAB and MAPLE. These will be used to simulate DDE models and compute their bifurcation diagrams.