APM 598 (MAT 494): Topics in Applied Mathematics: Dynamics, Computation and Statistics in Biosciences (Spring 2021)

***Lecture Schedules**: Tuesdays and Thursdays 4.30 pm–5:45 pm in WXLR A109*
***Office hours**: Tuesdays and Thursdays 3-4 pm or by appointment (online)*

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Overview: The mathematical modeling of real-life phenomena in the natural, engineering and social sciences often involve having to solve systems of differential equations. These systems are inherently complex. They are typically large and nonlinear, hence their exact solution are difficult (if at all feasible) to obtain. Hence, these systems are studied using a combination of asymptotic analysis (on the associated dynamical systems) and the design of suitable numerical methods to obtain their (approximate) solutions. Furthermore, these systems typically contain numerous parameters, which need to be (realistically) estimated using available data. Issues pertaining to uncertainties in the estimates of such parameters need to be taken into account in the modeling process, in particular determining the impact of such uncertainties on the simulation results obtained. Other related issues, such as determining the parameters that have the most impact on the dynamics of the model system, are also relevant. In other words, the study of realistic models arising from phenomena in the natural, engineering and social sciences generally requires a multi-faceted and multi-disciplinary approach. This course is based on using techniques, tools and theories from applied nonlinear dynamical systems, computational mathematics and statistical sciences (data analytics) to gain qualitative and quantitative insight into dynamical systems arising from the mathematical modeling of real-life phenomena in the aforementioned sciences. Applications in the biological sciences (particularly disease ecology, epidemiology and immunology) will be emphasized**.**

The course will cover diverse topics, such as:

Continuous-time and discrete-time dynamical systems (existence and stability of solutions; bifurcations; chaotic dynamics etc.). **Numerical solutions of differential equations** (special focus on the design of finite-difference numerical methods that are dynamically-consistent with the continuous-time models being discretized). **Mathematical ecology, epidemiology and immunology:** emphasis on the design, analysis and simulations of differential equation models arising from the mathematical modeling of phenomena in ecology, epidemiology and immunology of human diseases. Some of the models that may be discussed include those for the spread and control of emerging and re-emerging diseases, within-host (immunological) dynamics, coupling within- and between-hosts dynamics, assessing the impact of climate change on the spread of vector-borne diseases and social and molecular epidemiology. Specifically, models for the spread and control of the COVID-19 pandemic and selected mosquito-borne diseases (such as malaria, dengue, Zika) will be discussed. Tools and techniques for statistical data analysis, such as model fitting and parameter estimation, will also be discussed.