Course Announcement: Fall 2024

M514 (3 credits)
Topics in Applied Mathematics: Asymptotic Methods (with case studies in Neuroscience, Mathematical Biology, Physics, Pharmacokinetics, Data Analytics and Computational Modeling)

Tuesdays 1:00PM – 3:30PM; Room: Math 211

Instructor: Leonid Kalachev (kalachev@mso.umt.edu, MA309, 243-4373)

Text: All the course materials will be provided by instructor.

The course will be devoted to a detailed treatment of various asymptotic techniques that help to analyze complex models of real-life phenomena. Many such models are formulated in terms of differential equations containing small (or large) numerical parameters. These parameters appear naturally after non-dimensionalization due to the presence of vastly different characteristic time scales, spatial scales, etc., in the original model systems. Complicated models containing small (or large) parameters may be treated as perturbations of some simpler models capturing the behavior of solutions of the original model formulations. The notions of regular and singular perturbations will be introduced, and the algorithms that allow one to construct asymptotic approximations of solutions for various perturbed problems related to applications in **neuroscience**, **chemical and biological kinetics**, **physics**, **pharmacokinetics**, and other applied fields will be discussed. Special attention is going to be devoted to making the right choice of an asymptotic algorithm for a particular applied problem and to justifying the asymptotic correctness of the constructed approximations.

The major portion of the course will address the, so-called, Boundary Function Method that is most naturally used for treating problems of **neuroscience, chemical and biological kinetics**, **pharmacokinetics**, **heat and mass transfer**, etc. Such asymptotic techniques as matching, multiple scales and averaging will also be briefly discussed (if time permits).

It will be shown how the perturbation techniques help in qualitative and quantitative analysis of model solutions, as well as how they assist in **computational modeling** and **appropriate data collection for reliable estimation of model parameters**. The ideas behind a unified approach to dynamic model identification from experimental data and related model reduction techniques will be discussed. A number of **unsolved scientific problems** (suitable for either Master’s or Ph.D. thesis project) in this important area of applied mathematics **will be suggested** to the students interested in the topic. Students are also encouraged to bring their own problems (complex models from various scientific fields that need to be reduced) for the analysis as part of their final project in the course.