MfPH International Collaborative Summer Program in Nonlinear Differential Equations with Applications

Inaugural Lecture: Multi-scale Differential Equations in Mathematical Biology

Speaker: Professor Woldegebriel Assefa Woldegerima

Date: July 29, 2024, at 10:30 AM-11:30 AM
Location: Kinsmen Building, York University: Room # 277

Abstract: Biological and physical systems evolve across different spatial, temporal and size scales. Modeling such complex systems gives rise to multi-scale differential equations that may be written as ODEs, PDEs, DDEs, SDEs, or Difference Equations. One common phenomenon encountered in multi-scale differential equations is the occurrence of singular perturbations. Singular perturbation theory (SPT) provides insights into systems where regular perturbation methods fail due to multiple scales. Theories such as the Tikhonov–Fenichel's Theorem and Geometric Singular Perturbation Theory (GSPT) are powerful tools for analyzing multiple-time-scale systems. This public lecture will introduce the general theory of multi-scale differential equation models with a focus on applications in biomathematics. We will discuss singular perturbation theory, a key mathematical approach to study these complex equations by exploiting the presence of distinct time or spatial scales. Through concrete examples, we will explore the application of SPT to various biological models, including fast–slow versions of the SIR, SIRS, and other epidemiological models, followed by fast-slow ecological models and Michael-Menton type chemical kinetics. Mult-scale models combining within-host and between-host models, Quick dynamics epidemic models, multi-time scale vector-borne models, and the method of multi-scale techniques for general nonautonomous system. A brief of some potential research areas of muti-scale differential equations, and the use of machine learning in multi-scale modeling.

The Speaker:

Woldegebriel Assefa Woldegerima,

wassefaw@yorku.ca

The speaker is the Associated Director of the Laboratory for Industrial and Applied Mathematics and an Assistant Professor, Dept. of Math & Statistics, York University. His research has been funded by both CIHR and NSERC. His research interest and expertise includes Within-host immunopathogenesis modeling, Multi-scale modeling, Disease modeling, Applied differential equations, AI/ML in health epidemiology, and solving ODEs using neural networks. Professor Woldegerima received his Postdoc training at M3B2 Lab, University of Pretoria, supervision of Prof. Jacek Bansiak & Rachid Ouifki. His PhD thesis was supervised by Profs. Gideon Ngwa & Miranda Teboh-Ewungkem