MATH 6115 Mathematical Epidemiology

Course instructors
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Course description This course will cover different formulations and analyses of epidemiological models. Topics include host heterogeneity, multiple pathogens, spatial spread, within-host dynamics, and zoonotic spillover.

Prerequisites. Students should have completed undergraduate courses in dynamical systems and modelling.

Textbook: Modelling Infectious Diseases in Humans and Animals by Matt Keeling and Pejman Rohani (K&R) (available as a .pdf from the MUN library).

Rationale: This course will cover the different types of epidemiological models so that students understand the scope of options when modelling infectious diseases. Students will learn the assumptions of the different model formulations (the models are autonomous and non-autonomous, delay, and integro- differential equations, partial differential equations, and branching processes) and mathematical approximations that simplify computationally complex specifications (i.e., Gillespie's Direct Algorithm, moment equations, master equations, separation of time scales, commuter approximations). Students will analyze the models to understand their temporal dynamics (i.e., disease-free equilibrium stability as determined by the net reproduction number, dynamic resonance, bifurcation diagrams, numerical solutions), how the temporal dynamics depend on the biological assumptions, and how to interpret models to answer public health questions.

Format: The course will be part of the Atlantic Association for Research in the Mathematical Sciences (AARMS) summer school in 2023. This summer school has run every summer (aside from during the COVID-19 pandemic) and offers graduate mathematics courses for credit.

The course will take place at Bonne Bay Marine Station, August 19-31. This is a compressed schedule (i.e., 3.5 hours of instruction x 10 days = 35 hours total) relative to typical length of the AARMS summer school, but the course format meets the requirement of at least 30 hours of instructions (specified by AARMS director Sanjeev Seahara). A regular semester is 50 mins x 13 weeks x 3 / week = 32.5 hours.

To help students focus given the instructional intensity, we will teach using combinations of 15 x 1 hr lectures, 8 x1 hr math and/or computer analysis problem sets (similar to computer labs), guest lectures, and guided work on student projects (10 hrs). The decision to have students work on projects is to capitalize on the venue where students will reside on site in close proximity, having come from across Canada and sharing similar interests, such that students can complete projects that are novel and ground-breaking.

Grading: Assignments (40%), Project (60%)

Course outline

[1] Simple Epidemiological Models (Ch 2 K&R)

[2] Host Heterogeneity (Ch 3 K&R)

[3] Multipathogen/Multihost (Ch 4 K&R)

[4] Pathogen evolution

[5] Temporally-forced models (Ch 5 K&R)

[6] Within-host dynamics

[7] Stochastic dynamics (Ch 6 K&R)

[8] Spatial models (Ch 7 K&R)

[9] Modelling importations

[10] Zoonotic spillover

[11] Controlling Infectious Disease (Ch 8 K&R)