SFU

Mathematical Epidemiology

MATH 496/796

Instructor Info

Ailene MacPherson

Office Hrs: Tu&Fr 12:30-1:30

SCK9523

ailenem@sfu.ca

Course Info

https://amacp.github.io/Math496/

Prerequisite: MATH310

Recommended: MATH316

Tu 10:30–12:20 (AQ 5025)

Fr 10:30–11:20 (AQ 5047)

Overview

A survey of contemporary methods and applications of mathematical models of infectious disease. As a rapidly changing field, this course will focus on understanding, analyzing, and applying the recent scientific literature.

Learning Objectives

- Develop an understanding of the theory and implementation of fundamental methods in mathematical epidemiology.
- Understand the organizing principals and theoretical approaches in disease ecology, evolution, and genomic epidemiology.
- Learn to apply mathematical and statistical methods to contemporary scientific questions.
- Engage with the scientific literature through the reading, interpretation, and analysis of peer-reviewed articles.
- Gain skills in scientific writing, this involves the formulation and communication of perspectives and the expression scientific findings in a clear and concise manner.

Required Text

Keeling, M.J., Rohani, P., *Modeling Infectious Diseases In Humans and Animals*. Princeton University Press. 2008. ISBN-13: 978-0-11617-4 (KR8)

Additional Helpful References:

- Foppa, I.M., *A Historical Introduction to Mathematical Modeling of Infectious Diseases: Seminal Papers in Epidemiology*. 2016. ISBN: 0128022604
- Dieckmann et al. *Adaptive Dynamics of Infectious Diseases: In Pursuit of Virulence Management*. 2002. ISBN: 9780511525728

Grading Scheme

	Math 496	Math 796
Challenge Questions	20%	20%
Written assignments $\times 6$	30% (5% each)	30% (5% each)
Project Proposal (2 drafts)	20% (10% each)	10% (5% each)
Final Project	30%	20%
Computer Lab $\times 4$	Optional	20% (5% each)

Math 796:
Graduate students enrolled in Math 796 will be required to complete computer labs covering the application of core course material. Math 796 are also required to include an additional literature review with each written assignment.

Challenge Questions

Each lecture will pose one or more challenge questions related to the lecture material. Complete one or more challenge questions to receive credit. Questions are graded by completion. You are strongly encouraged to collaborate on completing these.

FAQs

How do I read a journal article?

First its okay that its hard! No one method works for everyone. This is what I do: Skip the *Abstract* (too intimidating!). Read the *Introduction*, understand the *Figures* and skim the *Results*, then read the discussion. Finally, go back and read the *Methods*.

How do I get started with my writing assignment?

1) Write a rough outline that is centered around a thesis statement. 2) Add details to your outline. 3) Translate your outline into full sentences and paragraphs. Hint: Write an "Introduction" backwards, start with the thesis statement and then write an intro that exemplifies the relevance of this thesis.

How do I pick a project?

Start in one of two ways: 1) start with a question, 2) start with a system (aka epidemic). Then read, read, read! Be creative, there is no right answer but there are justifiable answers.

Why are there no proofs in this class?

This course samples methods from an extraordinarily wide range of fields: math, biology, public health, stats, and computer science. The focus of our work will be on finding the best approaches (regardless of field) to answer real-world questions rather than on understanding every detail of each and every method.

Written Assignments

Length Requirement: 2pg max

Section	Description	Grade (796)
Introduction	Provides background and mathematical and biological context. Include a thesis statement (e.g., "Here I argue...", "This critical analysis concludes...").	30% (30%)
Article Summary	Explain what the paper did and why. Explain what was found	30% (10%)
Analysis	A written summary of your analysis of the model design, the validity and robustness of the results, and accuracy of the inferences drawn.	40% (40%)
References	Reference list of additional literature	NA (20%)

Project Proposal

Length Requirement: 4pg max, $\geq$1 figure

Section	Description	Grade
Introduction	Provides context, and relevance for the proposed thesis. Must include a thesis statement (e.g., "I will examine...", "This works will...").	40%
Methods	Summarize what methods you will use. Why are they appropriate? What challenges do you foresee?	30%
Figure	Supports the content of the introduction and/or methods	20%
References	Reference list of additional literature	10%

Final Project

Length Requirement: 10pg max, $\geq$1 figure

Section	Description	Grade
Abstract	A short summary (200 word max) of the project that clearly states aims and focal conclusions.	5%
Introduction	Provides background, context, and motivation. Must include a thesis statement (e.g., "This works evaluates...").	20%
Methods & Results	Summarize what methods you used. Why are these methods were appropriate. Explain what you found.	30%
Discussion	What are the implications of what you found? What are the limitations of your work?	30%
Figure & Tables	Figure(s) that support(s) the content of the methods or results	10%
References	Reference list of additional literature	5%

Diversity and Inclusivity Statement

In this course you will treat others and be treated with respect. We welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, orientations, national origins, abilities, and other visible and non-visible differences. All members of this course are expected to contribute respectfully and in return each contribution will be appreciated and treated with respect.

Academic Integrity

“All members of the university are expected to uphold the values of academic integrity: honesty, trust, fairness, respect, responsibility, and courage. SFU considers any act of falsification, misrepresentation or deception to be destructive because it is unfair to students who pursue their studies honestly, it compromises the worth of other’s work, and ultimately prevents students from meaningfully reaching their own scholarly potential.

Being an SFU student means you belong to a scholarly community where you will develop the critical thinking and research skills to not only be job ready but life ready. The satisfaction of a degree earned through hard work and persistence is a prize that is profoundly meaningful and universally respected.” https://www.sfu.ca/students/academicintegrity.html

Class Schedule

MODULE 1: Mathematical Modelling in Epidemiology

week	topic	references	assignments
Week 1: Jan 10	1. Course Intro		
	2.Basic Compartmental Models	KR8: 2.1-2.5	
	3. Distributed delays [integro-differential equ.]	KR8: 3.3, Gonçalves et al. 2011	
Week 2: Jan 17	4. Transmission heterogenities [Age and Risk]	KR8: 3.1-3.2, Kribs-Zaleta 1999	Lab 1
	5. Spatial Models [household & meta-population]	KR8: 7.1.Pellis et al. 2012	Assign. 1
Week 3: Jan 24	Stochastic Epidemic Models	KR8: 6.3-6.6, Finkenstädt 2002	Lab 2
	Network Models [pair approximation, cellular automata, ABC]	KR8: 7.3-7.6, 7.8, Volz & Meyers 2009, Groendyke et al. 2011	Assign. 2
Week 4: Jan 31	Model parameterization [R_e, R_0 estimation, serial interval estimation]	KR8: 2.8 Gostic et al. 2020	
	Model parameterization [seroprevealence, time-series]	KR8: 2.8, Lernout et al. 2019	Assing. 3
Week 5: Feb 7	Model uncertainty, adequacy, and selection [sensitivity analyses]		
	Prediction and Forecasting	Held et al. 2017	Lab 3
Week 6: Feb 14	Interventions 1 [NPIs, contact tracing]	KR8: 8.2	
	Interventions 2 [Vaccines]	KR8: 8.1	Draft 1

MODULE 2: Disease Ecology and Evolution

week	topic	references	assignments
Week 7: Feb 21	Reading Week		
Week 8: Feb 28	Disease Ecology 1 [multi-host, vector transmission, zoonses]	KR8: 4.2	
	Disease ecology 2 [Multi-pathogen co-infection, super-infection]	KR8: 4.1	Assign. 4
Week 9: March 7	Disease Ecology 3 [Abiotic conditions, Biological control]	KR8: 5.2,5.3	

	Evolutionary-epidemiology 1 [evolution of epidemiological traits]		Draft 2
Week 10: March 14	Evolutionary-epidemiology 2 [vaccine and antibiotic resistance]		Lab 4
	Evolutionary-epidemiology 3 [emergence of infectious disease]	KR8: 4.2.3	Assign. 5

MODULE 3: Genomic Epidemiology

week	topic	references	assignments
Week 11: March 21	Fundamentals of Genomics and Phylogenetics		
	Transmission chains		
Week 12: March 28	Phylodynamics		Lab 5
	Phylogeography		Assign. 6

MODULE 4: Within-host Models

week	topic	references	assignments
Week 13: April 4	Within-host models		Lab 6
	Immunology and Original Antigenic Sin		
TBD	Project Due		