

Syllabus for MATH 361-101 2024W1

Introduction to Mathematical Biology

Course description

This course provides an introduction to mathematical modelling with a specific focus on questions in biology. We will focus on models of biological systems and their analysis using various tools including dimensional analysis and non-dimensionalization, stability analysis, bifurcation theory, multiple time scale analysis, and various computational methods (using Matlab or Python, XPPAUT). We'll start with ODE models and their analysis. Later in the course, we will focus on probabilistic and stochastic models, using the latter to derive some simple ODE models to build intuition into what lies behind most deterministic (ODE/PDE) models.

Although no formal background in biology is required, topics from across the life sciences will come up. The focus will be on the mathematics and any biological knowledge needed will be introduced in class.

Course details

- **Lectures:** MWF 2:00-2:50 pm
- **Location:** CHEM C124
- **Instructor:** Prof Eric Cytrynbaum (he/him)
- **Contact:** via Piazza or email to cytryn@math.ubc.ca
- **Office hours:** Monday 3pm (in-person right after class) with a second one TBA based on student availability.

Workload

1. There will be six quizzes throughout the term, roughly every two weeks. I will drop your lowest one.
2. There will be six assignments posted throughout the term. These will be optional. Submitted assignments will be “marked” with feedback but are not for points. Solutions will be posted shortly after the deadlines. It is strongly recommended that you work on all assignment questions BEFORE solutions are posted (whether or not you submit them) because reading solutions is a far less effective method of learning than working things out yourself.
3. Final exam.

Grading scheme:

Quizzes (6)	10 pts each	50 pts
Final exam		50 pts

Missing quizzes, exams, late homework

If you are unable to attend more than one quiz (one can be dropped as described above), you must submit an Academic Concession form by email to me before (preferred) or within two days after (only in the case of emergencies) the quiz date. Provided the concession is granted, your final exam mark will be used in place of the missing quiz mark. Undocumented absence from more than one quiz will result in a score of zero on all but the first missed quiz.

No extensions for the homework will be given.

As always, **DO NOT** make any travel plans for December until the exam schedule is announced (some time in October) as no accommodation will be made for students unable to attend the final exam due to conflicting plans.

Land Acknowledgement

UBC's Point Grey Campus is located on the traditional, ancestral, and unceded territory of the x^wməθk^wəyəm (Musqueam). The land it is situated on has always been a place of learning for the Musqueam people, who for millennia have passed on culture, history, and traditions from one generation to the next.

If you would like to know more about the joint history of UBC and Musqueam, one place to start is at UBC's Indigenous Portal.

Schedule

The schedule below will be revised as the term progresses. The topics will not change much but we will likely cover them more slowly than predicted here.

Week	Dates	Topics (some topics may move forward or backward a day or so)
1	Sep 4-6	Introduction. One-variable ODE models and phase lines: logistic growth with harvesting, lac operon; non-dimensionalization, stability, bistability.
2	Sep 9-11-13	Bifurcation diagrams, bifurcations - fold/saddle-node. Two-variable ODE models and phase planes: Lotka-Volterra Competition model; linearization and classification of steady states, Trace-Determinant plane, bifurcations - transcritical, degeneracy and unfolding. Predator-Prey model.
	Sep 13	Assignment 1 due
3	Sep 16-18-20	Epidemiology models (SIS, SIR, with vaccination), R_0 , final size estimates, evolution of virulence.
	Sep 20	Quiz 1 (on material up to and including whatever is covered on Sep 13 which may differ from the planned list on this table)
4	Sep 23-25-27	Introduction to XPPAUT. Cell responses to signals, Michaelis-Menten kinetics.
	Sep 27	Assignment 2 due
	Sep 30	No class today - National Day for Truth and Reconciliation
5	Oct 2-4	Multiple time scale analysis, quasi-steady states and slow/fast manifolds.
	Oct 4	Quiz 2 (on material up to Sep 27)
6	Oct 7-9-11	Modelling insulin, glucose, and diabetes.
	Oct 11	Assignment 3 due
	Oct 14	No class today - Thanksgiving
7	Oct 16-18	Hardy-Weinberg population genetics without/with selection (discrete and continuous).
	Oct 18	Quiz 3 (on material up to Oct 11)
8	Oct 21-23-25	Electrophysiology - The Hodgkin-Huxley model, the FitzHugh-Nagumo model.
	Oct 25	Assignment 4 due
9	Oct 28-30-Nov 1	Periodic solutions and the Hopf bifurcation.
	Nov 1	Quiz 4 (on material up to Oct 25)
10	Nov 4-6-8	Basic probability definitions. Discrete random variables: Bernoulli, Binomial, Poisson. Sampling from a discrete distribution (ITS).
	Nov 8	Assignment 5 due
	Nov 11	No class today - Remembrance Day
11	Nov 13-15	Continuous random variables: Exponential, Gamma, Normal. Stochastic process. Poisson process and exponentially distributed times. Sampling from a continuous distribution (ITS and PIT). Kolmogorov Forward Equation (KFE) for Dr. Banner \leftrightarrow Hulk reaction.
	Nov 15	Quiz 5 (on material up to Nov 8)
12	Nov 18-20-22	KFE for bacterial replication. From KFE to (expected value) ODE.
	Nov 22	Assignment 6 due
13	Nov 25-27-29	Stochastic epidemiology model. Simulating ODE. Simulating hybrid ODE/stochastic models.
	Nov 29	Quiz 6 (on material up to Nov 22)
14	Dec 2-4-6	TBA