MATH 361 101 Introduction to Mathematical Biology

Instructor: Prof. Yue-Xian Li

Office location and hours: Math Annex 1202, MWF 12:30 - 1:30 pm.

Email: Please email me through the Canvas mailing system. This helps me keep your messages organized and allows me to prioritize answering them.

Course Description: Mathematical modelling of basic biological processes in ecology, physiology, neuroscience and genetics. Dynamic behaviour of difference equations, differential equations, and partial differential equations, explained with reference to concrete biological examples. [3-0-0]

Mathematical Biology has developed into a broad area of research that includes numerous subareas and disciplines. Besides skills in model construction, the present course is focused at introducing some basic concepts in the study of the formation of some biological patterns ubiquitously observed in nature. An introductory level of mathematical and computational skills required in the analysis of pattern formation in linear and nonlinear dynamical systems will be introduced. Examples covered range from molecular biology, cell biology, physiology to ecology and evolutionary biology.

Prerequisite: One of Biol 301, Math 215, Math 255, Math 256, math 265 or any equivalent course. This implies that a student must have taken differential and integral calculus courses (i.e. Math 100 and 101 or equivalents).

Rules for assignments and exams:

- Missing or late homework assignment receives a grade of 0.
- Missing a test/exam results in a grade of 0.
- To claim legitimate emergency: Instructor must be notified within 48 hours of missed test. Doctor's or other relevant person's notes must be presented.
- Notes, books, any electronic devices (cell phone, pads, ...) are NOT allowed.
- One single A4-sized formula sheet might be allowed at special permission by instructor.
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Text:

Strogatz, Steven H. "*Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering*", Westview Press, 2nd Edition, 2014.

Preliminary Course Schedule (subject to changes as the course proceeds):

1. Introduction to mathematical biology and pattern formation
    - Brief overview of mathematical biology and modelling.
    - Mathematics of biological pattern formation.
    - Examples of temporal, spatial, and spatio-temporal patterns in biology.
    - Mechanisms governing spontaneous pattern formation.
2. Simple models in discrete time
    - Linear systems: Exponential growth/decay of a single species.
    - Evolution without selection: Hardy-Weinberg Model
    - Evolution with selection.
    - Nonlinear systems: Logistic map. Fixed points and cobwebing. Linear stability.
    - Demography described in age-structured models.
3. Simple models in continuous time
    - Linear systems. Exponential growth/decay of a single species.
    - A model of a simple molecular switch.
    - Nonlinear systems. Logistic model of a single species.
    - Phase space: a geometric way of thinking. Fixed points and linear stability.
    - Bifurcations in one-dimensional nonlinear differential equations.
    - Introduction to XPP and numerical solutions to differential equations.
    - A nonlinear model of spruce budworm population.

4. Models involving two interacting components

- Michaelis-Menten model of enzyme-catalyzed biochemical reactions. Multiple times scales.
- A model for two competing species. Steady states and stability. Phase-plane analysis.
- A model for predator-prey systems. More about XPP.
- A model for enzyme-catalyzed oscillations observed in glycolysis.
- A model for neuronal excitability. More about XPP and AUTO.

(Approximately 36 hours, September 2018)