BIOL 364 Click here to listen to an audio overview of the noteworthy features of this course outline. **atical Modelling in Biology** **Fall Term 2013**

Time and place: MW 11:30-12:20 MC 4060 F 11:30-1:20 QNC 1506/BI 370

Instructor: Dr. Kim Cuddington, B2 241, 888-4567 ext. 33669, e-mail: kcudding@uwaterloo.ca
Instructor office hours: B2 241 Monday 1:30 pm or by appointment

Course description
We will study the process of mathematical modelling in biology using examples from a variety of subdisciplines including ecology, epidemiology, physiology, and genetics.

Prerequisites: Level 3A and one of MATH 127, 137, PHYS 111, 115, or 121

Intended learning outcomes
A student that successfully completes this course should be able to construct and analyze simple, aspatial, deterministic dynamic models with biological content. Specifically, students should be able to:
IDENTIFY good modelling questions that correspond to a given biological question
FORMULATE a mathematical model to simultaneously answer a given question and to aid analysis
ANALYZE mathematical models using a variety of techniques (e.g., phase plane analysis)
SELECT appropriate methods of analysis for a given biological question and model formulation
INTERPRET model predictions to answer a given biological question

The instructor identifies the Intended Learning Outcomes for the course. On the fourth page of this course outline, she links those Intended Learning Outcomes to the in-class exercises and lab exercises.

Course presentation
This course has two lectures each week, and one lab/lecture. Materials will be address different learning styles (e.g., lectures, slides, chalkboard calculations

Audiovisual material: Please note that the slides used in class are just simple visual aids and **do not contain all material covered in lecture**. Some material will be written on the blackboard, some slides are simply questions that are answered by the class discussion, and complex methods and concepts cannot be deduced by looking at slides for a lecture you missed.

Required text: Otto, S. and Day, T. 2007. *A Biologist's Guide to Mathematical Modeling in Ecology and Evolution*. Princeton University Press. ISBN-13: 978-0-691-12344-8 (on reserve)
Additional text: Edelstein-Keshet, L. 2005 (originally 1988). *Mathematical Models in Biology*, reprinted by SIAM under the "classics" editions. ISBN-13: 978-0075549505 (on reserve)
Required lab text: Attaway, S. 2013. *Matlab: A Practical Introduction to Programming and Problem Solving.* Butterworth-Heinemann. ISBN-13: 978-0124058767

Expectation of student commitment to the course
Students are expected to complete all assigned readings and homework before class, and to be prepared to answer questions about these readings and homework.

Student assessment:

Type	**Weight**	**Date**
Assignments (4 @ 5% each)	20%	Friday, Sept 20, Oct 18, Nov 1, & Nov 22, 11:30 am;
Midterm (50 minutes)	20%	Monday, Oct 8 11:30 am
Lab completion	10%	Monday, Dec 2 11:30 am
Final project	25%	Wed, Oct 2, Nov 6, Nov 27, & Mon, Dec 2 11:30 am
Take home final	25%	Monday, Dec 16, 11:30 am

In order to pass the course, in addition to receiving >50% overall, your combined score on the midterm and final must also be greater than 50% (>22.5/45).
There will be no extra credit nor grade curving.

Illness: Assignments, Projects and Midterm

No late assignments or project components will be accepted. No missed midterms will be rescheduled.
If for any reason a student misses an assignment or midterm, **the weight of that assessment will be automatically added to the final exam**. I require no notification, no email, and do not wish to see a verification of illness form. The opportunity to be graded on assignments and midterms is for your benefit, and if you do not wish to take advantage of this, that is totally up to you. However, please note that students who choose to take a 100% final exam are unlikely to pass the course.

In addition, a midterm that you have written and assignments you have submitted will **always be counted toward your final grade**. Note that if you enter the midterm room and sit down in front of an exam paper, you have written the midterm, and it will be counted. Under no circumstances will the grade for a midterm that you have written, or an assignment you have submitted, be discarded, and its weight shifted to the final exam.

Illness: Final exam

Failure to submit a final exam will result in a grade of 0% (F) on the exam unless the a student presents a Verification of Illness Form to the Science Undergraduate Office (ESC 253) that indicates they were SEVERELY incapacitated on 10 days of the exam period. **Mild or moderate incapacitation will not be accepted as a verified absence**. Please note that the Faculty of Science has instituted the policy that only VIFs issued from our campus Health Services will be acceptable documentation, when the service is available. Documentation for the missed examination is required within 48 hours of the missed exam. If the required documentation for a verified illness is not received in the indicated time frames, and no ancillary circumstances pertain, a grade of 0% (F) will be assigned.

In the event of a verified illness, the student will receive a grade of INC. The INC grade will be converted to a numeric grade after and scheduled alternate final exam date (i.e., the make-up exam will not be take home). Please note that **travel plans or work term relocation will not be accepted as an excuse for missing the scheduled alternative final exam**. If the student fails to sit for the scheduled alternative exam a grade of 0% (F) will be assigned.

Student accommodation

The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.

Academic integrity

To create and promote a culture of academic integrity, the behaviour of all members of the University of Waterloo should be based on honesty, trust, fairness, respect and responsibility.

Note on avoidance of academic offences: All students registered in the courses of the Faculty of Science are expected to know what constitutes academic integrity, to avoid committing academic offences, and to take responsibility for their actions. When the commission of an offence is established, disciplinary penalties will be imposed in accord with Policy #71 (Student Discipline). For information on categories of offences and types of penalties, students are directed to consult Policy #71 (http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm).
I recommend a grade of 0% (F) when I have evidence of academic dishonesty.

If you need help in learning what constitutes an academic offence; how to avoid offences such as plagiarism, cheating, and unauthorized resubmission of work; how to follow appropriate rules with respect to “group work” and collaboration; or if you need clarification of aspects of the discipline policy, ask me for guidance. Other resources regarding the discipline policy are your academic advisor and the Undergraduate Associate Dean.

Student grievances and appeals
Students who believe that they have been wrongfully or unjustly penalized have the right to grieve; refer to Policy #70, Student Petitions and Grievances, http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm.

Concerning a decision made under Policy 33 (Ethical Behaviour), Policy 70 (Student Petitions and Grievances) or Policy 71 (Student Discipline), a student may appeal the finding, the penalty, or both. Students who believe that they have grounds for an appeal should refer to Policy 72 (Student Appeals) http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Description of Graded Assessments:

Assignments (20%: 4@5% each): These are written assessments designed to help you evaluate if you have achieved the identified learning objectives. After practicing these skills in class and lab, you will demonstrate your grasp of the material on paper.

Midterm and Take home final (45%): The midterm and final exam are a written assessment of your ability to identify good modelling questions, formulate mathematical models, and perform those analyses we have covered in class. All questions will be short answer. In order to pass the course, your combined score on the midterm and final must be greater than 50%.

Project (25%): The group project will assess your ability to perform all aspects of the modelling cycle. The project grade is divided into smaller components to ensure that you make steady progress on your work throughout the term. In addition, because this is a group work project, your contribution to the group will be evaluated.

Project A (5%): The group will present to class the biological question that they will address in class, and provide a rationale for why they believe the question can be addressed with a mathematical model (oral presentation in class). The research you have done to support your conclusions will be indicated in an annotated bibliography

Project B: (5%): Individually, each group member will submit a written formulation of a mathematical model to address the selected biological question, including the rationale for this choice, suggest an appropriate analysis, and begin the first steps of this analysis

Project C (5%): The group will present to class the model formulation they chose, the analysis they selected, their model predictions and interpretation

Project D (5%): The group will submit a lab report describing their project

Project E (5%): Group members will evaluate their own and other members contributions

Lab completion (10%): To encourage students to keep up with the material, a small portion of your grade will be based on your completion of lab exercises. These exercises in the computer lab may employ Matlab, mathematical software that can aid your calculations and produce informative graphs. Please bear in mind that Matlab is designed to make your efforts at analysis easier, but this course is not about using Matlab. Focus on understanding the mathematical concepts rather than simply entering computer commands and producing pretty figures. Completion of a lab exercise is defined as:

1. attending the lab, and
2. finishing a small online evaluation exercise.

You must attend and complete 10 out of the 11 lab exercises, and you must complete exercise 10 and 12 in order to receive the lab grade. These two lab exercises are particularly important since they encompass the entire modelling cycle.

The instructor links the previously identified Intended Learning Outcomes with the in-class exercises and lab exercises.

Tentative Course Schedule

		Self-Assessment		Graded Assessment	Pts
Wk	**Lecture Topics**	**In class exercise**	**Lab Exercise**		
S 9-13 (Ch 1)	What is a model? The modelling cycle. Model formulation: Diagramming models; difference and differential equations	How to **IDENTIFY** good modelling questions. **FORMULATE** a mathematical model: Logistic population growth	**IDENTIFY** good modelling questions. Group dynamics exercise. **FORMULATE** a mathematical model (group chalk talk). (QNC 1506)		
S 16-20 (Ch 2 & 3)	Intro to analysis (numeric techniques for discrete time models): Explicit solutions	**ANALYZE**: exact solutions	Matlab intro I. ANALYZE: explict solutions (B1 370)	Assign 1: **IDENTIFY** & **FORMULATE**	5
S 23-27 (Ch 4)	Cobwebbing, Bifurcation diagram)	**ANALYZE**: Cobwebbing discrete time logistic growth	**TBD** (QNC 1506/B1 370)		
S 30- O 4 (Ch 5)	Stability analysis of one variable continuous time models: Phase Line Analysis, Local stability analysis	**ANALYZE**: Allee model	Matlab intro II. **ANAYZE** bifurcation diagrams (group) (B1 370)	Project A: **IDENTIFY** (group present and written bibliography)	5
O 7-11 (Ch 4)	Stability analysis of two variable continuous models: Phase space analysis	**ANALYZE:** Phase space analysis of LV competition model	**ANALYZE:** Phase space analysis of predator-prey model (individual) (QNC 1506/B1 370)	midterm	20
O 15-18 (Pr 2 & Ch 7 & 8)	Linear algebra review for local stability analysis. Local stability analysis (2D continuous systems): eigenvalues and Routh-Hurwitz conditions	**ANALYZE**: Cancer metastasis and the meaning of eigenvalues	**FULL MODELLING CYCLE:** SIR model: Formulate and analyze (group) (B1 370)	Assign 2: **FORMULATE & ANALYZE**	5
O 21-25 (Ch 7 & 8)	Local stability analysis (2D discrete systems): Jury conditions	**SELECT & ANALYZE:** Ventilation volume and blood CO2 levels	**SELECT:** TBD (QNC 1506/B1 370)		
O 28-N 1 (Ch 11)	Cycles in continuous 2D systems: complex eigenvalues, Hopf bifurcation theorem	**ANALYZE:** Rosenzweig-MacArthur predation	**ANALYZE:** fructose-6-phosphate and ADP model: Hopf bifurcation (group) (B1 370)	Assign 3: **SELECT & ANALYZE**	5
N 4-8 (Ch 10)	Linear multi-variable discrete time systems	**ANALYZE & INTERPRET:** sensitivity analysis of stage-structured populations	**ANALYZE & INTERPRET:** Endangered species management (group) (QNC 1506/B1 370)	Project B: **FORMULATE & SELECT** (individual analysis)	5
N 11-15 (Ch 7 & 8)	Linear multi-variable models in continuous time	**ANALYZE:** Press perturbations in food webs (inverse matrix)	**FULL MODELLING CYCLE** 1: Three chain enzyme kinetics: Formulate, select, analyze and interpret (required: individual) (B1 370)		
N 18-22 (Ch 7 & 8)	Non-linear multi-variable models in continuous time: Routh-Hurwitz conditions for 3 variable system	**ANALYZE & INTERPRET:** Separation of time scales.	(QNC 1506/B1 370)	Assign 4: **ANALYZE & INTERPRET**	5
N 25-29	Relating model to the biological question	**INTERPRET:** TBD	**FULL MODELLING CYCLE** 2: Three chain enzyme kinetics cont'd (required: individual) (B1 370)	Project C: **ANALYZE** & **INTERPRET**	5
D 2				Project D: write up Project E: evals Lab completion	5 5 10