

**BIOL 321 COURSE SYLLABUS**

**COURSE TITLE:** Mathematical Modeling in Biology

**TERM:** Winter 2024

**COURSE CODE:** BIOL 321.020.7 **DELIVERY:** Lectures/Labs

**COURSE CREDITS:** 3 cu **START DATE:** January 4, 2023

**CLASS SECTION:** 01 **LAB. LOCATION:** Education 3133

**CLASS LOCATION:** Geology 269 **LAB TIME:** Tuesday 1:30-4:20 pm

**CLASS TIME:** Tuesday, Thursday 10:00-11:20 AM

**WEBSITE**: Further information accessed through Canvas

**LECTURER: J.D. Benson**

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**Course Description:**

Mathematical modeling is the art of mathematically analyzing a real-world problem and, applied to biology, informs both experimental design and outcomes. It is fast becoming a critical component of any biologist’s toolbox. This course, relying only on concepts from introductory calculus, will explore and develop a number of mathematical modeling tools in the context of biology, develop mathematical intuition into biological problems, and introduce a sophisticated mathematical software package to enable analysis.

**ANTICIPATED LEARNING OUTCOMES:**

On successful completion of this course, students will have demonstrated their ability to

1. To engage effectively and efficiently in problem solving, as an individual and in cooperative situations.
2. Understand and connect concepts of mathematics with biological problems
3. Communicate mathematics clearly, in writing and orally.
4. Develop creative thinking.
5. Use the tools developed in the course, including
	1. The modeling process in general
	2. Models involving proportion and geometric similarity.
	3. Graphical and analytical model-fitting; least squares.
	4. Ordinary differential equations.
	5. Autonomous systems of differential equations.
	6. Techniques for big data analysis
	7. A flexible computational package (“The “R” Programming Language”)

**Important Dates**

* January 4, 2024 First Day of Classes (Thursday)
* February 19-23, 2024 MIDTERM BREAK (No lectures or lab)
* April 5, 2024 Last Day of Classes (Friday)

**Required reading, textbook, and equipment:**

See course schedule for required reading each week. Each week there are both recommended and auxilliary readings that are posted within each module. Please read the recommended readings before lecture to enable good discussion in the course lectures and lab sessions. This course will develop competency in the “R” programming language. There are many texts available both for free online and for purchase. There is no required textbook, but one recommended example of each category is:

1. The R Book 3rd Edition. E. Jones, S. Harden, and M. Crawley. 2022. Wiley Publisher. ISBN: 1119634326.
2. YaRrr! The Pirate’s Guide to R. N. Phillips. 2018. Self published. <https://bookdown.org/ndphillips/YaRrr/>

This course depends on the use of the R programming language. This language and all components used in the course are free to download. As such, students may wish to conduct their lab work and project work on their own computers.

**OVERALL EVALUATION (Total = 100%) – All components listed are required course work:**

* Final exam 30%
* Projects (5 projects, 10% each project) 50%
* Laboratory exercises 20%

**Policy for submission of assignments: All assignments will be submitted through Canvas and will be due at the specific date and time indicated.**

**Policy for submission of late assignments: 20% of the assignment’s final grade will be deducted for each day that has passed since the assignment’s due date.**

**Detailed Course Schedule**

**Week 1** (Jan 4; Introduction to the course)

Lecture 1 – Why model in Biology? (Class introduction - Course schedule; Scope of the course; Policy about assignments and their deadlines.)

Reading material: See course website

**Week 2** (Jan 8 - 12; Discrete time series models)

Lab #1 – Introduction to the R studio computational package

Lecture 2 – Discrete time series introduction: single population growth in yeast, digoxin in blood concentration and disease spread

Lecture 3/4 – Population dynamics – rabbits and foxes and disease modeling

Reading material: See course website

**Week 3** (Jan 15 - 19; Proportionality and linear modeling)

 Lab #2 – Coding tips and tricks, introduction to projects and time series models

Lecture 4/5 – Can unicorns fly and other important questions

Reading material: See course website

**Week 4** (Jan 21 - 26; Proportionality and linear modeling)

Lab #3 – Worked examples of discrete time series models

Lecture 6 – Allometry

Lecture 7 – Blood flow and LSD modeling

Reading material: See course website

*Project 1 due (Friday, Jan 26, 5 pm)*

**Week 5** (Jan 29 – Feb 2; Model fitting)

 Lab #4 – Proportionality and linear models

Lecture 8/9 – Graphical and linear least squares

Reading material: See course website

**Week 6** (Feb 5 – 9; High-order polynomials)

 Lab #5 – Modeling using geometric similarity

 Lecture 10/11 – Harvesting fish and yeast cultures

Reading material: See course website

*Project 2 due (Friday, Feb 9, 5 pm)*

**Week 7** (Feb 12 - 16; Making models from thin air)

 Lab #7 – Graphical and linear least squares

Lecture 12/13 - Dimensional analysis

Reading material: See course website

**Week 8** (Feb 19 -23; Winter Mid Term Break)

**Week 9** (Feb 26 – Mar 1; More dimensional analysis)

Lab #8 – Phenomenological models

Lecture 14/15 – Introduction to differential equations

Reading material: See course website

*Project 3 due (Friday, Mar 1, 5 pm)*

**Week 10** (Mar 4 -8; Introduction to differential equations)

Lab #9 – Dimensional analysis

Lecture 16/17 – One-dimensional ODE modeling: birth of a growth model

Reading material: See course website

**Week 11** (Mar 11-15; Continuous single population growth)

 Lab #10 – Numerical ODE solving

Lecture 18 – Revisiting rabbits and foxes, and how to build in interesting dynamics

Lecture 19 – Two- and three-dimensional ODE systems

Reading material: See course website

*Project 4 due (Friday, Mar 15, 5 pm)*

**Week 12** (Mar 18 - 22; Continuous population dynamics)

Lab #11 – Optimal caffeination ODE modeling

Lecture 20/21 – Introduction to big data analysis using R

Reading material: See course website

**Week 13** (Mar 25 - 29; Big data analysis)

Lab #12 – Continuous population dynamics – ODE systems

 Lecture 21/22 –Data Analysis using Python (continued)

Reading material: See course website

*Project 5 due (Friday, Mar 29, 5 pm)*

**Week 14** (April 1-5; Big data analysis cont.)

Lab #13 – Data analysis with R

Lecture 23/24 – Round up of topics covered

**Learning assessment details**

**Final examination**

This individual 3 hours open book cumulative examination is designed to assess a student’s knowledge and understanding of the core concepts covered throughout the entire course. The exam will consist of free response questions. Consult the Final Exam Schedule when it is released for the examination date and time. Students who miss the final exam for a valid reason must contact the College of Arts & Science and apply for a deferred final exam. Deferred exams may utilize a different format than the regular exam. Students are encouraged to review all University examination policies and procedures: <http://policies.usask.ca/policies/academic-affairs/academic-courses.php>

**Laboratory exercises and project reports**

A major part of laboratory sessions will be the completion of assigned laboratory exercises. These will include both individual and group work that grows out of the explored topic covered that day, and will be submitted by the end of the laboratory period. Completed work will depend on the use of the computational tools developed in the course. The exercise worksheets will be assessed on completeness (33%), clarity (33%), and correctness (34%).

Projects will be submitted as an appropriately formatted research paper, with title, introduction, methods/model development, results, discussion, conclusion, and reference sections. An example paper will be made available through the course website. Projects will be evaluated with an eye towards both the correct use of skills learned in the course so far and the analysis and discussion of the results. In particular, 50% of the grade will be assessed on the correctness of mathematical analysis, 25% of the grade will be assessed on the creativity and thoroughness of the discussion and analysis, and 25% of the grade will be assessed on clarity, detail, and formatting of the exposition.

Project Due date (5 pm)

1 Week 4 (Jan 26)

2 Week 6 (Feb 9)

3 Week 9 (March 1)

4 Week 11 (March 15)

5 Week 13 (March 29)

**STUDENTS WRITING EXAMINATIONS WITH ACCESS AND EQUITY SERVICES (AES)**

Students who have disabilities (learning, medical, physical, or mental health) are strongly encouraged to register with Access and Equity Services (AES) if they have not already done so. Students who suspect they may have disabilities should contact AES for advice and referrals. In order to access AES programs and supports, students must follow AES policy and procedures. For more information, check [www.students.usask.ca/aes](http://www.students.usask.ca/aes), or contact AES at 966-7273 or aes@usask.ca.

Students registered with AES may request alternative arrangements for mid-term and final examinations. Students must arrange such accommodations through AES by the stated deadlines. Instructors shall provide examinations for students who are being accommodated by AES, by the deadlines established by AES.

**STUDENT INTEGRITY (from the Office of the University Secretary)**

The University of Saskatchewan and the Department of Biology are committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize themselves with the provisions of the Student Academic Misconduct Regulations section of the University Secretary Website and avoid any behaviour that could potentially result in suspicions of cheating, plagiarism, misrepresentation of facts, and/or participation in an offence. Academic dishonesty is a serious offence and can result in suspension or expulsion from the University.

It is a requirement of each student enrolled in BIOL 321 to read and be familiar with the Academic Integrity Handout available as a link on the Office of the University Secretary website.

In a course such as BIOL 321 where students are focused on scientific writing and presentation, note **especially the Academic Integrity Handout’s definition of** [***plagiarism***](http://www.usask.ca/philosophy/undergrad/honesty.html#PLAG)**. “**Plagiarism: the presentation of the work or idea of another in such a way as to give others the impression that it is the work or idea of the presenter. Adequate attribution is required. What is essential is that another person have no doubt which words or research results are the student’s and which are drawn from other sources. Full explicit acknowledgement of the source of the material is required.”

## Many cases of plagiarism result from confusion or ignorance rather than from a genuine intent to deceive. **Note, however, that these are not excuses**: "The critical consideration is the impression created in the mind of others, not the subjective intent of the student. No intent to deceive is required to establish plagiarism." (University Council policy on [Student Academic Misconduct](http://www.usask.ca/university_secretary/honesty/academic_misconduct.php)).

**Attendance Expectations**

Attendance is required for synchronous lab sessions. Each lab session is associated with a lab assignment that will be completed in lab. Attendance is expected in the synchronous lectures.

**Copyright**

Course materials are provided to you based on your registration in a class, and anything created by your professors and instructors is their intellectual property, unless materials are designated as open education resources. This includes exams, PowerPoint/PDF slides and other course notes. Additionally, other copyright-protected materials created by textbook publishers and authors may be provided to you based on license terms and educational exceptions in the Canadian Copyright Act (see [http://laws-lois.justice.gc.ca/eng/acts/C-42/index.html)](http://laws-lois.justice.gc.ca/eng/acts/C-42/index.html).

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