

**BIOL 321 COURSE SYLLABUS**

**COURSE TITLE:** Mathematical Modeling in Biology

**TERM:** Winter 2021

**COURSE CODE:** BIOL 321 **DELIVERY:** Lectures/Labs

**COURSE CREDITS:** 3 cu **START DATE:** January 11, 2021

**CLASS SECTION:** 01 **TUT. LOCATION:** NA

**CLASS LOCATION:** NA **LAB TIME:** Monday

**CLASS TIME:** Tuesday, Thursday

**WEBSITE**: Further information accessed through Course Tools

**LECTURERS: 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.

# Remote Learning Context

This course is being offered for the first time remotely. We have strived to make the best of this, noting that the remote teaching and learning context is new to most. We ask that all participants in the course interact with empathy and care.

**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

**Important Dates**

* January 11, 2021 First Day of Classes (Monday)
* February 15-20, 2021 MIDTERM BREAK (No lectures or lab)
* April 13, 2021 Last Day of Classes (Tuesday)

**Required reading:**

See course schedule for required reading each week.

**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 11 – 15; Introduction to the course)

Lab #1 – Introduction to computational package, including Anaconda, Jupyter Notebooks and Python

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

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

Reading material: <https://mathinsight.org/intoduction_dynamical_system> ‘Can a biologist fix a radio’ (PDF)

**Week 2** (Jan 18 - 22; Discrete time series models)

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

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

**Week 3** (Jan 25 - 29; Proportionality and linear modeling)

 Lab #3 – Worked examples of discrete time series models

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

Reading material: <https://www.youtube.com/watch?v=AQFZuih2odo>

**Week 4** (Feb 1 - 5; Proportionality and linear modeling)

Lab #4 – Proportionality and linear models

Lecture 6 – Allometry

Lecture 7 – Blood flow and LSD modeling

Reading material: <https://www.nature.com/scitable/knowledge/library/allometry-the-study-of-biological-scaling-13228439/>

*- Project 1 due*

**Week 5** (Feb 8 - 12; Model fitting)

 Lab #5 – Modeling using geometric similarity

Lecture 8/9 – Graphical and linear least squares

Reading material: <https://www.mathsisfun.com/data/least-squares-regression.html>, <https://www.nctm.org/Classroom-Resources/Illuminations/Interactives/Understanding-Best-fit-with-a-Visual-Mode-Measuring-Error-in-a-Linear-Model/>

**Week 6** (Feb 15 - 19; No lectures or labs this week.)

**Week 7** (Feb 22 – 26; High-order polynomials)

 Lab #7 – Graphical and linear least squares

 Lecture 10/11 – Harvesting fish and yeast cultures

*- Project 2 due*

**Week 8** (Mar 1 - 5; Making models from thin air)

 Lab #8 – Phenomenological models

Lecture 12/13 - Dimensional analysis

Reading material: Dimensional analysis and similitude (PDF), <https://www.chem.tamu.edu/class/fyp/mathrev/mr-da.html>

**Week 9** (Mar 8 – 12; More dimensional analysis)

Lab #9 – Dimensional analysis

Lecture 14/15 – Introduction to differential equations

Reading material: <https://tutorial.math.lamar.edu/classes/de/eulersmethod.aspx>

 - *Project 3 due*

**Week 10** (Mar 15 -19; Introduction to differential equations)

Lab #10 – Numerical ODE solving

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

**Week 11** (Mar 22-26; Continuous single population growth)

 Lab #11 – Optimal caffeination ODE modeling

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

 Lecture 19 – Two- and three-dimensional ODE systems

 *- Project 4 due*

**Week 12** (Mar 29 – April 2; Continuous population dynamics)

Lab #12 – Continuous population dynamics – ODE systems

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

Reading material: <https://magazine.caltech.edu/post/biology-and-big-data>

**Week 13** (April 5 - 9; Big data analysis)

 Lab #13 – Data analysis with Python

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

*- Project 5 due*

**Week 14** (April 12-13; Big data analysis cont.)

Lab #14 – Big data in analysis in Python

Lecture 23 – 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 (33%).

Projects will be submitted as an appropriately formatted research paper, with title, introduction, methods/model development, results, discussion, conclusion, and reference sections. They 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

1 Week 4 (February 5)

2 Week 7 (February 26)

3 Week 9 (March 12)

4 Week 11 (March 26)

5 Week 13 (April 9)

**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 301 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 301 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 absence from more than one lab session will result in 5% deduction from the overall course marks. Attendance is expected in the synchronous lectures, each absence from more than three lectures will result in 5% deduction from the overall course marks. Absences will be excused up to the instructors discretion.

**Recommended Technology for Remote Learning**

Students are reminded of the importance of having the appropriate technology for remote learning. The list of recommendations can be found at <https://students.usask.ca/remote-learning/tech-requirements.php>.

**Recording of the Course**

**Use of video and recording of the course:**

Video conference sessions in this course, including your participation, will be recorded and made available only to students in the course for viewing via Canvas/Blackboard after each session. This is done, in part, to ensure that students unable to join the session (due to, for example, issues with their internet connection) can view the session at a later time. This will also provide you the opportunity to review any material discussed.

Please remember that course recordings belong to your instructor, the University, and/or others (like a guest lecturer) depending on the circumstance of each session, and are protected by copyright. Do not download, copy, or share recordings without the explicit permission of the instructor.

For questions about recording and use of sessions in which you have participated, including any concerns related to your privacy, please contact your instructor. More information on class recordings can be found in the Academic Courses Policy <https://policies.usask.ca/policies/academic-affairs/academic-courses.php#5ClassRecordings>.

**Required video use:**

At times in this course you will be required to have your video on during video conferencing sessions. It will be necessary for you to have use of a webcam built into or connected to your computer. For questions about use of video in your sessions, including those related to your privacy, contact your instructor.

**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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