Michael Hackett, Chair
General Education Governance Committee
Attn: Jared McBride, Academic Administrator
A265 Murphy Hall
Mail Code: 157101

August 9, 2021

Jukka Keranen
Academic Administrator
LS Core Education Department
241 Hershey Hall

Dear Chair Hackett,

I would like to submit LS 30A, Mathematics for Life Scientists, for consideration to be approved as a General Education (Foundations of Scientific Inquiry) course. I am attaching a completed GE Course Information Sheet, a sample syllabus, a sample final examination, and our CIMS form.

Upon successful completion of this course, students will satisfy the General Education requirement in Foundations of Scientific Inquiry. Assuming only the A-G subject requirement in mathematics (which typically includes Algebra 1, Geometry, and Algebra 2) required for entry into the UC, the course introduces students to differential equations modeling of dynamical systems, particularly systems studied in biology and its affiliated disciplines. Students will learn how to apply many mathematical tools and concepts that are of fundamental importance to research in physical and life sciences. In the process, they will gain an appreciation of the many ways in which mathematics allows us to explain and understand change in the physical world. In the computing labs, students will utilize computer simulations to further explore the models introduced in the course; as such, the course will also satisfy the Life Science Lab area requirement. Given the ever more prominent role computers play in life sciences research, the course will prepare students for a wide range of paths at UCLA and beyond.

Please let me know if you have any questions or concerns.

Sincerely,

Jukka Keranen

General Education Foundations of Scientific Inquiry (FSI) Course Information Sheet

Please submit this sheet for each proposed course along with 1) a syllabus describing the key components of the course that will be taught regardless of the instructor and 2) assignment guidelines.

The GE FSI Assessment Project Resource Team would be delighted to meet with you to assist in filling out this form. Please contact RRamachandran@teaching.ucla.edu if you wish to arrange a meeting.

Department, Course Number, and Title LS 30A

Indicate when the department anticipates offering this course in 2020-21 and give anticipated enrollment:

Fall: Enrollment >1200	Winter: Enrollment >400	Spring: Enrollment >100	Summer: Enrollment >60
___	___	___	___

As stated in the guidelines regarding courses in the Foundations of Scientific Inquiry (FSI), the aim of these course offerings is:

To ensure that students gain a fundamental understanding of how scientists formulate and answer questions about the operation of both the physical and biological world. These courses also deal with some of the most important issues, developments, and methodologies in contemporary science and technology, addressing such topics as the origin of the universe, environmental degradation, and the decoding of the human genome. Through lectures, experiential learning opportunities such as laboratories, writing, and intensive discussions students consider the important roles played by the laws of physics and chemistry in society, biology, earth and environmental sciences, and astrophysics and cosmology.

General Guidelines for GE FSI Courses: GE Courses may be upper or lower division, but they should have no prerequisites. Any student should be able to take them and understand the material with the background expected from all UCLA students. While the course may include material related to the history of science and the social and cultural implications of scientific research, **at least half** of the course should be devoted to students actively engaging in the scientific process of inquiry, analysis, problem-solving, and quantitative reasoning (Goal #1).

Please indicate the area/s which you believe this course should satisfy.

Life Science: [X] Physical Science: [ ] Life Science Lab*: [X] Physical Science Lab*: [ ]

**Courses approved as GE FSI Labs must complete the additional student learning outcomes for labs given in Page 4.*

Index:

General Education FSI Student Goals: Courses fulfilling the GE FSI requirement will provide a minimum of four units and should align with some (not necessarily all) of the following seven general goals:

1. Students will actively engage in the scientific process of inquiry, analysis, problem-solving, and quantitative reasoning.
2. Students will acquire an informed appreciation of scientists, scientific research, and technology.
3. Students will experience the interdisciplinary nature of science.
4. Students will develop information literacy.
5. Students will make evidence-based decisions in a wide array of science and non-science contexts.
6. Students will develop scientific literacy by addressing current, critical issues and topics in science that are personally meaningful in daily life and/or connected to the needs of society.
7. Students will recognize fundamental scientific principles and the connections between different domains of science.

General Education FSI Student Learning Outcomes: Each course should have student learning outcomes listed in the syllabus. These outcomes may be tied to a specific discipline but should be associated with the seven broad categories listed above (please see **Appendix I** for a sample list of possible learning outcomes supporting each goal).

Please identify measurable learning outcomes from your course and enter them in the first column of Table 1. You may add more rows as needed. Next, indicate how your learning outcomes relate to the GE FSI learning goals (above), by placing X's in the appropriate boxes. Note that all GE FSI courses must address Goal #1.

Table 1: Alignment of Course Learning Outcomes with GE FSI Learning Goals

	Your Course Learning Outcomes	Select GE FSI Goal #						
		1	2	3	4	5	6	7
1	Students will be able to construct *mathematical models* of dynamical systems from given sets of assumptions; they will be able to identify and critically examine the assumptions built into a given model	X			X			
2	Students will *apply* mathematical models to predict, for example, the spread of infectious diseases in populations, or the potential merits of different strategies of biodiversity conservation.	X		X		X	X	X
3	Students will apply the concept of *feedback* to explain a wide range of phenomena in biology, physiology, and other fields, including the functioning of biological switches.	X		X		X	X	X
4	Student will be able to define what it means for a system to be at an *equilibrium* and apply this concept in the analysis of the long-term behavior of systems.	X		X				
5	Students will be able distinguish *stable oscillations* from ones that are not stable, and be able to identify the critical parameters that give rise to the oscillations; students will be able to explain the role of stable oscillations in biological (and other) systems.		X					X
6	Students will be able to give examples of how *one* mathematical model may be useful in predicting the behavior of many *different kinds* of systems.			X				X
7	Students will be able to give representative examples of the vital role mathematical models (and mathematics generally) play in our ability to understand the physical universe, with an emphasis on *qualitative* dynamics over route computations.		X					X

Table 2: Course Activities and Assignments that Support the Learning Goals

Course Activities How will progress towards meeting the learning outcomes be facilitated? In other words, what types of course activities will be provided to assist students in achieving the outcomes?	**Course Assignments** How will students in the course demonstrate their ability to meet the learning outcomes? Please describe and provide a sample assignment, such as a term paper, exam, essay prompt, etc.
-Throughout the quarter, the students will construct a large number of differential equation models of steadily increasing complexity during class meetings, computing labs, and on their homework -The students will implement computer simulations of many of the models considered in the course, and use these simulations to analyze the long-term behavior of the models. -The students will engage in small-group discussions during class meetings and the computing labs. These discussions are aimed at applying the concepts introduced during lecture, and will typically require collaborative problem-solving.	The students will demonstrate their ability to meet the learning outcomes by -completing (graded) homework, -taking a midterm and a final exam, and -collaborating on a *content summary* with the members of their 4-member learning team A typical LS 30A final exam (one attached) will feature a number of question that will challenge the students to construct mathematical models and predict their long-term behavior through numerical simulation and qualitative exploration of the associated vector field.

Please provide information on estimated weekly hours for the class.

A) STUDENT CONTACT PER WEEK (if not applicable write N/A)

Activity	Number of hours per week
Lecture	3
Discussion Section	N/A
Labs	2
Experiential (Community-engagement, internships, other	N/A
Field Trips	N/A
A) TOTAL student contact per week	5

B) OUT-OF-CLASS HOURS PER WEEK (if not applicable write N/A)

Activity	Number of hours per week
General Review and Preparation	2
Reading	1
Group Projects	1
Preparation for Quizzes & Exams	1
Information Literacy Exercises	N/A
Written Assignments	5
Research Activity	N/A
B) TOTAL Out-of-class time per week	

GRAND TOTAL (A) + (B) must equal at least 15 hours/week: 15 (hours)

Additional Student Learning Outcomes for experiential learning courses approved as "GE FSI Labs"

GE FSI Lab Definition and Expectations: A hands-on laboratory, computer simulation, demonstration, or field experience that involves active participation in experimental observation, data generation and collection using the techniques, methodologies, and approaches of modern-day scientists. Any lab should be conducted under sufficient supervision by the instructor or a Teaching Assistant (TA). Furthermore, the instructor and TAs should meet regularly outside of class time (minimum weekly or biweekly) to practice performing the lab procedures and/or to review the experimental results.

Please put an "X" beside <u>one or more</u> of the following learning outcomes for your course (select all that apply):

X	1. Students will design, implement, and evaluate an experimental strategy for answering scientific questions, testing a hypothesis, or solving a problem.
	2. When possible, students will replicate experiments to allow testing for and interpretation of statistical significance.
X	3. Students will apply commonly used mathematical concepts and statistical methods (e.g., basic addition, subtraction, multiplication, division, averages, standard deviation, t-test for significance) in their analysis of different types of scientific data they collect.
X	4. Students will be able to visually depict a quantitative dataset as a chart, graph, table, or mathematical equation.
X	5. Students will be able to concisely summarize trends and patterns deduced from quantitative and qualitative data to make informed conclusions about their experimental results.
	6. When interpreting their results, students will distinguish between the most important and extraneous findings (i.e. identify those that are critical to addressing a question, solving a problem, or supporting/refuting a hypothesis).
	7. When interpreting their results, students will infer relationships between controls and experimental variables as well as assess causality and correlation among variables.
X	8. Students will be able to troubleshoot experimental procedures or methods of analysis to develop a sound scientific rationale for deducing what went wrong and why.

Please present concise explanation of how your course satisfies these criteria.

How will students in this course actively experiment and engage in the hands-on process of gathering, analyzing, and interpreting data?

How will progress towards meeting the student learning outcomes for "labs" be measured/assessed?

In other words, what types of assignments will be given to determine whether students are achieving the learning outcomes?

Students will complete weekly computer labs using the program SageMath. In these labs, students will learn the programming language Python and write simple programs. Debugging these programs partially addresses Obj. 8.

Students will use SageMath to run simulations of mathematical models of biological systems, addressing Obj. 3. Debugging these simulations also addresses Obj. 8.

Students will make at least two kinds of plots of simulation results (time series and trajectories) and interpret their biological meaning, addressing Obj. 4 and 5.

In at least 3 labs, students will systematically investigate the effect of changing a parameter or initial condition on a simulation of a biological system, addressing Obj. 1.

Appendix I. Student Learning Goals with Nested Learning Outcomes for All General Education (GE) Foundations in Scientific Inquiry Courses

Course Goals (1-7) and Student Learning Outcomes (a, b, c, etc.) for all "GE FSI" courses:

1. Students will actively engage in the scientific process of inquiry, analysis, problem-solving, and quantitative reasoning.
    a. Students will explain how scientists answer scientific questions, test a hypothesis, or solve a problem.
    b. Students will make reasonable predictions of experimental outcomes based on observation, measurements, and/or prior knowledge surmised from the scientific literature or other reliable, validated, accurate information sources.
    c. Students will break down, reason through, and solve complex quantitative problem sets.
    d. Students will be confident working with numerical data.
    e. Students will estimate and complete calculations to solve a quantitative problem.
    f. Students will recognize different objects and apply units of measurement at relevant scales (quantity, size, time) and orders of magnitude.

2. Students will acquire an informed appreciation of scientists, scientific research, and technology.
    a. Students will value their academic experiences in a science course that is outside their primary field of study.
    b. Students will recognize the benefits of science to society or their everyday life.
    c. Students will express interest in contributing to the sciences (e.g., engaging in research or scientific discourse with others).
    d. Non-science students will see scientists as role models, helping them to identify as scientists themselves.

3. Students will experience the interdisciplinary nature of science.
    a. Students will investigate topics from a variety of scientific fields.
    b. Students will explore the perspectives of multiple diverse scientists.
    c. Students will make logical connections between key concepts from multiple scientific disciplines.

4. Students will develop information literacy.
    a. Students will be mindful of information they encounter, recognizing contexts or situations when it is necessary to seek out other sources or data.
    b. Students will identify, locate, and critically evaluate information sources and datasets to ensure they are reliable, validated, accurate, and scholarly (i.e. associated with citations in peer-reviewed, public research studies).
    c. Students will explain the peer-review process in science and its role in critical evaluation and validation of published, scientific findings.

5. Students will make evidence-based decisions in a wide array of science and non-science contexts.
    a. Students will distinguish between opinion and fact (i.e. recognize data-supported conclusions).
    b. Students will use reliable, validated, accurate, and scholarly information sources and datasets before accepting or formulating a conclusion.
    c. Students will draw conclusions or make judgements about experimental results informed by critical thinking, that is, a comprehensive exploration of ideas and systematic engagement with the scientific process.

6. Students will develop scientific literacy by addressing current, critical issues and topics in science that are personally meaningful in daily life and/or connected to the needs of society (e.g., climate change, vaccination, GMOs, evolution).
    a. Students will clearly state the significance or relevance of a research question or problem (i.e. state why scientists are motivated to study the issue or topic).
    b. Students will discuss societal impacts by citing examples of the ways in which scientists and scientific research contribute to society.
    c. Students will describe the interactions between humans and their physical world and the positive and negative effects of this interaction.
    d. Students will explain why issues perceived as "controversial" in the public domain are not considered "controversial" among scientists.

7. Students will recognize fundamental scientific principles and the connections between different domains of science.
    a. Students will describe the nature, organization, and evolution of living systems.
    b. Students will explain the origin and physical processes of the planet earth and the surrounding universe.
    c. Students will differentiate between a scientific theory, hypothesis, fact, or law.

LS 30A: MATHEMATICS FOR LIFE SCIENTISTS

1. SUMMARY OF KEY INFORMATION ABOUT THE COURSE

Instructor

Email

Time Zone All time designations refer to **the Pacific Time Zone**.

Office Hours [at least 2 fixed hours]; and *also* by appointment

Lecture [3 hours a week]

Prerequisites None

Textbook Garfinkel, Shevtsov, and Guo. *Modeling Life: The Mathematics of Biological Systems*. New York: Springer International Publishing, 2017.

Grading Your overall course grade will be determined by the following scheme:

1. Participation	10%
2. Homework	18%
3. Quizzes	16%
4. Labs	16%
5. Midterm	20%
6. Final	20%
TOTAL	**100%**

Participation Multiple-choice questions in class, **or** on CCLE due one week after each class

Homework There will be 10 homework assignments.

Quizzes Multiple-choice and short-answer questions posted on CCLE every Saturday.

Labs A pre-lab quiz and a weekly coding assignment due before your lab section

Exams **Midterm**: 2 hours [in a 24-hour window] on [TBD]
Final: 3 hours [in a 24-hours window] on [TBD]

Please see Section 3 for the full details of our activities and assessment.

GE Credit Acknowledgment: Upon successful completion of this course, students will satisfy the General Education requirement in Foundations of Scientific Inquiry. Assuming only the A-G subject requirement in mathematics (which typically includes Algebra 1, Geometry, and Algebra 2) required for entry into the UC, the course introduces students to differential equations modeling of dynamical systems, particularly systems studied in biology and its affiliated disciplines. Students will learn how to apply many mathematical tools and concepts that are of fundamental importance to research in physical and life sciences. In the process, they will gain an appreciation of the many ways in which mathematics allows us to explain and understand change in the physical world. In the computing labs, students will utilize computer simulations to further explore the models introduced in the course; as such, the course will also satisfy the Life Science Lab area requirement. Given the ever more prominent role computers play in life sciences research, the course will prepare students for a wide range of paths at UCLA and beyond.

2. COURSE SCHEDULE

Date	Lecture	Section (textbook)	Topic
WEEK 0			
10/02	0	none	Introduction to the Course
WEEK 1			
10/05	1	1.1	Dynamical Systems and Their Models
10/07	2	1.1	Feedback Loops
10/09	3	1.4	Introduction to Modeling **Homework 1 due**
WEEK 2			
10/12	4	1.4	Modeling Interactions
10/14	5	1.4	Further Modeling Interactions
10/16	5	1.4	Further Modeling Interactions **Homework 2 due**
WEEK 3			
10/19	6	1.3	States and State Spaces
10/21	7	1.5	From Vector Field to Trajectories
10/23	8	1.2	Functions **Homework 3 due**
WEEK 4			
10/26	9	1.6	Trajectories and Determinism
10/28	10	1.7	Euler's Method
10/30	11	2.1-2.2	Instantaneous Rate of Change **Homework 4 due**

WEEK 5			
11/02	12	2.3-2.4	Tangent Line and Linear Approximation
11/04	13	2.4-2.5	Derivative and Differentiation as Functions
11/06	14	2.5	Differentiation Rules **Homework 5 due**
WEEK 6			
11/09	15	2.6	Integration I: Riemann Sums
11/11			**VETERANS DAY HOLIDAY**
11/13	16	2.6	Integration II: the Fundamental Theorem of Calculus
WEEK 7			
11/16	17	2.7	Explicit Solutions to Differential Equations **Homework 6 due**
11/18	18	3.1-3.2	Equilibrium Points in 1-d
11/20	19	3.2	Stability Analysis in 1-d **Homework 7 due**
WEEK 8			
11/23	20	3.3	Equilibrium Points in 2-d
11/25			**THANKSGIVING HOLIDAY**
11/27			**THANKSGIVING HOLIDAY**
WEEK 9			
11/30	21	3.4	Stability Analysis in 2-d: Nullclines **Homework 8 due**
12/02	22	3.5	Basins of Attraction: the lac Operon
12/04	23	3.6	Bifurcations of Equilibrium Points I **Homework 9 due**
WEEK 10			
12/07	24	3.6	Bifurcations of Equilibrium Points II
12/09	25	4.1	Stable Oscillations I
12/11	26	4.2	Stable Oscillations II **Homework 10 due**

3. ACTIVITIES, ASSESSMENT, AND GRADING

We are committed to making sure the assessment of your learning in this course is comprehensive, fair, and equitable. Your grade in this class will be based on the number of points you earn out of the total number of points possible and is not based on your rank relative to other students. Furthermore, grades are assigned without strict limits on the proportion of each letter grade given in the course.

3.1 Activities and Assessment Overview

Your overall course grade will be determined by the following scheme:

LEARNING ACTIVITY	% of GRADE	MAX PTS	HOW TO EARN THEM
1. Participation	10%	100	25 x 4
2. Homework	18%	180	8 x 22.5
3. Quizzes	16%	160	8 x 20
4. Labs	16%	160	8 x 20
5. Midterm	20%	200	60 + 80 + 60
6. Final	20%	200	60 + 80 + 60
TOTAL	**100%**	**1000**	

The individual assignments are **not curved in any way**, and **no letter grade is given** for them.

The percentage course score will be converted into a letter grade according to the usual cut-offs:

97 and up	A+
93 to < 97	A
90 to < 93	A-
87 to < 90	B+
83 to < 87	B
80 to < 83	B-
77 to < 80	C+
73 to < 77	C
70 to < 73	C-
67 to < 70	D+
63 to < 67	D
60 to < 63	D-
< 60	F

You should keep track of the points you have earned so that, at any time during the quarter, you can calculate how many more points you need to earn in order to hit your percentage course grade target:

points still needed = 1000 x (your % course grade target) – points already earned

Example I want 95% for the course and I have earned 650 points, so I still need 950 – 650 = 300 pts.

3.2 Learning Teams

Every one of you will be assigned to a **4-member learning team**: your persistent micro-community within the larger LS 30 community. The other 3 students in your team belong to the same lab section as you. The learning teams will be your Zoom breakout rooms both in the lectures as well as in your lab sections. In the lectures, you will discuss the clicker questions before coming back to the main session to submit your answers. In your lab sections, you will be collaborating on your coding assignments, again in Zoom breakout rooms. You will take components of your midterm and final exam together (please see Section 5.3 for the full details of the exams). And, finally, my hope is that you will want to work as a team on your homework, as well.

I am very excited about this concept, and I hope that you are, too. However, I recognize that, at times, perfectly reasonable people can find it difficult to work together; this can happen for any number of reasons. If you feel that your learning team just isn't right for you, please email me, and we will work out a solution. Finally, if you really, *really* don't want to be in a learning team, please email me.

3.3 Component Acitivities and Assessment

1) Participation There will be **27 class meetings with clicker questions** ("clicker sessions"), each one with **4 graded clicker questions**. The questions will be graded on completion, not on correctness. The 2 lowest clicker session scores will be dropped automatically. Thus, the maximum number of points available in this category is **25 x 4 = 100**.

You will be able to complete any clicker session on our CCLE site at any time **up to a week after** it took place in class.

You are strongly encouraged to attend class whenever you can. In class, most of the clicker questions will be completed after a small-group conversation. These conversations are an essential part of your learning process in this course, and you should not miss out on them, unless absolutely necessary.

2) Homework There will be **10 weekly homework assignments**, each one worth **22.5 points** (although the number of exercises will vary). The 2 lowest homework scores will be dropped automatically. Thus, the maximum number of points available in this category is **8 x 22.5 = 180**.

You are strongly encouraged to do all of them. This is a math course. The only way to learn math is to do many exercises, and not only that, work on them steadily throughout the week.

Homework will be collected through Gradescope. The assignments are due each Friday at 5:00 PM.

3) Quizzes There will be **9 weekly quizzes**, each one worth **20 points**. The quizzes will be posted on our CCLE site **at noon on Saturdays**, **except** for the week before the midterm, Week 5 (no quiz). You can complete the quiz at any time **before noon on the following Monday**. Each quiz will feature 4 or 5 questions about the material covered during the week. The lowest quiz score will be dropped automatically. Thus, the maximum number of points available in this category is **8 x 20 = 160**.

You are strongly encouraged to attempt every quiz. They are a tool that allows you to gauge your level of understanding of the materials covered each week. If you have attended the live class meetings (or viewed the recording), you should have little difficulty earning full marks with little or no further preparation.

4) Labs There will be **9 coding assignments**, assigned at your weekly lab section, and collected by your TA at the beginning of the next one (your TA will explain how this works in your first lab section). Each coding assignment will be worth **15 points**. In addition, before every lab section, except the one in Week 1, you will take a short **pre-lab quiz**. Each pre-lab quiz will be worth **5 points**. The scores from the coding assignment and the pre-lab quiz will be combined into a single weekly **lab score**, with a maximum of **20 points**. The lowest weekly lab score will be dropped automatically. Thus, the maximum number of points available in this category is **8 x 20 = 160**.

You are strongly encouraged to attempt every coding assignment and every pre-lab quiz. Each pre-lab quiz will have 5 questions about the coding assignment for that week. **It's just our way of rewarding you for looking at the assignment before you attend your weekly lab section.** The questions will not be difficult, and you can generally answer them very quickly, provided you have taken a look at the coding assignment. The coding assignments themselves will be a bit more challenging, and we will provide you with a lot of resources for completing them successfully. Your TA will help you get started on each one during the lab section, and they will be available to assist you throughout the week.

5) Midterm Exam There will be one midterm exam. It will have three stages:

Stage 1: Compose a "study guide" for the exam (60 points)

- Working together with your 3 learning team members, using any and all resources, you will compose a summary "study guide" of the materials covered by the midterm.
- We will give you detailed directions for this in Week 4.
- Due **11:59 PM on Sunday, November 8** (one day before stage 2 begins)
- So, basically, **we are giving you points for studying for the exam with your team**.

Stage 2: Take an individual exam on CCLE (80 points)

- You will take a **2-hour online exam on CCLE**. You will have a 24-hour window, from **6:30 PM on November 9 to 6:30 PM on November 10**, within which to take your exam.
- This will be **an individual exam**: you are not allowed to consult anyone else, or provide assistance to anyone else.
- You are allowed to make full use of the "study guide" you composed with your team.
- However, you are **not** allowed to use any other resources.
- If your exam session is interrupted by temporary Internet trouble, **you will be allowed to log back in** and continue taking your exam.
- Due to concerns about privacy and equity, the individual exam will operate on an honor system. In other words, **you will not be proctored**.

Stage 3: Take a collaborative exam on Gradescope (60 points)

- Working together with your 3 learning team members, using any and all resources, you will answer three follow-up questions that will build on three of the questions you answered individually in stage 2.
- You will get the questions at **6:30 PM on November 12, and you will have until 6:30 PM on November 13** to submit your answers on Gradescope.
- Thus, for this stage, it is not necessary to be online, other than for accessing the questions and, eventually, submitting your answers on Gradescope.
- While you will be working out the answers with your team, each member of a team must write up their own final answer and submit it to Gradecope. (You are allowed to have your teammates check your answer after you have written it up.)

Your score for the Midterm will be the sum total of the points you earned in all three stages.

6) Final Exam The basic template of the Final will be the same as that of the Midterm:

Stage 1: Compose a "study guide" for the exam (60 points)

- Working together with your 3 learning team members, using any and all resources, you will compose a summary "study guide" of the materials covered by the Final.
- We will give you detailed directions for this in Week 9.
- Due **11:59 PM on Sunday, December 13** (one day before stage 2 begins).
- So, basically, **we are giving you points for studying for the exam with your team**.

Stage 2: Take an individual exam on CCLE (80 points)

- You will take **a 3-hour online exam on CCLE**. You will have a 24-hour window, from **6:30 PM on December 14 to 6:30 PM on December 15**, within which to take your exam
- This will be **an individual exam**: you are not allowed to consult anyone else, or provide assistance to anyone else.
- You are allowed to make full use of the "study guide" you composed with your team.
- However, you are **not** allowed to use any other resources.
- If your exam session is interrupted by temporary Internet trouble, **you will be allowed to log back in** and continue taking your exam.
- Due to concerns about privacy and equity, the individual exam will operate on an honor system. In other words, **you will not be proctored**.

Stage 3: Take a collaborative exam on Gradescope (60 points)

- Working together with your 3 learning team members, using any and all resources, you will answer three follow-up questions that will build on three of the questions you answered individually in stage 2.
- You will get the questions at **6:30 PM on December 17, and you will have until 6:30 PM on December 18** to submit your answers on Gradescope.
- Thus, for this stage, it is not necessary to be online, other than for accessing the questions and, eventually, submitting your answers on Gradescope.

- While you will be working out the answers with your team, each member of a team must write up their own final answer and submit it to Gradecope. (You are allowed to have your teammates check your answer after you have written it up.)

Your score for the Final will be the sum total of the points you earned in all three stages.

3.4 Regrading policy

We make every effort to make sure that your homework and exam answers are graded accurately and fairly. Nevertheless, due to the large number of questions that each TA will have to grade, mistakes do occasionally happen. If you believe that a mistake has been made in scoring your work, please submit a regrade request **within one week** of the assignment being returned to you.

For issues pertaining to questions you answered through Gradescope, please use the built-in functionality of Gradescope to submit a regrade request. For issues pertaining to questions you answered on CCLE, please contact your TA through email.

If you and your TA are unable to reach a mutually satisfactory resolution to the scoring issue within a week of you submitting the request, **please email me**.

4. IMPORTANT NOTICES from UCLA Life Sciences Core Education

4.1 Academic Integrity – a Bruin's Code of Conduct

UCLA is a community of scholars committed to the values of integrity. In this community, all members including faculty, staff, and students alike are responsible for maintaining the highest standards of academic honesty and quality of academic work. As a student and member of the UCLA community, you are expected to demonstrate integrity in all of your academic endeavors. When accusations of academic dishonesty occur, the Office of the Dean of Students investigates and adjudicates suspected violations of this student code. Unacceptable behaviors include cheating, fabrication, plagiarism, multiple submissions without instructor permission, using unauthorized study aids, or facilitating academic misconduct.

Please review our campus' policy on academic integrity in the UCLA Student Conduct Code:

http://www.deanofstudents.ucla.edu/Student-Conduct-Code.

Once referred to the Office of the Dean of Students, allegations of academic dishonesty can lead to formal disciplinary proceedings. Being found responsible for violations of academic integrity can result in disciplinary actions such as the loss of course credit for an entire term, suspension for several terms, or dismissal from the University. Such negative marks on your academic record may become a major obstacle to admission to graduate, medical, or professional school.

We cannot make exceptions to our campus' policy on academic integrity, and as we hopefully have communicated effectively here, penalties for violations of this policy are harsh. Please do not believe it if you hear that "everyone does it". The truth is, you usually don't hear about imposed disciplinary actions because they are kept confidential. So our advice, just don't do it! Let's embrace what it means to be a true Bruin and together be committed to the values of integrity.

Examples of academic dishonesty possible in LS Core courses
With respect to our course, examples of academic dishonesty include giving answers on assignments to someone else, receiving answers from someone else, turning in any written work that is not your own for points in our course, copying passages from websites, copying passages from your or any other textbook on any graded material in the course, or bringing a classmate's clicker to class to get participation points for them when they are absent. If you engage in these types of unacceptable behaviors, then you will receive a zero as your score for that assignment. If you are caught cheating on an exam, then you will receive a score of zero for the entire exam.

Exams
No cell phones, smart watches, or similar types of devices are allowed during exams. Accordingly, you may not use cell phones as a clock to keep time or as a calculator.

4.2 Enrollment
In the event that we are at maximum enrollment capacity and you would like to enroll in this course, please monitor the Schedule of Classes in case someone drops the course. If you have other enrollment concerns, please email you course's SAO at the LS Core office. Please note that we and the SAOs are unable to provide students permission to enroll (PTE) numbers.

4.3 Changing Discussion/Lab Sections
Participation in discussion and lab sections is required for this course, and you must attend the section in which you are enrolled.

Please note that you are not permitted to switch enrollment in discussion/lab sections after the first week of the quarter. If you would like to switch sections during the first week but there are no spots available in the desired section, you need to find another student who agrees to switch sections with you. To make the switch in discussion/lab sections official with the registrar, you both will need to email the LS Core office and discuss your intention to switch sections in person.

4.4 Absences in Discussion/Lab Sections (including required documentation policy)444 expect students to attend all lectures and lab sections. However, we recognize that there will be times when students are forced to miss class. In lieu of requiring notes for college-related or unexpected events (medical, religious, or other), we provide you with options for missing some assignments without penalty (refer to policy on iClickers and homework). No additional excused absences will be granted except under extenuating circumstances.

4.5 Absences in Lecture or Exams (including required documentation policy)
In the event that you must miss an exam, you should contact your instructors as soon as is reasonably possible. You will be asked for verification of the event (injury, death, etc) and the course instructor will determine whether a makeup exam is possible or to pro-rate your exam. Please note that only an exam can be pro-rated.

4.6 Integrity of Course Contest
Please protect the integrity of all course materials and content. By enrolling in this course, you agree to honor this request. Be mindful of the hard work and time that our instructors and TAs in the LS Core put into creating course materials such as exam and quiz questions, worksheets, lecture videos, and Bruincasts. Please do not upload course materials not created by you onto third-party websites or share content with anyone who is not enrolled in our course. We are grateful for your cooperation in honoring this important request.

4.7 Center for Accessible Education (CAE)
Students needing academic accommodations based on a disability should contact the Center for Accessible Education (CAE) at (310) 825-1501. CAE will assess all requested accommodations and communicate appropriately with us (your instructors). Any students with CAE approval for proctoring arrangements during exams will need to please inform us (or your TA) prior to the date of the exam. When possible, students should contact CAE within the first two weeks of the quarter to allow reasonable time to coordinate accommodations. For more information, please visit the CAE website: http://www.cae.ucla.edu.

4.8 Counseling and Psychological Services (CAPS)
Resources are available to foster the well-being of all UCLA students as they pursue their academic goals. Any student who finds themselves in immediate distress, please call Counseling and Psychological Services (CAPS) to speak directly with a counselor 24/7 at (310) 825-0768, or please call 911. For more information, pleases visit the CAPS website: http://www.counseling.ucla.edu.

4.9 Our Inclusive Learning Environment
UCLA values diversity and inclusion. We expect everyone in this class to contribute to a respectful, welcoming, and inclusive environment to support the learning of all other members of the class. If there are aspects of the instruction or design of this course that result in barriers to your inclusion or accurate assessment or achievement, please notify us.

4.10 Student Resources for Support and Learning
UCLA has a multitude of resources available to *all* students. Many of these resources are listed below (alphabetized by name), and we encourage students to explore them as needed.

- **Academic Achievement Program (AAP):** This program advocates and facilitates the access, academic success, and graduation of students who have been historically underrepresented in higher education; informs and prepares students for graduate and professional schools; and develops the academic, scientific, political, economic, and community leadership necessary to transform society: https://www.aap.ucla.edu

- **Academics in the UCLA Residential Community:** Free workshops on a wide variety of issues relating to academic & personal success; (310) 825-9315; https://reslife.ucla.edu (click on "academics")
- **Bruin Resource Center:** Includes services for transfer students, undocumented students, veterans, and students with dependents; http://www.brc.ucla.edu.
- **Career Center:** Don't wait until your senior year – visit the career center today! http://www.career.ucla.edu
- **Center for Accessible Education (Formerly Office for Students with Disabilities):** Located in A255 Murphy Hall: (310) 825-1501, TDD (310) 206-6083; http://www.cae.ucla.edu.
- **Counseling and Psychological Services (CAP):** Located in Wooden Center West; students in distress may call to speak directly with a counselor 24/7 at (310) 825-0768, or may call 911; http://www.counseling.ucla.edu
    - Commonly known as the "Red Folder", this tool is intended to provide you with quick access to important resources for assisting students in distress (see, say, do): https://ceils.ucla.edu/wp-content/uploads/sites/2/2016/08/911Guide.pdf
- **Dashew Center for International Students and Scholars:** Located in 106 Bradley Hall; (310) 825-1681; http://www.internationalcenter.ucla.edu
- **Dean of Students Office:** General resource for all Bruins. Learn about academic integrity issues and your first amendment rights. Get help if you've experienced rape or sexual assault. Report a bias incident, and much more. Located in 1206 Murphy Hall; (310) 825-3871; http://www.deanofstudents.ucla.edu
- **Lesbian, Gay, Bisexual and Transgender Resource Center:** Located in the Student Activities Center, B36; (310) 206-3628; http://www.lgbt.ucla.edu
- **Letters & Science Academic Counseling Service:** Located in A316 Murphy Hall; (310) 825-1965; http://cac.ucla.edu.
- **Library**: Get help with your research, find study spaces, attend a workshop, rent a laptop, and more. Learn more at http://www.library.ucla.edu.
- **Student Legal Services:** Located in A239 Murphy Hall; (310) 825-9894; http://www.studentlegal.ucla.edu
- **Undergraduate Writing Center:** Peer learning facilitators (PLFs) are undergraduates who understand the challenges of writing at UCLA. Scheduled appointment and walk-in options are available, see http://wp.ucla.edu/wc for more information and to get assistance with your writing.
- **UCLA ONE**: This website (https://uclaone.com/) serves as UCLA's interactive, online gateway for mentorship, professional networking, peer driven career advice, and exclusive job leads. (Similar to LinkedIn but for the UCLA community).

5. LS 30A LEARNING OUTCOMES

1. Given a description of a *dynamical system*, you will be able to construct a *differential equation model* of that system. Conversely, given such a model, you will be able to identify and critically examine the *assumptions* built into it.

2. You will apply mathematical models to *predict*, for example, the spread of infectious diseases in populations, or the potential merits of different strategies of biodiversity conservation.

3. You will use the concepts of *state space*, *tangent space*, and *vector field* to study the qualitative dynamics of differential equation models.

4. You will be able to define what it means for a system to be at an *equilibrium* and apply this concept in the analysis of the long-term behavior of systems.

5. You will be able distinguish *stable oscillations* from ones that are not stable, and be able to identify the critical parameters that give rise to the oscillations; you will be able to explain the role of stable oscillations in biological systems.

6. You will use the fundamental concepts of calculus, including that of *derivative* and *definite integral*, to describe the behavior of differential equation models.

7. You will apply the concept of *feedback* to explain a wide range of phenomena in biology, physiology, and other fields, including the functioning of *biological switches*.

8. You will write Python-like code to simulate differential equation models using *Euler's method*.

9. You will be able to give representative examples of the vital role mathematical models play in our ability to *understand* (rather than to merely describe) the physical universe.

LS 30A: MATHEMATICS FOR LIFE SCIENTISTS
FALL 2019 - LECTURES 2 and 3
Jukka Keranen

FINAL EXAMINATION

Your Name _____

The Last **Six** Digits of Your Student ID number | | | | | | |

Your TA Section _____

By signing below, you confirm that you did not cheat on this exam. No exam booklet without a signature will be graded.

_____

INSTRUCTIONS

- Please do **not** open this booklet until you are told to do so.
- In addition to basic writing instruments, you are allowed to use a non-programmable calculator.
- Your cell phone must be **turned off completely** and stowed away where you cannot see it.
- No books or notes.
- If you have a question at any time during the exam, please raise your hand.
- You will receive points only for work written on the numbered pages. Please use the reverse side as scratch paper.
- Make sure to write legibly. **Illegible work will not be graded.**
- Make sure to show all your work and justify your answers fully.

SCORE

1. _____	6. _____
2. _____	7. _____
3. _____	8. _____
4. _____	9. _____
5. _____	10. _____

TOTAL _____

1. (10 pts) Unicorns, U, are preyed upon by dragons, D. Write a differential equation model of the unicorn and dragon populations, by using the following assumptions. In what follows, all rates are per year rates.

- The unicorn per capita birth rate is 0.5.
- The unicorn per capita death rate (independent of predation) is twice the unicorn per capita birth rate.
- Only dragons prey upon unicorns.
- The probability that any one unicorn gets eaten by a dragon is proportional to the number of dragons, with a proportionality constant of 0.03.
- Dragon mating takes place according to ancient rules, and is largely independent of things like the availability of food. Accordingly, the dragon birth rate can be modeled as a constant 0.002.
- Being essentially immortal and peerless in power, dragons only die in combat with other dragons. Thus, the dragon per capita death rate is proportional to the number of dragons, with proportionality constant 0.01.

2. Oxygenation of hemoglobin is a common chemical reaction in red blood cells. In order to model this reaction, let's denote

- X = the concentration of oxygen molecules in the cell,
- D = the concentration of deoxygenated hemoglobin in the cell,
- H = the concentration of oxygenated hemoglobin in the cell.

In the cell, the following processes are occurring:

- Deoxygenated hemoglobin combines with 4 oxygen molecules to form oxygenated hemoglobin, as depicted below:

$$D + 4X \xrightarrow{f} H;$$

  in particular, the rate constant of this process is f.

- Oxygenated hemoglobin can also split up into deoxygenated hemoglobin and 4 oxygen molecules, as depicted below:

$$H \xrightarrow{g} D + 4X;$$

  in particular, the rate constant of this process is g.

In addition,

- oxygen enters the cell at a constant rate of w, and
- deoxygenated hemoglobin leaves the cell at a per-molecule (like per capita) rate of r.

(10 pts) Write a differential equation model for X, D, and H, by using the assumptions above. All rates are per second.

3. (10 pts) The annual rate of change of a hunted unicorn population, X, is given by the differential equation

$$X' = 0.2X\left(1 - \frac{X}{200}\right) - 0.1X.$$

The current population is 180 unicorns. Use Euler's method with step size of 1 year to find the approximate population three years later. During your calculation, use values accurate to 2 decimal places. Round your final answer to whole numbers.

4. By using the differentiation rules we learned in this course, find $\frac{df}{dx}$ for each of the following functions $f(x)$. Indicate clearly which rules you are using at each step of your calculation.

(*Hint.* You will need to use, among other things, the fact that $\frac{d}{dx}(\ln x) = \frac{1}{x}$.)

a) (4 pts) $f(x) = (x^4 + x^3)(x^6 + \ln x)(\sqrt{x} + 3)$

b) (4 pts) $f(x) = \ln\left(\frac{1}{x^6 + x^4 + 3}\right)$

By using the differentiation rules we learned in this course, find $\left.\frac{df}{dx}\right|_{x=1}$ for the following function $f(x)$. Indicate clearly which rules you are using at each step of your calculation.

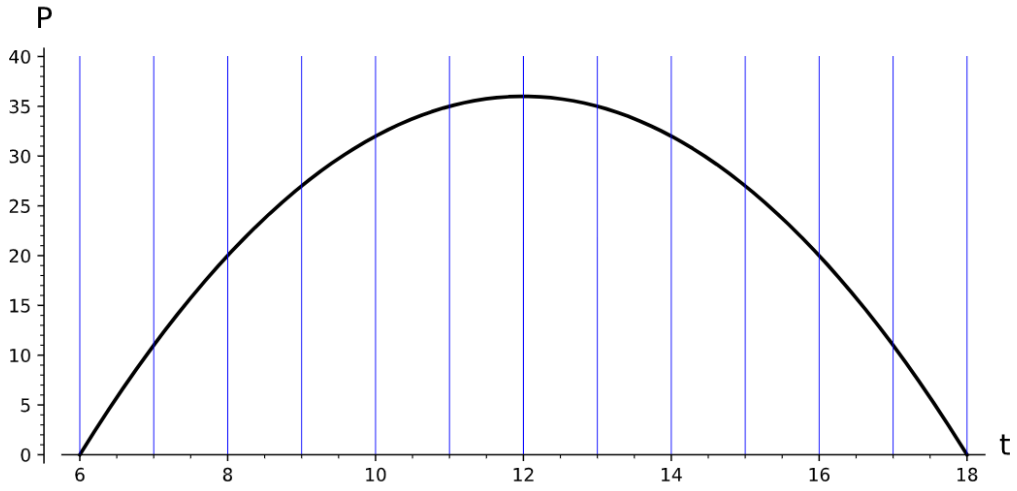
c) (2 pts) $f(x) = e^{x^{\ln x}}$

(You will need to use the fact that $\ln 1 = 0$.)

5. A **solar power plant** has a power output of $P(t)$ kW, where t represents time (measured in hours). Suppose that from 6:00 (6 AM) to 18:00 (6 PM), the power output $P(t)$ is given by the function

$$P(t) = -(t-6)(t-18),$$

whose graph is shown below:



a) (4 pts) By using time interval $\Delta t = 1$ hour, write down and evaluate the Riemann sum approximating the total energy produced by the power plant over the period from $t = 9$ (9 AM) to $t = 15$ (3 PM).[1]

(*Reminder.* In your answer, energy will have units of kWh, kilowatt hours.)

b) (1 pts) In the diagram above, indicate the graphical meaning of the Riemann sum you calculated in part *a*).

[1]For us, "Riemann sum" always means "left Riemann sum". If you don't know what this remark means, you don't need to worry about it.

c) (4 pts) Write down and evaluate the definite integral that represents the total energy produced by the power plant over the period from $t = 9$ (9 AM) to $t = 15$ (3 PM).

(*Hint.* You may wish to use the fact that $P(t) = -t^2 + 24t - 108$.)

d) (1 pts) The correct numerical answer to part *a*) is 197; the correct numerical answer to part *c*) is 198. By referencing the shape of the graph of $P(t)$, explain why these answers are so similar.

e) (1 pt extra credit) By referencing the shape of the graph of $P(t)$, explain why the answer to part *a*) is a little bit smaller than the answer to part *c*).

6. You are studying a differential equation model, $X' = f(X)$, of a dynamical system. Suppose you know that

$$\frac{df}{dX} = 3X^2 - 8X - 4,$$

and that the equilibrium points are at

$$X = -2, X = 2, X = 4.$$

a) (4 pts) Determine the stability of each equilibrium point by using linear stability analysis. (*Note.* So far, you have only been given $\frac{df}{dX}$, not $f(X)$.)

b) (2 pts) Suppose now that you know, *in addition*, that

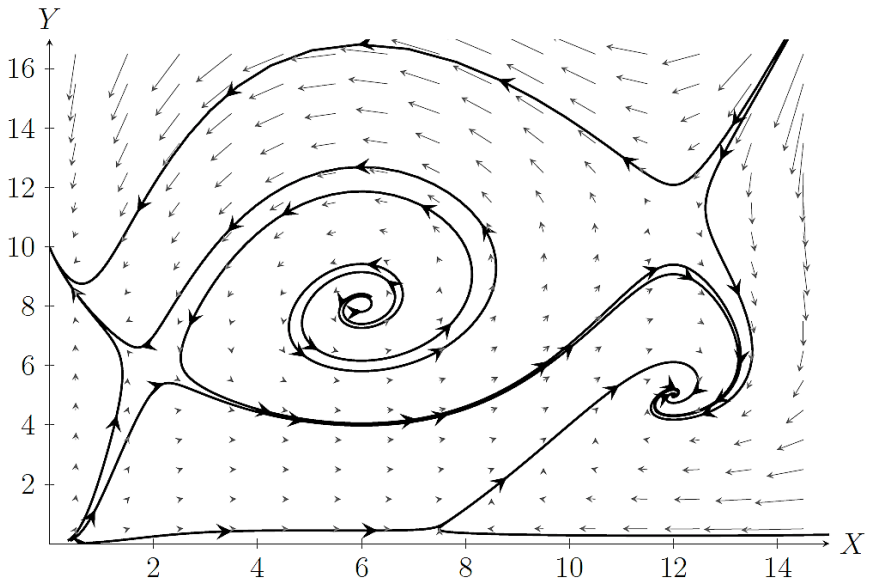
$$f(X) = X^3 - 4X^2 - 4X + 16.$$

Choose suitable test points and verify that the stability of $X = -2$ is what you claimed it is in part *a*).

c) (2 pts) Sketch the vector field with equilibrium points of this model. (*Note.* You only need to represent accurately the direction of the change vectors, not their length.)

d) (2 pts) Suppose you discover that the system is currently in the state $X = 3$. According to this model, how will the system's state change in the future?

7. The diagram below shows the vector field and several trajectories of a 2-variable system of differential equations.



(10 pts) Indicate the location of all the **seven** equilibrium points in the diagram, then list them in the space below and indicate their type (in the classification of equilibrium points in 2 dimensions that we learned).

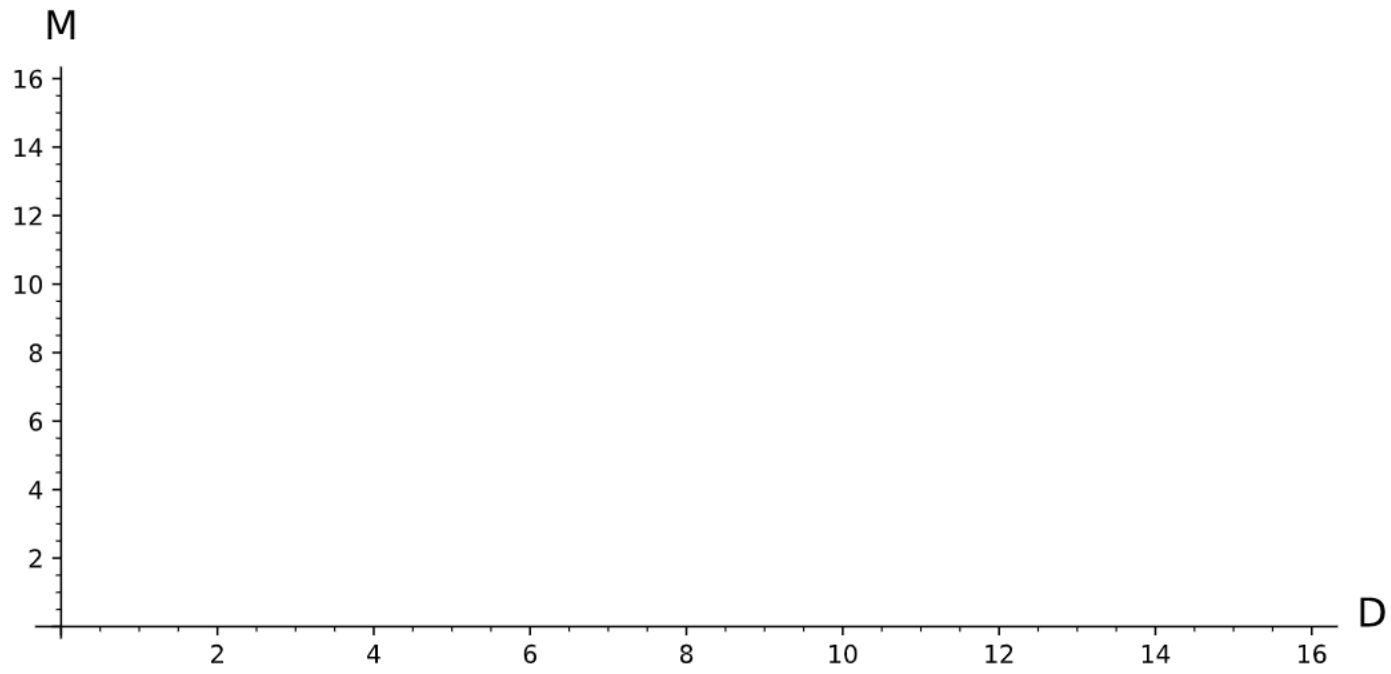
8. Let D be the size of a population of deer, and M the size of a population of moose. Suppose that the population dynamics of the two species can be modeled by the following differential equations:

$$D' = 24D - 2D^2 - 3DM$$
$$M' = 15M - M^2 - 3DM$$

a) (2 pts) Find the nullclines of this model.

b) (2 pts) By using your answer to part *a*), find the equilibrium points of this model.

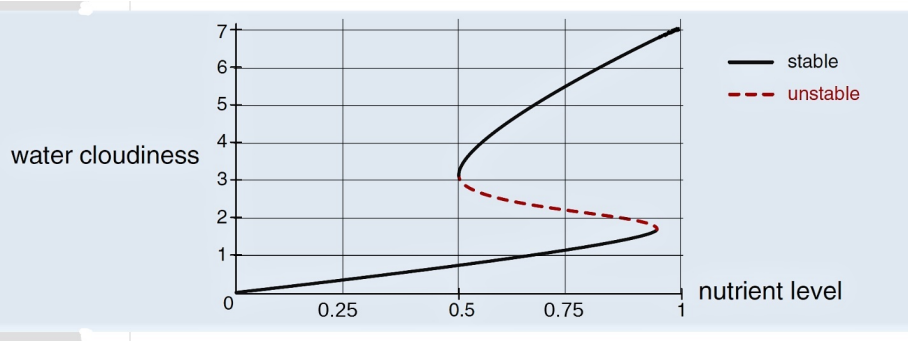
c) (3 pts) On the axes provided below, draw the nullclines and equilibrium points of this model. Make sure to indicate clearly which ones are the D-nullclines, which ones the M-nullclines.



d) (2 pts) By picking a test point from within each region demarcated by the nullclines, determine for each equilibrium point whether it is stable or unstable. Indicate the result of your analysis in the diagram.

e) (1 pt) Can the two species coexist in the long run? Justify your answer by referencing your answer to part *d*).

9. The diagram below shows a possible relationship between nutrient levels and water cloudiness ("murkiness") in a lake.



Let's assume that, from the point of view of the dynamics of this system, 1 year is a "long time".

a) (2 pts) List the bifurcations that occur in this diagram. For each one, state what type of bifurcation it is and at what nutrient level it occurs.

b) (2 pts) At the beginning of the year, the nutrient level is 0.2 and the water cloudiness is 7. At what level will the water cloudiness be at the end of the year?

c) (2 pts) At the beginning of the year, the nutrient level is 0.4 and the cloudiness is 2. There is now a sudden increase in pollution, and the nutrient level quickly increases to 0.7. At what level will the water cloudiness be at the end of the year?

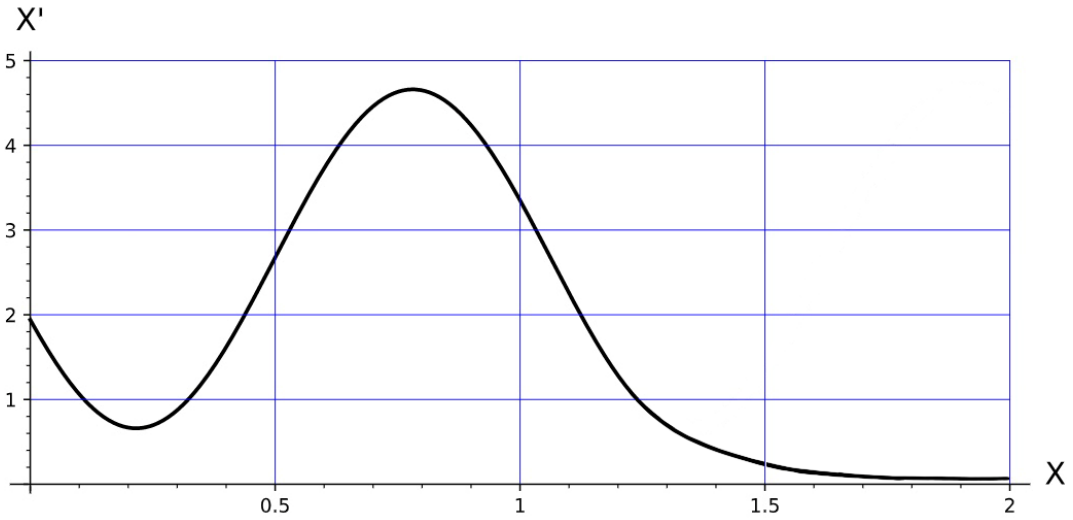
d) (2 pts) At the beginning of the year, the nutrient level is 0.8 and the cloudiness is 1. There is now a further sudden increase in pollution, and the nutrient level quickly increases to 1. At what level will the water cloudiness be at the end of the year?

e) (2 pts) You are now in the year-end situation of part *d*). Propose a water quality restoration policy that will return water cloudiness to below 1 with the least possible reduction in the nutrient level.

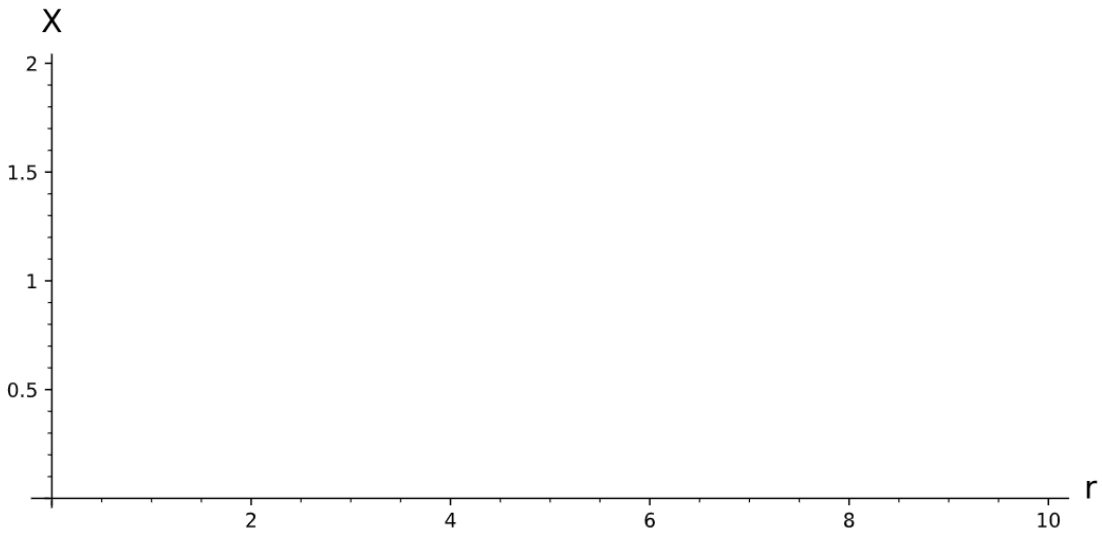
10. A hormone is produced at a rate that depends on the current level of that hormone in the body, according to the function whose graph is shown below. The hormone leaves the system at a rate proportional to the current hormone level, with proportionality constant r. In other words, if X is the hormone level, then X satisfies the differential equation

$$X' = [\text{Input}] - rX,$$

where [Input] is the function whose graph is shown below:



(10 points) On the axes below, draw a bifurcation diagram for this system, as the parameter r varies from 0 to 8.



- Be sure to indicate graphically the stability of each equilibrium point in your diagram.
- You should consider 6 different values for r, including $r = \frac{1}{2}$ and $r = 8$.
- It is not necessary to consider values of X greater than 2.
- The purpose of the grid is to help you find the r.

LIFESCI 30A

UCLA Course Inventory Management System

Main Menu | Inventory | Reports | Help | Exit

Revise a Course

Required fields are marked with a red letter **R**.

LIFESCI 30A
Mathematics for Life Scientists

Check all requested revisions that apply:

☐ Renumbering ☐ Title ☐ Format ☐ Requisites ☐ Units ☐ Grading ☑ Description

Multiple Listing: ☐ Add New ☐ Change Number ☐ Delete

Concurrent Listing: ☐ Add New ☐ Change Number ☐ Delete

		CURRENT	PROPOSED
Department	R	7-character code **LIFESCI**	7-character code **LIFESCI**
Requested Course Number	R	7-character code **LIFESCI** Course Number **30A**	7-character code **LIFESCI** Course Number prefix: ____ number: 30 suffix: A Check box if Multiple Listed: ☐ Multiple Listed Course Check box if Concurrent: ☐ Concurrent Course
Course Catalog Title	R	**Mathematics for Life Scientists**	Mathematics for Life Scientists
Short Title		**MATH-LIFE SCIENTIST**	MATH-LIFE SCIENTIST (19 character limit)
Units	R	Fixed: **5**	◉ Fixed: 5 ○ Variable: Minimum ____ Maximum ____ ○ Alternate: ____ or ____
Grading Basis	R	**Letter grade only**	--- SELECT A GRADING BASIS ---
Instructional Format	R	Primary Format **Lecture** Secondary Format **Laboratory**	Primary Format: Lecture Hours per week: 3 Secondary Format: Laboratory Hours per week: 2 Next
TIE Code	R	**LABS - Laboratory (Skills/Techniques) [T]**	LABS - Laboratory (Skills/Techniques) [T]
GE Requirement	R	**No**	○ Yes ◉ No If yes, submit a proposal to the GE Governance Committee.
Requisites			Include enforcement level (enforcement, warning, none).
Course		Lecture, three hours; laboratory,	

LIFESCI 30A

Description R

one hour. Preparation: three years of high school mathematics (to algebra II), some basic familiarity with computers. Mathematical modeling as tool for understanding dynamics of biological systems. Fundamental concepts of single-variable calculus and development of single- and multi-variable differential equation models of dynamical processes in ecology, physiology, and other subjects in which quantities change with time. Use of free computer program Sage for problem solving, plotting, and dynamical simulation in laboratory. Letter grading.

```
Lecture, three hours; laboratory, two
hours. Preparation: three years of high
school mathematics (to algebra II), some
basic familiarity with computers.
Mathematical modeling as tool for
```

495 characters remaining

Justification R

Justify the need and state the objectives for this course revision. Identify effects on other courses in your department or on courses or curriculum in other departments. List departments and chairs consulted and summarize responses.

Maximum 1080 characters

1080 characters remaining

Syllabus

A syllabus and/or reading list is required for new courses.

Choose File No file chosen

Upload syllabus file.
Read the upload instructions for help.

Supplemental Information

Effective Date R **Fall 2013**

Select Term 0

Contact

Name

JUKKA KERANEN

E-mail

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Routing Help

Route Form Now | Save Form for Later | Exit without Saving | Cancel Form