

# Assignment 1

CSCI 2897 - Calculating Biological Quantities - Larremore - Fall 2022

**Notes:** Remember to (1) familiarize yourself with the collaboration policies posted on the Syllabus, and (2) turn in your homework to Canvas as a **single PDF**. Hand-writing some or most of your solutions is fine, but be sure to scan and PDF everything into a single document. Unsure how? Ask on Slack!

## Squats

Calculate these derivatives.

1.  $\frac{d}{dx}x^3 =$

2.  $\frac{d}{dx}x^{-3} =$

3.  $\frac{d}{dx}e^{\alpha x} =$

4.  $\frac{d}{dx}e^{\pi x^{-2}} =$

5.  $\frac{d}{dx}\ln 2x =$

## Situps

Find solutions to each of these differential equations.<sup>1</sup>

6.  $\frac{dy(t)}{dt} = 0$

7.  $\frac{dy(t)}{dt} = t$

8.  $\frac{dy(t)}{dt} = y(t)$

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<sup>1</sup>Hint: ask yourself, “What function, if I were to take its derivative, would satisfy this equation?”

## Modeling in the News

9. Find **two** stories in the recent news that spark your curiosity about modeling, one related to biology in some form, and another unrelated to biology. For each, please
- Provide a link to the story, as well as the date and title of the story.
  - Write a paragraph describing *as a narrative* a dynamical process occurring in the story.
  - Pose a relevant question about that dynamical process or system.
  - Identify the important variables; and identify the important parameters.
  - Produce a flow diagram or a life cycle diagram of the dynamics using a graphics software<sup>2</sup> that would help you to translate the process or system from narrative steps (qualitative) into a quantitative model with variables and parameters included.

## Minors and Majors

10. Each year, the Computational Biology Minor has  $N$  new enrollees who start as freshmen. These freshmen are split with  $p\%$  majoring in Computation ( $C$ ) and  $100(1-p)\%$  majoring in Biology ( $B$ ). At the end of freshman year, sophomore year, and junior year, a fraction  $f_{C \rightarrow B}$  of Computation students change to Biology, while a fraction  $f_{B \rightarrow C}$  Biology students change to Computation. Also at the end of each year, a fraction  $f_X$  of the students drop the CB Minor entirely. The remaining students keep their existing major and show up in the fall in the next grade; Seniors graduate and leave.

Draw a **flow diagram** that tracks the numbers of students in Computation across the four years ( $C_f, C_s, C_j, C_r$ ) and the numbers of students in Biology across the four years ( $B_f, B_s, B_j, B_r$ ). Include parameters in your diagram. State any fundamental requirements on the parameters that you can think of.

## Extra Credit

E.C. As noted in class, we can use *Forward Euler* to numerically solve the differential equation

$$\frac{dn(t)}{dt} = \sqrt{n(t)}, \quad n(0) = 1$$

by determining our current “slope”, and then taking a small step ( $\Delta t$ ) in that direction to update the value of  $n$ . In this way, we can step along the path of the solution, and solve a differential equation by transforming it into a recursion.

For this extra credit, write some code in Python and produce a single plot that shows three solutions: (a)  $\Delta t = 2$ , red, (b)  $\Delta t = 1$ , blue, and (c)  $\Delta t = 0.01$ , black. Your plot should have a horizontal axis

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<sup>2</sup>Keynote or Powerpoint are good bets

from  $t = 0$  to  $t = 10$ . Please also attach your source code along with your plot — a screenshot of your code is fine.