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.[1]

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

[1] 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[2] 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 a fraction p majoring in Computation (C) and the remaining fraction $1-p$ majoring in Biology (B). At the end of freshman year, sophomore year, and junior year, a fraction $f_{C\to B}$ of Computation students change to Biology, while a fraction $f_{B\to C}$ 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.

[2] Keynote or Powerpoint are good bets

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