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!

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Squats

Calculate these derivatives.

1. $\frac{d}{dx}x^3 = \boxed{3x^2}$ 1
2. $\frac{d}{dx}x^{-3} = -3x^{-4}$ or $\boxed{\frac{-3}{x^4}}$ 2
3. $\frac{d}{dx}e^{\alpha x} = \boxed{\alpha e^{\alpha x}}$ 3
4. $\frac{d}{dx}e^{\pi x^{-2}} = e^{\pi x^{-2}} \pi(-2)x^{-3} = \boxed{\frac{-2\pi e^{\pi x^{-2}}}{x^3}}$ 4
5. $\frac{d}{dx}\ln 2x = \frac{1}{2x} 2 = \boxed{\frac{1}{x}}$ 5

Situps

Find solutions to each of these differential equations.[1]

6. $\frac{dy(t)}{dt} = 0$ $\boxed{y(t) = c}$ 6
7. $\frac{dy(t)}{dt} = t$ $\boxed{y(t) = \frac{t^2}{2} + c}$ 7
8. $\frac{dy(t)}{dt} = y(t)$ $\boxed{y(t) = ke^t}$ 8

[1] Hint: ask yourself, "What function, if I were to take its derivative, would satisfy this equation?"

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Modeling in the News

20 each

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.

Answers will vary!

Full Attempts → Full Credit

[2] Keynote or Powerpoint are good bets

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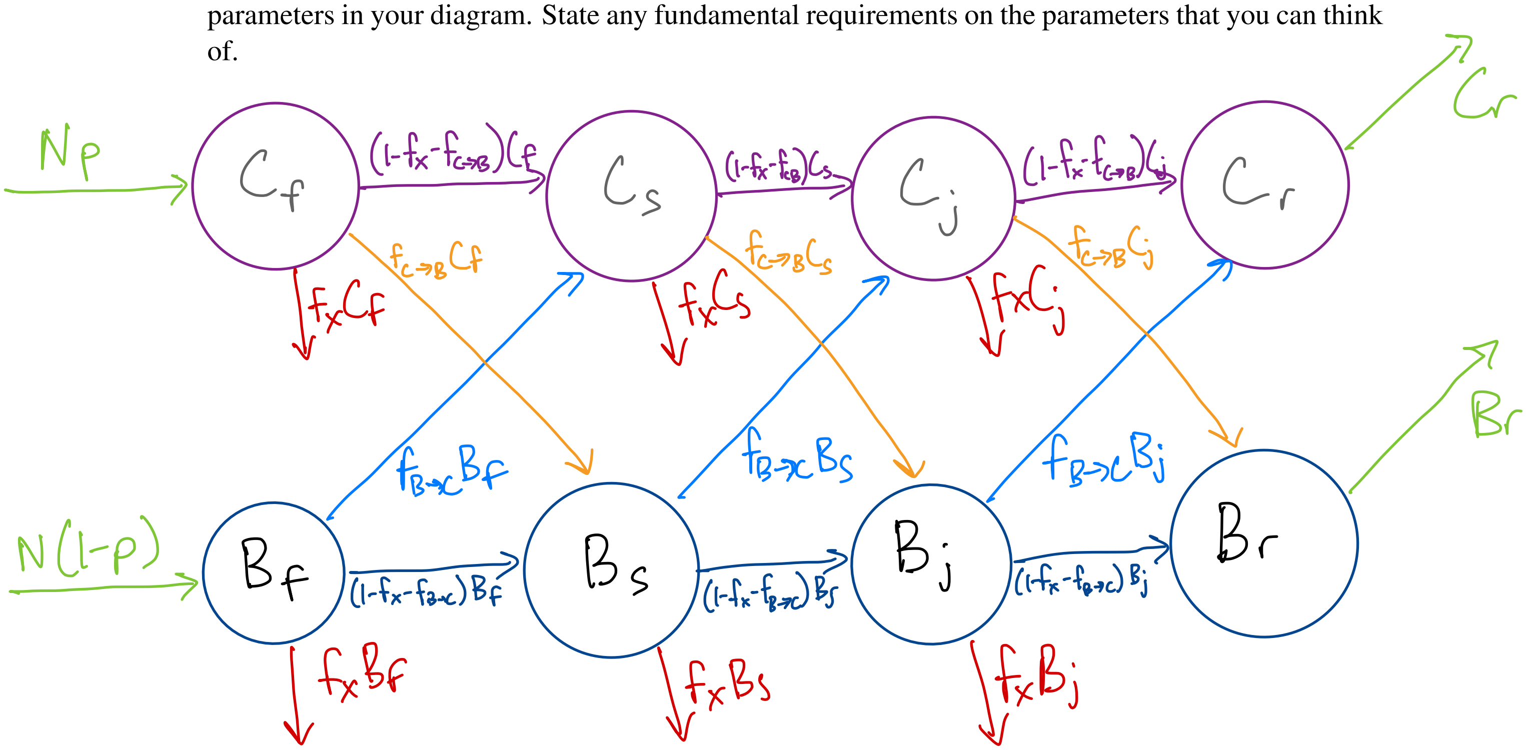
Minors and Majors

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 $f_{C \to B}$ 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.



4
$0 \le p \le 1$
$0 \le f_x \le 1$
$0 \le f_{B\to C} \le 1$
$0 \le f_{C\to B} \le 1$

2
$0 \le f_x + f_{B\to C} \le 1$
$0 \le f_x + f_{C\to B} \le 1$

4 8 variables
2 2 inflows
2 f_x outflows
2 f_{CB}/f_{BC} crossflows
2 labeled upflows
2 labeled outflows

Extra Credit

up to +15

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.

See github.