# Ethical Reasoning in Calculus I

SIMIODE Expo

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# Why Add Ethical Reasoning to Calculus I?

- This project arose as part of the NSF grant: *Normalizing Ethical Reasoning in Mathematics as a Foundation for Ethical STEM*
- Ethical reasoning in STEM is usually taught late in undergraduate education or in graduate school (if at all)
- Teaching it earlier may help normalize it as an integral component of doing mathematics
- An ethical code is not useful if students are not taught how to use it

# How to define Ethical Reasoning?

- A process of reasoning about ethical issues that involves the following steps:
  1. identify and ‘quantify’ your prerequisite knowledge
  2. identify decision-making frameworks
  3. identify or recognize the ethical issue
  4. identify and evaluate alternative actions (on the ethical issue)
  5. make and justify a decision
  6. reflect on the decision

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# How to add Ethical Reasoning to Calculus I?

- Goal: Integrate into existing material rather than adding extra material to an already-packed syllabus
- Our problem structure:
  - Calculation
  - Interpretation
  - Ethical Question
- Different Formats for Ethical Questions
  - Cost/Benefit analysis of different actions
  - Evaluate whether an action (such as presenting a given mathematical argument) is ethical
  - Find relevant items in the Mathematical Ethical Proto-Guidelines to justify decisions

# Mathematical Ethical Proto-Guidelines

**The ethical mathematics practitioner...**

(IN GENERAL)

1. Is honest about their qualification to complete work they accept; articulates any limitation of expertise, and consults others when necessary or in doubt. They accept full responsibility for their professional performance and practice.
2. Treats others with respect. Promotes the equal dignity and fair treatment of all people, and neither engages in nor condones discrimination based on personal characteristics. Respects personal boundaries in interactions, and avoids harassment, including sexual harassment; bullying; and other abuses of power or authority. Takes appropriate action when aware of disrespectful behaviors by others.
3. Accepts full responsibility for their own work; does not take credit for the work of others; and gives credit to those who contribute. Respects and acknowledges the intellectual property of others.
4. Should be forthright about any circumstances that might lead to either real or perceived conflicts of interest or otherwise tend to undermine the independence of their judgment. Discloses conflicts of interest, financial and otherwise, and manages or resolves them according to established (institutional/regional/local) rules and laws.

# Created Problems for:

- Average Rate of Change
- Limits (at infinity)
- Continuity
- Basic Derivatives
- Product Rule
- Second Derivatives
- Implicit Differentiation
- Related Rates
- Linear/Tangent Line Approximation
- L'Hospital's Rule
- Analyzing and Sketching Graphs of Functions
- Optimization

# JB Class

- 19 students - 12 freshmen/sophomores and 7 juniors/seniors
- majors: Engineering, Biochemistry, Undeclared, Business, Art
- met MWF for 50 minutes, for 15 weeks
- textbook: *Calculus: Early Transcendentals* by Rogawski, Adams, Franzosa
- weekly online homework

# JB Implementation: Math & Consequences

- Intro Activity done on first day of class
- most Fridays other than exam days were "Math & Consequences" Days (total of 8)
- Worksheets completed in groups
- Worth 10 points but graded mostly for participation
- Discussed briefly on Monday, Wednesday, or Friday of the next week

# CE Class

- 13 students, mostly freshmen with a few upperclassmen
- met MWF for 80 minutes, for 12 weeks
- textbook: *Active Calculus* by Matt Boelkins
- weekly written homework and optional online practice problems

# CE Implementation

- Intro Activity done on first and second day of class
- Initially planned to include ethical questions only for in-class work
- Ended up doing a combination of in-class and homework problems, with follow-up discussion

# Sample Problem: Average Rate of Change

- Students were given data on the Consumer Price Index every month from January 2017 to June 2023, and asked to compute the average rate of change for certain intervals
- Then they were asked to find time intervals to make average rate of change seem as alarming as possible or as reasonable as possible
- Finally, they were asked, “If you were asked to advise a policy-maker on the change in the CPI, would it be your responsibility to present both of the viewpoints in the previous questions? Why or why not? How would the choices you make in presenting this information impact others, positively or negatively?”

# Sample Problem: Average Rate of Change

| Label | Observation Value |
|---|---|
| 2017 Jan | 243.618 |
| 2017 Feb | 244.006 |
| 2017 Mar | 243.892 |
| 2017 Apr | 244.193 |
| 2017 May | 244.004 |
| 2017 Jun | 244.163 |
| 2017 Jul | 244.243 |
| 2017 Aug | 245.183 |

| Label | Observation Value |
|---|---|
| 2019 Apr | 255.211 |
| 2019 May | 255.290 |
| 2019 Jun | 255.159 |
| 2019 Jul | 255.685 |
| 2019 Aug | 256.059 |
| 2019 Sep | 256.511 |
| 2019 Oct | 257.244 |
| 2019 Nov | 257.803 |

| Label | Observation Value |
|---|---|
| 2021 Jul | 271.764 |
| 2021 Aug | 272.870 |
| 2021 Sep | 274.028 |
| 2021 Oct | 276.522 |
| 2021 Nov | 278.711 |
| 2021 Dec | 280.887 |
| 2022 Jan | 282.599 |
| 2022 Feb | 284.610 |

Follow-up homework question:

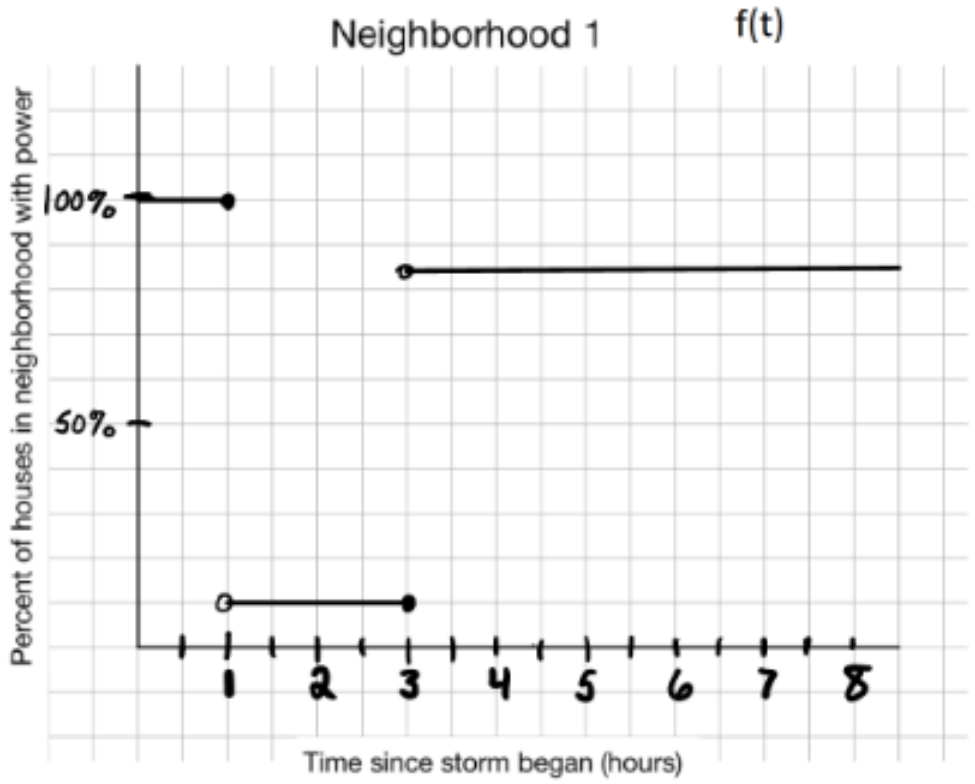
In class, we discussed using the average rate of change of the Consumer Price Index (CPI) to measure how prices are changing due to inflation. We saw that we could manipulate how people perceive the growth of prices by changing the time period on which we computed the average rate of change. What would be a better (more truthful and/or realistic) way to talk about how prices are changing, based on the data that we have? Use ideas from this class; explain why you think your method is better, or explain why you think we cannot do better. Write several complete sentences - this is not a one-word answer.

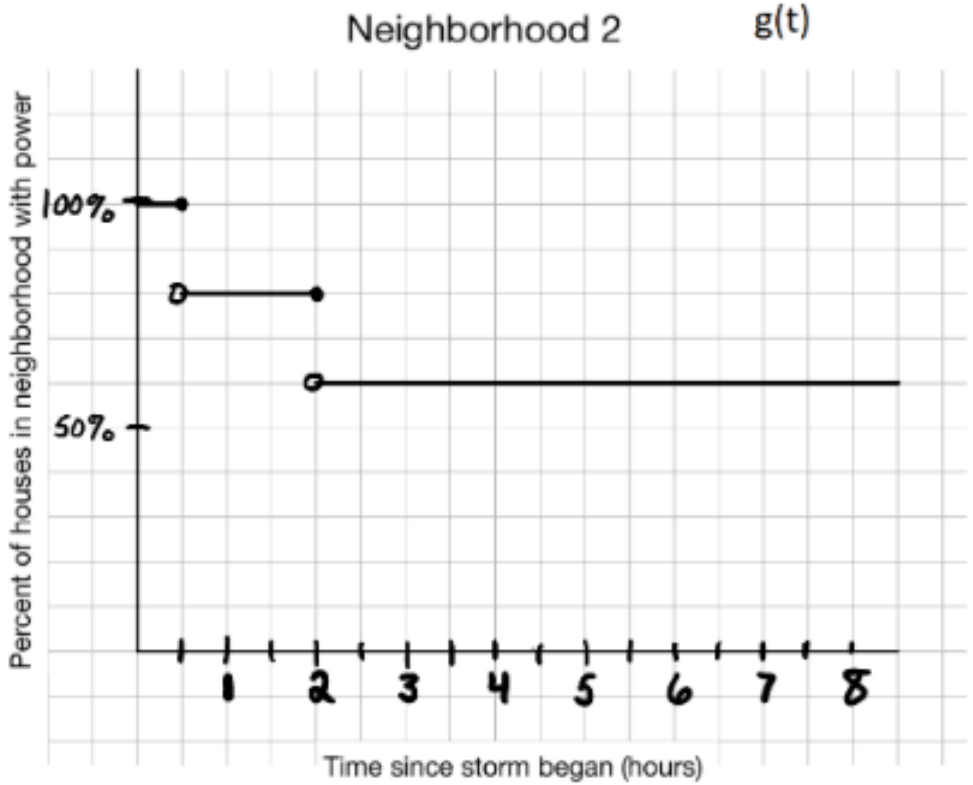
# Responses to Average Rate of Change Problem

- First ethical problem given in class
- Revealed students' misconceptions about average rate of change in general
- Many students did not realize there was an ethical decision to be made
  - This led us to including and asking students to reference the Mathematical Ethical Guidelines in future problems
- We realized we needed to be more careful about time allowed to answer the problems

# Sample Problem: Continuity

The graphs below show the percentage of houses that have power during a storm, in two different neighborhoods. The corresponding function for the first graph is called $f(t)$ and the corresponding function for the second graph is called $g(t)$.



# Sample Problem: Continuity

- parts (a)-(e) ask about one sided limits, discontinuities, and interpretation of the graphs (which neighborhood should have its power restored first?)

Ethical Reasoning Part - Fall 2023 Version

(f) Suppose that Neighborhood 1 has an average house value of \$60,000 and Neighborhood 2 has an average house value of \$120,000. Does that affect your choices in Part (c)?

(g) Referencing the excerpt from the Mathematical Ethical Proto-Guidelines provided, find one that could help guide you in using the graphs and the house income data to decide where to dispatch the repair teams. Explain your answer.

- did not generate very much discussion from the students

# Sample Problem: Continuity

## Spring 2024 Version

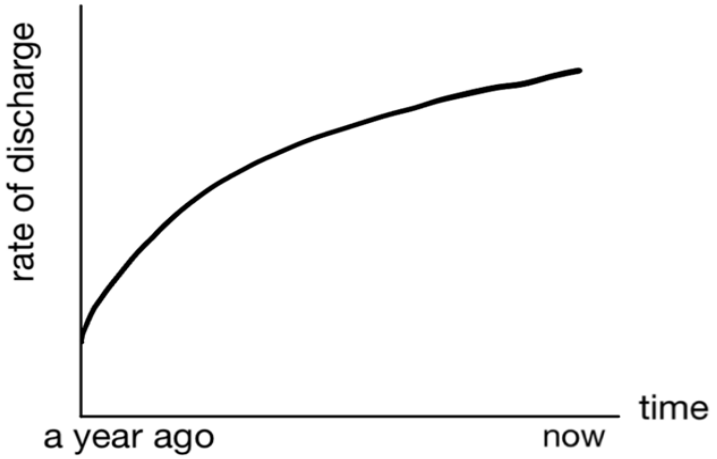
(f) There are several factors that power companies can take into account when deciding which neighborhoods to send crews to first. Which of the following factors would be ethical to add to the model above to assist decision making?

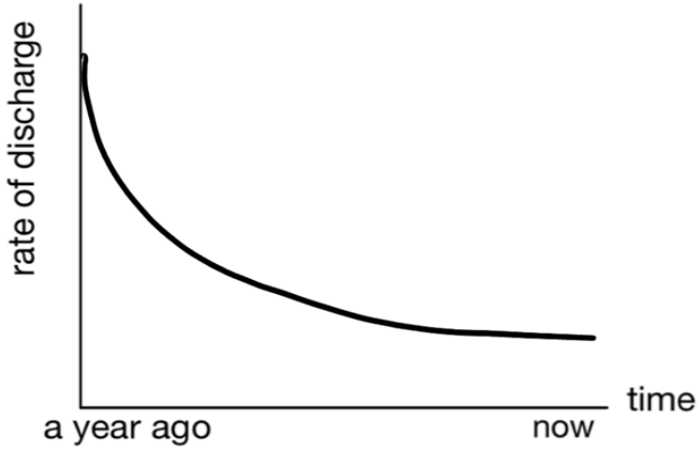
- the locations of critical facilities like hospitals, police stations, and fire stations
- the average amount in local property taxes that each neighborhood pays
- the distance from each neighborhood to the nearest major power transmission line

You may reference the ethical guidelines on the back of the next page.

# Sample Problem: The Second Derivative

An industry is being charged by the Environmental Protection Agency (EPA) with dumping unacceptable levels of toxic pollutants in a lake. Over a several month period, an engineering firm takes daily measurements of the rate at which pollutants are being discharged into the lake.




Adapted from a problem in Hughes-Hallett and Gleason's *Calculus*

# Sample Problem: The Second Derivative

- Suppose you work for the engineering firm. You are approached by representatives from both the industry and the EPA, asking you to make a mathematical argument for their side in court. They each offer you the same amount of money for the job.

- Which group will you choose to work for? Why? Give reasons for both rejecting the group you decide not to work for, and for accepting the other group's offer.

- What is the mathematical argument you will make to support the group you chose? Use the ideas of this class to support your argument, but make it understandable to a jury of people with little mathematical background.

# Responses to Second Derivative Problem

- Students tried to apply the guidelines to the *industry*, and not themselves
- Example: The guideline, “Is informed about applicable laws, policies, rules and guidelines,” was used to justify not representing the industry because the industry was ignoring the laws.
- Better guideline use: “Minimizes the possibility of harming others” was used to justify representing the EPA
- Many students defaulted to the argument that pollution is bad, so there is no ethical way to work for the industry, regardless of the situation

# Results of the Pilot Semester (JB)

- did 8 Math and Consequences worksheets as planned, but most of the time they were longer than what we had time for in class
- the calculation and interpretation generally took longer than expected
- did not discuss much as a whole class

# Results of the Pilot Semester (CE)

- Only 5 Ethical Scenarios completed throughout the semester
- Discussion of ethics questions usually took longer than expected
- Moving parts of ethics questions to homework allowed students more time to think about them before discussing in class
- Mathematical misunderstandings were often revealed when discussing ethics questions
- Students needed the guidelines to make better ethical arguments

# Student Feedback (JB)

- 16 students completed an extra credit reflection and gave consent for their answers to be shared anonymously
- (However, their responses were not gathered anonymously)
- Most students were positive about the Math & Consequences worksheets, which they saw not just as ethics worksheets but a chance to take a break from "normal" classwork and work on a longer, more detailed, more realistic problem with classmates

# Selected Student Comments (JB)

- "The Math and Consequences worksheets helped **me connect what I was learning in class with how it was used in the outside world**."

- "This year the math and consequences exercises showed me **a different side of math**, **one that could be ethically wrong even if the numbers were right**."

- "discussing ethical reasoning scenarios allowed me to not only apply math skills but also think a little bit deeper about **how calculus can apply to real-world issues**."

# Student Criticisms/Suggestions (JB)

- "I found the scenarios that we talked about to be interesting but didn’t help, the problems were [too] hard so **most of the time the math was the only thought**."

- "This is a great practice for upperclassmen like seniors and juniors but for freshmen, this is almost **not needed at this time**."

- I think if the **scenarios were a little more applicable and common**, it would make it even more enticing to most."

# Student Feedback (CE)

- Most students thought discussing ethics was worthwhile
- The biggest takeaway for most students is that math is not just about computation.
- A few said that at first they did not think ethics was applicable to mathematics, but did change their minds throughout the course.
- One said that a single conversation about ethical reasoning would have been enough

# Selected Student Comments (CE)

- "The scenarios made me realize that **math is more than just numbers**…. It often involved more thinking because it became more of a word problem, rather than just numbers."

- "Personally, in one way it was interesting was being able to take a step back away from the numbers, etc., and focus on the application of math in the world…. The scenarios enlightened me to the idea that **sometimes I calculate away without interpreting what it is I am doing**."

- "Scenarios…were **difficult and easy at the same time**. What I mean by that is that I felt that if the math part was easy, then the ethical reasoning was difficult or vice versa."

# Selected Student Comments (CE)

- “It felt to me that ethical reasoning is significantly more arbitrary than math, as I have always thought of any types of math to be very concrete and absolute….There were times thought **that I did not realize a question was one involving ethics**, **because no one that I know of has ever been raised to think about math as anything but objective numbers or letters on a page that mean nothing**"

# Ideas for Improvement

- Give students readings on big topics like modelling, data privacy, bias, etc
- Provide a simplified version of the ethical guidelines that the students can reference
- Shorten the problems or make the "calculation" parts easier so they can be completed in one class period
- More discussion as a whole class

# Continuing Work

- Calculus I materials are being used again this Spring in JB's class
- We will write a similar set of problems for the rest of the Calculus sequence
  - Some have been written and are being used in CE's Calculus II this Spring
- Create a full-semester project including ethical reasoning (in progress for Calculus II)

# Thank you!

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