Hallowe’en Party

A Mathematics Project In Three Parts

Hi Students - it's me Dr. Boocher! As you know, we won't be having a third "in-class" midterm. Instead, we will work on a project that uses Calculus to help solve "applied" problems. As you'll see, I've concocted a zany mystery puzzle for you to solve by using the methods of Calculus. All of the problems you'll have to solve are like problems we've seen in class (we'll work on a few in the coming days), but what's new in this project is that **you have to figure out what the problem is asking and you have to write up your solutions in a way that offers an explanation using concepts from class as well as any relevant figures, graphs, formulas, etc.**

Here's how everything will go down: Because this is a mystery problem, at each stage the number of potential ghosts will be reduced (at the end of this document there is a list of many possible ghosts. The ghost that actually featured in our story is one of these! Your first task will be to *greatly* reduce that down. Then you'll narrow it down further. And then finally you will solve the mystery in the final stage by figuring out what happens on the beach as one of our characters observes from afar! By the end of the project, you should be able to determine who the ghost is. By that point you will also have written many pages of well-written mathematics that explains the concepts we've been learning in the course.

Since I don't want you to get too far off track, I'm going to ask you to turn in this project in stages. This is for several reasons:

- It gives you a chance to get feedback before you turn in the remaining parts.
- If you made a mistake and narrowed it down to the wrong suspects, then you'll be able to correct and adjust for the subsequent parts of the project.

You are welcome to turn in any part of the project early.

What follows might seem like a lot - what I recommend doing is reading everything (estimated time: 10-15 minutes) and trying to plot out how you're going to tackle each of the tasks below. The rubric for this project is

Each Task will be worth 25 points

- 10 points will be for the mathematical correctness of your solution. Did you correctly solve what the task asked for and clearly indicate your steps in the solution?
- 5 points will be for mathematical correctness of explanation. Did you include labels, did you specify what your functions were, your variables, and did you correctly use mathematical terminology.
- 5 points will be for your exposition. Did you explain your terms in a way that a fellow Calculus student could understand your reasoning and how you came to your conclusions?
- 5 points is for presentation and creativity. Are your equations clearly separated from the text? Is your work clear and easy to read? Do you refer to the appropriate parts of the document when making your case? Have you personalized this project - feel free to create a conversational tone. Maybe you want this to read like a note to your friend Detective P. Or maybe you want to practice writing formal business or scientific writing. This is all up to you. What's important is that you write clearly.

Task 1: (Due Wednesday Nov. 10th at the beginning of class)
Which Ghost Did They See In the Maze?

After reading all of the clues, you will see that there was a ghost sighted in a corn maze. **Your first task is to figure out which of the many possible ghosts could have been seen.** The clues you need are in the project, and should involve **tangent lines** and will require you to **look at our written HW8.** Your solutions should include the following:

- It should be addressed to Detective P. and provide an introduction and explain your methods. For instance, you might want to say something like "I can help you narrow down the list of ghosts to the following. …. Here is my explanation..."
- Using Desmos is **strongly encouraged** as is **including pictures that communicate your work.**
- Your answer should narrow down the potential ghosts to somewhere between 3 and 6. (If you get more or less, double check your work.)
- You don't have to show all of your calculations - in fact it is **good to use a computer to help support your answer.** However to get Desmos to cooperate you will need to calculate the **slope** of **tangent lines** at various points, and for this you will need to **carefully** use **implicit differentiation**.
- Your **solution should include the calculation of a derivative.** (You only need to show your work fully in one example, but I will be looking for this) for instance you might say - "Dear Detective P.: I need to find the equations of lots of tangent lines. I'll show you carefully what I did to find the first one, and then just write the answers for the other ones. I can tell you what I did with Desmos to help..."
- You may want to include relevant graphs to support your answer. Screenshots from Desmos are strongly encouraged. Be particularly careful about your explanations of **why** your answer is correct. Explain what your graphs are showing - is the scale appropriate to show the x and y ranges? Are there labels? How many graphs will you include? Talk with your group about presentation and how you want to present your answer.
- If you are making any assumptions make them clear - this is a "real life" problem, so you may need to make some assumptions. For instance, it's very reasonable to assume that the people in the story are telling the truth, and that the values in the table represent what they would in our class.
- Hint: I recommend FOILing out the left and right hand side of the equation for the curve. Double-check that you did it correctly by typing the FOILed out version and seeing if it matches. This will make calculating derivatives MUCH easier.

Task 2: Due Friday Nov. 19th
Who Had The Strength Required

- By this point you should have narrowed down the list of suspects (and I will send out the correct list in case there were any errors.) Your next task is to figure out which of these suspects was strong enough to throw the magical stone as described in the project.
- Your answer should eliminate some ghosts.
- You will use the laws of physics as they behave on Earth (e.g) the h(t) = -16t^2 + (v_0)*t + s_0 formula will hold true, (if everything is in feet and seconds).
- Please address everything to Detective P. as before and explain your mathematics! I want you to include details about how you know the formula for the height. It's ok to reference our work from class.

Task 3: Due Monday Nov. 29th
What was Agent Keen Running Toward?

- We are now ready to determine the final answer to this problem - which ghoul was in San Diego County that evening. You should have a narrow list of possible ghosts, and you know from the table where in the water they were likely to be. Presumably FBI Agent Keen saw one of the ghosts from her position near the rock and wanted to get out to the ghost **as fast as possible.**
- Use the information in this story to figure out which ghost it was.
- Make sure your explanation is clear with proper figures and you explain who your final choice is for the suspect. I'm looking for a good setup and explanation for this problem.
- For this problem you are expected to set everything up and use Calculus and algebra. This might be involved, but you can do it! This is similar to the problem we will have solved in class by the end of this week. You can follow along / modify the solution we do in class to solve this problem.
- Again, the math is just part of the problem, your presentation and writing will be important as well.

You are absolutely welcome to turn things in early! In fact there will be a prize for whoever is the first to identify the ghost! You may work in a group and you may talk with your classmates but please do not ask tutors or other professors for help with this project. **This should be treated like an exam, but one where you are encouraged to collaborate, brainstorm and of course ask me lots of questions. Posting any part of this project on the Internet will be considered a severe violation of the Honor Code and will be reported to the Dean's office and can result in receiving an F in the course. Please don't do this - My goal with this project is to give you an alternative to timed in-class exams and to give you a chance to express yourself in writing. I want everyone to succeed on this project, so that's why I've scaffolded everything in this way**.

Good Luck and I hope this is fun!

Hint: You might want to learn how to use sliders / functions on desmos. It will really help for this project - just give it a try, type f(x) = ax^2 and it should prompt you to make a slider for the letter a. Then slide away!

And Now Let the Hallowe’en Party Begin...

Halloween Party
Finding: Inconclusive / Unsolved
Reporting Agent: Detective P

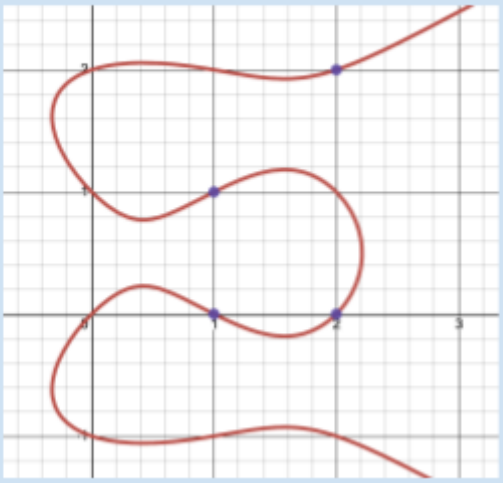
Summary:

On the night of Oct 31st, 2021 unexplained events occurred in San Diego County, initiating within the city limits of Carlsbad, just east of Highway 5, but also with paranormal activity at Solana Beach. We are still putting together all the details, but what is known is this:

- There were ghost sightings by several students who were in the corn maze. Curiously, the only students who could see the ghosts were those who were stationed near the magical stones. We have learned that people were near at least two of the different stones when they saw the ghost. But there could have been people at 3 or 4 of the stones too. We aren't sure!
- The shape of the maze seems relevant. In interviewing the subjects, it sounds like one could only see "directly ahead" while they were in the maze. Our sketch artists have drawn straight lines to the graph in our internal records.
- Apparently there was an FBI agent at the party and her report has given us a list of possible ghosts, based on their known locations, in the maze area and the ocean, but at the moment we cannot narrow down the possibilities at all. We need help with the mathematics of it all.
- Below is the information we have. Unfortunately we spilled ink over some of the interviews - **sorry about that!**
- We are publishing this notice to any and all mathematics students. **If you can help us with this project, please let us know!**

Exhibits: Invitation:

You are invited to an e'ening you'll ne'er forget
2021 Hallowe'en Party



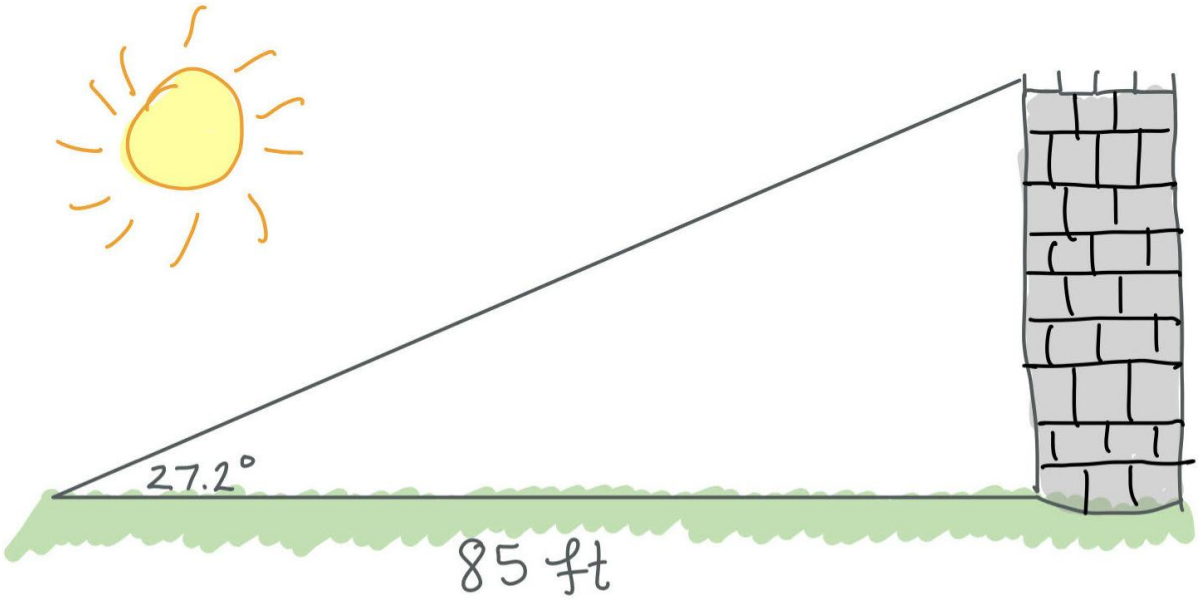
There will be an amazing corn maze!
(That's a pun!)

Visit the 4 magical stones inside the maze
Pictured here

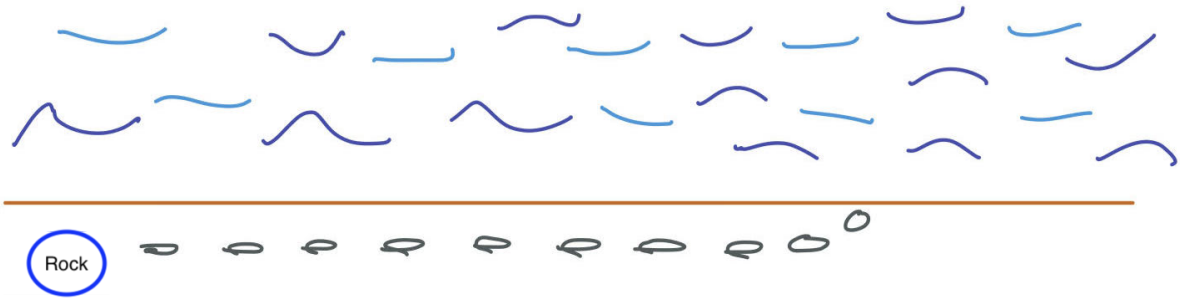
Stare into the sky directly ahead in the maze
and you may see a ghoul!

Location: Corn Maze in Carlsbad
Time: 5pm

"artist's" rendering of the tower



and beach



Interview Number 1: Fiona C.

Detective P: Please tell us about the encounter in the corn maze.

Fiona C. It was all the most bizarre thing. I had gotten an invitation to attend a Halloween party (the invitation had spelled it Halowe'en, which I thought was ridiculous, but also intriguing.) I was particularly interested in the corn maze that they were having. I grew up in the midwest and was frankly surprised that they could grow corn in California, and missed the talls rows of corn of my youth. Oh and the corn maze looked *exactly* like a graph that I saw on Homework 8 in my Math 150 class, so I knew the equation for it - what are the odds? It's almost like I was meant to find this invitation.

Detective P: Who gave you the invitation?

Fiona C: Oh that's the weirdest thing. It just appeared in my backpack one day. Kind of spooky, actually.

Detective P: Please continue:

Fiona C: So I went to the party, and everything was pretty normal, lots of students, some food and music. And then around 6pm we entered the corn maze. It was getting dark, and the corn was so tall that the only real part of the sky you could see was directly in front of you. Like you know if you extended straight forward in a straight line in the direction you were facing. And of course the maze kept curving to and fro, so these directions kept changing. Oh and whoever made the maze, had put in these "Magical Stones" - which were just big rocks that you had to climb over.
I was by the magical stone at 7pm when I saw the ghost. It was unlike

The remaining page(s) of this interview are missing.

Interview 2: Martin G

Detective P: Tell us what happened, Martin

and then after all of those events in the corn maze, I was pretty shaken up. I went back to the party tent and everyone was there. We all talked about the ghost, but the weirdest thing was that only the people who were near the magical stones at 7pm were able to see the ghost. I guess it must have been something with the directions of the maze, and what people could see. But in total, there were four of us who saw the ghost, and each of us at one of the magical stones. And then it happened. I couldn't believe it. The stones, they started to … they started to fly up into the air! Really high, too

ehavior?

st position to see what was

up to a maximum height higher

yes, higher than the tower.

Interview 3: Gregory G.

Detective P: I'm interested in hearing what happened after the party ended.

Gregory G: Yeah, so I wasn't that impressed with the ghosts at first. I mean, I didn't see any in the maze, because I wasn't near the magical stones. But then when the stones started to rise up and fall. Like wow, that was pretty intense. The upward velocity necessary to get something so high is really unreal. There was an FBI Agent at the party, she had all these calculations - one column of her table said "upward velocity" which she told me was in feet/sec and was how much each ghost could push up when throwing something. I asked her if that applied even to heavy stones and she said yes.

Oh yeah, so after the party ended… Well I went down to Solana Beach to go listen to the waves. There wasn't much of a moon that night I don't think, or maybe there were clouds. But the sounds of the waves were relaxing, and helped me calm down after the frightful events of the night.

And that's when I saw Liz running on the beach.

Detective P: This is the same Agent Elizabeth Keen who was at the party?

Gregory G: Yes, I had just met her. She worked for the FBI or something. Said she was investigating something. But anyways, I saw her running on the beach and then went in at an angle to swim. She clearly wanted to get out to whatever it was she saw as fast as possible. And then … she vanished!

Detective P: And then you went and measured the footprints? That seems suspicious - why would you do that?

Gregory G: Yeah, so that's fair. You see, I'm in this calculus class and we learned how to minimize the amount of time that it would take to get out to a point in the water, based on your running and swimming speeds. I worked out that she had run exactly 153.8 feet on the beach before swimming at an angle. Who knows what angle she was going though. But clearly, she must have been trying to minimize her time to get out to the object.

Detective P: And this was all close to the rock on the beach, right?

Gregory G: Yes, this was all relative to this rock where Liz was sitting before she started to run. I can draw a picture if you want, though warning, I'm not an artist.

Detective P: Oh, please - can you also draw a picture of the tower. Martin G. mentioned a tower too.

From the Files of FBI Agent Elizabeth Keen
(Currently Missing, last seen on Solana Beach)

I have reason to believe that there will be ghost activity on Halloween night 2021 in San Diego County. I shall advertise a Hallowe'en party to mathematics students in hopes that any ghost sightings will come with accurate and precise information. Based on previous sightings, I know that the possible ghost positions are given on the table (with relative coordinates) in Carlsbad and Solana Beach area. I predict that only one ghost will be active and will appear first in Carlsbad and then at Solana Beach. My only hope is that I can get close enough with my instruments to learn more. My running speed is 8 miles per hour, and my swimming speed is one third of that. I will write more soon. (Oct. 31, 4pm)

Name of Ghoul	Corn x	Corn y	upward velocity	how far out in the water perpendicular from beach?	Distance along beach from "rock"
Trick	4	1	65.4	30	94
Treat	4	2	8.3	75	63
Salem	4	3	26.8	80	62
Ghost of Christmas Present	4	4	14.4	45	186
Storm	4	5	34.9	60	185
Jack O Lantern	4	-2	46.4	87	52
Shadow	5	1	37.4	70	129
Boourns	5	3	48.7	75	196
Scary	5	2	49	120	185
Ghost of Christmas Past	5	7	48.8	25	153
Boo	5	-1/3	75.5	188	86
Beast	3	0.7	11.6	180	51
Ghost of Christmas Future	3	1	58.4	154	142
Spirit	3	-.5	33.3	108	198
Carl	3	9	74.1	70	113
Earl	1.5	-1.5	22.9	81	132
Myrtle	1.7	2.9	14.5	79	173
No Bones	1.666	-.33	53	60	175
Bella	1	1	92.0	85	143

Bram	1	0	28.5	55	18
Blinky	1	-1	34.4	93	97
Bones Day	0	2	104.4	86	103
Pumpkin	0	3	10.31	46	140
Raven	0	2.5	45.5	83	200
Casper	0	0.5	51.5	92	150
Reaper	0	.66	42.3	198	75
Ruby	-1	-1	44.5	99	34
Sabrina	-1	0	11.2	198	40
Wolfie	-1	1	60.1	40	120
Spooky	-1	2	83.4	129	40
Tick Tock	-1	3	98.5	65	40