Space Modulator Research Agency
Planet Mars

Math 113 Students
Suite 125, Manchester Hall
Wake Forest University
Winston-Salem, NC 27109

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Dear Earthlings:

I am writing for your help. After many years of work on my Illudium Q-36 Space Modulator, it is finally ready to go. I need your vector calculus expertise to help me decide where to position the blasted thing for optimum blasting.

I'm offering you a chance to save your planet. I couldn't decide whether to modulate Earth or Pluto, but I've temporarily chosen to blast Pluto into bits, but only if you can help me with this conundrum. (Hey, Pluto's no longer a planet, so who needs it around anyway???)

My spaceship will need to orbit Pluto along an ellipsoid, whose major/minor axes are as follows: along $x$, 10 $km$; along $y$, 10 $km$; along $z$, 20 $km$. (An ellipsoid with two equal length axes is known as a *spheroid*.) But the Q-36 operates at different strengths on this spheroid. A practice blast at the wrong location had insufficient power to detonize Pluto. This makes me very angry, very angry indeed.

So I turn to you for help. The Illudium Q-36 Space Detonator uses vast quantities of the element illudium, which is not found on Earth and unknown to your scientists. Around Pluto, my spaceship's receptors can process illudium at the rate of

$$I(x, y, z) = xyz$$

$kg$ per hour. So my **first question** to you is *at what point(s)* $(x, y, z)$ *on the spheroid should I park my spaceship for maximal illudium processing*?

The Q-36 operates at power

$$P(x, y, z) = yI(x, y, z) + 20000$$

gigawatts based on my location in space around Pluto. My second question is *at what point(s)* $(x, y, z)$ *on the spheroid should I park my spaceship for maximal blasting power for the Q-36*? Will this be the same point(s) as above? Why or why not?

The fate of your planet is in your hands. If you are unable to give me these locations, I will turn the Q-36 Space Modulator towards Earth. (I already know where to place the Q-36 for the optimal blasting of Earth into millions of tiny bits.)

Using Lagrange multipliers, find the answers to these two questions. I plan to modulate over your spring break, so please have your answers to me by Thursday, March 4th, or else your break may be a bit warmer than you imagined. If you don't already have spring break plans, grab the next flight out to Neptune and enjoy the show!

Yours sincerely,
Marvin T. Martian

Re: **Written Requirements for Project**
To: Math 113 students
From: Jason Parsley

Marvin the Martian has sent a threatening request, and I think it's best to comply with his wishes. You will need to use the methods of Lagrange Multipliers (§3.4 in the textbook) to solve these two maximization problems.

**Requirements for Written Report**

You will work in groups of 2 students, as given on the last page. Your findings should be detailed in a typed technical report of 3-6 pages (not including figures). Marvin will accept computer-generated graphics (possibly from Maple); as for calculations, they may be typed or (neatly) hand-drawn in ink on typing paper (i.e., no notebook paper); the use of color pictures is encouraged.

You should begin by finding the equation of the ellipsoid which represents where the spaceship may orbit. This equation represents the constraint to be used in the Lagrange multiplier problem.

Your report should, at some point, summarize the idea of Lagrange multipliers, and then explain how it applies to these problems. Finally, solve both problems. You should include a sketch of where on the ellipsoid the answers lie. Explain geometrically why the answers to the two problems are the same/different.

This is a technical report; you will be evaluated on how clearly and correctly it communicates the desired results. I leave the formatting choices to you. One difficult task with any technical report is to be concise and thorough at the same time. (A technical report that is much longer than it should be is as bad as one that is shorter than it should be.)

The report should be written in a clear, concise manner using proper grammar. You are free to use any references you like. You should cite any references that you utilize, except for the course lecture and book. I encourage you to work within your group and to work very little with other groups; please cite any group which has helped you with your project.

The report is due at the start of class on **Thursday, March 4th**.

**Grade Determination**

Your compensation ('grade', if you prefer such language), beyond the chance to be a hero and save the planet, will be calculated in five categories as given below. The first four concern the correctness of your mathematical presentation and explanation. The fifth measures your composition style.

| *Category* | *Worth* |
|---|---|
| Mathematical Description of the Problem | 15 pts |
| Correct Solution | 40 pts |
| Explanation of Reasoning for Solution | 30 pts |
| Style, Figures, and Grammar | 15 pts |
| *Total* | *100 pts* |

## Project Groups

1. Calvin Arter, Kaitlin Battreall
2. Ben Blais, Gavin Borg
3. Mike Carlotti, Rakeem Chesney
4. Zac Christ, Greg Cordo
5. Katie Crabtree, Matt Deal
6. Mikal Drye, Epiphany Espinosa
7. Wes Farrell, Winston Fleishman
8. Colleen Hannan, Xiaochen Hu
9. CJ Junewicz, Gretchen Kaiser
10. Sam Kitchin, Tyler Kruse
11. Andrew McCarty, Shannon McGorry
12. Sungju Moon, Mitch Moore
13. Caitlin Pulling, Faith Sedberry
14. 
15. Evan Trawick, Stewart Warther, Xinyu Yao