Some details regarding projects and their write-ups

You will work on the project in groups of 2 or 3 people. You can work with anyone currently enrolled in APPM 2360, not just those in your lecture or recitation. If you choose to work alone (discouraged) you will incur a 10 percent (5 point) penalty. Your group will submit your final project report to the appropriate place in Gradescope following these guidelines:

- Submit all of your project (writeup and code) in a single, all-inclusive PDF file only (you can export MATLAB® scripts to PDF format). The single PDF must contain the entirety of the project: write-up, figures, code, *etc.* - everything. It cannot contain links to files external to it.
- Submit the code used for your project as part of the single PDF file (*e.g.* in an appendix to the report). Remember, code in Excel, Numbers, Google Sheets and other similar spreadsheet apps is not acceptable. However, Mathematica, Python, C/C++, *etc.* are acceptable alternatives to MATLAB®. Note that some projects may require the use of built-in functions in MATLAB®
- Have only ONE group member submit the project, but include ALL group member's names in the submission, both on the title page and in the Gradescope submission.
- Include the names of all group members working on the project on the title page of the report and also in the submission to Gradescope.
- NO late projects will be accepted. Start early on the project, giving yourself plenty of time to overcome all unforeseen circumstances that may arise. Anticipate potential uploading problems by submitting your project to Gradescope well before the actual deadline.
- Further information regarding the projects is in the syllabus.

Writing Guidelines

Your report needs to accurately and consistently describe the steps you took in answering all the questions asked. This report should have the look and feel of a technical paper. Documents submitted with numbered responses or in question/answer format will be severely penalized. Presentation and clarity are very important. Here are some important items to remember:

- Start with an introduction that describes what you will discuss in the body of your document. A brief summary of important concepts that you will be using in your discussion could be useful here as well.
- Summarize what you have accomplished in a conclusion. No new information nor new results should appear in your conclusion. You should only review the highlights of what you wrote about in the body of the report.
- Always include units in your answers.
- The main body of your paper should NOT include lengthy calculations. These should be included in an appendix and referred to in the main body. However, do include the results of any pertinent calculations in the main body of your report.
- Projects must be typed, including the equations in the main body (part of your learning experience is to learn how to use an equation editor), but an exception can be made for lengthy calculations in the appendix (which can be hand written as long as they are neat and clear)
- Your report doesn't have to be long. You need quality, not quantity of work. Of course, you cannot omit any important piece of information, but you need not add any extras.
- You do not need to screenshot your code and put it in the main body of the report. Instead, put your code as a neatly formatted PDF in the appendix, and simply state in the body of the report what software you used and how you used it to obtain your results.
- Include all plots relevant to your discussion in the body of the report and refer to them in the text. Plots should be neatly formatted, with appropriate labeling and scaling so that relevant features are clearly visible.
- Do introduce relevant equations that will be used or discussed in the report before you use them. Numbering the equations will help you reference them later.
- Write your report in an organized and logical fashion. Section headers such as Introduction, Background, Problem Statement, Calculations, Results, Conclusion, Appendix, *etc.* are not all mandatory, but are highly recommended. They not only help you write your report, but help the reader navigate through your paper, besides giving it a cleaner look.
  - Start with an introduction that gives an overview of what you will discuss in the body of the report. A brief summary of important concepts used in your discussion could be helpful here.
  - Use the body of the report to discuss the investigation process and to report your findings. You should answer all questions, include any plots, and report the results of all calculations here.

CONTINUED

- End the report with a conclusion that summarizes what you accomplished. No new information or new results should appear in your conclusion. You should only review the highlights of what your wrote about in the body of the report.
- Add an appendix to the report that includes the code used in the project as well as any lengthy calculations/proofs/derivations that you wish to submit. The appendix should be considered supplemental to the main parts of the report. No answers to questions, results, or plots should be found in the appendix.

If this is your first time writing a technical report, the following example project may be of some use to you. Following that is an example of a good report and a bad report, based on this example project. Please note that these examples are likely shorter than your finished reports and are meant to only serve as a guide to promote good writing habits. Even though they refer to Calculus III, these examples are relevant for Differential Equations. Though not shown here, be sure to include your code in an appendix to your report.

EXAMPLE PROJECT

APPM 2350 - Calculus III Sample Lab Assignment

This is a sample Lab assignment for Calc III. It is based on a Calc I style optimization problem, and this is intended to show examples of "good" and "bad" lab write-ups. Adapted from Brief Applied Calculus by Berresford and Rockett.

To celebrate the acquisition of Styria in 1261, Ottokar II sent hunters into the Bohemian woods to capture a unicorn. To display the unicorn at court, the King wants to build a rectangular cage. The material for the three sides of the cage cost 3 ducats per running cubit, while the fourth wall was to be gilded (covered in gold) and cost 51 ducats per running cubit.

In 1261, it was well known that a happy unicorn requires an area of 2500 square cubits. Of course, the King wanted to build a cage that would keep the unicorn happy, but not cost him his whole kingdom!

1. Draw a picture of the cage and define some variables to be the lengths of the unknown sides.
2. Intuitively, what shape will the cage have? Will it be square or rectangular? What sides will be the shortest?
3. Derive an equation for the *cost* of the cage as a function of the longer side.
4. Plot the cost function.
5. Use calculus to determine the dimensions of the cage with minimum cost.
6. Suppose the King decided that the unicorn's cage would not have a guilded wall (thus making all sides of the cage cost 3 ducats per running cubit). Then what would be the dimensions of the optimally shaped cage?
7. What conclusions can you make?

EXAMPLE OF A GOOD WRITEUP ON THE NEXT TWO PAGES

This is a sample Lab assignment for Calc III. It is based on a Calc I style optimization problem, and this is intended to show examples of "good" and "bad" lab write-ups. This lab would be considered "good" and would likely result in a grade in the 'A' range. Note: Your lab should be double spaced, and have a title page. This is single spaced so it fits on two pages

1 Introduction

King Ottokar II of Styria wants to build a cage for his new pet unicorn. He wants this cage to be rectangular, with one side of the cage decorated and covered in gold (gilded). It is well known that King Ottokar I wanted to save money. So he built a cage that was very inexpensive, and way too small for his unicorn. One day, this unicorn broke free, and trampled the King [1]. Ottokar II doesn't want to make the same mistake as his father.

A happy unicorn will have a cage with area 2500 square cubits. The three cheaper sides of the cage cost 3 ducats per running cubit, while the gilded side costs 51 ducats per running cubit.

In this lab, we will help Ottokar II find the optimum size of the cage. That is, the dimensions that will minimize the cost of the cage, but still have an area of 2500 square cubits.

2 Designing the Cage

The King wants to build a rectangular cage to display the unicorn at court. We will define this rectangular cage with two sides of length x and two sides of length y. For a diagram of this cage see Figure 1. Everyone knows that happy unicorns require an area of 2500 square cubits. Since our cage's area is xy, we know that $xy = 2500$. The gilded wall costs 51 ducats per running cubit while the other three walls costs 3 ducats per running cubit. Because the cost of the gilded wall is much greater than the cost of other walls, the gilded wall and the wall opposite it should be shorter than the other two walls. Having a rectangular cage with a shorter gilded wall will help minimize the cost. The gilded wall will be one of the walls with length y.

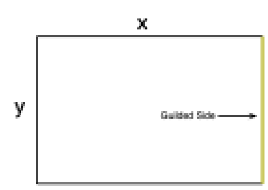


Figure 1: Diagram of the unicorn's cage.

The cost of the cage depends on how much of each material is used. Three of the walls cost 3 ducats per running cubit and the gilded wall costs 51 ducats per running cubit. The cost of the cage is $C(x, y) = 3x + 3x + 3y + 51y$, where the fourth wall is the gilded wall. We want to simplify this to an equation for the cost as a function of the longer side, x. Since we know that the area of the cage is $xy = 2500$, we can solve for y as a function of x. Doing this gives $y = \frac{2500}{x}$. Replacing the y in $C(x, y)$ with $y = \frac{2500}{x}$ and simplifying, gives the equation for the cost as a function of the longer side as $c(x) = 6x + \frac{135000}{x}$. To see how the cost varies as the length of side x changes, see the plot of the cost function in Figure 2. From the figure, it is clear there is some value of x that minimizes the cost.

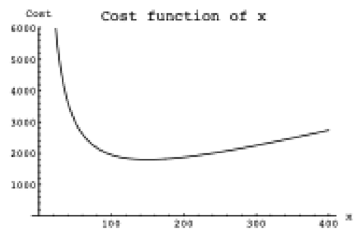


Figure 2: The cost of the cage as a function of the length of the longer side.

3 Determining the Cheapest Way to Build the Cage

We need to use calculus to determine the minimum value of the cost of the cage. In order to find where extreme values occur, we need to find where the derivative of the cost function is zero. The derivative of $c(x)$ is $c'(x) = 6 - \frac{135000}{x^2}$. Solving this for x gives $x = 150$. To determine if this is a maximum or minimum, we need to look at the value of the second derivative at $x = 150$. The second derivative is $c''(x) = \frac{270000}{x^3}$ so $c''(150) = 0.08$. Since the second derivative is positive, the cost function is concave up at $x = 150$ so it is a minimum. We now calculate the minimum cost as $c(150) = 6(150) + \frac{135000}{150} = 1800$ ducats. We know two sides have lengths of 150 cubits. We can find the lengths of the other two sides using $y = \frac{2500}{x}$. Plugging in $x = 150$, gives the lengths of the other two sides as $\frac{50}{3} \approx 16.7$ cubits. Therefore, our happy unicorn lives in a cage that is 150 cubits by 16.7 cubits and costs 1800 ducats.

4 A Not So Fancy Cage

If we do away with the gilded wall to save on ducats (but making our unicorn a little less happy), all four walls will cost 3 ducats. This changes the cost function to $c(x) = 6x + \frac{6(2500)}{x}$. Again, we use calculus to find the minimum cost. The first derivative of the cost function is $c'(x) = 6 - \frac{15000}{x^2}$. Solving this for x gives $x = 50$. A check of the second derivative shows that this is indeed a minimum. With all walls costing 3 ducats, the optimal cage is square with sides of length 50 cubits. The cage only costs 600 cubits.

5 Conclusions

We found that having a happy unicorn in a gilded cage requires a rectangular cage of size 150 cubits by 16.7 cubits. This cage costs 1800 ducats. If the King wants to be cheap and not have a gilded wall, the optimal cage for the happy unicorn is a square with sides of length 50 cubits. This non-gilded cage costs only 600 cubits.

In doing this lab, we learned a practical application of calculus — minimizing costs. If it wasn't for our help, King Ottokar II would have spent too much on his new cage.

6 References

[1] M. R. Calculus. A Brief History of Styria: From Ottocar I to Ottocar VIII. Sunnydale: Newton's Publishing Co., 2003.

EXAMPLE OF A BAD WRITEUP ON THE NEXT PAGE

This is a sample Lab assignment for Calc III. It is based on a Calc I style optimization problem, and this is intended to show examples of "good" and "bad" lab write-ups. This lab would be considered "bad" and would likely result in a grade in the 'C' range, or lower. Note: Your lab should be double spaced and have a title page. This is single spaced so it fits on one page

1 Introduction

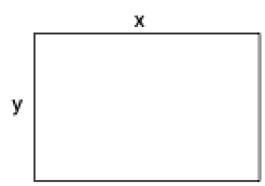
To celebrate the acquisition of Styria in 1261, Ottokar II sent hunters into the Bohemian woods to capture a unicorn. To display the unicorn at court, the King wants to build a rectangular cage. The material for the three sides of the cage cost 3 ducats per running cubit, while the fourth wall was to be guilded (covered in gold) and cost 51 ducats per running cubit.

In 1261, it was well known that a happy unicorn requires an area of 2500 square cubits. Of course, the King wanted to build a cage that would keep the unicorn happy, but not cost him his whole kingdom!

In this lab we will find the optimal dimensions of a cage for this unicorn's cage. We will use the calculus idea that a function is minimized when its derivative is zero.

2 Body

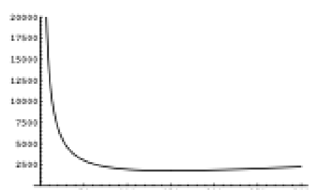
1) Let x be the length of the longer side, and y be the length of the shorter side.



2) The cage should be a rectangle. Since one side costs more that side will be shorter.

3) The area of a rectangle is $A = xy$. The area of our cage is 2500, so $xy = 2500$. The cost of the cage is the cost of the sum of the 4 sides. As a function of x, $c(x) = 6x + 135000/x$.

4)



5) Since $c(x) = 6x + 135000/x$, $c'(x) = 6 - 135000/x^2$. This is zero when $x = 150$. So, the cost of the cage is cheapest when $x = 150$.

6) Since the cost of all the sides is the same, the cage should be a square.

7) To have a cage with an area of 2500, the long side should be 150, and the short side should be 16.66666.

3 Conclusion

We helped the King find the dimensions of the cheapest possible cage. It is a rectangle. If the cost was the same for all four sides, the cage should be square.