MA103: Mathematical Modeling & Intro to Calculus
Robust Optimization 1

Lesson Objectives: Cadets will

1. Articulate the worst-case among multiple options in the context of a linear programming modeling problem
2. Explore robust optimization graphically
3. Interpret the results of a robust optimization in the context of a modeling problem
4. Analyze and articulate ethical considerations of performing prescriptive analytics using the ethics checklist

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Recall the lemonade problem:

A company produces 2 types of lemon flavored drinks: Regular and Charged Lemonade. The number of Charged Lemonade drinks is limited by machine mixing capacity and is limited to 10 per hour. Your pantry also has limited space to store lemons for processing. The regular Lemonade requires 2 lemons per large drink and the Charged one requires 5 lemons. You can only fit 60 lemons at a time in the pantry. The lemonades are also served in special cups and you only have 18 cups total available per hour. Finally, you are limited by the amount of ice your ice machine can make. The regular Lemonade usually has 3 scoops of ice per large drink, while the Charged Lemonade is full of caffeine and chemicals which leaves less room for ice. The Charged Lemonade only requires 1 scoop of ice per drink. Your ice machine only makes enough ice to fill 44 scoops total every hour. The Regular Lemonade generates a profit of \$2 and the Charged Lemonade only generates \$1 per drink. How many of each type of Lemonade should the bread company make every hour to maximize their profit?

$$\begin{aligned} \max_{x_1,x_2} \quad & P = 2x_1 + 1x_2 \\ \text{s.t.} \quad & x_2 \leq 10 \\ & 2x_1 + 5x_2 \leq 60 \\ & x_1 + x_2 \leq 18 \\ & 3x_1 + x_2 \leq 44 \\ & x_1, x_2 \geq 0 \end{aligned} \tag{1}$$

Link to solution: https://www.desmos.com/calculator/9kgdsuhuxm

1. What is **robust optimization**?

2. Identify the **parameters** in each of the functional constraints.

3. You've been observing the workers in your restaurant, and you've noticed that the actual number of scoops of ice required for a Charged Lemonade varies depending on the drink and the person preparing it. It looks like the number of scoops actually varies from 0.5 to 2.5 instead of always being 1. What is the most conservative value (worst case) for this parameter? Determine the Robust Solution.

4. Similarly you discover that the size of lemons can vary significantly. If the lemons are smaller than average, you can fit 75 in the pantry, but you now have to use between 5 and 7 lemons to make the Charged Lemonade and 2 to 4 to make the regular. What does this change in the problem? Determine the Robust Solution.