MATH 318 *Operations Research* Spring 2023

Team Project I: McDonald's Linear Programming Problem

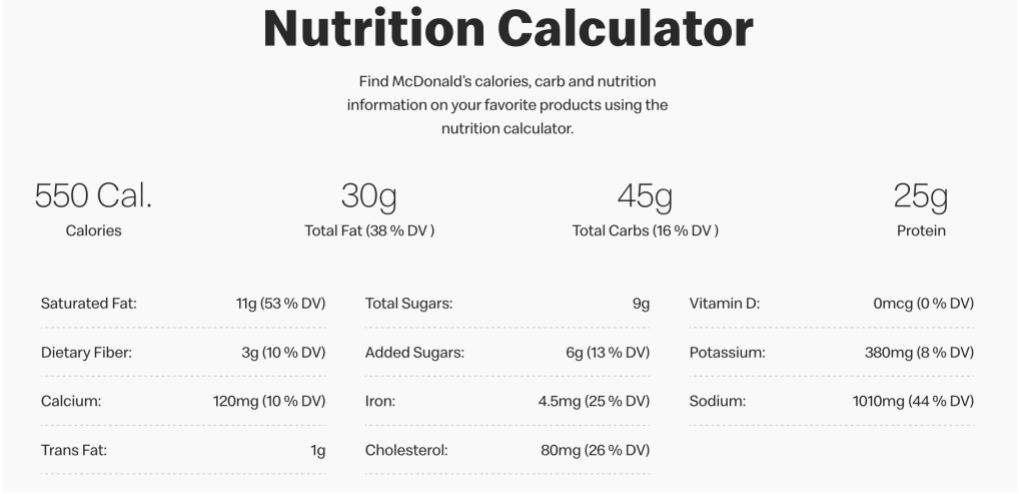
Due Friday, April 3

The goal of this project is to formulate and solve a linear programming problem related to the food items available at McDonald's.

The classic formulation of this exercise is *The Diet Problem*: Determine a minimum cost diet for an adult that meets the recommended daily allowances of nutrients and calories. It was first posed and solved heuristically (using 77 foods) by George Stigler, a subsequent winner of the Nobel Prize in Economics ("The Cost of Subsistence," *Journal of Farm Economics*, Volume 27, No. 2 [May, 1945], 303 – 314). After George Dantzig developed the Simplex Method, its first large computational test in 1947 was the Diet Problem. I strongly urge you to read Dantzig's delightful essay "The Diet Problem" which appeared in *Interfaces* (Volume 20,No. 4, July–August, 1990, 43 – 47). Here is a link: https://dl.dropboxusercontent.com/u/5317066/1990-dantzig-dietproblem.pdf

Your team's goal is to find the optimal selection of food from McDonald's that will satisfy a list of maximum and minimum constraints. You'd certainly want to keep the number of calories and amount of saturated fats and salt at or below recommended levels; these would be $\leq$ inequalities. But you also have to meet or exceed certain nutritional demands ($\geq$ inequalities). Our government's *Dietary Guidelines for Americans* recommends, for example, limiting calories from saturated fats to less than 10% of the total calories you eat and drink each day. That's about 200 calories for a 2,000 calorie diet. The American Heart Association recommends aiming for a dietary pattern that achieves 5% to 6% of calories from saturated fat. The Food and Drug Administration, on the other hand, recommends you get at least 1.5 milligrams of thiamin (vitamin B1), milligrams of riboflavin (vitamin B2), 20 milligrams of niacin (vitamin B3), and 1,000 milligrams of calcium. Your team should come up with your own defensible list of constraints; I think 10 to 12 of these would suffice.

I chose McDonald's because it's not difficult to obtain a list of the food items they offer and their nutritional content. See https://www.kaggle.com/datasets/mcdonalds/nutrition-facts , for example or McDonald's own claims at https://www.mcdonalds.com/us/en-us/about-our-food/nutrition-calculator.html. Here is their report on a Big Mac, for instance:



Nutrition Calculator

Find McDonald's calories, carb and nutrition information on your favorite products using the nutrition calculator.

550 Cal.	30g	45g	25g
Calories	Total Fat (38 % DV)	Total Carbs (16 % DV)	Protein

Saturated Fat:	11g (53 % DV)	Total Sugars:	9g	Vitamin D:	0mcg (0 % DV)
Dietary Fiber:	3g (10 % DV)	Added Sugars:	6g (13 % DV)	Potassium:	380mg (8 % DV)
Calcium:	120mg (10 % DV)	Iron:	4.5mg (25 % DV)	Sodium:	1010mg (44 % DV)
Trans Fat:	1g	Cholesterol:	80mg (26 % DV)		

A trip to a McDonald's will also enable you to ascertain the prices of the various items on the menu. If you want to visit our local Golden Arches and don't have a car, there's free bus service in town that will take you there; I may be able you a ride. Your team members can also check out prices at home during the Spring Break to see how much they vary from state to state.

You may want to consider several different objective functions. The classic choice is to minimize the cost. Dantzig reports on his effort to maximize the feeling of "fulness," measured by the weight of the food item minus the weight of water in it. [Warning: his basic feasible solution called for drinking 500 gallons of vinegar every day!]. A more interesting choice might be maximizing *tastiness* or *palatability* where you've added a cost constraint; some food sampling seems needed. Your team may well come up with other interesting objective functions.

The Linear Programming problem you formulate will have too many decision variables and constraints to solve by hand or even enter in the IOR Tutorial. We'll learn how to use LINGO to enter and solve large scale LP problems. At this early stage of the project, you'll want to formulate your objective function(s) and collect data.

kaggle.com/kapastor

HEALTHY MCDONALDS MEAL

Using linear optimization to find the most nutritious meal

Nutritional Assumptions

MINIMIZE CALORIES

TOTAL FAT	SATURATED FAT	SUGARS
< 70g	< 20g	~ 90g
CARBOHYDRATES	**PROTEIN**	**SODIUM**
> 260g	~ 50g	< 6g

Optimal Menu Items

6 *Apple Slices*

2 *Hotcakes*

5 *Side Salads*

1 *Fruit & Maple Oatmeal*

2 *Non-Fat Vanilla Latte*

There is a distinct lack of burgers and fries and all of the fun stuff on the menu. *This of course is very sad.*

Our final optimization shows that a McHealthy Combo is super super boring!