Data Collection

For this assignment, we were tasked to find the combination of quantities of food items with the minimal dollar cost while achieving a set of 7 additional dietary constraints. The options of food items were chosen from our own kitchens, after which we recorded the relevant quantities of micronutrients from the chosen items. In my kitchen, most of what we eat is ready-to-eat microwaveable meals. This meant it was trivially easy to collect the nutritional data needed to provide the parameters for the constraints in this exercise. These nutritional values are presented in the Appendix as Table 1, while the dietary needs/constraints are provided on the as Table 2.

The final component of the data collection, and the one I couldn't lift off of the nutrition label, is the costs of these meals. Because these are all delivered from the same service, they have the same price; $10. From an optimization perspective it doesn't matter much if it's $10 or $12 or anything else, as long as the prices are the same across the board. It means that we're trying to minimize the quantity of meals needed regardless of which meals we're choosing. This might be somewhat atypical from the intent of the assignment, but there's also another, more subtle complication from the chosen food items. These food items are intended to be complete meals in and of themselves. However, the nutritional value of these meals vary in a very specific way.

To start, the daily recommended requirement for iron is 18mg. The maximum value of iron within any of the meals is 3.5mg. This would mean that it would take at a minimum 5.14 meals to achieve that requirement, which is… suboptimal. Many other micronutrients each have a specific meal which lends itself towards satisfying the requirement; the Salmon is the only option with great Vitamin D, the Shredded Chicken is the only choice with more than nominal Calcium, and the Chicken & Mash is noticeably high in Potassium. This variety implies that an optimal solution should include several different meal items, rather than one option clearly rising above the rest.

Analysis & Results

Solving the problem via python using the pulp package for minimization required that I convert the various values into a standard equation. The collected data translated to the objective functions in standard form when calculating for the optimal weekly quantity of each meal are as follows:

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980*CVTP + 920*CHKN + 880*RICE + 850*SLMN + 770*MASH <= 5000*7 #Sodium
440*CVTP + 690*CHKN + 580*RICE + 660*SLMN + 500*MASH >= 2000*7 #Energy
29*CVTP + 41*CHKN + 34*RICE + 37*SLMN + 41*MASH >= 50*7 #Protein
0.0*CVTP + 0.1*CHKN + 0.1*RICE + 11.2*SLMN + 0.1*MASH >= 20*7 #Vitamin D
160*CVTP + 380*CHKN + 130*RICE + 110*SLMN + 100*MASH >= 1300*7 #Calcium
2.2*CVTP + 1.8*CHKN + 3.5*RICE + 1.3*SLMN + 2.5*MASH >= 18*7 #Iron
930*CVTP + 980*CHKN + 1010*RICE + 910*SLMN + 1430*MASH >= 4700*7 #Potassium
10*CVTP + 10*CHKN + 10*RICE + 10*SLMN + 10*MASH #Cost/Minimization Optimization
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The results of the equations can be found in Figure 1, while the results of a slight modification where each meal needed to be represented at least once can be found in Figure 2.

These results were quite counterintuitive. I had expected that at least 4 of the 5 meal items would be utilized in the optimal solution; certainly the Cream Cheese Salmon and the Loaded Chicken would be used due to their extraordinary Vitamin D and Calcium values respectively, and then the remainder of the nutritional requirements could be split between the three others. This was close, but what I didn't expect was that the Rice would be identified as an objectively better option than either the Cavatappi or the Mash. In retrospect, this is because, after the two "mandatory" items were selected in enough quantity to satisfy their associated nutritional requirements, Energy, Protein, and Potassium were all already satisfied, meaning only Iron was necessary to round out the remaining dietary needs.

Conclusion

In the end, the total weekly cost of this menu was just shy of $500 (regardless of the enforced variety). This result gave me immediate pause; $500 means 50 meals a week, far more than the 21 meals I would expect to need. The calories are even worse; this solution results in about 8000 weekly Calories from the Chicken, another 10350 from the Salmon, and a whopping 21400 each week from the Rice. That's a combined 40000 calories, or about 5700 Calories a day, far beyond most dietary recommendations. The main thing I attribute this to is the lack of any iron-rich food among the menu items. Even the Rice at 3.5mg of Iron would take more than 5 servings to reach the recommended daily requirements. Replacing either the Rice or the Mash with an item with greater Iron content would decrease the amount of meals needed, and with specific items addressing specific dietary requirements, there would also be a potential for other meal items to be included in the menu to address any remaining dietary requirements.

Another way to improve variety would be to change the optimization problem entirely. That shocking caloric result has me thinking perhaps I should minimize caloric intake instead of cost and prioritize losing weight over saving money. If that were the case, otherwise lackluster options like the Cavatappi might shine as a lower-calorie option with many comparable nutritional values. In fact, I had tried to follow a similar method to the cost minimization method to determine the lowest-calorie solution, but when solving and troubleshooting, I received nonsensical negative values for some of the higher-calorie meals. I'll need to return to the problem, learning more about the pulp package to correct my parameters, or go about solving it via means other than python to identify and correct what I was doing wrong.

Large-Language Model Approach

I'm not in the habit of incorporating predictive text engines into my workflow, so this is an exercise I wasn't particularly familiar with. It worked! I provided ChatGPT.com with the equations in standard form and provided a prompt to provide code solving those equations using the PuLP python package. The code (which can be found in the git repo) provided the same result as the equations here. I also tried to get it to correct my attempt at finding the minimum calorie solution… and it resulted in the same nonsensical answer I kept getting. My conclusion is that the "Garbage In = Garbage Out" principle remains alive and well in the age of LLMs, and the error is in either my interpretation of the results, or some flaw I cannot detect within my equations.

Appendix

Table 1

Items	Sodium	Energy	Protein	Vitamin D	Calcium	Iron	Potassium
Artichoke Cream Shredded Chicken Cavatappi	980mg	440 kcal	29g	0.0mcg	160mg	2.2mg	930mg
Loaded Bacon & Spinach Shredded Chicken	920mg	690 kcal	41g	0.1mcg	380mg	1.8mg	980mg
Mushroom Chicken Thighs & Wild Rice	880mg	580 kcal	34g	0.1mcg	130mg	3.5mg	1010mg
Herb Cream Chesse Salmon	850mg	660 kcal	37g	11.2mcg	110mg	1.3mg	910mg
Grilled Chicken & Browned Butter Yukon Mash	770mg	500 kcal	41g	0.1mcg	100mg	2.5mg	1430mg

Table 2

Component	Max/Min	Daily Amount and measure
Sodium	Maximum	5,000 milligrams (mg)
Energy	Minimum	2,000 Calories (kilocalories, kcal)
Protein	Minimum	50 grams (g)
Vitamin D	Minimum	20 micrograms (mcg)
Calcium	Minimum	1,300 milligrams (mg)
Iron	Minimum	18 milligrams (mg)
Potassium	Minimum	4,700 milligrams (mg)

Figure 1 - Initial Results

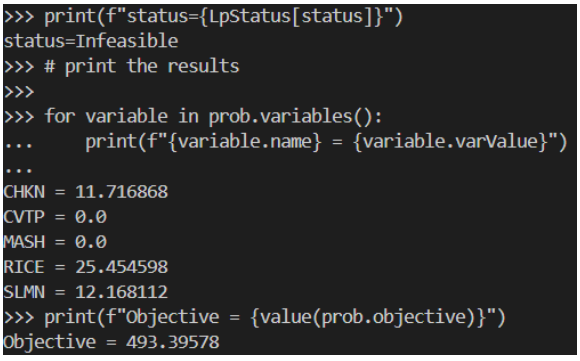

Figure 2 - Revised Results