Assignment One
Linear Programming Problem:
Daisy's Department Store

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MSDS 460 - Decision Analytics
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Part One:

Prices for the food items in this Diet Problem assignment can be found in the 'part_one_photographs' folder. All Packaged food prices in this assignment were sourced from the online Costco website and Trader Joe's. We will be following standard serving sizes defined in the existing product packaging. Calculations for individual serving prices all follow the following format and do not include tax + transportation costs:

Price Per Serving = Base Item Cost / Serving Amounts in Package

Using this price per serving cost, we can attach a set cost per serving to each of the seven required nutritional requirements set by the Food & Drug Administration.

Part Two:

We will be leveraging Linear Programming to construct a personalized diet that includes five unique food items found in my pantry; Chicken, Rice, Greek Yogurt, Mole Sauce, and Almonds. The food in this personalized diet is expected to cover all necessary nutritional requirements that are defined by the U.S. Food and Drug Administration. The U.S. Food & Drug Administration (FDA) has determined that for an American to have a healthy diet, they will need a set amount of Potassium, Iron, Calcium, Vitamin D, Protein, Energy, and Sodium. The items in our diet holistically include each of these seven identified nutrients. We are optimizing our food diet to meet these nutritional requirements set by the FDA at the lowest possible cost. Below is the set up for our linear programming model as well as data tables defining nutritional values per item serving as well as costs per serving.

The Linear Programming Model

Decision Variables:

Chicken → X1 servings, ***Almonds*** → X2 servings, ***Rice*** → X3 servings, ***Mole Sauce*** → X4 servings, ***Greek Yogurt*** → X5 servings

Cost Coefficients:

C1 = Cost of Chicken/serving, ***C2*** = Cost of Almonds/serving, ***C3*** = Cost of Rice/serving, ***C4*** = Cost of Mole Sauce/serving, ***C5*** = Cost of Greek Yogurt/serving

Objective Function:

Minimize Diet Cost

$$Z = 0.79(X1) + .02(X2) + .0013(X3) + 0.4(X4) + 0.78(X5)$$

Weekly Nutritional Constraints:

Subject to:

Sodium (mg): 260X1 + 0X2 + 0X3 + 280X4 + 55X5 =< 5000mg

Energy: 90X1 + 170X2 + 160X3 + 150X4 + 90X5 >= 2000 Calories

Protein (g): 21X1 + 6X2 + 3X3 + 3X4 + 15X5 >= 50g

Vitamin D (mcg): 0.1X1 + 0X2 + 0X3 + 0X4 + 2X5 >= 20mcg

Calcium (mg): 10X1 + 80X2 + 0X3 + 0X4 + 150X5 >= 1300mg

Iron: 0.4X1 + 1X2 + 0.36X3 + a4X4 + 0X5 >= 18mg
Potassium: 370X1 + 220X2 + 0X3 + 190X4 + 150X5 >= 4700mg

Additional Constraints:

Chicken → X1 >= 0, Almonds → X2 >= 0, Rice → X3 >= 0, Mole Sauce → X4 >= 0, Greek Yogurt → X5 >= 0

Serving Size	Chicken Breast			
4 oz (112g)	Component	Amount /serving	Amount/gram	% Daily Value/serving
	Total Fat (g)	1	0.009	1%
Calories/ Serving	*Saturated Fat (g)*	1	0.009	1%
90	*Trans Fat (g)*	0	0.000	
	Cholesterol (mg)	65	0.580	21%
Cost	*Sodium (mg)*	260	2.321	11%
$31.69	*Total Carb (g)*	0	0.000	0%
	Dietary Fiber (g)	0	0.000	0%
Servings	*Total Sugars (g)*	0	0.000	0%
40	*Protein (g)*	21	0.188	
			0.000	
Cost/Serving	*Vitamin D (mcg)*	0.1	0.001	0
$0.79	*Calcium (mg)*	10	0.089	0
	Iron (mg)	0.4	0.004	0.02
Cost/gram	*Potassium (mg)*	370	3.304	0.08
$0.00707				

Serving Size	Rice			
1/4 cup (45g)	Component	Amount/ serving	Amount/gram	% Daily Value/serving
	Total Fat (g)	0	0.000	0%
Calories/ Serving	*Saturated Fat (g)*	0	0.000	0%
160	*Trans Fat (g)*	0	0.000	
	Cholesterol (mg)	0	0.000	0%
Cost	*Sodium (mg)*	0	0.000	0%
$14.99	*Total Carb (g)*	36	0.800	13%
	Dietary Fiber (g)	1	0.022	0%
Servings	*Total Sugars (g)*	0	0.000	0%
250	*Protein (g)*	3	0.067	
			0.000	
Cost/Serving	*Vitamin D (mcg)*	0	0.000	0%
$0.06	*Calcium (mg)*	0	0.000	0%
	Iron (mg)	0.36	0.008	2%
Cost/gram	*Potassium (mg)*	0	0.000	0%
$0.00133				

Serving Size	Almonds			
1/4 cup (30g)	Component	Amount /serving	Amount/gram	% Daily Value/serving
	Total Fat (g)	15	0.500	23%
Calories/ Serving	*Saturated Fat (g)*	2	0.067	5%
170	*Cholesterol (mg)*	0	0.000	0%
	Sodium (mg)	0	0.000	0%
Cost	*Total Carb (g)*	7	0.233	2%
$10.82	*Dietary Fiber (g)*	4	0.133	16%
	Total Sugars (g)	1	0.033	0%
Servings	*Protein (g)*	6	0.200	6%
16			0.000	
	Vitamin D (mcg)	0	0.000	0%
Cost/Serving	*Calcium (mg)*	80	2.667	8%
$0.68	*Iron (mg)*	1	0.033	6%
	Potassium (mg)	220	7.333	4%
Cost/gram				
$0.02254				

Serving Size	Oikos Triple Zero Greek Yogurt			
1 cup (150g)	Component	Amount/ serving	Amount/gram	% Daily Value/serving
	Total Fat (g)	0	0.000	0%
Calories/ Serving	*Saturated Fat (g)*	0	0.000	0%
90	*Cholesterol (mg)*	10	0.067	3%
	Sodium (mg)	55	0.367	2%
Cost	*Total Carb (g)*	7	0.047	3%
$13.98	*Dietary Fiber (g)*	0	0.000	0%
	Total Sugars (g)	5	0.033	0%
Servings	*Protein (g)*	15	0.100	30%
18			0.000	
	Vitamin D (mcg)	2	0.013	10%
Cost/Serving	*Calcium (mg)*	150	1.000	10%
$0.78	*Iron (mg)*	0	0.000	0%
	Potassium (mg)	150	1.000	4%
Cost/gram				
$0.00518				

Serving Size	Mole Sauce			
1/2 cup (26g)	Component	Amount/ serving	Amount/ gram	% Daily Value/serving
	Total Fat (g)	10	0.385	13%
Calories/ Serving	*Saturated Fat (g)*	1.5	0.058	8%
150	*Trans Fat (g)*	0	0.000	
	Cholesterol (mg)	0	0.000	0%
Cost	*Sodium (mg)*	280	10.769	12%
$3.59	*Total Carb (g)*	11	0.423	4%
	Dietary Fiber (g)	2	0.077	8%
Servings	*Total Sugars (g)*	2	0.077	3%
9	*Protein (g)*	3	0.115	
			0.000	
Cost/Serving	*Vitamin D (mcg)*	0	0.000	
$0.40	*Calcium (mg)*	0	0.000	0%
	Iron (mg)	1.1	0.042	6%
Cost/gram	*Potassium (mg)*	190	7.308	4%
$0.02				

Part Three:
Our linear programming model has been coded out in Python using the PuLP package. The code can be found in the diet_problem_python_lpmodel.ipynb (OpenAI 2023) python file in our repository. Our solution found that in order to minimize the cost of our weekly diet, we would need to eat no chicken and no mole sauce :(. We are able to have 70 servings of greek yogurt (10,500 grams/23ish lbs), 67.171717 servings of rice (3022 grams/6.7 lbs), and 101.81818 servings of almonds (3054 grams/6.7lbs). This minimum cost weekly diet is ***$56.72 per week***.

Part Four:
Changing the constraints to allow for at least one serving of each food item will likely just have our model include one serving of each of the two previously omitted food items. When we update the lower limits of our model with this one minimum serving requirement, we see that we are now able to have one serving of chicken (112 grams) and one serving of mole sauce (26 grams). We also see the same 69.95 servings of greek yogurt (10,500 grams/23ish lbs), more servings of rice (73.171717 servings or 3022 grams/6.7 lbs), and less almonds (101.81818 servings or 3054 grams/6.7lbs). This minimum weekly diet cost is ***$57.83 per week*** which is surprisingly similar to our previous cost.

I personally cannot fathom a week where I eat 23 pounds of greek yogurt. We'll adjust the upper limit of the x5 variable in our model in hopes of balancing out the serving sizes. Within this specific diet with 5 items, the cost goes up astronomically when we set the upper bound of greek yogurt to anything under 70 servings. On top of that, we end up having to eat a lot of chicken... With this in mind, we can work to add other items into our diet if we want to expand on the concept of realistic serving sizes while still adhering to FDA standards.

Part Five:

I have selected ChatGPT (https://chatgpt.com) to be the LLM I use for this solution. I believe an LLM agent can absolutely be used for this assignment because the diet problem is a standard linear programming problem with a documented history. I was able to have the LLM set up an initial framework for the linear programming problem that just needs real data input. The LLM had no issues with creating python code using the pulp package. It also was able to segment the linear programming problem into its key components (objective function, constraints, decision variables).

I started with a short description of the assignment by letting the LLM know that we are working with a linear programming diet problem that has 5 prepackaged food items. I then gave it details on the five food items as well as requested some starter python code. The experience was surprisingly simple and a bit scary. Although adding additional layers to the diet problem or trying to connect this specific linear

programming model to another scenario could prove problematic, I believe an LLM could absolutely be used to complete this first assignment.

References:

OpenAI. ChatGPT. Accessed January 19, 2025. https://www.openai.com/chatgpt.