Part 1

Nutrition facts

Sweet potato
Sources include: USDA

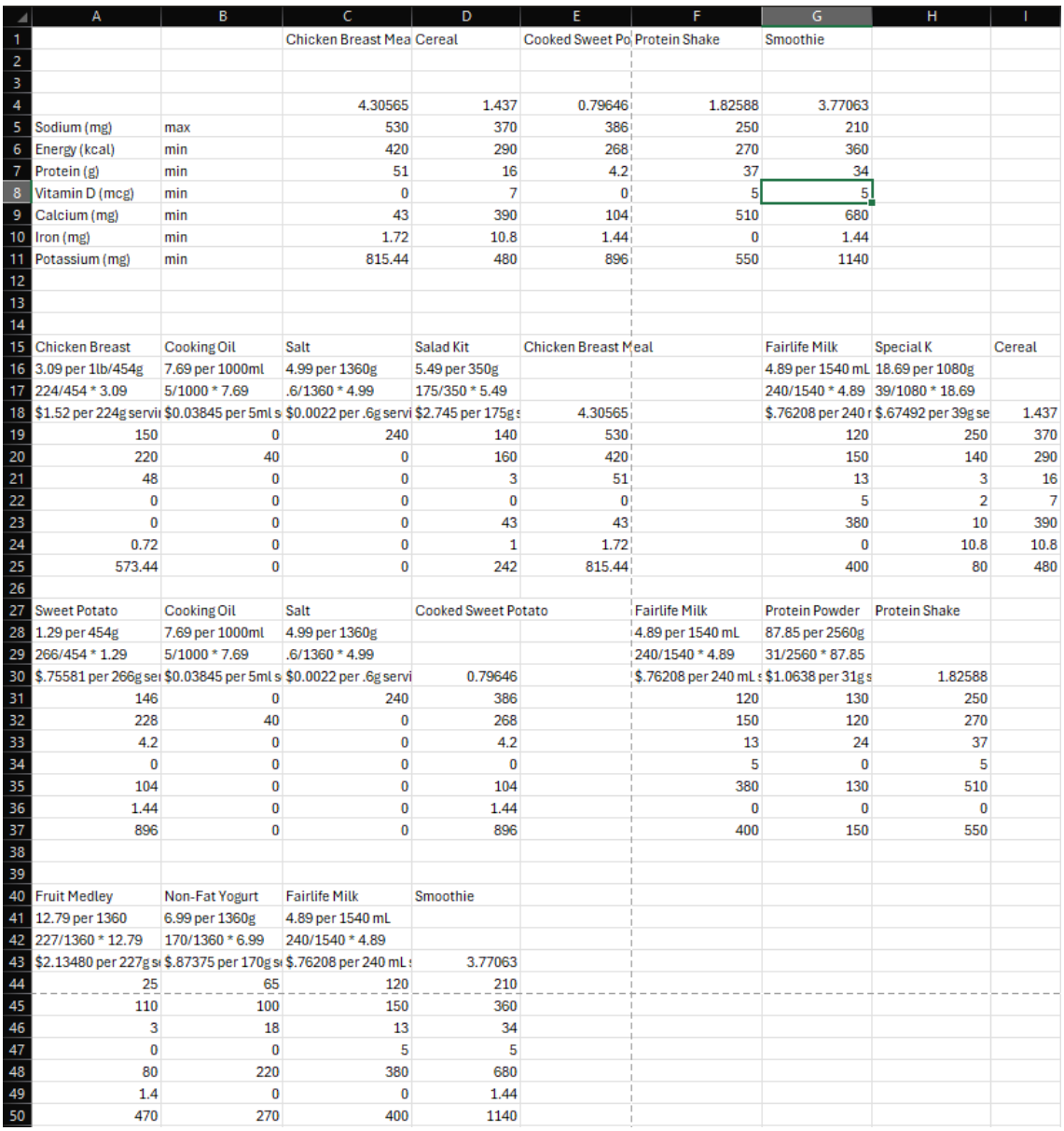
Amount Per 1 cup, cubes (133 g)

Calories 114			
			% Daily Value*
Total Fat 0.1 g			0%
Saturated fat 0 g			0%
Cholesterol 0 mg			0%
Sodium 73 mg			3%
Potassium 448 mg			12%
Total Carbohydrate 27 g			9%
Dietary fiber 4 g			16%
Sugar 6 g			
Protein 2.1 g			4%
Vitamin C	5%	Calcium	4%
Iron	4%	Vitamin D	0%
Vitamin B6	15%	Cobalamin	0%
Magnesium	8%		

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

I chose to use custom recipes for the 5 foods for this assignment. These were very simple recipes and the majority of the ingredients had nutrition labels from which information could be gathered. The only item that didn't come with its own label was the sweet potato and that nutrition label was taken from google, which sourced its information from the FDA. Each ingredient has their recommended servings shown on the labels, with the corresponding nutrition, but since these were custom recipes, all respective nutritional information was scaled to according to how much was used in the recipe.

Prices for each item were taken directly from the sellers website, and costs per serving were calculated by dividing the custom serving size by the total amount of the product and then multiplied by item price. Attached is a picture of the Excel file in which this work was done.



	A	B	C	D	E	F	G	H	I
1			Chicken Breast Mea	Cereal	Cooked Sweet Po	Protein Shake	Smoothie		
2									
3									
4			4.30565	1.437	0.79646	1.82588	3.77063		
5	Sodium (mg)	max	530	370	386	250	210		
6	Energy (kcal)	min	420	290	268	270	360		
7	Protein (g)	min	51	16	4.2	37	34		
8	Vitamin D (mcg)	min	0	7	0	5	5		
9	Calcium (mg)	min	43	390	104	510	680		
10	Iron (mg)	min	1.72	10.8	1.44	0	1.44		
11	Potassium (mg)	min	815.44	480	896	550	1140		
12									
13									
14									
15	Chicken Breast	Cooking Oil	Salt	Salad Kit	Chicken Breast M	eal	Fairlife Milk	Special K	Cereal
16	3.09 per 1lb/454g	7.69 per 1000ml	4.99 per 1360g	5.49 per 350g			4.89 per 1540 mL	18.69 per 1080g	
17	224/454 * 3.09	5/1000 * 7.69	.6/1360 * 4.99	175/350 * 5.49			240/1540 * 4.89	39/1080 * 18.69	
18	$1.52 per 224g servi	$0.03845 per 5ml s	$0.0022 per .6g servi	$2.745 per 175g s	4.30565		$.76208 per 240 r	$.67492 per 39g se	1.437
19	150	0	240	140	530		120	250	370
20	220	40	0	160	420		150	140	290
21	48	0	0	3	51		13	3	16
22	0	0	0	0	0		5	2	7
23	0	0	0	43	43		380	10	390
24	0.72	0	0	1	1.72		0	10.8	10.8
25	573.44	0	0	242	815.44		400	80	480
26									
27	Sweet Potato	Cooking Oil	Salt	Cooked Sweet Potato		Fairlife Milk	Protein Powder	Protein Shake	
28	1.29 per 454g	7.69 per 1000ml	4.99 per 1360g			4.89 per 1540 mL	87.85 per 2560g		
29	266/454 * 1.29	5/1000 * 7.69	.6/1360 * 4.99			240/1540 * 4.89	31/2560 * 87.85		
30	$.75581 per 266g se	$0.03845 per 5ml s	$0.0022 per .6g servi	0.79646		$.76208 per 240 mL s	$1.0638 per 31g s	1.82588	
31	146	0	240	386		120	130	250	
32	228	40	0	268		150	120	270	
33	4.2	0	0	4.2		13	24	37	
34	0	0	0	0		5	0	5	
35	104	0	0	104		380	130	510	
36	1.44	0	0	1.44		0	0	0	
37	896	0	0	896		400	150	550	
38									
39									
40	Fruit Medley	Non-Fat Yogurt	Fairlife Milk	Smoothie					
41	12.79 per 1360	6.99 per 1360g	4.89 per 1540 mL						
42	227/1360 * 12.79	170/1360 * 6.99	240/1540 * 4.89						
43	$2.13480 per 227g s	$.87375 per 170g s	$.76208 per 240 mL s	3.77063					
44	25	65	120	210					
45	110	100	150	360					
46	3	18	13	34					
47	0	0	5	5					
48	80	220	380	680					
49	1.4	0	0	1.44					
50	470	270	400	1140					

Part 2.

Decision Variables	Chicken Breast	Cereal	Sweet Potato	Protein Shake	Smoothie
	x_1	x_2	x_3	x_4	x_5

Objective Function and Cost Coefficients

$$4.31x_1 + 1.44x_2 + .80x_3 + 1.83x_4 + 3.77x_5 = cost$$

Weekly Nutritional Constraints

$$530x_1 + 370x_2 + 386x_3 + 250x_4 + 210x_5 \leq 35000$$

$$420x_1 + 290x_2 + 268x_3 + 270x_4 + 360x_5 \geq 14000$$

$$51x_1 + 16x_2 + 4.2x_3 + 37x_4 + 34x_5 \geq 350$$

$$0x_1 + 7x_2 + 0x_3 + 5x_4 + 5x_5 \geq 140$$

$$43x_1 + 390x_2 + 104x_3 + 510x_4 + 680x_5 \geq 9100$$

$$1.72x_1 + 10.8x_2 + 1.44x_3 + 0x_4 + 1.44x_5 \geq 126$$

$$815.44x_1 + 480x_2 + 896x_3 + 550x_4 + 1140x_5 \geq 32900$$

Non-negativity Constraints

$$x_1, x_2, x_3, x_4, x_5 \geq 0$$

The problem is as follows. We must create a week-long personal diet plan from 5 foods that fulfill the recommended nutritional intake values for 7 nutrients. Using linear programming, our goal is to find the cheapest combination of these items that will still provide the necessary required nutrition. The code for the solution is available on GitHub.

Part 3.

Python PuLP was used to solve this linear programming problem. The solution according to the solver is $x_2 = 20.0$ servings, $x_3 = 30.60$ servings, and 0 servings for the rest of the items, with a minimum-associated cost of $53.28 for the weeks' worth of food.

Part 4.

According to the optimal solution, only 2 of the 5 foods are necessary for the cheapest option that will still satisfy our nutritional needs. It isn't necessarily realistic, so we decided to add a condition that at least 1 serving of each food must be eaten throughout the week. The solution to the revised LP is as follows. $x_1 = 1$ serving, $x_2 = 18.57$ servings, $x_3 = 28.22$ servings, $x_4 = 1$ serving, and $x_5 = 1$ serving. The associated cost for this amount of food is $59.23, which is $5.95 more expensive than the previous optimal solution.

Still working within the boundaries of the chosen foods, I do believe it would make sense to make it so that 1 serving of each food is eaten at least once a day, for a total of a minimum of 7 servings per item. Outside of this new condition, it is possible to add additional foods into the equation to create more variety.

Part 5.

I used the Google Gemini LLM for this portion of the assignment, the web address for it is gemini.google.com

When I inquired about the diet problem Gemini readily gave a simple example that I believe explained the concept very well. I then asked for a more complex example that, just like this assignment, included 5 food items and the nutritional constraints from this assignment. It was also relatively successful in setting up the linear equations necessary for solving this problem, the LLM included nonnegativity constraints, nutritional constraints, the decision variables, and the objective function. Further asking for code it also supplied python code using linprog, that when pasted into python successfully executed. When asked to use PuLP instead of linprog, it once again provided code that was able to be executed. Lastly I had Gemini add a constraint that at least 1 serving of each food must be consumed and it completed that task.

Overall, this was a very pleasant experience dealing with the LLM in a capacity that tried to challenge it. Gemini was successful in presenting ideas and a basic structure for code and how it would be used. But so far its answers must be taken with a bit of skepticism. While the majority of what it stated seemed truthful and correct, there seems to be some sort of mistake with the optimal solutions it gave. For the last problem, when I had asked for the food constraints to involve at least 1 serving of each food, it gave back an answer with a cost lower than the original optimal solution.