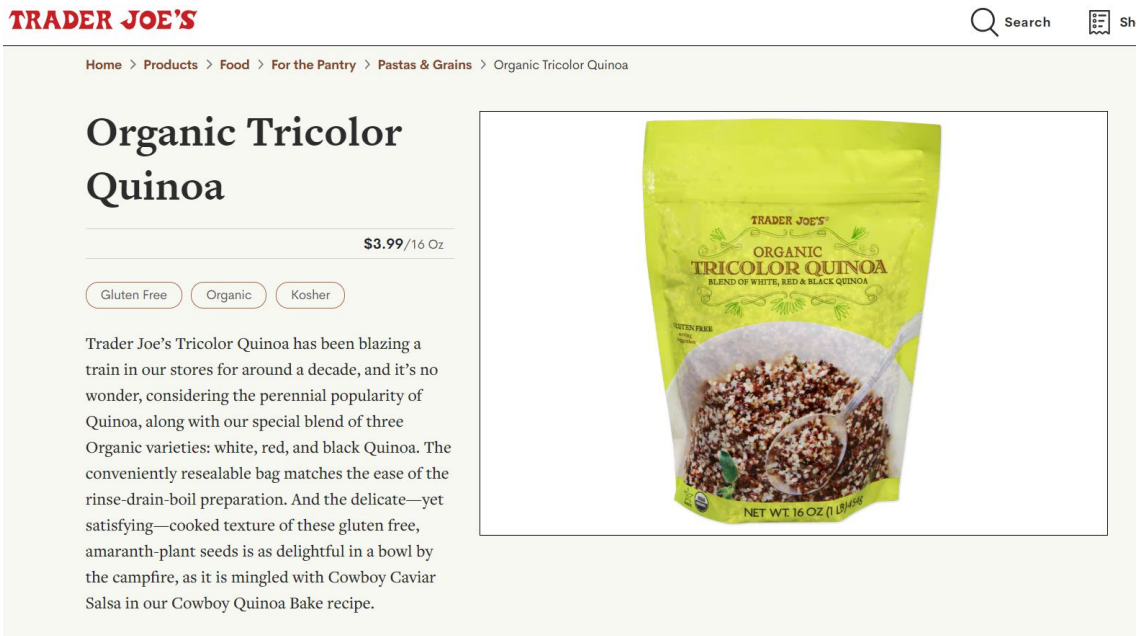
In this assignment, the diet problem aims to find the most cost-effective way to meet specified nutritional requirements, based on five food items I eat daily. In the context of the code provided, the diet problem involves selecting a combination of food items from a given set, each with its cost and nutritional content per serving. The goal is to minimize the total cost of the selected food items while ensuring that the combined nutritional content meets or exceeds certain weekly nutritional requirements. These requirements typically include components like sodium, energy (calories), protein, vitamin D, calcium, iron, and potassium.

The problem involves several key components: decision variables, constraints, and the objective function. For this scenario, the decision variables are the quantities of each food item to include in the diet. The objective of the problem is to minimize the total cost of the diet, and the provided code defines the objective function which calculates the total cost based on the quantities of selected food items and their respective costs. The constraints are each of the eight nutritional components that have specific minimum or maximum limits that the diet must meet. The problem of determining the quantity of each food item to minimize the objective function while meeting the nutritional limits is solved using a linear programming solver.

The food items I have selected for this diet problem are the following: Tricolor quinoa, whole milk, eggs, coconut water, and Lightlife tempeh. The following are screenshots of the nutrition labels and prices of each item, as well as the calculated cost per serving for each item.

Quinoa



SERVING SIZE

1/4 cup (42g)

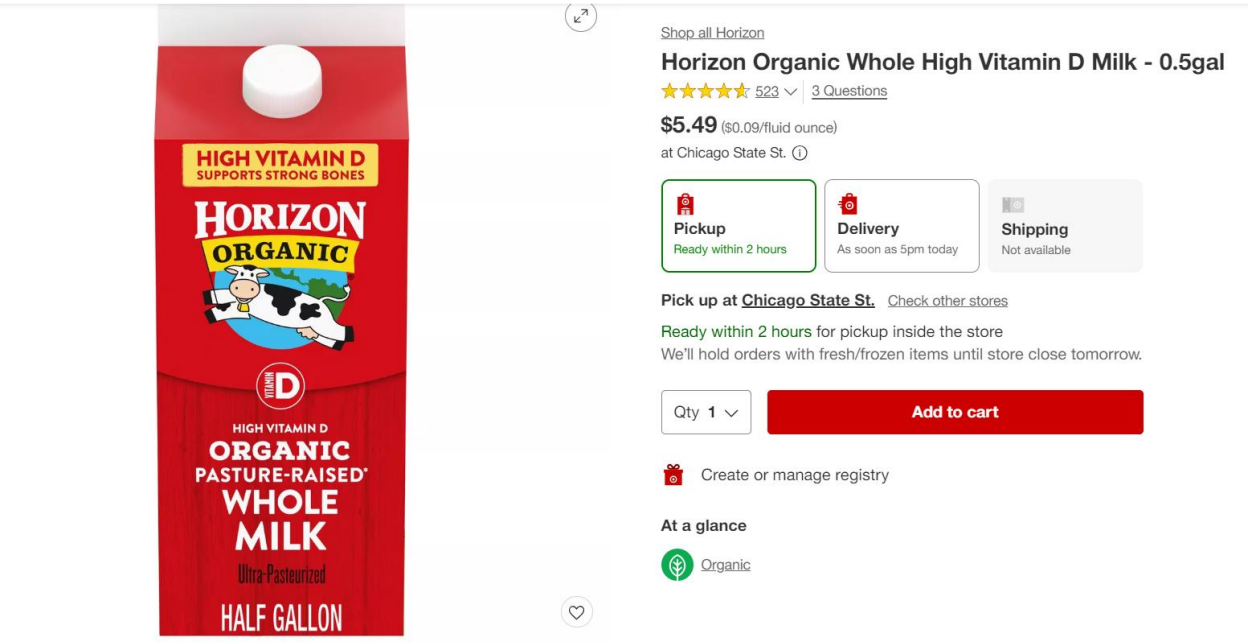
CALORIES PER SERVING

150

SERVES ABOUT 11	AMOUNT	%DV
Total Fat	2.5 g	3%
Saturated Fat	0 g	0%
Trans Fat	0 g	
Cholesterol	0 mg	0%
Sodium	0 mg	0%
Total Carbohydrate	27 g	10%
Dietary Fiber	3 g	11%
Total Sugars	1 g	
Includes	0 g Added Sugars	0%
Protein	6 g	
Vitamin D	0.0 mcg	0%
Calcium	20 mg	2%
Iron	1.9 mg	10%
Potassium	240 mg	6%

Cost per serving of quinoa = $3.99/11 = $0.69/serving

Whole milk



Nutrition Facts

About 8 servings per container
Serving size 1 cup (240mL)

Amount per serving
Calories 160

	% Daily Value*
Total Fat 8g	**10%**
Saturated Fat 5g	**25%**
Trans Fat 0g	
Polyunsaturated Fat 0g	
Monounsaturated Fat 2.5g	
Cholesterol 35mg	**12%**
Sodium 135mg	**6%**
Total Carbohydrate 13g	**5%**
Dietary Fiber 0g	**0%**
Total Sugars 12g	
Includes 0g Added Sugars	**0%**
Protein 8g	**16%**

Vitamin D 4.5mcg 25%	Calcium 310mg 25%
Iron 0mg 0%	Potassium 410mg 8%
Vitamin A 90mcg 10%	Riboflavin 0.4mg 30%
Vitamin B12 1.2mcg 50%	Phosphorus 240mg 20%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Cost per serving of whole milk = $5.49/8 = $0.36/serving

Eggs

Vital Farms

Pasture-Raised Organic Extra Large 12ct Eggs, 27 oz

$10.49

Sold in West Loop

Add to list

INGREDIENTS NUTRITION FACTS

Nutrition Facts
12 servings per container
Serving size 1 egg (56 g)

Nutrition Facts

12 servings per container

Serving size 1 egg (56 g)

Amount per serving

Calories 80

	% Daily Value *
Total Fat 5g	6%
Sat Fat 2g	10%
Trans Fat 0g	
Polyunsaturated Fat 1g	
Monounsaturated Fat 2g	
Cholesterol 210mg	70%
Sodium 80mg	3.5%
Carbohydrates 0g	0%
Fiber 0g	0%
Sugars 0g	
Added Sugar 0g	0%
Protein 7g	

Zinc 0.7mg	6%
Vitamin E 0.6mg	4%
Vitamin D 1.1mcg	6%
Vitamin B6 0.1mg	6%
Vitamin B12 0.5mcg	20%
Vitamin A 90mcg	10%
Selenium 17mcg	30%
Riboflavin 0.3mg	25%
Potassium 80mg	2%
Phosphorus 110mg	8%
Pantothenic Acid 0.9mg	20%
Niacin 1.6mg	10%
Iron 1mg	6%
Iodine 31mcg	20%
Folate 25mcg	6%
Choline 160mg	30%
Calcium 30mg	2%
Biotin 12mcg	40%

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Cost per serving of eggs = $10.49/12 = $0.87/serving

<u>Coconut water</u>

Vita Coco

Pure Coconut Water - 16.9 Fl Oz

$3.19

Sold in One Chicago

Add to list

INGREDIENTS

Ingredients: Coconut Water, Less Than 1% Sugar, Vitamin C (Ascorbic Acid).
Allergens
Tree Nuts

gf Gluten-Free kf Keto-Friendly k Kosher*

* Certified Kosher (no-type) by Star-K

Nutrition Facts

About 2 servings per container
Serving size **8 FL OZ (240 mL)**

	per Serving		per Container	
Calories	**45**		**90**	
		% Daily Value*		**% Daily Value***
Total Fat	0g	**0%**	0g	**0%**
Saturated Fat	0g	**0%**	0g	**0%**
Trans Fat	0g		0g	
Cholesterol	0mg	**0%**	0mg	**0%**
Sodium	35mg	**2%**	75mg	**3%**
Total Carbohydrate	11g	**4%**	23g	**8%**
Dietary Fiber	0g	**0%**	0g	**0%**
Total Sugars	10g		20g	
Incl. Added Sugars	1g	**2%**	2g	**4%**
Protein	0g		0g	
Vitamin D	0mcg	0%	0mcg	0%
Calcium	38mg	2%	80mg	6%
Iron	0mg	0%	0mg	0%
Potassium	470mg	10%	979mg	20%
Vitamin C	34mg	40%	70mg	80%
Phosphorus	12mg	0%	25mg	2%
Magnesium	18mg	4%	37mg	8%

* The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet.

Cost per serving of coconut water = $3.19/2 = $1.60/serving

Tempeh

Lightlife

Original Organic Tempeh

$3.79

Sold in One Chicago

Add to list

INGREDIENTS NUTRITION FACTS

Ingredients: Cultured Organic Soybeans (Soybeans, Lactic Acid from Plant Source), Water, Organic Brown Rice.

Allergens

Soy

df Dairy-Free | 2 Engine 2 | k Kosher* | sc Sugar-Conscious | v Vegan | vg Vegetarian

Nutrition Facts

2.5 servings per container

Serving size	3 oz (84 g)
Amount per serving	
Calories	**160**
	% Daily Value *
Total Fat 4.5g	**6%**
Sat Fat 0.5g	**2.5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 0mg	**0%**
Carbohydrates 12g	**4.4%**
Fiber 6g	**21%**
Sugars 0g	
Added Sugar 0g	**0%**
Protein 18g	
Vitamin D 0mcg	0%
Potassium 284mg	6%
Iron 2mg	10%
Calcium 87mg	6%

Cost per serving of tempeh = $3.79/2.5 = $1.52/serving

Here's a description of each part of the code:

1) Import Libraries: The code starts by importing the necessary libraries, including PuLP, for linear programming.
2) Define Nutritional Requirements and Food Items: The code defines the weekly nutritional requirements for the eight components and lists five food items along with their cost and nutritional content per serving. Each food item is represented as a list with specific attributes such as its name, cost, sodium content, energy content, etc.
3) Create Variables and Dictionaries: The code creates dictionaries to store the cost and nutritional content of each food item separately. Decision variables are defined using the LpVariable method from PuLP to represent the quantities of each food item to include in the diet.
4) Create the Linear Programming Problem: The code creates a problem object using LpProblem from PuLP and sets the objective function to minimize the total cost of the diet, using LpMinimize.
5) Add Nutritional Constraints: Constraints are added to ensure that the nutritional content of the selected food items meets or exceeds the weekly nutritional requirements. These constraints are formulated based on the specified nutritional requirements and the nutritional content of each food item. A for loop is used to access each food item from the list of items and ensure that the nutritional content for all the food items used in total doesn't exceed the weekly limit for sodium and is greater than or equal to the value set for the other nutrients.
6) Solve the Problem: The linear programming problem is solved using the solve() method, which uses PuLP's solver to optimize the decision variables and minimize the total cost while satisfying all constraints.

After solving the problem, the output was the following:

Optimal Diet Plan:

Horizon Organic Whole High Vitamin D Milk : 43.4 servings

Organic Tricolor Quinoa : 63 servings

Total Cost of the Diet per week: $ 59.08

The minimum cost and total cost for the week is $59.08, where I would need 43.4 servings of whole milk and 63 servings of quinoa to meet the weekly nutritional constraints and the minimum cost objective. Essentially, the three other food items were wiped out and I am only left with quinoa and milk to consume in very large quantities for the week, in order to meet the nutritional goals set. This is of course very unsustainable and boring, but it makes

sense why the solver resolved to using these items to get the most bang for the buck. These two items cost the least amount of money per serving out of the five food items. Additionally, when I was trying to determine what items to use to meet some of the nutritional goals, I was having the most trouble trying to find items that had enough, or any, iron and Vitamin D. Quinoa and tempeh have the highest amount of iron per serving, with both items having 2mg of iron per serving. However, the cost per serving of quinoa is only $0.69, which is more than two times less compared to the cost per serving of tempeh of $1.52. The whole milk also has the highest vitamin D content out of all 5 food items, and is the cheapest item per serving. These two items together also have the other nutritional components that were required, so overall, the solution makes sense.

For part 4, where the additional constraint of having at least one serving of each food item in a week is required, the total minimum cost ended up being $61.62, which is $2.54 higher than the total minimum cost from the initial problem without the constraint of having at least one serving of each food item. The quantities of each food item were the following: one serving of tempeh, one serving of coconut water, one serving of eggs, 42.2 servings of whole milk, and 61.5 servings of quinoa. As we can see, the overall amount of quinoa and milk didn't change too much, with the quinoa only being 0.5 servings less this time, and the milk being 1.2 servings less. Therefore, this still isn't the most balanced diet for the week, and it did the bare minimum in meeting the constraint of having at least 1 serving of each item, which is exactly what it did for the other 3 food items that weren't part of the solution in the initial problem.

To add more variety to my diet, I could revise the code by adding more food items that have more diverse nutritional profiles to provide a balanced diet, as well as add more constraints to encourage a more balanced nutritional intake. For example, I could set constraints to ensure a minimum number of fruits, vegetables, whole grains, lean proteins, and dairy in the diet. This way, I don't end up removing an important food group.

For part 5, I selected Google Gemini as the LLM to work with to answer the diet problem. This is the URL to the service: https://gemini.google.com/app

From my experience with it, it could definitely be used to complete the assignment. It provides pretty accurate code, that is a bit different from what I did, but leads in the same direction. The answer is a lot different than what I had gotten after running my code, however. The LLM has different opinions on what a serving of each food item is compared to me. For example, it considers two eggs as a one serving. Therefore, the costs per servings are definitely different from what I had. The overall weekly minimum cost is vastly

different than what I had, as well as the items chosen for the diet. Therefore, I have realized that while it is a very helpful tool to get some baseline code for the assignment, it still requires personal tweaks and more work to make it perfect and isn't completely reliable for the assignmnet on its own. My interaction with Google Gemini is in the README.md section of the Github Repository.