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Homework Assignment 1: Linear Programming Example---The Diet Problem

1.0 Part 1

I approached the packaged food selection intending to recreate meals and snacks I eat during a typical day. I chose three "meal" foods (Kodiak Cakes Plant-Based Flapjack Mix, Trader Joe's Tortilla Española, and Trader Joe's Madras Lentils) and two "snack" foods (Kirkland Cheese, Fruit & Nut Packs and BOOST Vanilla Drink Mix). I located prices for these foods at Amazon.com and my local Trader Joe's, Smith's Food and Drug, and Costco.

The nutrition facts, price per serving, and serving size for the final five packaged foods are detailed in Appendix A. The price per serving is rounded to the nearest hundredth of a cent in Appendix A but is not rounded in the Python code.

2.0 Part 2

The objective of this linear programming problem is to find the combination of the five foods that minimizes my weekly food costs while ensuring I ingest the weekly recommended amounts of sodium, energy, protein, vitamin D, calcium, iron, and potassium. The equations below represent the problem in standard form:

Objective function: Min $Z = (6.29/8)*x_1 + (13.59/16)*x_2 + (5.49/6)*x_3 + (33.99/24)*x_4 + (2.49/2)*x_5$
Subject to:
$440*x_1 + 160*x_2 + 320*x_3 + 170*x_4 + 510*x_5 + x_6 = (5000*7)$ - maximum sodium (mg)
$230*x_1 + 180*x_2 + 150*x_3 + 220*x_4 + 150*x_5 + x_7 = (2000*7)$ - minimum energy (kcal)
$14*x_1 + 8*x_2 + 5*x_3 + 10*x_4 + 7*x_5 + x_8 = (50*7)$ - minimum protein (g)
$1*x_1 + 0.1*x_2 + 0.2*x_3 + 6*x_4 + 0.1*x_5 + x_9 = (20*7)$ - minimum vitamin D (mcg)
$24*x_1 + 150*x_2 + 30*x_3 + 260*x_4 + 40*x_5 + x_{10} = (1300*7)$ - minimum calcium (mg)
$3*x_1 + 0.4*x_2 + 0.8*x_3 + 3.6*x_4 + 2.1*x_5 + x_{11} = (18*7)$ - minimum iron (mg)
$155*x_1 + 80*x_2 + 320*x_3 + 290*x_4 + 360*x_5 + x_{12} = (4700*7)$ - minimum potassium (mg)
$x_i \geq 0, \ \forall \ i$

Each packaged food is assigned a variable (x1, x2, x3, x4, and x5), which is detailed in Appendix A. Each constraint equation represents the five food's contributions to the weekly

recommended minimum or maximum of the nutritional component. The objective function details the price per serving of each of the five foods.

3.0 Part 3

I wrote the linear programming code in Visual Studio Code and utilized the Python PuLP library to perform the calculations. The Python code and output can be reviewed in this assignment's GitHub repository.

4.0 Part 4

The optimal solution includes only two of the five foods: Tortilla Española (x_3) and BOOST Drink Mix (x_4). To meet the weekly dietary constraints, I would need to eat 79.4 servings of Tortilla Española and 25.84 servings of BOOST Drink Mix. The total of this diet is $109.24. This combination of foods barely fulfills the minimum requirements for calcium and potassium, indicating those two dietary constraints are the most difficult to meet based on my selection of packaged foods.

5.0 Part 5

Altering the constraints to require at least one serving of each food per week does not drastically change the optimal solution. To meet the weekly dietary constraints and include at least one serving of each food, I would need to consume 1 serving of Kodiak Cakes Mix, 1 serving of Cheese, Fruit & Nut Packs, 78.15 servings of Tortilla Española, 25.16 servings of BOOST Drink Mix, and 1 serving of Madras Lentils. The total of this diet is $110.02, only $0.78 more than the original recommended diet. Similar to the original problem, the altered problem barely meets the minimum requirements for calcium and potassium. Although the altered constraints introduce more variety into the weekly diet, the new optimal solution still relies heavily on Tortilla Española and BOOST drink mix to satisfy the nutritional constraints.

Appendix A

Packaged Food Documentation

1. x_1 - Kodiak Cakes® Plant-Based Classic Protein Flapjack & Waffle Mix

    a. Price: $6.29

    b. Servings: 8

    c. Price per serving: $0.79

2. x_2 - Kirkland Signature Cheese, Fruit & Nut Snack Packs

    a. Price: $13.59

    b. Servings: 16

    c. Price per serving: $0.85

    d. NOTE: This packaged food includes two varieties with slight differences in iron and sodium. I used the lower values between the two varieties in the model.

3. x_3 - Trader Joe's Tortilla Española

    a. Price: $5.49

    b. Servings: 6

    c. Price per serving: $0.92

Nutrition Facts

SERVING SIZE

1/6 omelet (100g)

CALORIES PER SERVING

150

SERVES 6	AMOUNT	%DV
Total Fat	7 g	9%
Saturated Fat	1.0 g	5%
Trans Fat	0 g	
Cholesterol	145 mg	48%
Sodium	320 mg	14%
Total Carbohydrate	15 g	5%
Dietary Fiber	2 g	7%
Total Sugars	2 g	
Includes	0 g Added Sugars	0%
Protein	5 g	
Vitamin D	0.2 mcg	2%
Calcium	30 mg	2%
Iron	0.8 mg	4%
Potassium	320 mg	6%

4. x_4 - BOOST Original Balanced Nutritional Powder Drink Mix, Very Vanilla

    a. Price: $33.99

    b. Servings: 24

    c. Price per serving: $1.42

5. x_5 - Trader Joe's Indian Fare Madras Lentils

    a. Price: $2.49

    b. Servings: 2

    c. Price per serving: $1.25

Nutrition Facts

per serving	per container

SERVING SIZE
2/3 cup (140g)

CALORIES PER SERVING
150

SERVES ABOUT 2	AMOUNT	%DV
Total Fat	6 g	8%
Saturated Fat	3 g	15%
Trans Fat	0 g	
Cholesterol	15 mg	5%
Sodium	510 mg	22%
Total Carbohydrate	17 g	6%
Dietary Fiber	5 g	18%
Total Sugars	1 g	
Includes	0 g Added Sugars	0%
Protein	7 g	
Vitamin D	0.1 mcg	0%
Calcium	40 mg	4%
Iron	2.1 mg	10%
Potassium	360 mg	8%