Problem Set 1B: The Diet Problem in Miniature

Help

The **due date** for this homework is **Mon 10 Nov 2014 3:00 PM CST**.

This question concerns the diet problem that was discussed in this video .

We will use a miniature version of the data for this problem as provided in question 1. The problem also assumes that you are able to setup and solve linear programs using **any LP solver** of your choice. We have a set of video tutorials and forum discussions to help you learn how to solve LPs. Have you made use of those resources?

The Diet Problem Data

The miniature version of the diet problem has $n = 5$ foods and $m = 3$ nutrients.
The foods considered are *rice, quinoa, tortilla, lentils* and *broccoli* .
The nutrients are *carbohydrates, proteins* and *fat*

The caloric and pricing information (fictional) is as below:

Food Name	Carbs/Unit	Proteins/Unit	Fat/Unit	Price/Unit
Rice	53	4.4	0.4	0.5
Quinoa	40	8	3.6	0.9
Tortilla	12	3	2	0.1
Lentils	53	12	0.9	0.6
Broccoli	6	1.9	0.3	0.4

The data on daily minimal and maximal requirements are below:

Nutrient	Minimum	Maximum
Carbohydrates	100	1000
Protein	10	100
Fat	0	100

The following are the decision variables used:

Food Name	Decision Variable
Rice	x_r
Quinoa	x_q
Lentils	x_l
Tortilla	x_t

Brocolli	x_b

- [ ] **In accordance with the Coursera Honor Code, I (Kevin Zhu) certify that the answers here are my own work.**

Question 1

Which of the following describes the correct objective function for the problem of a **minimal cost** meal plan? Recall the problem data below:

Food Name	**Carbs/Unit**	**Proteins/Unit**	**Fat/Unit**	**Price/Unit**	Decision Var
Rice	53	4.4	0.4	0.5	x_r
Quinoa	40	8	3.6	0.9	x_q
Tortilla	12	3	2	0.1	x_t
Lentils	53	12	0.9	0.6	x_l
Broccoli	6	1.9	0.3	0.4	x_b

Nutrient	Minimum	Maximum
Carbohydrates	100	1000
Protein	10	100
Fat	0	100

- $\min 0.4x_r + 3.6x_q + 2x_t + 0.9x_l + 0.3x_b$
- $\min\ 53x_r + 40x_q + 12x_t + 53x_l + 6x_b$
- $\max\ 0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b$
- $\min\ 0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b$

Question 2

Which of the following constraint enforces that the purchased foods satisfy the minimum **protein** consumption requirement? Again, recall the relevant data

Food Name	**Carbs/Unit**	**Proteins/Unit**	**Fat/Unit**	**Price/Unit**	Decision Var

Rice	53	4.4	0.4	0.5	x_r
Quinoa	40	8	3.6	0.9	x_q
Tortilla	12	3	2	0.1	x_t
Lentils	53	12	0.9	0.6	x_l
Broccoli	6	1.9	0.3	0.4	x_b

Nutrient	Minimum	Maximum
Carbohydrates	100	1000
Protein	10	100
Fat	0	100

- $4.4x_r + 8x_q + 3x_t + 12x_l + 1.9x_b \leq 100$
- $0.4x_r + 3.6x_q + 2x_t + 0.9x_l + 0.3x_b \geq 0$
- $4.4x_r + 8x_q + 3x_t + 12x_l + 1.9x_b \geq 10$

Question 3

A person wishes to satisfy all the requirements by simply eating rice and nothing else. What is the minimum amount of rice that the person should eat? **This problem may need a calculator**

Food Name	**Carbs/Unit**	**Proteins/Unit**	**Fat/Unit**	**Price/Unit**	Decision Var
Rice	53	4.4	0.4	0.5	x_r
Quinoa	40	8	3.6	0.9	x_q
Tortilla	12	3	2	0.1	x_t
Lentils	53	12	0.9	0.6	x_l
Broccoli	6	1.9	0.3	0.4	x_b

Nutrient	Minimum	Maximum
Carbohydrates	100	1000
Protein	10	100
Fat	0	100

- 0
- $\frac{1000}{53}$ or $18.8679..$

- $\frac{10}{4.4}$ or 2.2727... units
- $\frac{100}{53}$ or $1.88679\ldots$ units.
- $\frac{100}{40}$ or 2.5

Question 4

Setup and solve the diet problem instance presented thus far using your favorite solver. Write down the value of the **cost (objective function)** you obtained to **three places of decimal** . We will accept a small range of answers due to the possibility of floating point errors that may vary across solvers and computers.

Food Name	**Carbs/Unit**	**Proteins/Unit**	**Fat/Unit**	**Price/Unit**	Decision Var
Rice	53	4.4	0.4	0.5	x_r
Quinoa	40	8	3.6	0.9	x_q
Tortilla	12	3	2	0.1	x_t
Lentils	53	12	0.9	0.6	x_l
Broccoli	6	1.9	0.3	0.4	x_b

Nutrient	Minimum	Maximum
Carbohydrates	100	1000
Protein	10	100
Fat	0	100

Question 5

Unsatisfied with the solution obtained in the previous question, we add the following extra requirement in an attempt to obtain a larger selection of foods:

No single food should account for more than 60% of the total cost In other words, the cost of rice alone should be less than or equal to 60% of the total cost. And likewise, the

cost of quinoa alone should be less than 60% of the total cost, and so on for each of the foods in the list.

Which of the constraints below correctly expresses this new requirement for **quinoa** ?

Food Name	Carbs/Unit	Proteins/Unit	Fat/Unit	Price/Unit	Decision Var
Rice	53	4.4	0.4	0.5	x_r
Quinoa	40	8	3.6	0.9	x_q
Tortilla	12	3	2	0.1	x_t
Lentils	53	12	0.9	0.6	x_l
Broccoli	6	1.9	0.3	0.4	x_b

- $0.9x_q \geq 0.6 \times (0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b)$
- $x_q \leq 0.6(x_q + x_r + x_t + x_b)$
- $0.6(x_q + x_r + x_t + x_b) \leq x_q$
- $x_q \leq 0.6 \times (0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b)$
- $0.9x_q \leq 0.6 \times (0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b)$

Question 6

Setup and solve the **modified diet problem** with the extra constraints described in the previous question using your favorite solver. Write down the value of the **cost** you obtained to **three places of decimal** .

We will accept a small range of answers due to the possibility of floating point errors that may vary across solvers and computers.

In accordance with the Coursera Honor Code, I (Kevin Zhu) certify that the answers here are my own work.

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