Feedback — Assignment #2: The Diet Problem in Miniature

Help Center

You submitted this homework on **Sat 7 Sep 2013 10:31 AM PDT**. You got a score of **50.00** out of **50.00**.

This question concerns the diet problem that was discussed in the 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

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

Your Answer	**Score**	**Explanation**

$\min\ 53x_r + 40x_q + 12x_t + 53x_l + 6x_b$			
$\min\ 100x_r + 1000x_q + 10x_t + 100x_l + 100x_b$			
$\min 0.4x_r + 3.6x_q + 2x_t + 0.9x_l + 0.3x_b$			
$\max\ 0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b$			
$\min\ 0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b$	✔	5.00	This is the correct expression for the total cost of the purchased foods and the cost needs to be minimized.
Total		5.00 / 5.00	

Question Explanation

Cost for a food is simply the price/unit of each food times the decision variable for that food. The total cost is the sum of costs for each individual food.
Therefore, we minimize the total cost as :$\min\ 0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b$

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

Your Answer		Score	Explanation
◉ $4.4x_r + 8x_q + 3x_t + 12x_l + 1.9x_b \geq 10$	✔	5.00	This is the correct answer. The LHS represents protein consumption and the RHS represents the minimum required protein.
○ $53x_r + 40x_q + 12x_t + 53x_l + 6x_b \geq 10$			
○ $0.4x_r + 3.6x_q + 2x_t + 0.9x_l + 0.3x_b \geq 0$			
○ $4.4x_r + 8x_q + 3x_t + 12x_l + 1.9x_b \leq 10$			
○ $4.4x_r + 8x_q + 3x_t + 12x_l + 1.9x_b \leq 100$			
Total		5.00 / 5.00	

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

Your Answer		**Score**	**Explanation**
0			
$\frac{100}{53}$ or $1.88679...$ units.			
$\frac{10}{4.4}$ or 2.2727... units	✔	5.00	This is the correct answer. Eating this much rice will satisfy all the three nutritional requirements.
$\frac{100}{40}$ or 2.5			

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

Total	5.00 / 5.00

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

You entered:

0.833

Your Answer		Score	Explanation
0.833	✔	10.00	Correct answer is 0.833333
Total		10.00 / 10.00	

Question Explanation

The linear programming problem is as follows

$$\begin{array}{lrrrrrr} \min & 0.5x_r & +0.9x_q & +0.1x_t & +0.6x_l & +0.4x_b & \\ \text{s.t.} & & & & & & \\ 100 \leq & 53x_r & +40x_q & +12x_t & +53x_l & +6x_b & \leq 1000 \\ 10 \leq & 4.4x_r & +8x_q & +3x_t & +12x_l & +1.9x_b & \leq 100 \\ 0 \leq & 0.4x_r & +3.6x_q & +2x_t & +0.9x_l & +0.3x_b & \leq 100 \end{array}$$

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

Your Answer		Score	Explanation
$0.6(x_q + x_r + x_t + x_b) \leq x_q$			
$x_q \leq 0.6(x_q + x_r + x_t + x_b)$			
$0.9x_q \geq 0.6 \times (0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b)$			
$0.9x_q \leq 0.6 \times (0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b)$	✔	5.00	Correct answer.
$x_q \leq 0.6 \times (0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b)$			
Total		5.00 / 5.00	

Question Explanation

The cost of quinoa is given by $0.9x_q$ and the expression for total cost is $(0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b)$

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.

You entered:

0.867

Your Answer		Score	Explanation
0.867	✔	10.00	GLPK yielded the answer 0.8741
Total		10.00 / 10.00	

Question 7

Rather than minimizing the total cost, we consider a new problem of **eating a protein rich diet for an olympic athlete** .

Bob the builder wants to train for the weightlifting team and therefore needs to eat the maximum amount of protein possible. However, he cannot afford to spend more than 2 dollars in total food cost. Therefore, reformulate the original problem (stated at the start of the quiz) to find the optimal diet for Bob.

Note: please consider the problem stated at the very beginning of this assignment which includes limits on carbohydrate, protein and fat consumption. However, new constraints added in the intermediate problem (eg., 60% cost constraints in Q5) are to be **discarded**.

Which of the following changes need to be made to the original LP formulation? Choose all changes that apply and make sure that incorrect changes are not selected. The problem data is recalled.

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

Your Answer		**Score**	**Explanation**
☐ Bob does not need to eat Brocolli. Therefore, add the constraint $x_b = 0$.	✔	1.00	This assumption is not stated anywhere in the problem definition, or does not logically follow from it either. Therefore, this is also inappropriate.
☐ Remove the non-negativity constraints: $x_r, x_q, x_t, x_l, x_b \geq 0$	✔	1.00	This is an inappropriate change
☐ Remove the constraint $53x_r + 40x_q + 12x_t + 53x_l + 6x_b \leq 1000$	✔	1.00	Removing this constraint changes the meaning of the problem. This change is therefore inappropriate.
☑ Add a new constraint $0.5x_r + 0.9x_q + 0.1x_t + 0.6x_l + 0.4x_b \leq 2$	✔	1.00	This is correct. We have to express the budget limit on the total cost, as stated.
☑ Change the objective function to $\max\ (4.4x_r + 8x_q + 3x_t + 12x_l + 1.9x_b)$	✔	1.00	This is correct. We maximize protein consumption as stated.
Total		5.00 / 5.00	

Question 8

Solve the problem in the previous question using your favorite solver and write down the **optimal protein consumption** (the value of the objective function) that your solver obtained?

You entered:

60

Your Answer		Score	Explanation
60	✔	5.00	Exactly right
Total		5.00 / 5.00	