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# PERSONAL NUTRITIONIST VIA OPTIMIZATION

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### PERSONAL NUTRITIONIST via OPTIMIZATION

Choosing a healthy and balanced eating pattern can help maintain a healthy body weight and reduce the risk for chronic diseases such as Type 2 diabetes and cardiovascular diseases. The U.S. Department of Agriculture and Department of Health and Human Services drafted an updated dietary guidelines for 2015-2020 that, for the first time, specifically limits the intake of sugar to no more than 10 percent of daily calories.

With the changing guidelines, further understanding in nutrition science, and personal preferences and dietary restrictions, consumers can be faced with a multitude of choices at the grocery store aisle. In this problem, we look at some real food data and use optimization to derive personalized nutritional recommendations.

We get the nutritional values of each food from U.S. Department of Agriculture's API service (https://ndb.nal.usda.gov/ndb/doc/index). The results are aggregated and subsetted to some common food types. In addition, the consumer can enter his or her preference for each food on a scale from 1 (least favorite) to 5 (most favorite). For the purpose of this problem, the values are entered to reflect one of the 15.071x teaching staff's preference. The input data can be downloaded here: nutrient\_input.csv.

The data has the following fields:

• name: name of the food

• measure: the unit measure

energy: Calories (in kcal)

• protein: protein in gram

sugar: total sugars in grams

fat: total lipid (fat) in grams

• VC: Vitamin C in miligrams

• **happiness**: the preference rating from 1-5, with 5 being the most preferred

The personal goal is to **eat less sugar** (in fact, as little as possible), while **maintaining other nutritional requirements**. The requirement for daily intake is summarized the following table (modified from FDA food labeling regulation documents):

	energy	protein	sugar	fat	fiber	vc
lower bound	2000	50	NA	NA	25	60
upper bound	2500	70	NA	65	NA	NA

Where for each component, we indicate the minimum value (lower bound) and maximum value (upper bound) that the total food intake should satisfy. If NA, there is no requirement. The units are consistent with what is provided in the data. For example, the total fat intake should be no more than 65 grams.

In this problem, we'll help the health-conscious consumer use optimization to **determine which and how much of each food to take everyday**. The food amount can be <u>non-integer</u> numbers.

## Problem 1 - The Decision Variables

0/1 point (graded)

As mentioned above, the consumer needs to decide the amount of food to eat from each category. These are the decisions for our optimization problem.

Open the csv file and inspect. How many decision variables will there be in your optimization formulation?



#### **Explanation**

There are 32 rows of data, excluding header. Each food item needs its own decision variable, therefore there will be 32.

Submit You have used 2 of 2 attempts

**1** Answers are displayed within the problem

## Problem 2 - The Decision Variables

1/1 point (graded)

What type of decision variables should be used in the optimization formulation?

- Continuous variables allowed to take negative or non-negative values
- Continuous variables limited to non-negative values
- Binary variables
- Integer variables allowed to take negative or non-negative values
- Integer variables limited to non-negative values

### **Explanation**

Continuous variables should be used, as the food amount can be fractional. However, the amount of food cannot be negative.

Submit

You have used 1 of 1 attempt

**1** Answers are displayed within the problem

### Problem 3 - Constraints

2/2 points (graded)

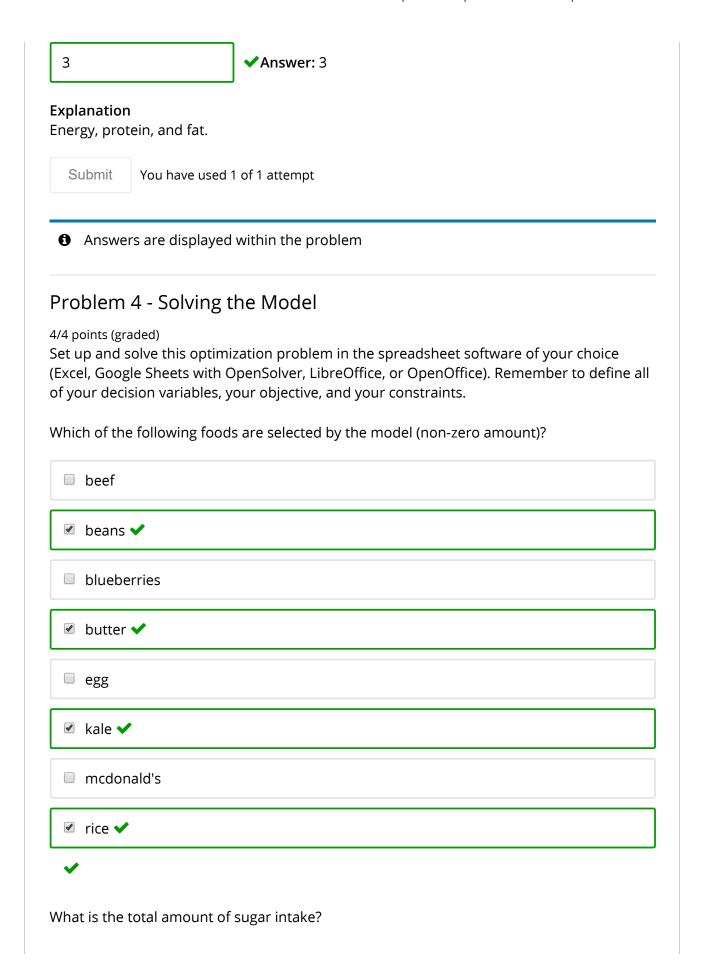
The consumer needs to satisfy the lower bound and upper bound constraints for the other nutritional requirements (energy, protein, etc.). How many lower bound constraints are there?

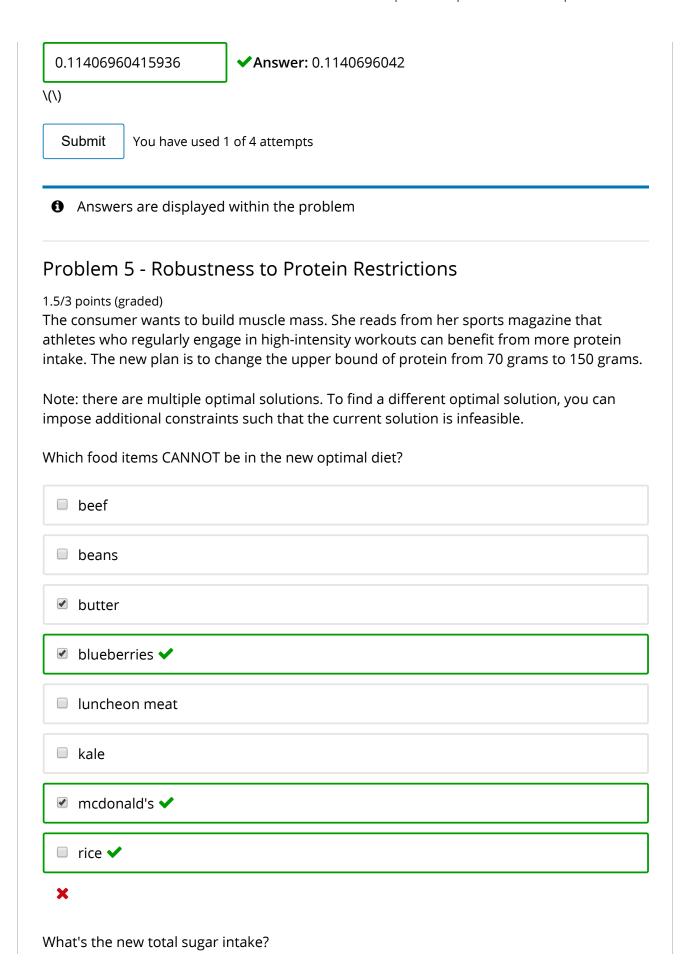


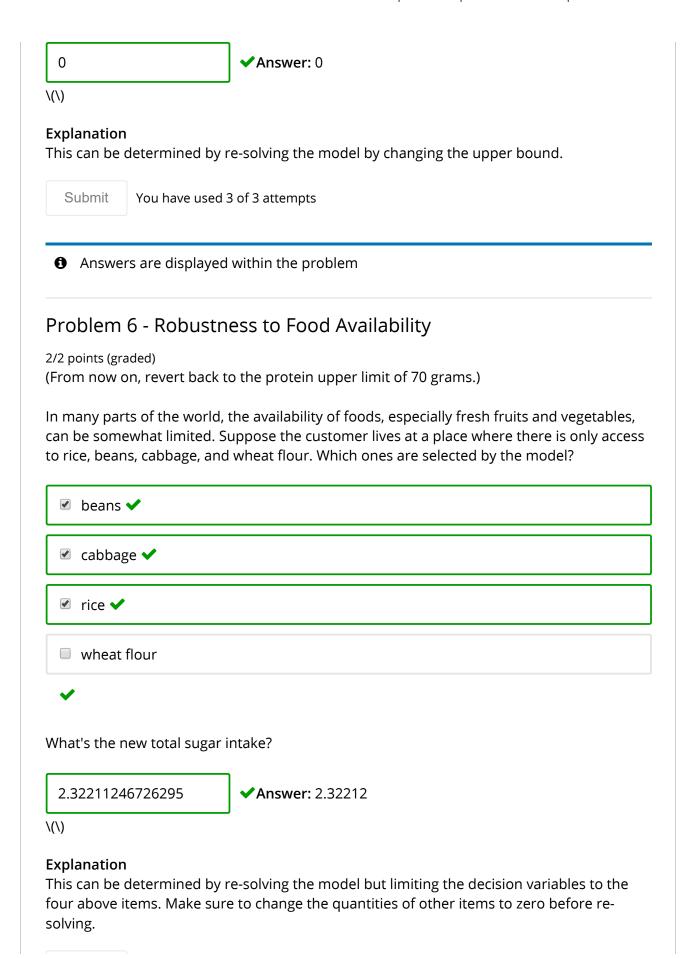
#### **Explanation**

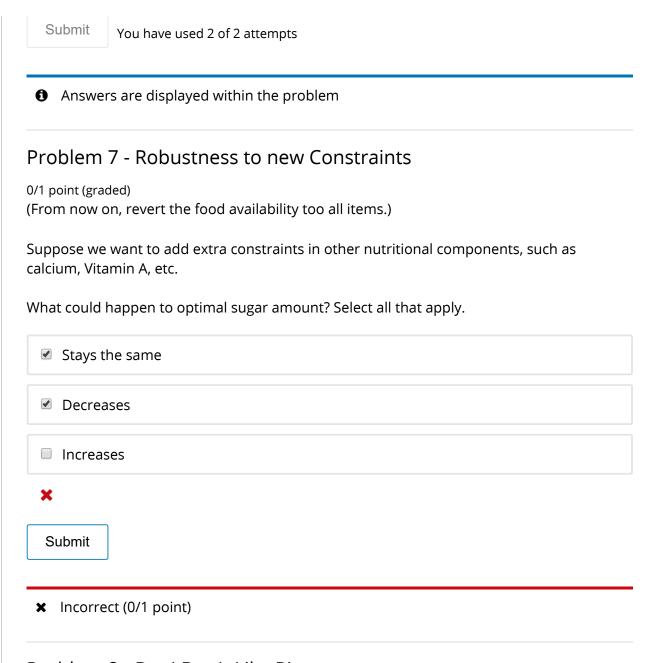
From table above, there are 4 non-NA values in the lower bound row. Energy, protein, fiber, and Vitamin C.

How many constraints correspond to the upper bound requirements?









# Problem 8 - But I Don't Like Rice

3/3 points (graded)

The consumer understands this ultra-low sugar diet is probably good, but just can't make herself eat rice and beans all the time. She decides to use her preference measure, the "happiness" column in the data where a 1-5 rating is given to each food (with 5 giving her most happiness). She now wants to maximize the total happiness, of course still satisfying all the constraints, with an additional constraint:

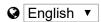
sugar upper limit of 30 grams.

apples	
<b>☑</b> aspara	gus <b>✔</b>
<b>☑</b> butter	✓
<b>✓</b> carrots	5 <b>✔</b>
<b>☑</b> cereal	✓
□ cookie	s
ice cre	ams
the optim	al sugar amount at the limit of 30 grams, or below?
<ul><li>below</li><li>at limit</li><li>xplanation</li><li>thange the</li></ul>	<u>-</u> ✓

The consumer decides that a rating of "3" for carrots is too high, especially if she eats a lot of them. She wants to downgrade it to a "2" and see what changes to her diet. She is still maximizing her happiness, with sugar limited to 30 grams. Instead of carrots, which one is selected now? apples cake chocolate cookies ice creams lamb **Explanation** Change the value of happiness on carrots from 3 to 2 and resolve. Submit You have used 1 of 2 attempts



**1** Answers are displayed within the problem



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