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PERSONAL NUTRITIONIST VIA OPTIMIZATION

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 non-integer numbers.

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Problem 2 - The Decision Variables

0.0/1.0 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

Answers are displayed within the problem

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Problem 4 - Solving the Model

0.0/4.0 points (graded)

Set up and solve this optimization problem in the spreadsheet software of your choice (Excel, Google Sheets with OpenSolver, LibreOffice, or OpenOffice). Remember to define all of your decision variables, your objective, and your constraints.

Which of the following foods are selected by the model (non-zero amount)?

- [ ] beef
- [ ] beans ✔
- [x] blueberries
- [ ] butter ✔
- [ ] egg
- [x] kale ✔
- [x] mcdonald's
- [x] rice ✔

✖

What is the total amount of sugar intake?

12

✖ **Answer:** 0.1140696042

12

Submit

You have used 4 of 4 attempts

Answers are displayed within the problem

Problem 5 - Robustness to Protein Restrictions

0.0/3.0 points (graded)

The consumer wants to build muscle mass. She reads from her sports magazine that athletes who regularly engage in high-intensity workouts can benefit from more protein intake. The new plan is to change the upper bound of protein from 70 grams to 150 grams.

Note: there are multiple optimal solutions. To find a different optimal solution, you can impose additional constraints such that the current solution is infeasible.

Which food items CANNOT be in the new optimal diet?

- [x] beef
- [ ] beans
- [x] butter
- [ ] blueberries ✔
- [x] luncheon meat
- [ ] kale
- [x] mcdonald's ✔
- [ ] rice ✔

✖

What's the new total sugar intake?

23 ✖ **Answer:** 0

23

Explanation
This can be determined by re-solving the model by changing the upper bound.

Submit You have used 3 of 3 attempts

Answers are displayed within the problem

Problem 6 - Robustness to Food Availability

0.0/2.0 points (graded)
(From now on, revert back to the protein upper limit of 70 grams.)

In many parts of the world, the availability of foods, especially fresh fruits and vegetables, can be somewhat limited. Suppose the customer lives at a place where there is only access to rice, beans, cabbage, and wheat flour. Which ones are selected by the model?

- [ ] beans ✔
- [ ] cabbage ✔
- [x] rice ✔
- [x] wheat flour

✖

What's the new total sugar intake?

14 ✖ **Answer:** 2.32212

14

Explanation
This can be determined by re-solving the model but limiting the decision variables to the four above items. Make sure to change the quantities of other items to zero before re-solving.

Submit You have used 2 of 2 attempts

Answers are displayed within the problem

Problem 7 - Robustness to new Constraints

0/1 point (graded)
(From now on, revert the food availability too all items.)

Suppose we want to add extra constraints in other nutritional components, such as calcium, Vitamin A, etc.

What could happen to optimal sugar amount? Select all that apply.

- [x] Stays the same ✔
- [ ] Decreases
- [ ] Increases ✔

✖

Explanation
By adding constraints, the current solution can stay optimal, or become infeasible (therefore resulting in a higher optimal sugar amount in the new solution).

Submit You have used 1 of 1 attempt

Answers are displayed within the problem

Problem 8 - But I Don't Like Rice

1.5/3.0 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.

Which items are recommended this time?

- [x] apples
- [ ] asparagus ✔
- [x] butter ✔
- [ ] carrots ✔
- [ ] cereal ✔
- [x] cookies
- [ ] ice creams

✖

Is the optimal sugar amount at the limit of 30 grams, or below?

- ( ) below
- (•) at limit

✔

Explanation
Change the objective function to be sumproduct between happiness and decision variables. Add sugar upper bound constraint. Resolve.

Submit You have used 3 of 3 attempts

Answers are displayed within the problem

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