Question 15.2

In the videos, we saw the "diet problem". (The diet problem is one of the first large-scale optimization problems to be studied in practice. Back in the 1930's and 40's, the Army wanted to meet the nutritional requirements of its soldiers while minimizing the cost.) In this homework you get to solve a diet problem with real data. The data is given in the file diet.xls.

1. Formulate an optimization model (a linear program) to find the cheapest diet that satisfies the maximum and minimum daily nutrition constraints, and solve it using PuLP. Turn in your code and the solution. (The optimal solution should be a diet of air-popped popcorn, poached eggs, oranges, raw iceberg lettuce, raw celery, and frozen broccoli. UGH!)

Answer

Code is in Solution15_2.py file

Cheapest diet that follows the maximum and minimum nutrition constraints is

> **52.64371 units of Celery, Raw**
> **0.25960653 units of Frozen Broccoli**
> **63.988506 units of Lettuce,Iceberg,Raw**
> **2.2929389 units of Oranges**
> **0.14184397 units of Poached Eggs**
> **13.869322 units of Popcorn,Air Popped**
> **Total cost of food = $4.34**

2. Please add to your model the following constraints (which might require adding more variables) and solve the new model:

- If a food is selected, then a minimum of 1/10 serving must be chosen. (Hint: now you will need two variables for each food i: whether it is chosen, and how much is part of the diet. You'll also need to write a constraint to link them.)

- Many people dislike celery and frozen broccoli. So at most one, but not both, can be selected.

- To get day-to-day variety in protein, at least 3 kinds of meat/poultry/fish/eggs must be selected. [If something is ambiguous (e.g., should bean-and-bacon soup be considered meat?), just call it whatever you think is appropriate – I want you to learn how to write this type of constraint, but I don't really care whether we agree on how to classify foods!]

Answer
Code is in Solution15_2.py file

Diet after adding additional constraints to the model

0.1 units of Bologna,Turkey
42.423026 units of Celery, Raw
82.673927 units of Lettuce,Iceberg,Raw
3.0856009 units of Oranges
1.9590978 units of Peanut Butter
0.1 units of Poached Eggs
13.214473 units of Popcorn,Air Popped
0.1 units of Scrambled Eggs
Total cost of food = $4.51

As specified in constraints all the units have more than or equal to 1/10 of serving.

Only Raw Celery is included in optimal diet and 3 protein foods are Turkey Bologna, Poached Eggs and Scrambles Eggs.

3. If you want to see what a more full-sized problem would look like, try solving your models for the file diet_large.xls, which is a low-cholesterol diet model (rather than minimizing cost, the goal is to minimize cholesterol intake).

Answer:

(Code is in Solution15_2_large.py)

diet_large required several data cleanup steps. This is my approach to prepare data for optimization model:

1. Skip first empty row while reading file.

2. File had several blank values for food nutrients. These are read as nan in python. I replaced these with 0.

3. While adding minimum and maximum nutrition constraints, I only added constraint if both minimum and maximum values were available. ie. skip the constraint if either value is nan.

4. Some of the Foods have duplicate entries. There are total 7146 food observations but after removing duplicates there are 6286 foods.

Optimal low cholesterol diet

0.084602457 units of Beans, adzuki, mature seeds, raw
0.12997145 units of Beans, pinto, mature seeds, raw
0.16453428 units of GREEN GIANT, HARVEST BURGER, Original Flavor, All Vegetable Pro
0.0021589366 units of Gelatin desserts, dry mix, reduced calorie, with aspartame, add
0.88530624 units of Infant formula, ROSS, ISOMIL, with iron, powder, not reconstitu
0.065999962 units of Leavening agents, baking powder, low sodium
0.02545092 units of Miso
0.05482638 units of Nuts, mixed nuts, oil roasted, with peanuts, with salt added
1.411285 units of Oil, whale, bowhead (Alaska Native)
0.017227144 units of Peanuts, all types, cooked, boiled, with salt
0.069209616 units of Seeds, cottonseed kernels, roasted (glandless)
0.015343761 units of Soup, clam chowder, manhattan style, dehydrated, dry
0.57132848 units of Soybeans, mature seeds, dry roasted
0.33481168 units of Spices, pepper, red or cayenne
0.45760296 units of Tomatoes, sun dried
9999.7193 units of Water, bottled, non carbonated, CALISTOGA
Total Cholesterol in Diet = 0.00