

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!)

For this problem, the code can be found in python file Homework 15.2.1.py. My output was a diet consisting of the following items:

- The amount of Celery,_Raw to use is: 52.64371
- The amount of Frozen_Broccoli to use is: 0.25960653
- The amount of Lettuce,Iceberg,Raw to use is: 63.988506
- The number of Oranges to use is: 2.2929389
- The amount of Poached_Eggs to use is: 0.14184397
- The amount of Popcorn,Air_Popped to use is: 13.869322

The overall cost of my meal plan was \$4.34. This approach satisfies the maximum and minimum daily nutrition constraints but nothing more than that. For that reason, I don’t think this diet is particularly balanced or, of course, tasty.

2. Please add to your model the following constraints (which might require adding more variables) and solve the new model:
 - a. 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.)
 - b. Many people dislike celery and frozen broccoli. So at most one, but not both, can be selected.
 - c. 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!]

For this problem, the code can be found in python file Homework 15.2.2.py. My output was a diet consisting of the following items:

- The amount of Bologna,Turkey to use is: 0.1
- The amount of Celery,_Raw to use is: 51.522935
- The amount of Frozen_Broccoli to use is: 0.22815709

- The amount of Lettuce,Iceberg,Raw to use is: 66.955456
- The amount of Oranges to use is: 2.3760495
- The amount of Poached_Eggs to use is: 0.1
- The amount of Popcorn,Air_Popped to use is: 13.847028
- The amount of Scrambled_Eggs to use is: 0.1

The total cost of this meal plan was \$4.38. Overall, the total diet cost was not a lot higher than the previous meal plan, but the items chosen seem a lot more balanced and tastier. This is a direct result of adding in the constraints described above. And a large part of why it was even possible to have those constraints was because of the introduction of a binary variable to indicate whether a food was selected (1) or not (0).

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). I don't know anyone who'd want to eat this diet – the optimal solution includes dried chrysanthemum garland, raw beluga whale flipper, freeze-dried parsley, etc. – which shows why it's necessary to add additional constraints beyond the basic ones we saw in the video!

The code for this approach can be found in the python file Homework 15.2.3.py. My output was a diet consisting of the following items:

- The amount of Beans,_adzuki,_mature_seeds,_raw to use is: 0.059863415
- The amount of Broccoli_raab,_raw to use is: 0.069514608
- The amount of Cocoa_mix,_no_sugar_added,_powder to use is: 0.42866218
- The amount of Egg,_white,_dried,_flakes,_glucose_reduced to use is: 0.14694398
- The amount of Infant_formula,_MEAD_JOHNSON,_ENFAMIL,_NUTRAMIGEN,_with_iron,_p to use is: 0.73805891
- The amount of Infant_formula,_NESTLE,_GOOD_START_ESSENTIALS__SOY,__with_iron, to use is: 0.4258564
- The amount of Infant_formula,_ROSS,_ISOMIL,_with_iron,_powder,_not_reconstitu to use is: 0.050114149
- The amount of Margarine_like_spread,_approximately_60%_fat,_tub,_soybean_(hyd to use is: 0.15033656
- The amount of Mung_beans,_mature_seeds,_raw to use is: 0.25918767
- The amount of Nuts,_mixed_nuts,_dry_roasted,_with_peanuts,_with_salt_added to use is: 0.18052856
- The amount of Oil,_vegetable,_sunflower,_linoleic,_ (hydrogenated) to use is: 1.184482

- The amount of Seeds,_sunflower_seed_kernels,_dry_roasted,_with_salt_added to use is: 0.10375187
- The amount of Snacks,_potato_chips,_fat_free,_made_with_olestra to use is: 0.031866196
- The amount of Spices,_paprika to use is: 0.070710308
- The amount of Tomatoes,_sun_dried to use is: 0.55106575
- The amount of Water,_bottled,_non_carbonated,_CALISTOGA to use is: 9999.6864

The total cholesterol in this meal plan is 0. As can be seen by looking at the food items, this does not seem like an appetizing meal plan at all. Also, that's a lot of water. This is because in the code I added no additional constraints other than trying to meet the minimum and maximum nutrition values required.