**Homework #1a**

**MSiA Program, Fall 2023**

**Optimization**

**Due: At the start of class on 9/25/23 (Mon)**

1. If X, Y, and Z are decision variables, which of the following relationships are valid in a linear program. Briefly explain why for each of your answers.
   1. X + Y = Z
   2. XY <= 100
   3. 3X + 2Y <= 
   4. X + 2Y = 50
   5.  + 10Y = 100
   6. X2 + Y2 >= 45

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***Note on Linear Programming problems***

A good way to learn linear programming is to do it. If you’ve done it before, you can still get insight from these models. For each of the problem, build the model in Excel or Python (I prefer Jupyter Notebooks), or both if it helps you learn. In Excel, solve with OpenSolver (or use Excel’s Solver if you have to—I think it is a little buggy and not as robust as OpenSolver). In either case, I want you to learn Linear Programming. So, make sure you understand the model, make sure you can explain the answer, and convince yourself that you have the right answer.

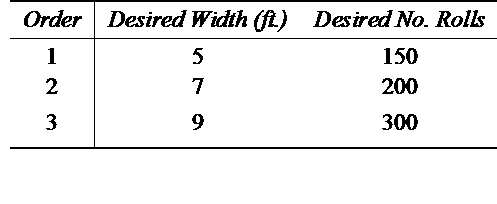
You will turn in your assignment as a group. But, I strongly recommend that you actually build each of these models yourself. I also suggest that you try to build the models with limited online searches—try to think about how you would model. Making mistakes and taking wrong turns is valuable. This will serve you well and help you learn the material.

We will discuss each model in class and use it as a learning experience.

We will assign each group one of the problems to talk about. You should treat this like a short presentation—but not like a full presentation (no one likes those). We mostly want you to put you on the spot and ask different questions so we can all learn more about optimization. Everyone will have done the problem- so you can present it showing what you did, the answer you got, any debates you had, any mistakes you made-things you tried, what you didn’t like about the model, what you liked, etc.

You are going to talk, and we’ll ask you tough (but fun) questions. And, we’ll all learn something about the models and how to think about them.

1. Formulate and solve the “Two Products – Three Machine” problem from Class #1 as a linear program. Also, how would you set up this model so you could scale it? That is, how would you structure it if you had a lot of machines and a lot of products?
2. Your non-vegetarian friend wants to determine how many units of different kinds of meat he should eat to get the right amounts of vitamins A, C, B1, and B2 over the week. He also wants to minimize his cost. What should his diet be? How would you modify the linear program to make it “better?” You can find the cost for each unit of food and the percent of daily requirements for each vitamin type in the spreadsheet.
3. Solve the gas blending problem introduced in class. That is, determine how much of each type of gas you should buy and what you should use it for. Make sure you can explain the full model and especially the blending constraints.
4. Solve the nurse scheduling problem introduced in class. You want to know the minimum number of nurses needed to cover the 24-hour period. You can assume that the next day is the same as this one.
5. Cutting Stock Problem. You need to cut large rolls of 20 foot rolls of paper to meet your orders. The following are your orders:



For example, if you had orders for a 10 foot roll, 8 foot roll, 6 foot roll, you could fill two of the orders with by cutting one 20-foot roll for the 10 and 8 foot order. Then, you would need to use another 20 foot roll to fill the demand for the 6 foot order. Of course, in this situation, you would waste 2 feet on the first roll and 14 feet on the other.

You need to minimize the number of total 20-foot rolls to fill the total demand.

For this problem, you need to formulate a linear program to minimize the number of 20-foot rolls. You must meet the total demand for the rolls listed above. For this homework problem, you need to do the following:

* Identify the decision variables
* Formulate a linear program to solve the problem
* Solve the linear program and determine the minimum number of 20-foot rolls you need.