

Homework 2 – Linear Programming

Recall our model formulation from class (below). It is critical you ask what are the decisions that need to be made as they are your variables and what you are trying to determine. You will then have constraints limiting these variables and then an objective (min/max) which is a linear combination of these variables. If you get stuck, try to guess at a solution, see where that solution takes you—replace your guess with variables and solve.

Model formulation: The three fundamental concerns in forming operations research models are

1. The **decisions** open to decision makers
 2. The **constraints** limiting decision choices
 3. The **objectives** making some decisions preferred to others
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1. This is a continuation of the Three Crude Petroleum problem from class. Three Crude Petroleum has decided to further diversify and enter the Russian crude market. Currently Russia is selling crude oil at \$60/barrel with each barrel of Russian crude equally yielding 0.2 barrels of gasoline, 0.3 of jet fuel, and 0.4 lubricants.
 - a. Find the new optimal solution to this problem
 - b. Assume Russia has spies that see your sensitivity report—at what price point should Russia sell their crude to continue to do business but make more money? (In other words, how much can Russia raise their price (from \$60/barrel) while still being in Three Crude's best interest to continue to purchase from them?)
 - c. Using the constraint sensitivity report, how much more would it cost to produce 500 more barrels of gasoline? (Remember "2" is actually 2000—so 500 is 0.5 more).
 - d. Changing the model, what is the new solution if 500 additional barrels are required? The optimal value should agree with your answer above.

2. A manufacturing company has discontinued the production of an unprofitable product line. This act created considerable excess production capacity. Management is considering devoting this excess capacity to one or more of three products (call them products X, Y, Z.) The available capacity on the machines is summarized in the following table:

Machine Type	Available Time (Machine Hours per Week)
Milling Machine	500
Lathe	350
Grinder	150

The number of machine hours required for each product is summarized in the following table:

Machine Type	Product X	Product Y	Product Z
Milling Machine	9	3	5
Lathe	5	4	0
Grinder	3	0	2

The sales department quotes profits values of \$50, \$20, and \$25 for products X, Y, and Z.

- How many of each product should be made to maximize profits?
- How much would the profits of product X need to increase in order to start producing product X?
- At what profit price point should we produce less of product Y?
- Management needs to use all the available grinder hours—what is the new optimal solution? How much profits are lost as a result of this decision?

3. The city of Rig Bapid's water distribution systems have three wells for water supply. There are ten pumps at these three wells. It is estimated that a pumping rate of 10,000 gallons per minute is needed to satisfy the city's total water demand. There are limits on how much water can be pumped from each well: 3000 gal/min from well 1; 2500 gal/min from well 2; 7000 gal/min from well 3. There are also different costs of operating each pump and limits on the rate of each pump as displayed in the following table: (you can copy/paste this into Excel)

Pump	Max (gal/min)	Cost (\$/gal/min)	From Well
1	1100	0.05	1
2	1100	0.05	2
3	1100	0.05	3
4	1500	0.07	1
5	1500	0.07	2
6	1500	0.07	3
7	2500	0.13	1
8	2500	0.13	2
9	2500	0.13	3
10	2500	0.13	3

The city of Rig Bapids wishes to determine the least cost way to meet its water needs.