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Introduction to Industrial Engineering: Operations Research

Paul Savory
University of Nebraska at Lincoln, psavory2@gmail.com

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Class Exercise 20: Operations Research

Introduction

Operations Research is an area of industrial engineering concerned with the allocation of scarce resources. One area of operations research is ***linear programming***. *Linear programming* is a method often used to solve large, complicated problems. These problems often require a manager to determine how to use the company's limited resources most efficiently.

Linear Programming Basics

Suppose you are the manager of a box making factory and must decide the weekly production schedule. How many of each size box should you make to maximize your profit given you have a limited amount of material to make boxes?

	Large Boxes	**Medium Boxes**	**Small Boxes**
Profit	\$20	\$11	\$5
Required Material	8 sq. feet	7 sq. feet	2 sq. feet

You have the requirements that you cannot produce more that 50 small boxes and must make at least 10 large boxes. You have a total of 160 sq. feet of material. How many of each box should you make to maximize profit?

The approach that operations research uses is to formulate (and then solve) a linear programming model if this situation:

(1) All the unknowns in the problem are nonnegative. Theses are called the **decision variables.**

(2) All the restrictions on the ***decision variables*** (the ***constraints***) can be expresses as **LINEAR** equations ("=") and/or **LINEAR** inequalities ("≤" or "≥").

For instance,

(3) The criterion for choosing the best values of the decision variables can be expressed as a **LINEAR** function of the variables. This is referred to as the ***objective function***.

Consider the box manufacturing example, what are the decision variables and what are the constraints...

Decision variables =

Constraints =

Objective function =

The general (or standard) form of a linear programming model is...

Let's write the linear programming problem to solve our box manufacturing decision....

FORMULATING A LINEAR PROGRAMMING MODEL

STEP 1: Define the problem objective. A brief statement describing the planned activities which will result in the objective function being *maximized* or *minimized*.

STEP 2: Identify/define the *decision variables* (the unknowns) in the problem. Be specific with regards to the units.

STEP 3: Construct the *constraints* (the restrictions on the decision variables expressed as linear inequalities or equations).

STEP 4: Determine the profit/cost associated with each decision variable. Express this as a linear function of the decision variables to maximized or minimized.

Exercise 1

Farmer Jane owns 45 acres of land. She is going to plant each with wheat or corn. Each acre with wheat yields $200 profit, each with corn yields $300 profit. The labor and fertilizer for each acre are given below:

	Wheat	**Corn**
Labor	3 hours	2 hours
Fertilizer	2 tons	4 tons

One hundred hours of labor and 120 tons of fertilizer are available. Use linear programming to determine how Jane can maximize profit form her land.

Exercise 2

My diet requires that all the food I eat come from one of four "basic food groups" (chocolate cake, ice cream, soda, and cheesecake). At present, the following four foods are available for consumption: brownies, chocolate ice cream, cola, and pineapple cheesecake. Each brownie costs $0.50, each scoop of ice creams costs $0.20, each bottle of cola costs $0.30, and each piece of pineapple cheesecake costs $0.80. Each day I must ingest at least 500 calories, 6 ounces of chocolate, 10 ounces of sugar, and 8 ounces of fat. The nutritional content per unit of each food is shown below:

	Calories	**Chocolate (ounces)**	**Sugar (ounces)**	**Fat (ounces)**
Brownie	400	3	2	2
Chocolate ice cream (1 scoop)	200	2	2	4
Cola (1 bottle)	150	0	4	1
Pineapple cheesecake (1 piece)	500	0	4	5

Formulate a linear programming model that can be used to satisfy my daily nutritional requirements at a minimum cost.

Exercise 3

A company has manufacturing facilities at two locations (A and B) and a single product that is to be shipped to three customers. The capacity of plants A and B are 100 and 70, respectively. The firm must ship at least 60 units to customer 1 and 40 units to customer 2. Customer 3 requires at most 10 units. The net profit associated with shipping a unit from each plant to every customer is given below:

	1	**2**	**3**
Plant A	6	7	8
Plant B	10	8	9

The company wants to know how many units to ship to each customer from plants A and B to maximize their profit.

Exercise #1

Exercise #2

Exercise #3

Examples of other areas operations research include: