Assignment Instructions: Assignment 2

# Purpose

The purpose of this assignment is to

* continue deepening your ability of modeling a problem with linear programming;
* solve a linear programming problem graphically.

# Directions

1. **(Computer Center Staffing)** You are the Director of the Computer Center for Gaillard College and responsible for scheduling the staffing of the center. It is open from 8 am until midnight. You have monitored the usage of the center at various times of the day and determined that the following numbers of computer consultants are required.

|  |  |
| --- | --- |
| Time of day | Minimum number of consultants required to be on duty |
| 8 am–noon | 4 |
| Noon–4 pm | 8 |
| 4 am–8 pm | 10 |
| 8 am–midnight | 6 |

Two types of computer consultants can be hired: full-time and part-time. The full-time consultants work for eight consecutive hours in any of the following shifts: morning (8 am – 4 pm), afternoon (noon – 8 pm), and evening (4 pm – midnight). Full-time consultants are paid $14 per hour.

Part-time consultants can be hired to work any of the four shifts listed in the table. Part-time consultants are paid $12 per hour. An additional requirement is that during every time period, at least one full-time consultant must be on duty for every part-time consultant on duty.

1. Determine a minimum-cost staffing plan for the center. In your solution, how many consultants will be paid to work full time and how many will be paid to work part time? What is the minimum cost?

Decision Variables:

Let Xij be the number of consultants on duty during shift j, where i=1 represents full time consultants, and i=2 represents part time consultants.

Objective function:

Min: Z = 14(X11 + X12 + X13) + 12(X21+X22+X23+X24)

ST:

X11 + X21 4

X11 + X12 + X22 8

X12 + X13 + X23 10

X13 + X24 6

X11 1

X13 1

X12 0, X21 0, X22 0, X23 0, X24 0

1. After thinking about this problem for a while, you have decided to recognize meal breaks explicitly in the scheduling of full-time consultants. In particular, full-time consultants are entitled to a one-hour lunch break during their eight-hour shift. In addition, employment rules specify that the lunch break can start after three hours of work or after four hours of work, but those are the only alternatives. Part-time consultants do not receive a meal break. Under these conditions, find a minimum-cost staffing plan. What is the minimum cost?
2. Decision Variables:

Fi = full time consultants during each shift, where i = 1 means full time consultants who take the lunch break at 11 AM, i = 2 means means full time consultants who take the lunch break at 12 AM, i = 3 means full time consultants who take the lunch break at 3 PM, etc.

Pi = part time consultants during each shift

Objective function:

Min: Z = 14(F1 + F2 + F3 + F4 + F5 + F6) + 12(P1+P2+P3+P4)

ST:

F1 + F2 + P1 >= 4

F2 + P1 >= 4

F1 + F3 + F4 + P2 >=8

F1 + F2 + F3 + F4 + P2 >=8

F1 + F2 + F4 + P2 >=8

F3 + F5 + F6 + P3  >=10

F3 + F4 + F5 + F6 + P3  >=10

F3 + F4 + F6 + P3  >=10

F5 + P4 >=6

F5 + F6 + P4 >=6

F2 >= 1

F1 + F3 + F4 >= 1

F3 + F4 + F6 >= 1

F5 >= 1

Hint: for this problem, you only need to formulate the LP problem without solving it.

1. Consider the problem from the previous assignment.

Back Savers is a company that produces backpacks primarily for students. They are considering offering some combination of two different models—the Collegiate and the Mini. Both are made out of the same rip-resistant nylon fabric. Back Savers has a long-term contract with a supplier of the nylon and receives a 5000 square-foot shipment of the material each week. Each Collegiate requires 3 square feet while each Mini requires 2 square feet. The sales forecasts indicate that at most 1000 Collegiates and 1200 Minis can be sold per week. Each Collegiate requires 45 minutes of labor to produce and generates a unit profit of $32. Each Mini requires 40 minutes of labor and generates a unit profit of $24. Back Savers has 35 laborers that each provides 40 hours of labor per week. Management wishes to know what quantity of each type of backpack to produce per week. Solve this problem graphically.

Max: Z = 32 X1 + 24 X2

ST:

3X1 + 2X2 = 5000

45 X1 + 40 X1 84000

X11000, X21200



As shown by the graph above, Z = 32 X1 + 24 X2 should pass through point (866.667,1200) in order to achieve maximum value of the function. Therefore, the objective function value is 56,533.344, while the variables are X1 = 866.667 X2 = 1200.

1. **(Weigelt Production)** The Weigelt Corporation has three branch plants with excess production capacity. Fortunately, the corporation has a new product ready to begin production, and all three plants have this capability, so some of the excess capacity can be used in this way. This product can be made in three sizes--large, medium, and small--that yield a net unit profit of $420, $360, and $300, respectively. Plants 1, 2, and 3 have the excess capacity to produce 750, 900, and 450 units per day of this product, respectively, regardless of the size or combination of sizes involved.  
    The amount of available in-process storage space also imposes a limitation on the production rates of the new product. Plants 1, 2, and 3 have 13,000, 12,000, and 5,000 square feet, respectively, of in-process storage space available for a day's production of this product. Each unit of the large, medium, and small sizes produced per day requires 20, 15, and 12 square feet, respectively.  
    Sales forecasts indicate that if available, 900, 1,200, and 750 units of the large, medium, and small sizes, respectively, would be sold per day.  
    At each plant, some employees will need to be laid off unless most of the plant’s excess production capacity can be used to produce the new product. To avoid layoffs if possible, management has decided that the plants should use the same percentage of their excess capacity to produce the new product.  
    Management wishes to know how much of each of the sizes should be produced by each of the plants to maximize profit.
   1. Define the decision variables

Let Xij be the amount of product j produced at plant i, where j=1 (large), 2 (medium), 3 (small); and 1 = 1, 2, 3

* 1. Formulate a linear programming model for this problem.

Objective function:

Max: Z = 420 (X11 + X21 + X31) + 360 (X12 + X22 + X32) + 300 (X13 + X23 + X33)

ST:

[production constraint]

X11 + X12 + X13 750

X21 + X22 + X23 900

X31 + X32 + X33 450

[in-process storage constraint]

20X11 + 15X12 + 12X13 13,000

20X21 + 15X22 + 12X23 12,000

20X31 + 15X32 + 12X33 5,000

[sales constraint]

X11 + X21 + X31 900

X12 + X22 + X32 1200

X13 + X23 + X33 750

[excess production percentage constraint]

(X11 + X12 + X13)/750 = (X21 + X22 + X23)/900

(X21 + X22 + X23)/900 = (X31 + X32 + X33)/450

* 900X11 + 900X12 + 900X13 - 750X21 - 750X22 - 750X23 = 0

450X21 + 450X22 + 450X23 - 900X31 - 900X32 - 900X33 = 0

* 1. Solve the problem using *lpsolve*, or any other equivalent library in R.

# Learning Outcomes

The assignment will help you with the following course outcomes:

1. To formulate and solve an LP model

# Requirements

All assignments are due before the next class.

# General Submission Instructions

*All work must be your own. Copying other people’s work or from the Internet is a form of plagiarism and will be prosecuted as such.*

* Upload a pdf file to your git repository. Name your file Username\_#.ext, where Username is your Kent State User ID (the part before @), and # is the Assignment number. In this case, 2.

Provide the link to your git repository in Blackboard Learn for the assignment.