Assignment 2

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1. **a)**

**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?**

Pi = Number of full-time workers working in 3 shifts (8 AM – 4 PM), (noon – 8 PM) and (4 PM – midnight) where I = 1,2,3

Qi = Number of part time workers working in 4 shifts (8 AM – noon), (noon - 4), (4 PM – 8 PM), (8 PM – midnight) where I = 1,2,3,4

Amount paid to full timers = $ 14/hr

Amount paid to part timers = $ 12/hr

Zmin = Minimize the cost.

***Zmin = 8 \* 14 \* (P1 + P2 + P3) + 4 \* 12 \* ( Q1 + Q2 + Q3 + Q4)***

**Constraints:**

P1 + Q1 >= 4

P1 + P2 + Q2 >= 8

P2 + P3 + Q3 >= 10

P3 + Q4 >= 6

P1 >= Q1

P1 + P2 >= Q2

P2 + P3 >= Q3

P3 >= Q4

Pi >= 0, Qi >= 0

Q1 = 2, Q2 = 4, Q3 = 5, Q4 = 3 and P1 = 2, P2 = 2, P3 = 3

***Zmin = 112 \* (7) + 48 \* (14) = 1456***

Full-time workers are = 7

Part-time workers are = 14

1. **b)**

**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. Inaddition, 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?**

We need to give **1 hour break** to **full time workers** and **no break** to **part-time workers.**

The break should start either in the 3rd hour or the 4th hour of their shift.

So we must remove 1 hr cost of full timers in 3 hours shifts from the above cost function.

So the ***Minimum Cost Function*** is:

***Zmin1 = 8 \* 14 \* (P1 + P2 + P3) – 14 \* (P1 + P2 + P3) + 4 \* 12 \* (Q1 + Q2 + Q3 + Q4).***

The ***Constraints*** will remain the same:

***Zmin1 = 112 \* (7) – 14 \* (7) + 48 \* (14) = 1358***

Zmin – Zmin1 = 1456 – 1358

= 98

**2.**

**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.**

Chart

Description automatically generated with medium confidence

**3.**

1. **Define the decision variables**

***Decision Variables:***

***Yij***, where ***i*** is the plants 1,2,3 and ***j*** is the sizes l, m, s.

***Y1l, Y1m, Y1s*** variables for plant 1

***Y2l, Y2m, Y2s*** variables for plant 2

***Y3l, Y3m, Y3s*** variables for plant 3

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

Let **Zmax** represent the maximum profit.

***Zmax = 420 \* (Y1l + Y2l + Y3l) + 360 \* (Y1m + Y2m + Y3m) + 300 \* ( Y1s + Y2s + Y3s)***

**Constraints for Max capacity*:***

Y1l + Y1m + Y1s <= 750

Y2l + Y2m + Y2s <= 900

Y3l + Y3m + Y3s <= 450

**Storage Space:**

20 \* Y1l + 15 \* Y1m + 12 \* Y1s <= 13,000

20 \* Y2l + 15 \* Y2m + 12 \* Y2s <= 12,000

20 \* Y3l + 15 \* Y3m + 12 \* Y3s <= 5000

**Percentage of Capacity:**

900 \* (Y1l + Y1m + Y1s) – 750 \* (Y2l + Y2m + Y2s) = 0

900 \* (Y2l + Y2m + Y2s) – 750 \* (Y3l + Y3m + Y3s) = 0

900 \* (Y1l + Y1m + Y1s) – 750 \* (Y3l + Y3m + Y3s) = 0

Y1l + Y2l + Y3l <= 900

Y1m + Y2m + Y3m <= 1200

Y1s + Y2s + Y3s <= 750

And Yij >= 0 where I = 1, 2, 3 and j = l, m ,s

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

**library(lpSolveAPI)**

**setwd("~/Documents/Quant Assignment 2/Quant\_assigment2")**

**# make an lp object with 0 constraints and 9 decision variables**

**lprec <- make.lp(0, 9)**

**lprec**

**# Create the objective function and since we need to maximize profit, change the sense to max.**

**set.objfn(lprec, c(420, 360, 300, 420, 360, 300, 420, 360, 300))**

**lp.control(lprec,sense='max')**

**# Add the constraints**

**add.constraint(lprec, c(1, 1, 1, 0, 0, 0, 0, 0, 0), "<=", 750)**

**add.constraint(lprec, c(0, 0, 0, 1, 1, 1, 0, 0, 0), "<=", 900)**

**add.constraint(lprec, c(0, 0, 0, 0, 0, 0,1, 1, 1), "<=", 450)**

**add.constraint(lprec, c(20, 15, 12, 0, 0, 0, 0, 0, 0), "<=", 13000)**

**add.constraint(lprec, c(0, 0, 0, 20, 15, 12, 0, 0, 0), "<=", 12000)**

**add.constraint(lprec, c(0, 0, 0, 0, 0, 0, 20, 15, 12), "<=", 5000)**

**add.constraint(lprec, c(1, 1, 1, 0, 0, 0, 0, 0, 0), "<=", 900)**

**add.constraint(lprec, c(0, 0, 0, 1, 1, 1, 0, 0, 0), "<=", 1200)**

**add.constraint(lprec, c(0, 0, 0, 0, 0, 0, 1, 1, 1), "<=", 750)**

**add.constraint(lprec, c(6, 6, 6, -5, -5, -5, 0, 0, 0), "=", 0)**

**add.constraint(lprec, c( 3, 3, 3, 0, 0, 0, -5, -5, -5), "=", 0)**

**#set.bounds(lprec, lower = c(0, 0, 0, 0, 0, 0, 0, 0, 0), columns = c(1, 2,3,4,5,6,7,8,9))**

**# To identify the variables and constraints, we can set variable names and name the constraints**

**RowNames <- c("CapCon1", "CapCon2", "CapCon3", "StoCon1", "StoCon2", "StoCon3", "SalCon1", "SalCon2", "SalCon3", "%C1", "%C2")**

**ColNames <- c("P1Large", "P1Medium", "P1Small", "P2Large", "P2Medium", "P2Small", "P3Large", "P3Medium", "P3Small")**

**dimnames(lprec) <- list(RowNames, ColNames)**

**lprec**

**write.lp(lprec, filename = "A2QMM.lp", type = "lp")**

**solve(lprec)**

**get.objective(lprec)**

**get.variables(lprec)**