Integer Programming

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2022-11-20

AP is a shipping service that guarantees overnight delivery of packages in the continental US. The company has various hubs at major cities and airports across the country. Packages are received at hubs, and then shipped to intermediate hubs or to their final destination.

The manager of the AP hub in Cleveland is concerned about labor costs, and is interested in determining the most effective way to schedule workers. The hub operates seven days a week, and the number of packages it handles varies from one day to another. The table below provides an estimate of the number of workers needed each day of the week.

```
#Loading the lpSolveAPI package
library(lpSolveAPI)
getwd()
```

```
## [1] "/Users/rohith/Desktop"
```

```
#Setting the working directory
setwd("/Users/rohith/Desktop")
#Loading the lp file
r_table <- read.lp("rd_table.lp")
r_table
```

```
## Model name:
##            x1   x2   x3   x4   x5   x6   x7
## Minimize  775  800  800  800  800  775  750
## R1          0    1    1    1    1    1    0  >=  18
## R2          0    0    1    1    1    1    1  >=  27
## R3          1    0    0    1    1    1    1  >=  22
## R4          1    1    0    0    1    1    1  >=  26
## R5          1    1    1    0    0    1    1  >=  25
## R6          1    1    1    1    0    0    1  >=  21
## R7          1    1    1    1    1    0    0  >=  19
## Kind      Std  Std  Std  Std  Std  Std  Std
## Type      Int  Int  Int  Int  Int  Int  Int
## Upper     Inf  Inf  Inf  Inf  Inf  Inf  Inf
## Lower       0    0    0    0    0    0    0
```

```
#The table below estimates how many employees are needed each day of the week.
workers_needed <-matrix(c("Sunday","Monday","Tuesday","Wednesday","Thursday","Friday","Saturday",
18,27,22,26,25,21,19),ncol=2,byrow = F)
colnames(workers_needed) <- c("Day_of_the_week", "workers_needed")
as.table(workers_needed)
```

```
##   Day_of_the_week workers_needed
## A Sunday          18
## B Monday          27
```

```
## C Tuesday          22
## D Wednesday        26
## E Thursday         25
## F Friday           21
## G Saturday         19
```

Package handlers at AP are guaranteed a five-day work week with two consecutive days off. The base wage for the handlers is $750 per week. Workers working on Saturday or Sunday receive an additional $25 per day. The possible shifts and salaries for package handlers are:

```
off_wages_emp <- matrix(c(1,2,3,4,5,6,7,
                          "Sunday and Monday","Monday and Tuesday","Tuesday and Wednesday",
"Wednesday and Thursday","Thursday and Friday","Friday and Saturday","Saturday and Sunday",
                          "$775","$800","$800","$800","$800","$775","$750"),ncol=3,byrow=F)
colnames(off_wages_emp) <- c("Shift", "Days_Off", "Wage")
as.table(off_wages_emp)
```

```
##   Shift Days_Off               Wage
## A 1     Sunday and Monday      $775
## B 2     Monday and Tuesday     $800
## C 3     Tuesday and Wednesday  $800
## D 4     Wednesday and Thursday $800
## E 5     Thursday and Friday    $800
## F 6     Friday and Saturday    $775
## G 7     Saturday and Sunday    $750
```

```
solve(r_table)
```

```
## [1] 0
```

```
get.objective(r_table)
```

```
## [1] 25675
```

Total cost = $25675

```
get.variables(r_table)
```

```
## [1]  2  4  5  0  8  1 13
```

The variables are labeled from R1, R2.....R7 where,

*R1 = Number of workers assigned to shift 1 = 2

*R2 = Number of workers assigned to shift 2 = 4

*R3 = Number of workers assigned to shift 3 = 5

*R4 = Number of workers assigned to shift 4 = 0

*R5 = Number of workers assigned to shift 5 = 8

*R6 = Number of workers assigned to shift 6 = 1

*R7 = Number of workers assigned to shift 7 = 13

Hence, the workers availabe for each day is

```
Avail_shifts <- matrix(c(0,4,5,0,8,1,0,0,0,5,0,8,1,13,2,0,0,0,8,1,13,2,4,0,0,8,1,13,2,4,5,0,0,1,13,2,3,4
colnames(Avail_shifts)<- c("Shift1", "Shift2", "Shift3", "Shift4", "Shift5", "Shift6", "Shift7")
row.names(Avail_shifts) <- c('Sunday', 'Monday', 'Tuesday','Wednesda','Thursday','Friday','Saturday')
Avail_shifts
```

```
##           Shift1 Shift2 Shift3 Shift4 Shift5 Shift6 Shift7
## Sunday         0      4      5      0      8      1      0
## Monday         0      0      5      0      8      1     13
## Tuesday        2      0      0      0      8      1     13
## Wednesda       2      4      0      0      8      1     13
## Thursday       2      4      5      0      0      1     13
## Friday         2      3      4      0      0      0     13
## Saturday       2      4      5      0      8      0      0
```

```
rowSums(Avail_shifts)
```

```
##    Sunday    Monday   Tuesday Wednesda Thursday    Friday Saturday
##        18        27        24        28        25        22        19
```