Integer Programming

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#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.

#Running the lpSolveAPI Package

```
library("lpSolveAPI")
```

#Running the lp file

```
ap.workers<-
  read.lp('/Users/ELMYLUKA/Desktop/MS BA/Quantitative  Management Modeling/Assignment-6/ap_workers.lp',
                type = c('lp'))
print(ap.workers)
```

```
## Model name:
##             x1   x2   x3   x4   x5   x6   x7
## Minimize   775  800  800  800  800  775  750
## Sunday       0    1    1    1    1    1    0  >=  18
## Monday       0    0    1    1    1    1    1  >=  27
## Tuesday      1    0    0    1    1    1    1  >=  22
## Wednesday    1    1    0    0    1    1    1  >=  26
## Thursday     1    1    1    0    0    1    1  >=  25
## Friday       1    1    1    1    0    0    1  >=  21
## Saturday     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 following table provides an estimate of the number of workers needed each day of the week.

```
workers_each_day_of_week <- matrix(c("Sunday","Monday","Tuesday","Wednesday","Thursday","Friday","Saturd
18,27,22,26,25,21,19),ncol=2,byrow = F)
colnames(workers_each_day_of_week) <- c("Day_of_the_week", "Workers_Required")
as.table(workers_each_day_of_week)
```

```
##   Day_of_the_week Workers_Required
## 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

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

```
##   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
```

#Running the lp model

```
solve(ap.workers)
```

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

#By obtaining the value 0 we know that there exists a model.

#Total Cost - Objective Function

```
get.objective(ap.workers)
```

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

#In order to keep labor costs as low as possible and have enough workers available each day to work, the total cost to the company is “$25,675”.

#How many workers are available each day to work - Variables

```
get.variables(ap.workers)
```

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

#The variables are labeled from x1, x2,x3,x4,x5,x6 and x7 where,

#x1 = Number of workers assigned for the shift-1 = 2

#x2 = Number of workers assigned for the shift-2 = 4

#x3 = Number of workers assigned for the shift-3 = 5

#x4 = Number of workers assigned for the shift-4 = 0

#x5 = Number of workers assigned for the shift-5 = 8

#x6 = Number of workers assigned for the shift-6 = 1

#x7 = Number of workers assigned for the shift-7 = 13

#With respect to the objective function as well as the constraints established by the organization, we can see how many workers are available to work each day by the variable values obtained, i.e.

#Sunday = x2 + x3 + x4 + x5 + x6 = 18 Workers

#Monday = x3 + x4 + x5 + x6 + x7 = 27 Workers

#Tuesday = x4 + x5 + x6 + x7 + x1 = 24 Workers

#Wednesday = x5 + x6 + x7 + x1 + x2 = 28 Workers

#Thursday = x6 + x7 + x1 + x2 + x3 = 25 Workers

#Friday = x7 + x1 + x2 + x3 + x4 = 24 Workers

#Saturday = x1 + x2 + x3 + x4 + x5 = 19 Workers