Integer Programming

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Overnight package delivery is a promise made by AP, a shipping company operating in the US. The company operates a number of hubs in significant American cities and airports. Packages are delivered to intermediate ports or their final destination after being picked up at hubs.

The manager of the Cleveland AP hub is worried about labor expenditures and is looking for the best approach to schedule employees. The hub is open seven days a week, and it handles a different volume of parcels every day.

Loading the required Package

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

lp file loading

```
ap.hub <- read.lp("C:/Users/shiva/Downloads/qmm.ap.lp")
print(ap.hub)
```

```
## 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 number of workers required for each day of the week is estimated in the table below.

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

```
##   Day       Workers_Required
## A Sunday    18
```

```
## B Monday    27
## C Tuesday   22
## D Wednesday 26
## E Thursday  25
## F Friday    21
## G Saturday  19
```

It is a requirement at AP that package handlers work a five-day week with two consecutive days off. The handlers receive a weekly base salary of $750. Those who work on Saturday or Sunday are compensated with an extra $25 per day. The potential shifts and pay for package handlers are as follows:

```
Day.offs.and.wages <- 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(Day.offs.and.wages) <- c("Shift", "Days_Off", "Wage")
as.table(Day.offs.and.wages)
```

```
##   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
```

implementing the lp model

```
solve(ap.hub)
```

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

We may determine that there is a model by getting 0 as the value.

Total Cost - Objective Function

```
get.objective(ap.hub)
```

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

The entire cost to the company in order to ensure that total wage expenses are kept to the bare minimum and that there are adequate workers available each day to work is "25,675$". How many workers are available each day

```
get.variables(ap.hub)
```

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

The variables are denoted as x1, x2.....x7 where,

x1 = Number of workers assigned to shift 1 = 2

x2 = Number of workers assigned to shift 2 = 4

x3 = Number of workers assigned to shift 3 = 5

x4 = Number of workers assigned to shift 4 = 0

x5 = Number of workers assigned to shift 5 = 8

x6 = Number of workers assigned to shift 6 = 1

x7 = Number of workers assigned to shift 7 = 13

We can determine how many workers are available to work each day in relation to the objective function and the constraints set by the organization by the possible values obtained.

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