

INTEGER PROGRAMMING ASSIGNMENT

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AP is a package delivery service that assures overnight delivery in the continental United States. The firm operates hubs in key cities and airports around the country. Packages are received at hubs before being delivered to intermediate hubs or their final destination.

The manager of the AP hub in Cleveland is concerned about labor expenses and is looking into alternatives. identifying the most effective strategy to schedule staff. The hub is open seven days a week and the amount of parcels handled changes from day to day.

Minimum number of workers required each day

Sunday 18 Monday 27 Tuesday 22 Wednesday 26 Thursday 25 Friday 21 Saturday 19

shifts constraints are

sunday : There are two off, shifts 1 and 7, and the limitation is: $0w_1 + 1w_2 + 1w_3 + 1w_4 + 1w_5 + 1w_6 + 0w_7$

Monday : There are two off's, shifts 1 and 2, and the limitation is $0w_1 + 0w_2 + 1w_3 + 1w_4 + 1w_5 + 1w_6 + 1w_7$

Tuesday : There are two off's, shifts 2 and 3, and the limitation is $1w_1 + 0w_2 + 0w_3 + 1w_4 + 1w_5 + 1w_6 + 1w_7$

Wednesday: There are two off's, shifts 3 and 4, and the limitation is $1w_1 + 1w_2 + 0w_3 + 0w_4 + 1w_5 + 1w_6 + 1w_7$

Thursday : There are two off's, shifts 4 and 5, and the limitation is $1w_1 + 1w_2 + 1w_3 + 0w_4 + 0w_5 + 1w_6 + 1w_7$

Friday : There are two off's, shifts 5 and 6, and the limitation is $1w_1 + 1w_2 + 1w_3 + 1w_4 + 0w_5 + 0w_6 + 1w_7$

Saturday : There are two off's, shifts 6 and 7, and the limitation is: $1w_1 + 1w_2 + 1w_3 + 1w_4 + 1w_5 + 0w_6 + 0w_7$

```
# Install and load the lpSolve package
if (!require(lpSolve)) {
  install.packages("lpSolve")
  library(lpSolve)
}
```

```
## Loading required package: lpSolve
```

```
# Define the coefficients of the objective function (total wages for each shift)
objective_coefficients <- c(775, 800, 800, 800, 800, 775, 750)

# Define the constraints matrix
# Each row corresponds to a day, and each column corresponds to a shift
constraints <- matrix(c(
  0, 1, 1, 1, 1, 1, 0, # Sunday
```

```

0, 0, 1, 1, 1, 1, 1, # Monday
1, 0, 0, 1, 1, 1, 1, # Tuesday
1, 1, 0, 0, 1, 1, 1, # Wednesday
1, 1, 1, 0, 0, 1, 1, # Thursday
1, 1, 1, 1, 0, 0, 1, # Friday
1, 1, 1, 1, 1, 0, 0 # Saturday
), nrow = 7, byrow = TRUE)

# Define the right-hand side of the constraints (workers required each day)
constraints_rhs <- c(18, 27, 22, 26, 25, 21, 19)

# Define the constraints direction (greater than or equal to)
constraints_dir <- rep(">=", 7)

# Define the integer constraint for each decision variable
int_constraints <- rep(1, 7)

# Solve the linear programming problem
solution <- lp("min", objective_coefficients, constraints, constraints_dir, constraints_rhs, all.int = TRUE)

# Output the solution
if (solution$status == 0) {
  print("Optimal solution found:")
  print(solution$solution)

  cat("Total wage cost:", sum(solution$solution * objective_coefficients), "\n")
} else {
  print("Solution not found")
}

```

```

## [1] "Optimal solution found:"
## [1] 2 4 5 0 8 1 13
## Total wage cost: 25675

```

substituting in the decision variables

```

constraints <- matrix(c(
  0, 4, 5, 0, 8, 1, 0, # Sunday
  0, 0, 5, 0, 8, 1, 13, # Monday
  2, 0, 0, 0, 8, 1, 13, # Tuesday
  2, 4, 0, 0, 8, 1, 13, # Wednesday
  2, 4, 5, 0, 0, 1, 13, # Thursday
  2, 4, 5, 0, 0, 0, 13, # Friday
  2, 4, 5, 0, 8, 0, 0 # Saturday
), nrow = 7, byrow = TRUE)

row.names(constraints) <- c("sunday", "monday", "tuesday", "wednesday",
  "thursday", "friday", "saturday" )
colnames(constraints) <- c("Shift 1", "Shift 2", "Shift 3", "Shift 4", "Shift 5", "Shift 6", "Shift 7")

print(constraints)

```

	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5	Shift 6	Shift 7
## sunday	0	4	5	0	8	1	0
## monday	0	0	5	0	8	1	13
## tuesday	2	0	0	0	8	1	13
## wednesday	2	4	0	0	8	1	13
## thursday	2	4	5	0	0	1	13
## friday	2	4	5	0	0	0	13
## saturday	2	4	5	0	8	0	0

```

row.names(constraints) <- c("sunday","monday","tuesday", "wednesday",
                             "thursday", "friday", "saturday" )

rowSums(constraints)

```

	sunday	monday	tuesday	wednesday	thursday	friday	saturday
##	18	27	24	28	25	24	19

```

#workers available for each day
# total wage expense is 25675

```