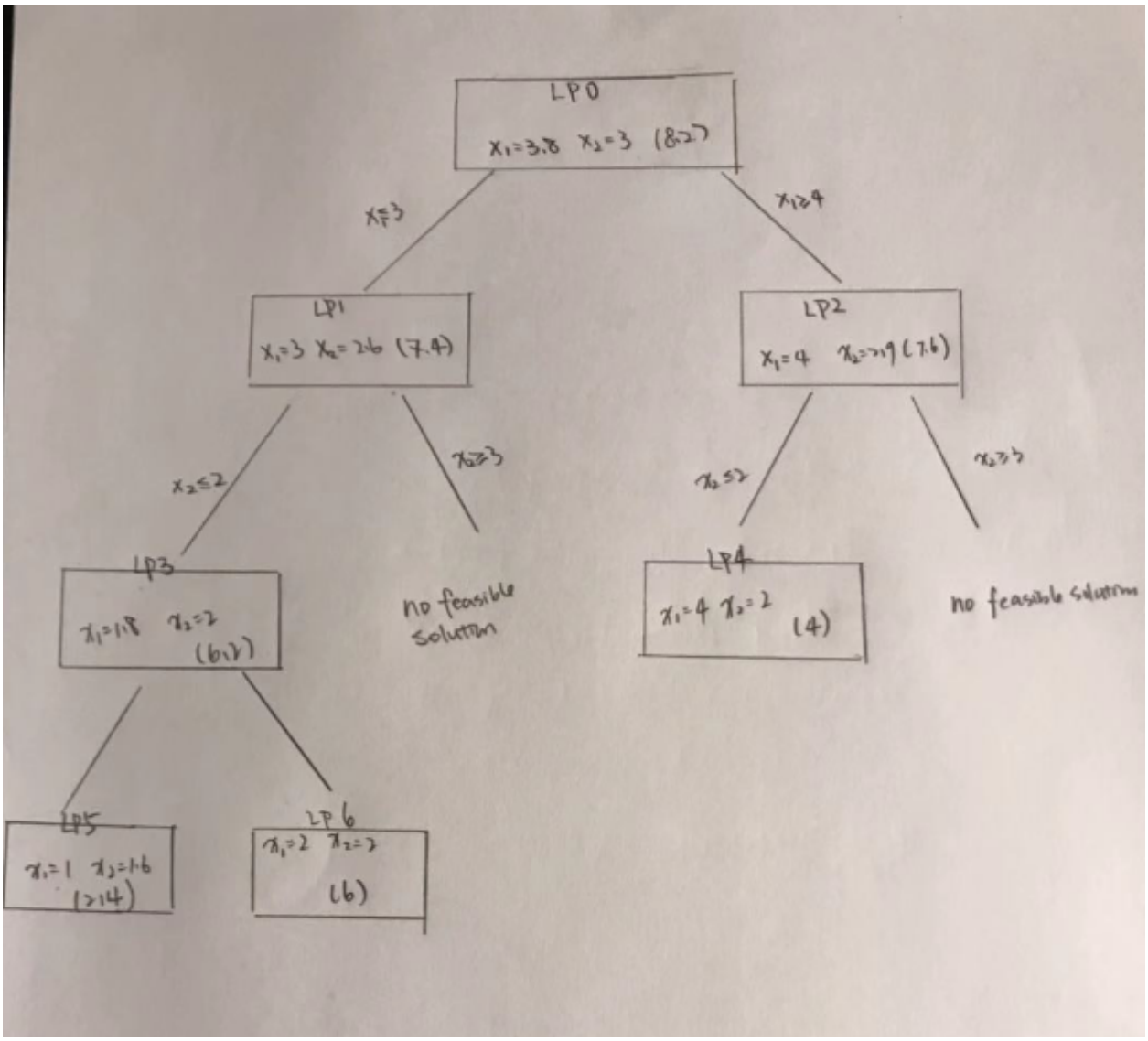
HW3

Problem 1

1)

```
knitr::include_graphics("question1.PNG")
```



2)

```
library('lpSolve')
c = c(-1,4)
A = matrix(c(-10,20,5,10,1,0),3,2,byrow = TRUE)
b = c(22,49,5)
dir = rep("<=",3)
s = lp("max",c,A,dir,b,all.int  = TRUE)
s$solution
```

```
## [1] 2 2
```

```
s$objval
```

```
## [1] 6
```

There are 16 feasible solutions.

3)

Thus, the difference between branch and feasible solutions is 8.

Problem 2

- Choose

Factory in Austin, Factory in Dallas, Warehouse in Austin Warehouse in Dallas as FA, FD, WA, WD.

- to maximize

$$9FA + 5FD + 6WA + 4WD$$

- subject to

$$\begin{aligned} 6FA + 3FD + 5WA + 2WD &\leq 11 \\ FA &\leq 1 \\ FD &\leq 1 \\ WA &\leq 1 \\ WD &\leq 1 \\ FA + FD &\geq 1 \end{aligned}$$

```
library('lpSolve')
c = c(9,5,6,4)
A = matrix(0,6,4)
A[1,] = c(6,3,5,2)
A[2:5,] = diag(4)
A[6,] = c(1,1,0,0)
b = c(11,1,1,1,1,1)
dir = c(rep("<=",5),">=")
s = lp("max",c,A,dir,b, all.int = TRUE)
s$solution
```

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

```
s$objval
```

```
## [1] 18
```

Based on the result, the company should build factory in Austin and Dallas and warehouse in Dallas.

Problem 3

- Choose

Cities as $x_1, x_2, ...x_12$.

- to minimize

$$x_1 + x_2 + ... + x_12$$

- subject to

$$\begin{aligned}
x_1 + x_3 + x_5 + x_7 + x_8 + x_9 &\geq 1 \\
x_2 + x_8 + x_9 &\geq 1 \\
x_1 + x_3 + x_7 + x_8 + x_9 &\geq 1 \\
x_4 + x_10 &\geq 1 \\
x_1 + x_5 + x_7 &\geq 1 \\
x_6 + x_10 + x_11 &\geq 1 \\
x_1 + x_3 + x_5 + x_7 &\geq 1 \\
x_1 + x_2 + x_3 + x_8 + x_9 &\geq 1 \\
x_1 + x_2 + x_3 + x_8 + x_9 &\geq 1 \\
x_4 + x_6 + x_10 + x_11 + x_12 &\geq 1 \\
x_6 + x_10 + x_11 + x_12 &\geq 1 \\
x_10 + x_11 + x_12 &\geq 1
\end{aligned}$$

```
library('lpSolve')
c = c(rep(1,12))
A = matrix(0,12,12)
A[1,] = c(1,0,1,0,1,0,1,1,1,0,0,0)
A[2,] = c(0,1,0,0,0,0,0,1,1,0,0,0)
A[3,] = c(1,0,1,0,0,0,1,1,1,0,0,0)
A[4,] = c(0,0,0,1,0,0,0,0,0,1,0,0)
A[5,] = c(1,0,0,0,1,0,1,0,0,0,0,0)
A[6,] = c(0,0,0,0,0,1,0,0,0,1,1,0)
A[7,] = c(1,0,1,0,1,0,1,0,0,0,0,0)
A[8,] = c(1,1,1,0,0,0,0,1,1,0,0,0)
A[9,] = c(1,1,1,0,0,0,0,1,1,0,0,0)
A[10,] = c(0,0,0,1,0,1,0,0,0,1,1,1)
A[11,] = c(0,0,0,0,0,1,0,0,0,1,1,1)
A[12,] = c(0,0,0,0,0,0,0,0,0,1,1,1)

b = c(rep(1,12))
dir = c(rep(">=",12))
s = lp("min",c,A,dir,b, binary.vec = c(1:12))
s$solution
```

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

```
s$objval
```

```
## [1] 3
```

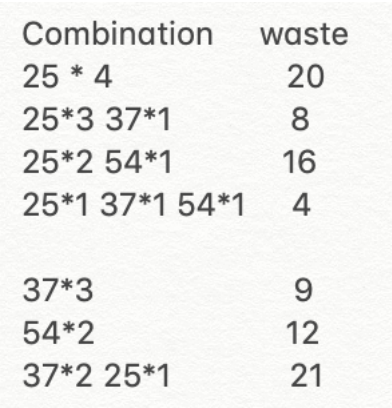
Should build hub in ATL, NY, and SLC.

Problem 4

- Choose

the type of combinations as $x_1, x_2, x_3, x_4, x_5, x_6, x_7$.

```
knitr::include_graphics("Combinations.PNG")
```



Combination	waste
25 * 4	20
25*3 37*1	8
25*2 54*1	16
25*1 37*1 54*1	4
37*3	9
54*2	12
37*2 25*1	21

- to minimize

$$20x_1 + 8x_2 + 16x_3 + 4x_4 + 9x_5 + 12x_6 + 21x_7$$

- subject to

$$\begin{aligned} 4x_1 + 3x_2 + 2x_3 + x_4 &\geq 233 \\ x_2 + x_4 + 3x_5 &\geq 148 \\ x_3 + x_4 + 2x_6 &\geq 106 \end{aligned}$$

```
c = c(20,8,16,4,9,12,21)
A = matrix(0,3,7)
A[1,] = c(4,3,2,1,0,0,1)
A[2,] = c(0,1,0,1,3,0,2)
A[3,] = c(0,0,1,1,0,2,0)


b = c(233,148,106)
dir = c(rep(">=",3))
s = lp("min",c,A,dir,b, all.int = TRUE)
s$solution
```

```
## [1]   0  42   0 107   0   0   0
```

```
s$objval
```

```
## [1] 764
```

Should cut 107 combinations of 1 25-inch, 1 37-inch and 54-inch. 42 combinations of 3 25-inch and 1 37-inch.

Problem 5

- Choose

the number of workers start on each day during the week as $x_1, x_2, x_3, x_4, x_5, x_6, x_7$

- to minimize

$$300x_1 + 300x_2 + 300x_3 + 300x_4 + 300x_5 + 360x_6 + 330x_7$$

- subject to

$$\begin{aligned} x_1 + x_4 + x_5 + x_6 + x_7 &\geq 13 \\ x_2 + x_5 + x_6 + x_7 + x_1 &\geq 12 \\ x_3 + x_6 + x_7 + x_1 + x_2 &\geq 10 \\ x_4 + x_7 + x_1 + x_2 + x_3 &\geq 14 \\ x_5 + x_1 + x_2 + x_3 + x_4 &\geq 8 \\ x_6 + x_2 + x_3 + x_4 + x_5 &\geq 6 \\ x_7 + x_3 + x_4 + x_5 + x_6 &\geq 5 \\ x_1, x_2..., x_7 allinteger & \end{aligned}$$

```
c = c(300,330,360,360,360,360,330)
A = matrix(0,7,7)
A[1,] = c(1,0,0,1,1,1,1)
A[2,] = c(1,1,0,0,1,1,1)
A[3,] = c(1,1,1,0,0,1,1)
A[4,] = c(1,1,1,1,0,0,1)
A[5,] = c(1,1,1,1,1,0,0)
A[6,] = c(0,1,1,1,1,1,0)
A[7,] = c(0,0,1,1,1,1,1)
b = c(13,12,10,14,8,6,5)
dir = c(rep(">=",7))
s = lp("min",c,A,dir,b, all.int = TRUE)
s$solution
```

```
## [1] 8 2 0 3 1 0 1
```

```
s$objval
```

```
## [1] 4830
```

3) 1 worker start on Sunday.

8 workers start on Monday.

2 workers start on Tuesday.

0 worker start on Wednesday.

3 workers start on Thursday.

1 worker start on Friday.

0 worker start on Saturday.

Start working on Sunday is the most popular.