
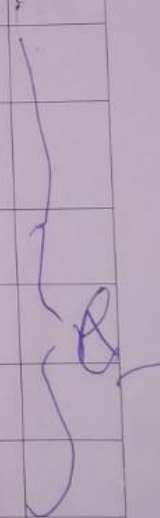


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Paper III (Operational Research)

MSC (Computer Science) Semester- III 2022-23.

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To solve linear programming using R studio, we need to install lpSolve package

`Install.packages("lpSolve")`

PRACTICAL 1

GRAPHICAL METHOD USING R PROGRAMMING

R Program

#Find a geometrical interpretation and solution as well for the following LP problem

#Max $z = 3x_1 + 5x_2$

#subject to constraints:

$x_1 + 2x_2 \leq 2000$

$x_1 + x_2 \leq 1500$

$x_2 \leq 600$

$x_1, x_2 \geq 0$

Load lpSolve

`require(lpSolve)`

Set the coefficients of the decision variables -> C of objective function

`C <- c(3,5)`

Create constraint matrix B

`A <- matrix(c(1, 2,`

`1, 1,`

`0, 1`

`), nrow=3, byrow=TRUE)`

Right hand side for the constraints

`B <- c(2000,1500,600)`

```
# Direction of the constraints
```

```
constranints_direction <- c("<=", "<=", "<=")
```

```
# Create empty example plot
```

```
plot.new()
```

```
plot.window(xlim=c(0,2000), ylim=c(0,2000))
```

```
axis(1)
```

```
axis(2)
```

```
title(main="LPP using Graphical method")
```

```
title(xlab="X axis")
```

```
title(ylab="Y axis")
```

```
box()
```

```
# Draw one line
```

```
segments(x0 = 2000, y0 = 0, x1 = 0, y1 = 1000, col = "green")
```

```
segments(x0 = 1500, y0 = 0, x1 = 0, y1 = 1500, col = "green")
```

```
segments(x0 = 0, y0 = 0, x1 = 600, y1 = 0, col = "green")
```

```
# Find the optimal solution
```

```
optimum <- lp(direction="max",
```

```
  objective.in = C,
```

```
  const.mat = A,
```

```
  const.dir = constranints_direction,
```

```
  const.rhs = B,
```

```
  all.int = T)
```

```
# Print status: 0 = success, 2 = no feasible solution
```

```
print(optimum$status)
```

```
# Display the optimum values for x1,x2
```

```
best_sol <- optimum$solution
```

```
names(best_sol) <- c("x1", "x2")
```

```
print(best_sol)

# Check the value of objective function at optimal point
print(paste("Total cost: ", optimum$objval, sep=""))
```

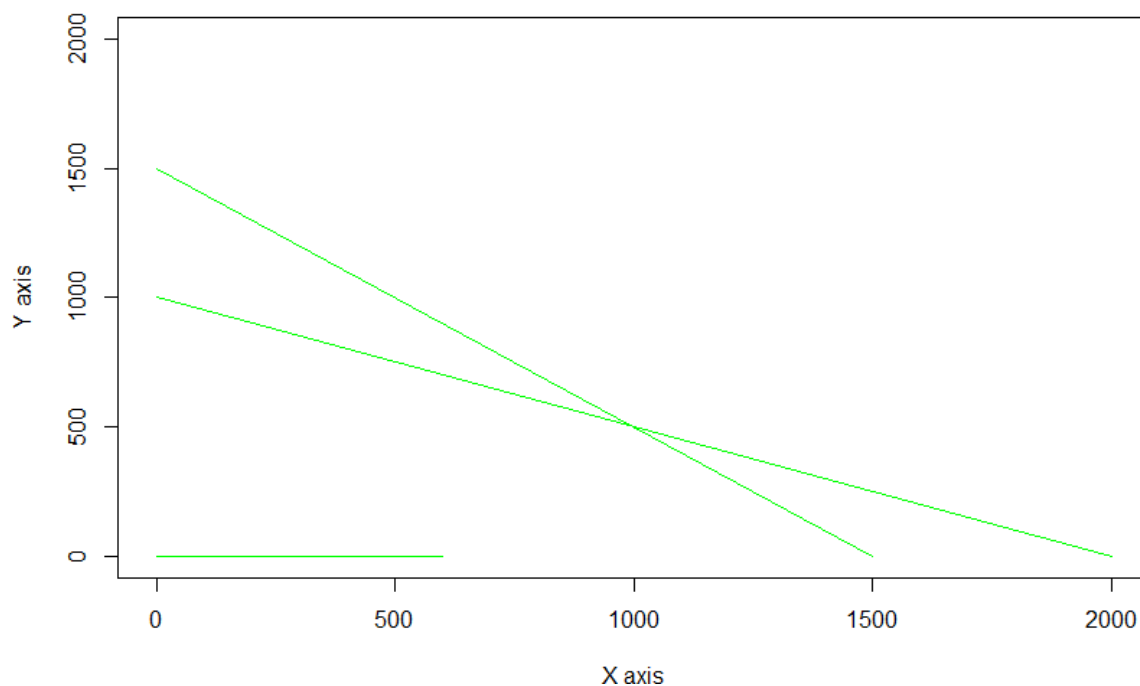
OUTPUT:

[Workspace loaded from ~/.RData]

```
> # Right hand side for the constraints
> B <- c(2000,1500,600)
> # R Program
> # Load lpSolve
> require(lpSolve)
Loading required package: lpSolve
> ## Set the coefficients of the decision variables -> C
> C <- c(3,5)
> # Create constraint matrix B
> A <- matrix(c(1, 2,
+             1, 1,
+             0, 1
+ ), nrow=3, byrow=TRUE)
>
> # Right hand side for the constraints
> B <- c(2000,1500,600)
>
> # Direction of the constraints
> constraints_direction <- c("<=", "<=", "<=")
>
>
> # Create empty example plot
> #plot(2000, 2000, col = "white", xlab = "", ylab = "")
> plot.new()
> plot.window(xlim=c(0,2000), ylim=c(0,2000))
> axis(1)
> axis(2)
> title(main="LPP using Graphical method")
> title(xlab="X axis")
> title(ylab="Y axis")
> box()
> # Draw one line
> segments(x0 = 2000, y0 = 0, x1 = 0, y1 = 1000, col = "green")
> segments(x0 = 1500, y0 = 0, x1 = 0, y1 = 1500, col = "green")
> segments(x0 = 0, y0 = 0, x1 = 600, y1 = 0, col = "green")
>
>
```

>

```
> # Find the optimal solution
> optimum <- lp(direction="max",
+   objective.in = C,
+   const.mat = A,
+   const.dir = constranints_direction,
+   const.rhs = B,
+   all.int = T)
> # Print status: 0 = success, 2 = no feasible solution
> print(optimum$status)
[1] 0
> # Display the optimum values for x1,x2
> best_sol <- optimum$solution
> names(best_sol) <- c("x1", "x2")
> print(best_s
ol)x1 x2
1000 500
>
> # Check the value of objective function at optimal point
> print(paste("Total cost: ", optimum$objval, sep=""))
[1] "Total cost: 5500"
```

LPP using Graphical method

PRACTICAL 2**Simplex Method with 2 variables using Python**

```
from scipy.optimize import linprog

#Max z=3x1+2x2

#subject to

#x1 + x2 <=4

#x1 - x2 <=2

#x1,x2>=0

obj = [-3, -2]

lhs_ineq = [[ 1, 1], # Red constraint left side
...          [1, -1]] # Blue constraint left side

rhs_ineq = [4, # Red constraint right side
...         2] # Blue constraint right side


bnd = [(0, float("inf")), # Bounds of x
...     (0, float("inf"))] # Bounds of y

>>> opt = linprog(c=obj, A_ub=lhs_ineq, b_ub=rhs_ineq,
...               bounds=bnd,method="revised simplex")
>>> opt

opt.fun

opt.success

opt.x
```

Jupyter simplex1with2variables Last Checkpoint: a day ago (unsaved changes)  Logout

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3

Run Code

Solve following linear programming problem with two variables using simplex method.

Max $z=3x_1+2x_2$

subject to

$x_1 + x_2 \leq 4$

$x_1 - x_2 \leq 2$

$x_1, x_2 \geq 0$

```
In [1]: from scipy.optimize import linprog

In [13]: obj = [-3, -2]

In [14]: lhs_ineq = [[ 1,  1], # left side of first constraint
...               [ 1, -1]] # left side of second constraint

In [15]: rhs_ineq = [4, # right side constant of first constraint
...                2] # right side constant of first constraint

In [16]: bnd = [(0, float("inf")), # Bounds of x
...             (0, float("inf"))] # Bounds of y

In [17]: >>> opt = linprog(c=obj, A_ub=lhs_ineq, b_ub=rhs_ineq,
...                       bounds=bnd, method="revised simplex")
>>> opt

Out[17]: con: array([], dtype=float64)
fun: -11.0
message: 'Optimization terminated successfully.'
nit: 2
slack: array([0., 0.])
status: 0
success: True
x: array([3., 1.])

In [18]: opt.fun

Out[18]: -11.0

In [19]: opt.success
```


PRACTICAL 3**Simplex Method with 3 variables using Python**

```
from scipy.optimize import linprog

#Min z= x1-3x2+2x3

#subject to

#3x1-x2+3x3<=7

#-2x1+4x2<=12

#-4x1+3x2+8x3<=10

#x1,x2,x3>=0


obj = [1, -3, 2]

lhs_ineq = [[ 3, -1, 3], # Red constraint left side
...         [-2, 4, 0], # Blue constraint left side
...         [-4, 3, 8]] # Yellow constraint left side

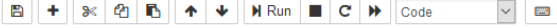
rhs_ineq = [7, # Red constraint right side
...         12, # Blue constraint right side
...         10] # Yellow constraint right side

bnd = [(0, float("inf")), # Bounds of x
...     (0, float("inf")),
...     (0, float("inf"))] # Bounds of y

>>> opt = linprog(c=obj, A_ub=lhs_ineq, b_ub=rhs_ineq,
...               bounds=bnd,
...               method="revised simplex")
>>> opt
```

jupyter SimplexWith3Variables Last Checkpoint: 2 hours ago (autosaved)  Login

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3



```
In [27]: from scipy.optimize import linprog

In [28]: #Min z= x1-3x2+2x3
#subject to
#3x1-x2+3x3<=7
#-2x1+4x2<=12
#-4x1+3x2+8x3<=10
#x1,x2,x3>=0

obj = [1, -3, 2]

In [29]: lhs_ineq = [[ 3, -1, 3], # Red constraint left side
...                [-2, 4, 0], # Blue constraint left side
...                [-4, 3, 8]] # Yellow constraint left side

In [30]: rhs_ineq = [7, # Red constraint right side
...                 12, # Blue constraint right side
...                 10] # Yellow constraint right side

In [33]: bnd = [(0, float("inf")), # Bounds of x
...             (0, float("inf")),
...             (0, float("inf"))] # Bounds of y

In [34]: >>> opt = linprog(c=obj, A_ub=lhs_ineq, b_ub=rhs_ineq,
...                       bounds=bnd,
...                       method="revised simplex")
>>> opt

Out[34]: con: array([], dtype=float64)
fun: -11.0
message: 'Optimization terminated successfully.'
nit: 2
slack: array([ 0.,  0., 11.])
status: 0
success: True
x: array([4., 5., 0.])
```

PRACTICAL 4**Simplex Method with Equality Constraints Using Python**

```
from scipy.optimize import  
linprog#Max z=x+2y  
#subject  
to  
#2x+y<=2  
0  
#-  
4x+5y<=10  
#-x+2y>=-2  
#-x+5y=15  
#x,y>=0  
obj = [-1, -2]  
  
lhs_ineq = [[ 2, 1], # Red constraint left side  
...      [-4, 5], # Blue constraint left side  
...      [ 1, -2]] # Yellow constraint left side  
  
rhs_ineq = [20, # Red constraint right side  
...      10, # Blue constraint right side  
...      2] # Yellow constraint right side  
  
lhs_eq = [[-1, 5]] # Green constraint left  
side rhs_eq = [15] # Green constraint  
right side  
  
bnd = [(0, float("inf")), # Bounds of x  
...   (0, float("inf"))] # Bounds of y
```

```
opt = linprog(c=obj, A_ub=lhs_ineq, b_ub=rhs_ineq,  
...         A_eq=lhs_eq, b_eq=rhs_eq, bounds=bnd,  
...         method="revised simplex")
```


PRACTICAL 5**BigM Simplex Method using Python**

Solve Following linear programming problem using Big M Simplex method.

$$\text{Min } z = 4x_1 + x_2$$

subjected to:

$$3x_1 + 4x_2 \geq 20$$

$$x_1 + 5x_2 \geq 15$$

$$x_1, x_2 \geq 0$$

```
from scipy.optimize import linprog
```

```
obj = [4, 1]
```

```
lhs_ineq = [[ -3, -4], # left side of first constraint
```

```
...          [-1, -5]] # right side of first constraint
```

```
rhs_ineq = [-20, # right side of first constraint
```

```
...          -15] # right side of Second constraint
```

```
bnd = [(0, float("inf")), # Bounds of x1
```


```
...    (0, float("inf"))] # Bounds of x2
```

```
>>> opt = linprog(c=obj, A_ub=lhs_ineq, b_ub=rhs_ineq,
```

```
...          bounds=bnd,method="interior-point")
```

```
>>> opt
```

method = "interior-point" solves linear programming problem using default simplex method.

Jupyter BigM Simplex Method Last Checkpoint: 37 minutes ago (autosaved)  Logout

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3

Solve Following linear programming problem using Big M Simplex method.

Min $z = 4x_1 + x_2$

subjected to:

$3x_1 + 4x_2 \geq 20$

$x_1 + 5x_2 \geq 15$

$x_1, x_2 \geq 0$

```
In [41]: from scipy.optimize import linprog

In [42]: obj = [4, 1]

In [43]: lhs_ineq = [[-3, -4], # left side of first constraint
...               [-1, -5]] # right side of first constraint

In [44]: rhs_ineq = [-20, # right side of first constraint
...                 -15] # right side of Second constraint

In [45]: bnd = [(0, float("inf")), # Bounds of x1
...            (0, float("inf"))] # Bounds of x2

In [48]: >>> opt = linprog(c=obj, A_ub=lhs_ineq, b_ub=rhs_ineq,
...                       bounds=bnd, method="interior-point")
>>> opt

Out[48]: con: array([], dtype=float64)
fun: 5.000000000236447
message: 'Optimization terminated successfully.'
nit: 5
slack: array([1.64277481e-10, 1.00000000e+01])
status: 0
success: True
x: array([6.01160437e-11, 5.00000000e+00])

In [ ]:
```

PRACTICAL 6**RESOURCE ALLOCATION PROBLEM BY SIMPLEX METHOD**

Use SciPy to solve the resource allocation problem stated as follows:

Max $z = 20x_1 + 12x_2 + 40x_3 + 25x_4$ (profit)

subjected to:

$x_1 + x_2 + x_3 + x_4 \leq 50$ ----- (manpower)

$3x_1 + 2x_2 + x_3 \leq 100$ -----(material A)

$x_2 + 2x_3 \leq 90$ -----(material B) $x_1, x_2, x_3,$

$x_4 \geq 0$

```
from scipy.optimize import linprog
```

```
obj = [-20, -12, -40, -25]    #profit objective function
```

```
lhs_ineq = [[1, 1, 1, 1],      # Manpower
```

```
...      [3, 2, 1, 0],        # Material A
```

```
...      [0, 1, 2, 3]]        # Material B
```

```
rhs_ineq = [ 50, # Manpower
```

```
...      100, # Material A
```

```
...      90] # Material B
```

```
opt = linprog(c=obj, A_ub=lhs_ineq, b_ub=rhs_ineq,
```

```
...      method="revised simplex")
```

Opt


```

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3.6
+ - < > Run Code

Use SciPy to solve the resource allocation problem stated as follows:

Max z= 20x1 + 12x2 + 40x3 + 25x4 .....(profit)

subjected to:

x1 + x2 + x3 + x4 <= 50 -----(manpower)

3x1 + 2x2 + x3 <= 100 -----(material A)

x2 + 2x3 <= 90 -----(material B)

x1, x2, x3, x4 >= 0

In [12]: from scipy.optimize import linprog

In [13]: obj = [-20, -12, -40, -25] #profit objective function

In [14]: lhs_ineq = [[1, 1, 1, 1], # Manpower
...                [3, 2, 1, 0], # Material A
...                [0, 1, 2, 3]] # Material B

In [15]: rhs_ineq = [ 50, # Manpower
...                 100, # Material A
...                 90] # Material B

In [16]: opt = linprog(c=obj, A_ub=lhs_ineq, b_ub=rhs_ineq,
...                    method="revised simplex")

In [17]: opt

Out[17]: con: array([], dtype=float64)
fun: -1900.0
message: 'Optimization terminated successfully.'
nit: 2
slack: array([ 0., 40., 0.])
status: 0
success: True
x: array([ 5., 0., 45., 0.])

The result tells you that the maximal profit is 1900 and corresponds to  $x_1 = 5$  and  $x_3 = 45$ . It's not profitable to produce the second and fourth products under the given conditions. You can draw several interesting conclusions here:

The third product brings the largest profit per unit, so the factory will produce it the most.

The first slack is 0, which means that the values of the left and right sides of the manpower (first) constraint are the same. The factory produces 50 units per day, and that's its full capacity.

The second slack is 40 because the factory consumes 60 units of raw material A (15 units for the first product plus 45 for the third) out of a potential 100 units.

The third slack is 0, which means that the factory consumes all 90 units of the raw material B. This entire amount is consumed for the third product. That's why the factory can't produce the second or fourth product at all and can't produce more than 45 units of the third product. It lacks the raw material B.

opt.status is 0 and opt.success is True, indicating that the optimization problem was successfully solved with the optimal feasible solution.

```

PRACTICAL 7**INFEASIBILITY IN SIMPLEX METHOD**

Solve following linear programming problem using Simplex method

WHILE SOLVING LINEAR PROGRAMMING PROBLEM USING SIMPLEX METHOD, IF ONE OR MORE ARTIFICIAL VARIABLES REMAIN IN THE BASIS AT POSITIVE LEVEL AT THE END OF PHASE 1 COMPUTATION , THE PROBLEM HAS NO FEASIBLE SOLUTION(INFEASIBLE SOLUTION).

Example:

Max $z = 200x - 300y$

subject to

$2x + 3y \geq 1200$

$x + y \leq 400$

$2x + 3/2y \geq 900$

$x, y \geq 0$

```
from scipy.optimize import linprog
```

```
obj = [-200, 300]
```

```
lhs_ineq = [[ -2, -3], # Red constraint left side
```

```
...      [1, 1], # Blue constraint left side
```

```
...      [ -2, -1.5]] # Yellow constraint left side
```

```
rhs_ineq = [-1200, # Red constraint right side
```

```
...      400, # Blue constraint right side
```

```
...      -900] # Yellow constraint right side
```

```
bnd = [(0, float("inf")), # Bounds of x
```

```
...      (0, float("inf"))] # Bounds of y
```

```
opt = linprog(c=obj, A_ub=lhs_ineq, b_ub=rhs_ineq,
```

```
...      bounds=bnd,
```

... **method="revised simplex")**

opt

The screenshot shows a Jupyter Notebook with a menu bar (File, Edit, View, Insert, Cell, Kernel, Widgets, Help) and a toolbar with icons for file operations, running, and saving. The notebook contains a code cell with the following text:

```
# INFEASIBILITY IN SIMPLEX METHOD
# Solve following linear programming problem using Simplex method

WHILE SOLVING LINEAR PROGRAMMING PROBLEM USING SIMPLEX METHOD, IF ONE OR MORE ARTIFICIAL VARIABLES REMAIN IN
THE BASIS AT POSITIVE LEVEL AT THE END OF PHASE 1 COMPUTATION , THE PROBLEM HAS NO FEASIBLE SOLUTION(
INFEASIBLE SOLUTION).

Example:

Max z= 200x - 300y
subject to

2x+3y>=1200

x+y<=400

2x+3/2y>=900

x,y>=0
```

Below the code cell, there are several input cells (In [1] to In [14]) and one output cell (Out [14]).

```
In [1]: from scipy.optimize import linprog

In [9]: obj = [-200, 300]

In [10]: lhs_ineq = [[ -2,  -3], # Red constraint left side
...                [1,  1], # Blue constraint left side
...                [-2, -1.5]] # Yellow constraint left side

In [11]: rhs_ineq = [-1200, # Red constraint right side
...                 400, # Blue constraint right side
...                 -900] # Yellow constraint right side

In [12]: bnd = [(0, float("inf")), # Bounds of x
...             (0, float("inf"))] # Bounds of y

In [13]: opt = linprog(c=obj, A_ub=lhs_ineq, b_ub=rhs_ineq,
...                    bounds=bnd,
...                    method="revised simplex")

In [14]: opt
```

Out [14]:

```
con: array([], dtype=float64)
fun: 120000.0
message: 'The problem appears infeasible, as the phase one auxiliary problem terminated successfully with a
residual of 3.0e+02, greater than the tolerance 1e-12 required for the solution to be considered feasible. C
onsider increasing the tolerance to be greater than 3.0e+02. If this tolerance is unnacceptably large, the pr
oblem is likely infeasible.'
nit: 1
slack: array([ 0.,  0., -300.])
status: 2
success: False
x: array([ 0., 400.])
```

**PRACTICAL 8 DUAL
SIMPLEX METHOD**

##SOLVE FOLLOWING LINEAR PROGRAMMING PROBLEM USING DUALSIMPLEX
METHOD USING R PROGRAMMING

Max $z=40x_1+50x_2$

#subject to

$2x_1 + 3x_2 \leq 3$

$8x_1 + 4x_2 \leq 5$

$x_1, x_2 \geq 0$

Import lpSolve package

library(lpSolve)

Set coefficients of the objective functionf.obj <-

c(40, 50)

Set matrix corresponding to coefficients of constraints by rows

Do not consider the non-negative constraint; it is automatically assumedf.con <-

matrix(c(2, 3,

8, 4), nrow = 2, byrow = TRUE)

Set unequality signs

f.dir <- c("<=",

```
"<=")

# Set right hand side coefficientsf.rhs
<- c(3,
      5)

# Final value (z)
lp("max", f.obj, f.con, f.dir, f.rhs)

# Variables final values
lp("max", f.obj, f.con, f.dir, f.rhs)$solution

# Sensitivities
lp("max", f.obj, f.con, f.dir, f.rhs, compute.sens=TRUE)$sens.coef.fromlp("max",
f.obj, f.con, f.dir, f.rhs, compute.sens=TRUE)$sens.coef.to

# Dual Values (first dual of the constraints and then dual of the variables)# Duals of
the constraints and variables are mixed
lp("max", f.obj, f.con, f.dir, f.rhs, compute.sens=TRUE)$duals

# Duals lower and upper limits
lp("max", f.obj, f.con, f.dir, f.rhs, compute.sens=TRUE)$duals.fromlp("max",
f.obj, f.con, f.dir, f.rhs, compute.sens=TRUE)$duals.to
```

OUTPUT:

##SOLVE FOLLOWING LINEAR PROGRAMMING PROBLEM USING DUAL SIMPLEX METHOD USING R PROGRAMMING

```
> # Max z=40x1+50x2
> #subject to
> #2x1 + 3x2 <= 3
> #8x1 + 4x2 <= 5
> # x1, x2>=0
>
>
> # Import lpSolve package
> library(lpSolve)
>
> # Set coefficients of the objective function
> f.obj <- c(40, 50)
>
> # Set matrix corresponding to coefficients of constraints by rows
> # Do not consider the non-negative constraint; it is automatically assumed
> f.con <- matrix(c(2, 3,
+                 8, 4), nrow = 2, byrow = TRUE)
>
> # Set unequality signs
> f.dir <- c("<=",
+           "<=")
>
> # Set right hand side coefficients
> f.rhs <- c(3,
+           5)
>
> # Final value (z)
> lp("max", f.obj, f.con, f.dir, f.rhs)
Success: the objective function is
51.25
>
> # Variables final values
> lp("max", f.obj, f.con, f.dir,
f.rhs)$solution[1] 0.1875 0.8750
>
> # Sensitivities
> lp("max", f.obj, f.con, f.dir, f.rhs,
compute.sens=TRUE)$sens.coef.from[1] 33.33333 20.00000
> lp("max", f.obj, f.con, f.dir, f.rhs,
compute.sens=TRUE)$sens.coef.to[1] 100 60
>
> # Dual Values (first dual of the constraints and then dual of the variables)
> # Duals of the constraints and variables are mixed
> lp("max", f.obj, f.con, f.dir, f.rhs,
compute.sens=TRUE)$duals[1] 15.00 1.25 0.00 0.00
>
> # Duals lower and upper limits
> lp("max", f.obj, f.con, f.dir, f.rhs,
```

```
compute.sens=TRUE)$duals.from[1] 1.25e+00 4.00e+00 -  
1.00e+30 -1.00e+30  
> lp("max", f.obj, f.con, f.dir, f.rhs,  
compute.sens=TRUE)$duals.to[1] 3.75e+00 1.20e+01  
1.00e+30 1.00e+30
```

>

PRACTICAL 9**TRANSPORTATION PROBLEM**

##SOLVE FOLLOWING TRANSPORTATION PROBLEM IN WHICH CELL ENTRIES REPRESENT UNIT COSTS USING R PROGRAMMING.

"Customer 1", "Customer 2", "Customer 3", "Customer 4" SUPPLY

#sUPPLIER 1	10	2	20	11	15
-------------	----	---	----	----	----

#sUPPLIER 1	12	7	9	20	25
-------------	----	---	---	----	----

#sUPPLIER 1	4	14	16	18	10
-------------	---	----	----	----	----

#DEMAND	5	15	15	15	
---------	---	----	----	----	--

Import lpSolve package

library(lpSolve)

Set transportation costs matrix costs

```
<- matrix(c(10, 2, 20, 11,  
            12, 7, 9, 20,  
            4, 14, 16, 18), nrow = 3, byrow = TRUE)
```

Set customers and suppliers' names

```
colnames(costs) <- c("Customer 1", "Customer 2", "Customer 3", "Customer 4")
```

```
rownames(costs) <- c("Supplier 1", "Supplier 2", "Supplier 3")
```

Set inequality/equality signs for suppliers

```
row.signs <- rep("<=", 3)
```

```
# Set right hand side coefficients for suppliersrow.rhs
<- c(15, 25, 10)

# Set unequality/equality signs for customers
col.signs <- rep(">=", 4)

# Set right hand side coefficients for customerscol.rhs
<- c(5, 15, 15, 15)

# Final value (z)
TotalCost <- lp.transport(costs, "min", row.signs, row.rhs, col.signs, col.rhs)

# Variables final values
lp.transport(costs, "min", row.signs, row.rhs, col.signs, col.rhs)$solution
print(TotalCost)
```

OUTPUT:

```
> ##SOLVE FOLLOWING TRANSPORTATION PROBLEM IN WHICH CELL ENTRIES REPRESENT UNIT COSTS
  USING R PR
>
> #      "Customer 1", "Customer 2", "Customer 3", "Customer 4"  SUPPLY
> #sUPPLIER 1  10      2      20      11      15
> #sUPPLIER 1  12      7      9      20      25
> #sUPPLIER 1  4      14     16     18      10
> #DEMAND     5      15     15     15
>
> # Import lpSolve package
> library(lpSolve)
>
> # Set transportation costs matrix
> costs <- matrix(c(10, 2, 20, 11,
+      12, 7, 9, 20,
+      4, 14, 16, 18), nrow = 3, byrow = TRUE)
>
> # Set customers and suppliers' names
> colnames(costs) <- c("Customer 1", "Customer 2", "Customer 3", "Customer 4")
```

```
> rownames(costs) <- c("Supplier 1", "Supplier 2", "Supplier 3")
>
> # Set unequality/equality signs for suppliers
> row.signs <- rep("<=", 3)
>
> # Set right hand side coefficients for suppliers
> row.rhs <- c(15, 25, 10)
>
> # Set unequality/equality signs for customers
> col.signs <- rep(">=", 4)
>
> # Set right hand side coefficients for customers
> col.rhs <- c(5, 15, 15, 15)
>
> # Final value (z)
> TotalCost <- lp.transport(costs, "min", row.signs, row.rhs, col.signs,
  col.rhs)
>
>
> # Variables final values
> lp.transport(costs, "min", row.signs, row.rhs, col.signs,
  col.rhs)$solution[,1] [,2] [,3] [,4]
[1,] 0  5  0 10
[2,] 0 10 15  0
[3,] 5  0  0  5
>
> print(TotalCost)
Success: the objective function is 435

>
```

PRACTICAL 10**ASSIGNMENT PROBLEM**

#SOLVE FOLLOWING ASSIGNMENT PROBLEM REPRESENTED IN FOLLOWING MATRIX USING R PROGRAMMING

Assignment Problem

JOB1 JOB2 JOB3

#W1 15 10 9

#W2 9 15 10

#W3 10 12 8

Import lpSolve package

library(lpSolve)

Set assignment costs matrix

**costs <- matrix(c(15, 10, 9,
 9, 15, 10,
 10, 12 ,8), nrow = 3, byrow = TRUE)**

Print assignment costs matrix

costs

Final value (z)

lp.assign(costs)

Variables final values

lp.assign(costs)\$solution

OUTPUT:

> #SOLVE FOLLOWING ASSIGNMENT PROBLEM REPRESENTED IN FOLLOWING MATRIX USING R PROGRAMMING

```
> # Assignment Problem
> #   JOB1  JOB2  JOB3
> #W1  15   10   9
> #W2  9    15   10
> #W3  10   12   8
>
> # Import lpSolve package
> library(lpSolve)
>
> # Set assignment costs matrix
> costs <- matrix(c(15, 10, 9,
+                   9, 15, 10,
+                   10, 12 ,8), nrow = 3, byrow =
TRUE)
>
> # Print assignment costs matrix
> costs
      [,1] [,2] [,3]
[1,]  15  10  9
[2,]   9  15  10
[3,]  10  12  8
>
> # Final value (z)
> lp.assign(costs)
Success: the objective function is 27
>
> # Variables final values
> lp.assign(costs)$soluti
on[,1] [,2] [,3]
[1,]  0  1  0
[2,]  1  0  0
[3,]  0  0  1
>
```