Name: - Anjali Vitthal Pingle Roll no:-528

Paper III (Operational Research)
MSC (Computer Science) Semester- III 2022-23.

INDEX

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= 3x1 + 5x2
#subject to constraints:
#x1+2x2<=2000
#x1+x2<=1500
#x2<=600
#x1,x2>=0

# Load lpSolve
require(lpSolve)

## Set the coefficients of the decision variables -> C of objective function
C <- c(3,5)

# Create constraint martix 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

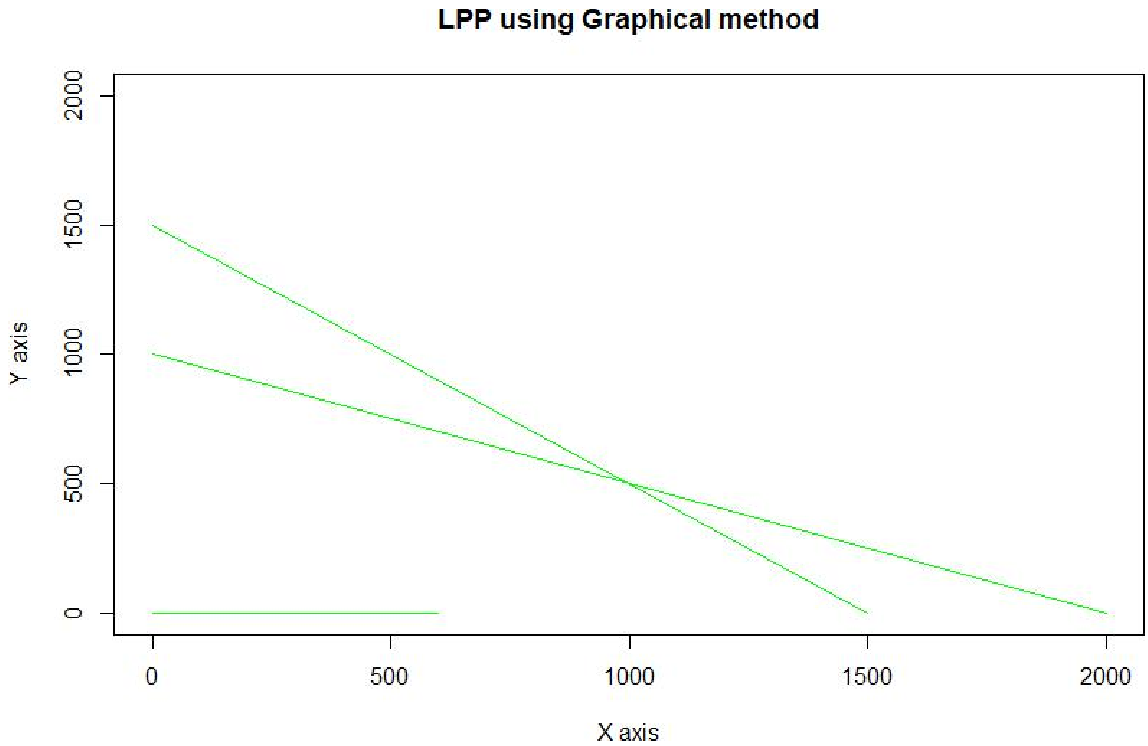
print(paste("Total cost: ", optimum$objval, sep=""))

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 martix 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(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_sol)
  x1   x2
1000  500
>
> # Check the value of objective function at optimal point
> print(paste("Total cost: ", optimum$objval, sep=""))
[1] "Total cost: 5500"
```



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) ;a Logout

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3 0

II'I + :lo< fl) ... + + H Run ■ C * Code _Jv C'l

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

Max z=3x1+2x2

subject to

x1 + x2 <=4

x1 - x2 <=2

X1,x2>=0

In {1]:
```
fi:omcipy.optimize impoi:t linprog
```

In [13],
```
ocj - [-3, -2]
```

In [14]:
```
lh.s_ineq = [( 1,   1],   I left sids of first constraint
             (1,  -1]J  I lt!ft sid!!!!= oi st!cond constraint
```

In [15]:
```
rh.s_ineq = [4,   : right side constant of first constraint
             2]   : right side constant of first constraint
```

In [16]:
```
bnd= 1(0, float("inf")),   IBoundsotx
       (0, flaat("inf"))]  : Bounds of y
```

In [17]:
```
>>> opt - linprog(e=cobj, A_ub=,.lh.9_ineq, b_ub-rh.9_ineq,
                  tound.9=bnd,method-"revi.9ed .9implex")
>>> opt
```

Out[17]:
```
         array ( [], dtype=float64)
     fun: -11.0
 me9.sage: 'Optimization terminated succe9.sfully.'
     n:i..t: 2
   !5lack: array( [O., 0.])
   status: O
         True
         array([3., 1.])
```

In [18]:
```
opt.fun
```

OUt[IS]: -11.0

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 (autosa•,ed) LO!iJO

File Edit View Insert Cell Kernel Widgets Help Trusted | Python 3

+ :|< I',') I', + + Run ■ C Code

In 127]:
```
from !5cipy.optimiz import linprog
```

In {28]:
```
#Min 2= x1-3x2+2x3
tsubp::ct to
#3xl-x.2+3x3<-7
f-2x1+4x2<=12
f-4xl+Jx2+8x3<=10
#xl,x.2,x3.>=0

obJ = 11, -3, 2]
```

In 129]:
```
lh.9_ineq = I[ 3, -1, 3], : Red constraint lsft side
            (-2, 4, 0], I Bl1le constraint left side
            [ -4, 3, 8]] i Yellov constraint le.fr. side
```

In JJO]:
```
rh!5_J.n q = 17, i Red constraint right side
             12, I Blue constraint right side
             10] f YslloJo'constraint right side
```

In {33]:
```
bnd = I {0, float {"inf")), i Bo11nds of x
        (0, float("inf")),
        (0, float ("1.nf"))] # Bounds of y
```

In {34]:
```
>>>opt= linprog(c=obJ, A_ub=ln.5_J.n q, b_ub=rh.5_J.n q,
                bound.9=bnd,
                method="revised simplex")
>>> opt
```

0Ut[34]:
```
          array([], dtyp-e::float64)
     fun: -11.0
 me5.5age: 'Optimization terminated .5ucce.5.5fully.'
     nit: 2
   slack: array{[ 0.,  0.,  11.])
  .5tatu.5: 0
          True
          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<=20
#-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")
```

Opt

method ="revised simplex" solves linear programming problem using two phase simplex method.

:

```
con: array([0.])
      fun: -16.818181818181817
 message: 'Optimization terminated successfully.'
      nit: 3
    slack: array([ 0.        , 18.18181818,  3.36363636])
   status: 0
  success: True
        x: array([7.72727273, 4.54545455])
```

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3

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

```
In [2]: #Max z=x+2y
        #subject to
        #2x+y<=20
        #-4x+5y<=10
        #-x+2y>=-2
        #-x+5y=15
        #x,y>=0
        obj = [-1, -2]
```

```
In [3]: lhs_ineq = [[ 2,  1],  # Red constraint left side
        ...         [-4,  5],  # Blue constraint left side
        ...         [ 1, -2]]  # Yellow constraint left side
```

```
In [4]: rhs_ineq = [20,  # Red constraint right side
        ...         10,  # Blue constraint right side
        ...          2]  # Yellow constraint right side
```

```
In [5]: lhs_eq = [[-1, 5]]  # Green constraint left side
```

```
In [6]: rhs_eq = [15]       # Green constraint right side
```

```
In [7]: bnd = [(0, float("inf")),  # Bounds of x
        ...    (0, float("inf"))]  # Bounds of y
```

```
In [8]: 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")
```

```
In [9]: opt
Out[9]:      con: array([0.])
             fun: -16.818181818181817
         message: 'Optimization terminated successfully.'
             nit: 3
           slack: array([ 0.        , 18.18181818,  3.36363636])
          status: 0
         success: True
               x: array([7.72727273, 4.54545455])
```

PRACTICAL 5

BigM Simplex Method using Python

Solve Following linear programming problem using Big M Simplex method.

Min z= 4x1 + x2

subjected to:

3x1 + 4x2 >= 20

x1 + 5x2 >= 15

x1, x2 >= 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) ;a Logout

File Edit View Insert Cell Kernel Widgets Help Trusted I Python 3 0

Solve Following linear programming problem using Big M Simplex method.

Min z= 4x1 + x2

subjected to:

3x1 + 4x2 >= 20

X1 +5X2>= 15

x1, x2 >= o

In (41]:
```
from .9cipy.optimize import linprog
```

In (42],
```
obJ (4, 1]
```

In (43]:
```
lhs_ineq = [[ -3, -4], f left sids of first constraint
            (-1, -5]] # right sid of first constrclint
```

In (44]:
```
rh!!_ineq = {-20, i right: sid of first const:r.aint:
            -15] right side of Second constraint
```

In (45]:
```
bnd = {(0, flaat("inf")), I Bounds of xl
       (0, float("inf"))] I Bounds of x2
```

In (48]:
```
>>> opt = linprog(e=obJ, A_ub=l.'l.!!_:i..neq, b_ub=rn!!_:i..neq,
                  bound.5=bnd, method="J.nterJ.or-point")
>>> opt
```

Out[48]:
```
        array {I], dtype=Eloat64)
   fun: 5.000000000236447
mes.sage: 'Optimization terminated 3ucce33fully.'
   nit: 5
  !!lack: array{11.642774Ble-10, 1.00000000e+0l])
 .5tatu.5: 0
        True
        array(16.01160437e-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= 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
```

```
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 Help Trusted | Python 3

+ :i,; + ,I, II Run ■ C » Code 13

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

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

subjocled to:

xl + x2 + x3 + x4 50---------------------------------(manpower)

3x1 + 2x2 + K3 100 -------------(m.atei::ial A)

x.2 + 2x3 90 -------------(m.atei::ial 8)

x.1. x.2, x3, x.4 >= 0

```
In [12]: M rrom :3cipy.optimize import linpi::og
```

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

```
In [14]: M lh:3 i.neq = [[1, 1, 1, 11,     # l'.,gnpover
                         [3, 2, 1, O],     #- i'f.:teric.l -
                         [0, 1, 2, 31 1    # Materia.1 B
```

```
In [15]: M :i::h:3_ineq =   50,     # ivr.,gnpover
                            100,    #- i'lateria.l A
                             90]    # i'la teria.l B
```

```
In [161; II opt     li.nprog(c=obj, A_ub=lh:3_1.neq, b_ub=:t:h:3 ineq,
                              method=":revi:3ed :3implex")
```

```
In [l'i']: M opt

Ou.t[l?J:            ai::i::ay( [], dtype=floatf.4)
             fun: -1900 .0
         me:3:3age: 'Optimization tei:m.inated :3ucce:3:3:fully.'
             nit: 2
           :3lack: ai::i::ay([ 0., 40.,   O.])
           :3tatu::1: 0
          :3ucce:3:3: True
                   an:ay([ 5.    0_, 45.,   0.])
```

The i::e:3ult tell:3 yo,u that the m.a.xim.al pi::ofit i:3 1900 a.nd coi::re:3pe-nd:3 to xl = 5 and ID = 45. I-c' :3 not p?:Dfitable to p::::oduce the :3econd and fo,urth p::::□duct:3 unde::: the given condition:3 You can draw :3evei::al inte:i::e:3ting conclu:3ion:3 he!:e:

The thii::d pre duct b::::ing:3 the lai::ge:3t pi::ofi t pe::: unit, :30the factor}; will produce it the mo:3"t.

The fir:3t :3lack i:3 O. whim mea.n:3 that the value:3 of the left and right :3ide:3 of the manpower (:fir:3t) on:3traint the :3ame. The factoi::y pi::oduce:3 50 unit:3pe::: day, a.nd tha-c':3 it:3 full capacity.

The :3econd :3lack i:3 40 becau:3e the factm:y con:3ume:3 60 unit:3 of r:aw mate:i:::ial A (15 unit:3 for: the :fir:3t p:i::oduct plu:3 45 for the third) out of a potential 100 unit::3.

The thii::d :3lack i:3 0, whim mea.n:3 -cha-c the :factoi::y con:3ume:3 all 90 unit:3 o,f the i::aw matei::ial B. Thi:3 entii::e amount i:3 con:3umed :fm: the thii::d pr:oduct. That':3 why the :facto:i::y can't pr:oduce the :3econd or: fourthpr:oduct at all a.nd ca.n' t p::::oduce mo::::e than 45 unit:3 of the thi:::dproduct. It lack:3 the i::aw material B.

opt .:3tatu:3 i:3 0 and opt i:3 True, indicating that the op-cimization problem wa:3 :3ucce:3:3:fully :301·..red with the

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>=1200

x+y<=400

2x+3/2y>=900

x,y>=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

File Edit View Insert Cell Kernel Widgets Help   Trusted   Python 3

Run   Markdown

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
```

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

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

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

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

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

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

In [14]:
```python
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 unacceptably 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 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)

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

OUTPUT:

```
##SOLVE FOLLOWING LINEAR PROGRAMMING PROBLEM USING DUAL SIMPLEX METHOD USING R PROGRAMM
> # 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 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

print(TotalCost)

OUTPUT:

```
> ##sOLVE FOLLOWING TRANSPORTATION PROBLEM IN WHICH CELL ENTRIES REPRESENT UNIT COSTS U
>
> #            "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 PROGRAMMI
> # 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)$solution
     [,1] [,2] [,3]
[1,]    0    1    0
[2,]    1    0    0
[3,]    0    0    1




>
```