

## Paper III (Operational Research)

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

INDEX				
No	Date	Title	Page no	Sign
1	1/08/22	Graphical method using R programming.		
2	1/08/22	Simplex method using two variables using python.		
3	1/08/22	Simplex method using three variables using python.		
4	1/08/22	Simplex method with equality constraints using python.		
5	1/08/22	Big M Simplex method using python.		
6	3/08/22	Resource allocation problems using simplex method.		
7	3/08/22	Infeasibility in simplex method.		
8	3/08/22	Dual simplex method.		
9	3/08/22	Transportation problems.		
10	3/08/22	Assignment problems.		

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:

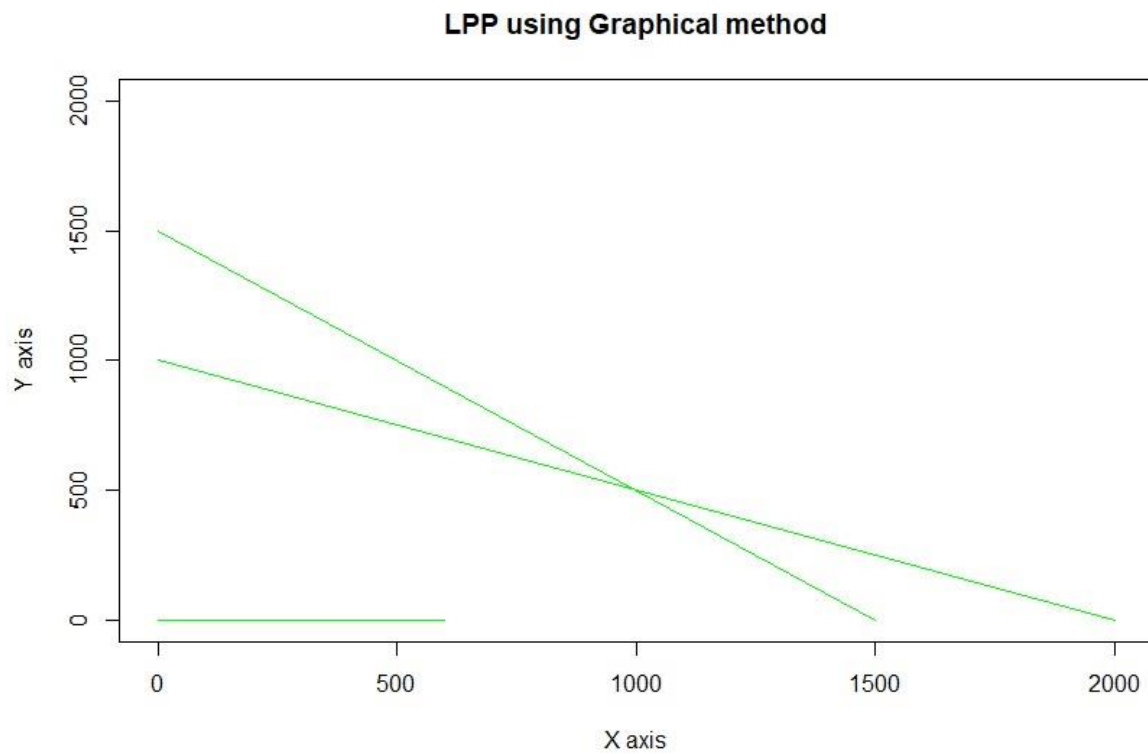
```
[Workspace loaded from ~/.RData]

> # 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 = constraints_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)  Logout

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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]:
```

**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]

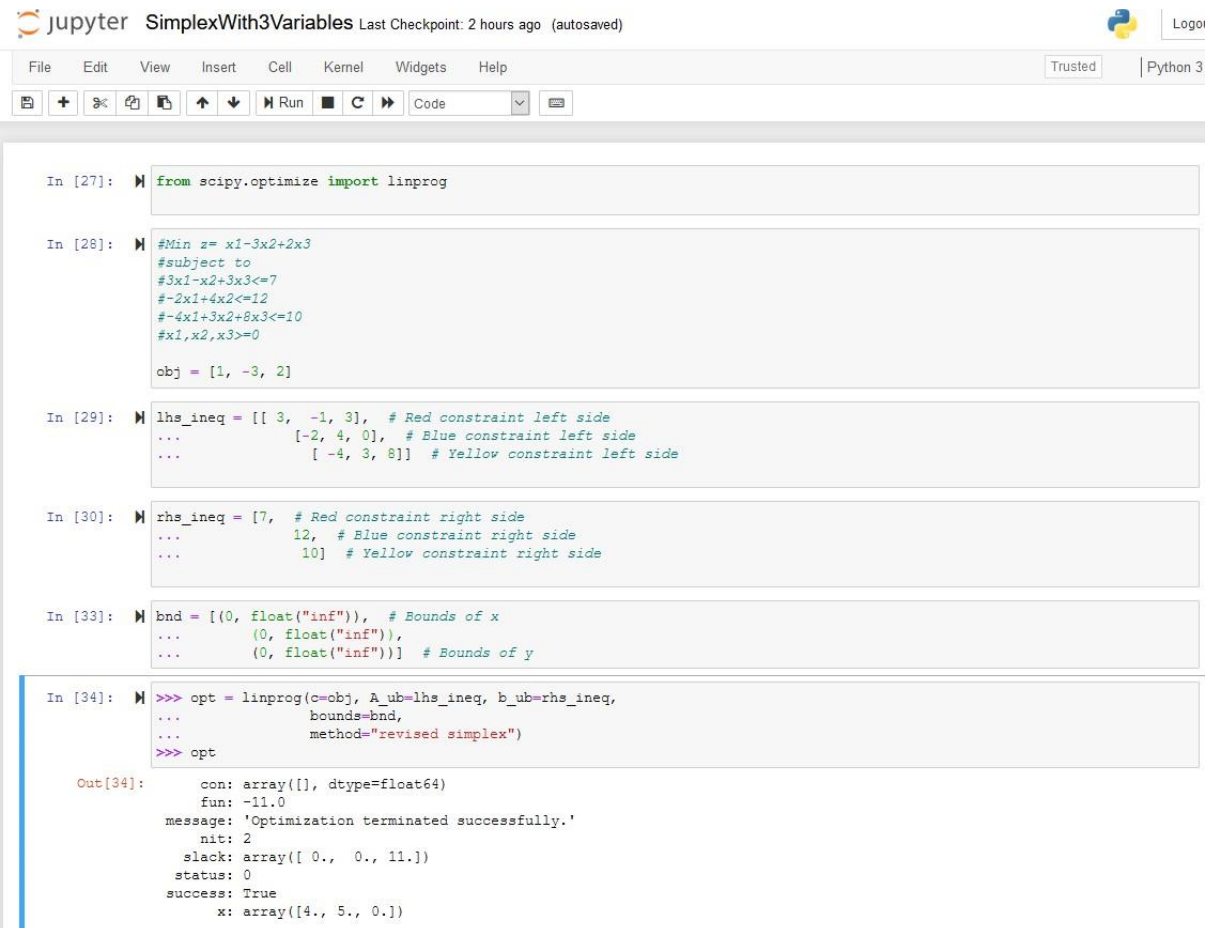
lhs_ineq = [[ 3, -1, 3], # Red constraint left side
...         [-2, 4, 0], # Blue constraint left side ...
[ -4, 3, 8]] # Yellow constraint left side

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
```





The image shows a Jupyter Notebook titled "SimplexWith3Variables". The notebook contains a series of code cells that define a linear programming problem and solve it using the `linprog` function from `scipy.optimize`. The problem is to minimize the objective function  $z = x_1 - 3x_2 + 2x_3$  subject to three constraints:  $3x_1 - x_2 + 3x_3 \leq 7$  (Red),  $-2x_1 + 4x_2 \leq 12$  (Blue), and  $-4x_1 + 3x_2 + 8x_3 \leq 10$  (Yellow). The variables  $x_1, x_2, x_3$  are non-negative. The solution is found using the "revised simplex" method, resulting in an optimal value of -11.0 at  $x = [4., 5., 0.]$ .

```
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<=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])
```

```
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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  $z = 4x_1 + x_2$  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

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Run Code

### 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:

$$x_1 + x_2 + x_3 + x_4 \leq 50 \quad \text{----- (manpower)}$$

$$3x_1 + 2x_2 + x_3 \leq 100 \quad \text{----- (material A)}$$

$$x_2 + 2x_3 \leq 90 \quad \text{----- (material B)}$$

$$x_1, x_2, x_3, x_4 \geq 0$$

```
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
```



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

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

subjected to:

$$\begin{aligned} x_1 + x_2 + x_3 + x_4 &\leq 50 && \text{-----(manpower)} \\ 3x_1 + 2x_2 + x_3 &\leq 100 && \text{-----(material A)} \\ x_2 + 2x_3 &\leq 90 && \text{-----(material B)} \\ x_1, x_2, x_3, x_4 &\geq 0 \end{aligned}$$

```
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**

```

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# 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]: 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 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  $z=40x_1+50x_2$

#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 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
PROGRAMMI
> # 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 inequality 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 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 US
>
> #           "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)$solution
[,1] [,2] [,3] [,1,] 0
1    0

```

[2, ]	1	0	0
[3, ]	0	0	1

>